EDITORIAL: BEST PRACTICE APPROACHES FOR MIXED METHODS RESEARCH IN PSYCHOLOGICAL SCIENCE

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Editorial: Best Practice Approaches for Mixed Methods Research in Psychological Science

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[†]Our heartfelt and emotional memory to Angel, co-author of this Editorial, who died prematurely during the development of this Research Topic

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Editorial on the Research Topic

Best Practice Approaches for Mixed Methods Research in Psychological Science

INTRODUCTION

Mixed methods research burst onto the scene around the beginning of the second millennium. After decades of intense dispute between those who preferred the qualitative perspective and their quantitative counterparts—with both sides having grown deeply entrenched in their respective views—a complementary approach promising the possibility of integration had finally been proposed. By that time, however, the vast majority of researchers had committed to one stance or the other; very few of us argued that the two approaches could be complementary.

Since then, the number of publications, scientific meetings and other activities devoted to the mixed methods approach has increased exponentially throughout the world. For us, there are two definitions specially relevant. Teddie and Tashakkori (2010) defined mixed methods research as "research design using qualitative and quantitative data collection and analysis techniques in either parallel or sequential phases" (p. 11). And Johnson et al. (2007) say that "Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration" (p. 123). Moreover, Johnson et al. (2007) have listed and analyzed 19 definitions of mixed methods, and the authors that have worked on this topic as a part of a big community. The expansion of mixed methods in the scientific community has been expanding rapidly.

At a substantive level, we are pleased to see that a growing number of fields are generating mixed methods research, and we are eager to assist in promoting this trend. However, the field has experienced some "growing pains": a certain degree of heterogeneity in terms of approaches, differences of opinion regarding certain conceptualizations (for example, mixed methods vs. multi-methods), numerous design taxonomies, multiple ways of integrating qualitative and quantitative elements, and various positions on how best to overcome the enduring lack of symmetry between qualitative and quantitative aspects. The methodological and substantive spectrum is vast and broad, possibly because the mixed methods approach has become "obligatory" for much research, not only in psychology but in practically all branches of the social sciences.

Our proposal for delineating between mixed methods and multimethods has been presented in a previous work (Anguera et al., 2018). We believe that a study will be multimethod when, driven by a common overall research goal, it uses a series of complementary methodologies, chosen according to a given criterion. According to our proposal, whether it has a predominantly qualitative or quantitative nature has no bearing on its consideration as a multimethod study. By contrast, the essence of mixed methods studies is that they contain qualitative and quantitative components that must be integrated to ensure the mixing of the information they carry. Combining and integrating quantitative and qualitative data in the same study, however, poses numerous challenges, and attempts have been made in recent years to untangle this *Gordian knot*, generating and developing strategies for successfully integrating qualitative and quantitative data.

The aim of this Research Topic is to present a selection of studies whose methodological approaches include, as a central element, aspects related to the *Gordian knot* of mixed methods, that also incorporate secondary—but no less important—elements such as dataset transformation, analytical techniques and data integration, as well as studies in which systematic observation is used as a mixed method in itself. The Research Topic has promoted a transparent presentation of the mixed approach used to develop the conceptual, methodological or application-related contribution of each article. This transparency will enable other researchers to critically appraise and replicate the methods used.

The 32 articles that make up the Research Topic *Best Practice Approaches for Mixed Methods Research in Psychological Science,* with contribution from 121 authors, are organized from a substantive point of view in different criteria, although each of the published articles could have been "classified" from several points of view.

METHODOLOGICAL DEVELOPMENTS

It is important to highlight the contributions made in the articles published in this Research Topic from the methodological criteria, given the conceptual amplitude of the *mixed methods* topic and its repercussions in applied studies.

We distinguish different procedural orientations, which could be structured around different facets, such as conceptual, technological, methodological, psychometric, and teaching.

Schoonenboom's work focuses centrally on case development from the perspective of *mixed methods*, conceptually showing how to save the successive controversies that may arise, to later develop subcases, and finally, a moderate case.

If we look from a technological perspective in the *mixed methods*, we locate the article by Müller et al., which focuses on the study of sensors to study social processes, which provide quantitatively and qualitatively treatable data. From a laboratory setting, Casarrubea et al. deepens in reflections about the meaning of "the qualitative" and "the quantitative." Zurutuza et al., in a telemetric study, use data from GPS technology, now expanding.

If we refer to computer programs used, we highlight the LINCE recording program (see Alcover et al.; Aranda et al.; Casal et al.; Escolano-Pérez, Acero-Ferrero et al.; Escolano-Pérez, Herrero-Nivela et al.; Maneiro et al.; Portell et al.; Prat et al.; Terrenghi et al.), the SAGT generalizability analysis program (see Vázquez-Diz et al.; Vázquez-Diz et al.), the GSEQ record and analysis program (see Del Giacco et al.; Escolano-Pérez, Acero-Ferrero et al.; Escolano-Pérez, Herrero-Nivela et al.; Morales-Sánchez et al.; Portell et al.; Venturella et al.), the HOISAN record and analysis program (see Alcover et al.; Camerino et al.; Del Giacco et al.; Escolano-Pérez, Herrero-Nivela et al.; Menescardi et al.; Morales-Sánchez et al.; Portell et al.; Vázquez-Diz et al.; Vázquez-Diz et al.), and the THEME analysis program (see Brill and Schwab; Camerino et al.; Casarrubea et al.; Escolano-Pérez, Herrero-Nivela et al.; Hunyadi; Morales-Sánchez et al.; Portell et al.; Prat et al.; Szekrényes). Furthermore, we highlight the studies by Suárez et al. and Terrenghi et al., in which the DRAGON program has been used for the transcription of interviews; that of Morales-Sánchez et al., where the FACE READER program has been used to obtain data on facial expressions, ALCESTE in the study by Rodríguez-Naveiras et al. for text analysis; ATLAS.ti in Suárez et al. also for text analysis; AMOS in the article by Teques et al. for the analysis of structural equations; MATLAB in Menescardi et al., and the WEKA tool to materialize data mining in the article by Pastrana et al.. In turn, the SPSS has been used in Aranda et al., Maneiro et al., Rodríguez-Naveiras et al., and R in Casal et al..

From a methodological approach, Magnusson's seminal work shows how T-Pattern Analysis (TPA) passes repeatedly between qualitative and quantitative analysis, and precisely this analysis technique has allowed the performance of multiple *mixed methods* studies, be treated in a unique way, or combined with others, with the analysis of polar coordinates, as in the work of Portell et al..

There are several articles published in this Research Topic that have used the TPA, and with a methodological purpose rather than application. Hunyadi's article is an exponent of the great possibilities in the field of communication understood in a multimodal way, through the HuComTech project, and that of Szekrényes, which technologically allows starting records in ELAN to analyze the data with THEME.

The essential *desideratum* of *mixed methods* lies in the use of data of diverse nature, and the study by Brill and Schwab uses data from self-reports (from questionnaires) and videographic recording of behavior, in addition to content analysis. Likewise, Teques et al. start from the data of self-reports and observational records. For their part, in Prat et al. data were obtained from observational instruments and Likert scales. In Suárez et al. interviews, questionnaires, and observational records are used. And in Terrenghi et al. videographic recordings, self-reports, manual registration, questionnaires, and focus groups were the chosen data gathering methods.

In recent years, consideration of the observational methodology began as mixed method itself (Anguera and Hernández-Mendo, 2016; Anguera et al., 2017), and has expanded rapidly, as this Research Topic attests. Among the 32 published articles, there are 17 that use observational methodology, and from this point of view, the great macro-stages that characterize the process are expressed through the QUAL-QUAN-QUAL, which allows qualitative data to be transformed into other types, also qualitative, but in such a way that they can be treated quantitatively, and then interpreted qualitatively (Anguera et al., 2020; Anguera et al., in press). This interpretation of *mixed methods* is strongly supported by the words of Creswell and Plano Clark (2007), when referring to *connecting* as a way of integration between qualitative and quantitative elements. The articles consisting of empirical studies found in this block are the following, in alphabetical order of the first author: Alcover et al., Aranda et al., Camerino et al., Casal et al., Del Giacco et al., Escolano-Pérez, Acero-Ferrero et al., Escolano-Pérez, Herrero-Nivela et al., Maneiro et al., Menescardi et al., Morales-Sánchez et al., Portell et al., Prat et al., Suárez et al., Vázquez-Diz et al., Vázquez-Diz et al., Venturella et al., and Zurutuza et al..

Reflecting on the transit that has been carried out in certain areas, from controlled clinical trials, considered as mono-method, to *mixed methods*, there is a conceptual path that is emphasized by Carey et al., and paying special attention to causation and operationalization.

With a clearly psychometric interest, the works of Timoszyk-Tomczak et al., and Llistosella et al. were published, about the adaptation of a measurement instrument.

From the point of view of data analysis, the following techniques have been used in the empirical studies of this Research Topic: TPA (9), analysis of polar coordinates (8), analysis of generalizability (4), lag sequential analysis (3), analysis of variance (3), and, to a lesser extent, comparison of proportions, Student's t, Pearson's correlation analysis, factor analysis, principal component analysis, cluster analysis, logistic regression, structural equation models, and decision tree.

And we end this block with teaching on *mixed methods*, with the work of Roberts et al., which advocates that the teaching of *mixed methods* be carried out by insisting from the beginning on the integration of qualitative and quantitative methods, instead of doing it separately and sequentially.

AREAS OF APPLICATION

The studies that we publish in this section stand out for both substantive and procedural aspects within *mixed methods*, but we have considered that the emphasis that they represent at the level of application areas was the most important.

In decreasing order, there are 11 articles in the field of sport, 7 in school-education, 4 in clinical psychology, 2 in conversation analysis, and one in each of the following fields: occupational health, the media, feeding behavior in rats, resilience, organizational psychology, time, and teaching. Furthermore, there is one that is purely methodological, and does not refer to any substantive scope.

CONCLUSIONS

In short, the articles included in the Research Topic make up a broad spectrum.

As Editors of this Research Topic, we want to express the satisfaction that comes from having the opportunity to offer the materialization of new studies in the exciting field of mixed methods to the scientific community.

The Research Topic proposal has been motivating, exciting and satisfying, as well as the highest level of acceptance of the originals. Regarding the management, the originals of the 32 articles that make up this Research Topic were published between January 2019 and July 2020. 48 manuscripts were sent; therefore, the acceptance percentage was 66.6%.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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OPINION
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A Call for the Inclusion of Mixed Methods Research in the Undergraduate Psychology Curriculum

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For mixed methods research in psychology to expand, a body of psychologists, and psychology academics who have the knowledge and expertise to conduct and review mixed methods research is required. Reviews of mixed methods articles in psychology (e.g., Bartholomew and Brown, 2012; Bartholomew and Lockard, 2018) have highlighted issues related to the lack of clarity of methods used in published mixed methods psychological research. These include the failures to identify the type of mixed method design, the mixed methods research question, the qualitative analysis methodology, and to explicitly state the process for integrating data. These findings highlight the lack of training for psychologists in both conducting and reviewing mixed methods research. Whilst the new American Psychological Association reporting standards for mixed methods research (Levitt et al., 2018) are helpful for authors and reviewers with some mixed methods expertise, they must be complemented by at least foundational training in mixed methods research to ensure the quality and rigor of mixed methods research published in psychology journals.

In order to develop a body of psychologists and psychology academics who have the knowledge and expertise to conduct and review mixed methods studies, we need to teach current and future generations of psychology students about mixed methods research. At present, mixed methods research training, where offered at all, is typically provided at the doctoral level and across disciplines (Christ, 2009; Baran, 2010; Poth, 2014). Whilst Onwuegbuzie et al. (2011) argued that we can expect mixed methods to be routinely taught in the majority of higher degree by research programs in the future, Poth (2014) viewed one-off mixed methods courses as inadequate preparation, calling instead for the teaching of mixed methods research to begin earlier, positioned alongside the teaching of qualitative and quantitative research. Similarly, while not specific to psychology, the Mixed Methods Task Force report on the future of mixed methods (Mertens et al., 2016a) has recommended the inclusion of mixed methods approaches in the undergraduate curriculum, describing this as "the natural starting point" (p. 19).

We echo the sentiment of the Task Force by calling for the inclusion of mixed methods research in the undergraduate psychology curriculum, beginning with teaching an appreciation of mixed methods research. The last decade has seen an increase in the number of psychology undergraduate programs in the United Kingdom, United States of America and Canada[1]

[1]The teaching of qualitative research methods in undergraduate psychology in other countries has not been documented in the academic literature. We acknowledge that there are likely to be large variations in the amount of qualitative research methods taught across countires, and this will impact on the feasibility of introducing mixed methods research.

teaching both quantitative and qualitative research methods (Gibson and Sullivan, 2018; McMullen and Winston-Proctor, 2018). Although these methods are often poorly integrated, and many educators tend to focus excessively on differences between qualitative and quantitative paradigms (Fielden et al., 2012), this teaching does provide a foundation for the introduction of mixed methods research. As exposure to quantitative and qualitative research increases, psychology students' perceptions of the incompatibility of qualitative and quantitative research methods decrease (Roberts and Povee, 2014). While the teaching of both quantitative and qualitative research methods equips students for multimethods research (the use of multiple methodologies to address different goals within a research project), mixed methods research varies from multimethods research in the focus on integration, as both qualitative and quantitative components are addressing the same objective (Anguera et al., 2018). Integration can occur during design, methods, interpretation or reporting (Fetters et al., 2013) and can result in additional insights and understanding. When moving from teaching qualitative and quantitative research methods separately to teaching mixed methods research, it is this mixing and integration that needs to be taught. Previous research has demonstrated that undergraduate psychology students are receptive to mixed methods, despite some misconceptions about mixed methods research and skepticism about the motivation and practices of mixed methods researchers (Povee and Roberts, 2015) that may stem from their unfamiliarity with this type of research.

Burgeoning literature on mixed methods research pedagogy at the postgraduate level (e.g., Earley, 2007; Christ, 2009; Baran, 2010; Onwuegbuzie et al., 2011; Frels et al., 2012, 2014; Poth, 2014) can be used to inform the development of mixed methods research courses at the undergraduate level. Frels et al. (2014) reported that leading mixed methodologists emphasized application and integration as learning goals when teaching mixed methods research. However, there is no "one size fits all" in terms of how mixed methods training can be delivered. Research conducted with experienced mixed methods teachers (Onwuegbuzie et al., 2011) indicates that courses vary in their orientation (importance placed on coverage of quantitative and qualitative methodologies before covering mixed methods), application (from conceptual to applied), and structure (from highly structured to exploratory/experiential), highlighting the possible range of teacher positions for mixed methods courses. This diversity of teaching approaches reflects the diversity of mixed methods research designs. Regardless of the teaching approach selected, Mertens et al. (2016a) highlight the role of educators to support students in aligning mixed methods research choices with philosophical assumptions.

A limited number of example models (e.g., Onwuegbuzie et al., 2013; Ivankova and Plano Clark, 2018) and syllabi (e.g., Earley, 2007; Christ, 2009) for mixed methods research courses are available. We encourage academics who teach mixed methods to undergraduates to share their syllabi, resources and experiences. We note that there are currently no materials that relate to teaching mixed methods research in the "statistics and research methods" teaching resources and "research methods" project syllabi sections of the *Society for the Teaching of Psychology* website (http://teachpsych.org/)[2]. The recently published *Oxford Handbook of Undergraduate Psychology Education* (Dunn, 2015) is similarly silent with regard to teaching mixed methods.

Whilst the availability of teaching resources, example syllabi and authoritative guides will no doubt encourage some instructors to introduce mixed methods into undergraduate research methods classes, the inclusion of mixed methods in our accreditation guidelines and textbooks will have a much larger and more immediate impact. In Australia, where the first author works, the Australian Psychology Accreditation Council (2018) require that research methods be taught to all undergraduate psychology students, but are not prescriptive about the range of methods students should be exposed to. In the United Kingdom (home of the second author), the British Psychological Society (2017a,b) specify that undergraduates should learn how to conduct quantitative and qualitative research, but make no mention of mixed methods research. The regulatory landscape in the United States is similar (American Psychological Association, 2016). Furthermore, the current[3] bestselling psychology research methods textbook on Amazon.com (Morling, 2018) does not include any coverage of qualitative, let alone mixed methods research. Coolican (2014), the current best seller on Amazon.co.uk, does provide coverage of both, although mixed methods is relegated to a handful of brief mentions in chapters on measurement and qualitative methods.

The positioning of mixed methods teaching within the undergraduate psychology curriculum needs careful consideration. Ideally, the way we teach research methods will change, integrating the teaching of qualitative and quantitative methods from the beginning, rather than teaching each separately and in opposition to each other (for an illustration of this approach, see Onwuegbuzie et al., 2010). This will overcome two key challenges currently faced in teaching mixed methods: the preconceived bias and misperceptions of students about quantitative and qualitative methods and the diversity of competence in qualitative and quantitative research of students entering postgraduate mixed methods research courses (Frels et al., 2012).

Where this restructuring of the research methods curriculum is not possible, there are a number of alternatives. First, it is possible to teach quantitative, qualitative and mixed methods courses sequentially throughout the undergraduate curriculum, such as is currently done at the first author's institution. A potential consequence of this sequential approach is that quantitative research is set up as the main research methodology for psychology, with qualitative research then seen as an alternative approach (Roberts and Castell, 2016). Mertens et al. (2016a) note that where either quantitative or qualitative approaches are priveliged in teaching, a cultural shift will be required to support mixed methods approaches. The priveliging of quantaitive research methods over qualitative research methods in order of teaching potentially leads to a

[2]We note that the only graduate level research methods project syllabus listed also neglects mixed methods research.
[3]At 28 September 2018.

misperception that the qualitative component of mixed methods research is tokenistic (Povee and Roberts, 2015).

Beyond this, decisions on how to incorporate the teaching of mixed methods research in the undergraduate psychology curriculum can be informed by the three components of a student-centered pedagogy for research methods identified by Kilburn et al. (2014): making the research process visible, engaging students in conducting research, and reflecting on the research process. Examples of activities that fit within this framework might include embedding mixed methods assignments and presenting and discussing relevant mixed methods research findings within subject courses. Greene (2010) asks students to select a mixed methods article and lead a class discussion on the quality of the study. The first author has individual and group assessments that require students to take the perspective of a journal article reviewer and critically review mixed methods articles. These tasks explicitly ask students to reflect on how well the qualitative and quantitative components of the research haved been integrated.

Regardless of the way in which mixed methods research is implemented within the undergraduate psychology curriculum, evaluation will be essential in order to determine "what works." Guetterman et al. (2017) have developed a reliable and validated self-rated measure of mixed methods skills that can be used to track students' self-ratings of skill development, and may be used by course coordinators to improve curricula in areas where students report they have limited skills.

We are not suggesting that introducing mixed methods to the undergraduate psychology curriculum will be an easy task. A key challenge facing mixed methods research educators is the time required to cover key quantitative and qualitative methods in addition to the mixing of methods (Onwuegbuzie et al., 2011; Frels et al., 2012). Students in graduate courses report finding mixed methods terminology and the concept of mixing paradigms challenging (Hesse-Biber, 2015; Gilmartin and Esterhuizen, 2017). This is not surprising given the "kaleidoscope" of mixed methods approaches and terminology (Mertens et al., 2016b) and questions over the relevant content and skills to be taught (Mertens et al., 2016b). Teachers of mixed methods courses often have not been formally taught mixed methods themselves, and may have strengths in only qualitative or quantitative research, indicating that a team-teaching approach may in some cases be required (Hesse-Biber, 2015). Further, in our experience, not all students are interested in learning mixed methods research, with some undergraduate students already expressing a clear preference for either quantitative or qualitative research methodologies by their final undergraduate year. Despite these challenges, we envisage there will be benefits to the discipline and employers in future years in terms of producing psychology graduates who are able to select from the full range of research designs: quantitative, qualitative and mixed methods.

AUTHOR CONTRIBUTIONS

LR was responsible for leading the writing of the paper. PA contributed to the design, ideas and writing.

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Transcendent and Transcendental Time Perspective Inventory

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The purpose of this paper is to propose a tool to examine the transcendent and transcendental time perspective (TTTP). The inspiration to develop the scale were Philip G. Zimbardo and John N. Boyd studies, as well as by Lars Tornstam's gerotranscendence theory and own research. The analysis of life from death to eternity is an interesting, heterogeneous and difficult subject of study. The proposed TTTP inventory can be utilized to investigate the future that extends beyond the frames of a personal time perspective, beyond the individual's death as well as beyond the recognized, standard ways of understanding oneself, other people and the world. The inventory refers to changes of quantitative and qualitative nature relating to what is going to happen. It is composed of two sub-scales: the transcendental future and the transcendent future. The paper outlines the psychometric values of the qualities of the inventory, its validity and accuracy based on such indicators as the discriminative of items, the Cronbach alpha index for each of the sub-inventories and the exploratory factor analysis. The study findings come from analyses conducted on a group of 211 elderly subjects (the average age of 65; 70% women, 30% men). A confirmatory factor analysis was also conducted on a group of 238 elderly subjects (the average age of 66; 69% women, 28% men, 3% no gender data available). Additionally, the paper presents data on the accuracy of the external scale. The data are interpreted in the light of the time perspective theory as well as the existing studies.

Keywords: transcendental time perspective, transcendent time perspective, gerotranscendence, future, time perspective

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INTRODUCTION

The questions of time and timing are a subject of interest in many fields of science. Time is one of the most fundamental and universal categories by means of which people can grasp the reality and which make it comprehensible. Time is an indispensable element of individual and social experience (Bokszański et al., 1998). The studies on the psychology of time date back to the beginning of the 20th century. The dynamics of these studies varied over years from initial fascination to the loss of interest to revival (Hancock and Block, 2012). The psychologists usually analyze psychological time, which people sometimes perceive subjectively. This means that psychological time is personal, biased and conditioned by one's experience. The non-objectivity of time is a function of human activity and of related experience (Bakiera and Stelter, 2011). The analyses of psychological time encompass a wide range of subjects from biological rhythms to the perception of diverse aspects of time to culture change and its rate. As a result of this diversity of subjects many models have been developed of psychological time seen from different angles: bio-psychological, behavioral, cognitive, developmental, psychoanalytical or socio-psychological

(Block and Grondin, 2014). Within the framework of the studied into psychological time the researchers examine such constructs as time perspective, temporal orientation, attitude toward time, time competences, time pressure, time structuring and planning, time awareness, the telic nature of time and time management, the passage of time or time in interpersonal relations (Nuttin, 1985; Zaleski, 1994; Uchnast, 2006; Zimbardo and Boyd, 2008).

Another term associated with psychological time is mental travel hypothesized by Tulving (1972, 1985, 2002). He considered episodic memory to be a basis for re-living the past and pre-living the future. Mental travel may envelop the spans of time beyond individual existence. An individual can travel in time to moments prior to their birth or after their death (Tulving and Kim, 2007). Traveling to these time moments comprises the personal, generational and metaphysical contexts and is connected with the stress caused by such ultimate experience as one's own death (Suddendorf and Corballis, 2007). Time traveling which transcends the time limits of one's own life cannot be compared to traveling in time within the limits of existence. It is based on the belief in the existence of something beyond death and related to confronting oneself with the end of one's own existence.

In reference both to psychological time and to the ability to travel mentally in time, the future becomes particularly important. The future is a domain where the individual is motivated and which influences their behavior and activity (Nuttin, 1985). It encompasses what is unexpected, what is ahead of us, what cannot be predicted and explored in any available way. It is a domain of realized plans as well as of surprise. It combines expected and unexpected changes, gives rise to hopes and fears. When we open our eyes to the future and step beyond the limits of our existence, it becomes even more difficult to grasp. This is a result of theoretical and methodological deficits experienced in studies on psychological time (Zimbardo and Boyd, 1999), particularly when the subject is approached from such a wide angle.

The studies on the future that stem from the time perspective analysis (Frank, 1939; Lewin, 1942) were initiated by such thinkers as Fraisse (1967). He focused on the topic of time prediction. His work directed the researchers' attention to temporality and its relationship with the functioning of individuals. Today, we have a multitude of studies that deal with the future time perspective and time orientation (but see Nuttin, 1984, 1985; Nurmi, 1991; Zaleski, 1994; Trempała and Malmberg, 1998; Nosal and Balcar, 2004; Diaz-Morales, 2006; Uchnast, 2006; Zimbardo and Boyd, 2008).

A problem which is rarely the subject of theoretical and empirical analyses is the future transcending the limits of temporality. In psychology it was Boyd and Zimbardo (1997, 2006) and Zimbardo and Boyd (2008), who attempted to operationalize and investigate the transcendental future. They explained the term as the time after life, i.e., from death to eternity (Boyd and Zimbardo, 1997, 2006; Zimbardo and Boyd, 2008). The transcendental future is associated with the capacity to believe in, think about and imagine the immortality (Seema et al., 2014). It encompasses the infinite time, which often reaches beyond our imagination and it is based on deep faith. Even if people make projections of that time (Boyd and Zimbardo, 2006; Zimbardo and Boyd, 2008; Timoszyk-Tomczak and Bugajska, 2012), they are of a different character than the projects created for the life below. What is essential is relevance rather that realism and subjectively perceived probability of success (Zaleski, 1988). Additionally, these projections last eternally, which gives it a different dimension (Zimbardo and Boyd, 2008). It also prevents their verification. Having created a vision of existence after death, one can only hope. In the context of the temporal future, the implementation of projects can be evaluated, improved, modified. In the context of the future beyond the mortality it is no longer possible to experience success or failure.

In psychology there are also other notions that refer to crossing the limits of earthly existence, such as spirituality, transcendence, transcendent wisdom or gerotranscendence. Spirituality is a concept of a complex structure whose components are such less abstract notions as hope, the meaning of life, forgiveness or a spiritual perspective (Reed and Rousseau, 2007). The spiritual perspective refers to the belief in something that cannot be directly experienced, something that is not subject to devaluation and that does not have to but may encompass religious experience (Reed and Larson, 2006). Transcendence and transcendent wisdom are also associated with spirituality (Straś-Romanowska, 2001; Heszen-Niejodek and Gruszczyńska, 2004). The process of transcendence taking place in late adulthood is a focal point in Tornstam's (2005, 2011). It is founded on an assumption that human aging includes a potential to mature into a new outlook on and understanding of life. Gerotranscendence implies a shift in metaperspective, from a materialistic and rational view of the world to a more holistic and transcendent one (Tornstam, 2011). This includes the re-definition of one's self, their relationship with other people and the world and, primarily, their concept of time. In such a context, their approach to the future beyond death may transcend their earlier understanding of this time. It may involve a new quality in integrating, experiencing and developing the time perspective.

Research on the future in old age (Timoszyk-Tomczak and Bugajska, 2012) led us to create a model for the future time perspective in late adulthood. This model was largely based on Nuttin's (1985) and Lens (1986) future time perspective. At that time, we concluded that the future of older people was open and could be extended to include a transcendental aspect. The material we collected allowed us to conclude that individuals in late adulthood think about their future not only in their personal dimension, but also in the generational or even in the metaphysical one. Hence, we divided the elderly people's future time perspective into personal (individual), generational and metaphysical parts. In the personal and generational future, we distinguished the temporal and transcendental aspects. Also, we linked transcendentalism with the metaphysical aspect, i.e., with the space-time transgression.

In the course of analyzing the data we had collected, doubts began to arise as to the realm beyond mortality which seemed heterogeneous. Faith in some form of life after death was not always associated with thinking about that time, but also with images of it. We were looking for explanations and distinctions in relation to that time. Tornstam's concept of gerotranscendence;

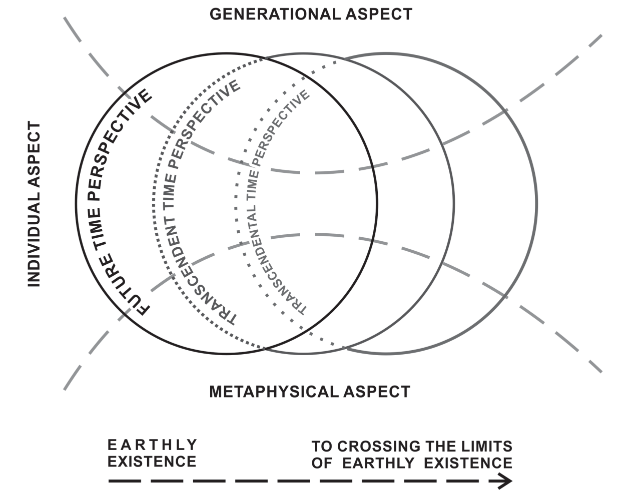

FIGURE 1 | The model of the future time perspective together with the transcendental and transcendent future.

Tornstam (2005, 2011) was helpful in this regard. We focused on distinguishing between the transcendent and transcendental. We considered the transcendentality of the future primarily as faith and ruminating on time after death in terms of personal images such as meeting with loved ones or salvation rather than thinking about the future of generations to come or the universe. And we acknowledged the transcendence of the future as embracing both the temporality and what is beyond the temporality, present in the personal and generational dimension, and including the metaphysical aspect (Timoszyk-Tomczak and Bugajska, 2016). Transcendentalism and transcendence are not completely inseparable, but they have a different specificity. They can complement each other, but they can also function relatively independently. Transcendentality may be more related to cultural message, including attitudes toward religion, while transcendence refers rather to the internalization of values and models as well as spiritual development (**Figure 1**).

SOURCES AND INSPIRATION TO CREATE PROPOSED INVENTORY

The theoretical model became the basis for the development of the inventory of the transcendental and transcendent future. Additional inspiration to develop the inventory was a 10-item Transcendental Time Perspective Inventory by Boyd and Zimbardo (1997, 2006) and Zimbardo and Boyd (2008). Measurements made with the use of this tool by the authors of this paper and other researchers (Ortuño et al., 2013; Seema et al., 2014; Maris Vázquez et al., 2016) show that the analysis of time after life to eternity can be a very interesting but difficult subject of studies. Zimbardo and Boyd's tool focuses on the aspect of belief in life after death, particularly on the belief in some form of existence after death. It does not, however, measure how often a given person thinks about the time after death (Seema et al., 2014). Neither does it examine the future beyond individual existence.

The future beyond human life is a sensitive and complicated research subject. It can trigger one's fear of death or engage their dysfunctional beliefs but, at the same time, it can reach beyond self-centeredness and elicit the process of transcendence. On the one hand it seems that the majority of humans think about death increasingly often as they are aging (Timoszyk-Tomczak and Bugajska, 2012). On the other hand, the nature of these thoughts may take various forms and refer to different issues. People can extend the future on a linear basis and simply create some projects for the time after death (Zimbardo and Boyd, 2008; Timoszyk-Tomczak and Bugajska, 2016), still remaining in the context of their lives below. They can also step outside their temporality and think about the future in the category of other generations, which is closer to the processes of gerotranscendence (Tornstam, 2011). Both these forms are not mutually exclusive but they can be partly separate ways to approach the future beyond mortal life. This is why it seems worthwhile to develop tools that will help examine these aspects of the future.

DESCRIPTION OF PROPOSED TOOL

Subjectively perceived future refers to different levels, such as individual, generational or metaphysical future (Nilsson et al., 2003). It can embrace the mortal life or reach beyond death (Boyd and Zimbardo, 1997, 2006; Zimbardo and Boyd, 2008). The future transcending earthly life may become the area of individual projects – the plans whose characteristics differ from the temporal ones. On the other hand, it may mean re-definition of the self, the time and the hitherto existing context (Timoszyk-Tomczak and Bugajska, 2015).

The authors' own studies on the elderly people's future time perspective show that many people think about the time after their death and make predictions about it in various ways (Timoszyk-Tomczak and Bugajska, 2012). This thinking and the approach to the future understood in an open manner, i.e., as crossing the limits of human life, takes different forms. Sometimes it is restricted to 'what is known' or to what lies within the framework of one's religious or non-religious beliefs, while sometimes it has a transcendental character, which means going beyond the way we have comprehended the reality and ourselves (Tornstam, 2011).

The transcendent and transcendental time perspective inventory examines the future that passes beyond the limits of personal future, beyond individual death and beyond the recognized, standard understanding of the self, the relationships and the world. It addresses the changes of qualitative and quantitative character. The inventory is composed of two sub-scales.

The Transcendental Time Perspective

The transcendental time perspective refers to individual capacity to cross the limits of the earthly life, to mental traveling to eternity. It is first and foremost about believing in existence after death and imagining "what will happen to me after my death."

It includes "planning" things such as a meeting with relatives or salvation as well as the emotional attitude toward that time.

The Transcendent Time Perspective

The transcendent time perspective is a holistic vision of life and death, devoid of the strong commitment of the "I." A qualitative change in the perception of the future, both temporal and non-mortal. Apart from the personal aspect, it increasingly often includes the generational aspect, as well as the metaphysical one which is associated with the fate of the universe. It gives meaning to one's own existence and allows one to reflect on their own life, but also on the life of other generations and the world. It makes the passing of human life easier to accept.

CONSTRUCTION OF PROPOSED TOOL

The studies on the future time perspective of elderly people have shown that people in the late stage of adulthood often plan their earthly future and go beyond temporality while thinking about death and the time after death (Zimbardo and Boyd, 2008; Timoszyk-Tomczak and Bugajska, 2012). When analyzing the notions of spirituality, transcendence, transcendent wisdom or gerotranscendence, the distinction has been made into transcendent and transcendental future. The former is closer to gerotranscendence, whereas the latter – to comprehending the future after death in terms of the life below (Timoszyk-Tomczak and Bugajska, 2016). Having made the distinction between the two, an initial selection of a pool of 36 statements was made. A half of the statements refer to the transcendent future and another half – to the transcendental one. The questions were created on the basis of the prior conceptualization. After a content analysis and linguistic consultation, and following a discussion with experts 26 items were selected for the first version of the inventory.

Survey Respondents and Procedure

The survey was carried out on two samples. An initial research procedure was run in 2017 in accordance with the Declaration of Helsinki. The written informed consent was obtained from the respondents of this study. The study was conducted in a group of 211 respondents (70% of women, 30% of men), with different levels of education and aging from medium to late adulthood (the average of 65). The selection for the sample was purposeful, as the tool is mainly designed for older people. The respondents were invited to the survey by trained students. The survey was of a group character, after presenting the purpose of the survey and instructions, the respondents filled in a questionnaire.

The second study was conducted in a group of 238 respondents (164 women and 67 men, 7 no gender data available), in the mean age of 66. As before, the selection of the sample was purposeful. The study was carried out in groups of people from the Senior Citizen's Home, Third Age University and Social Welfare Home. Respondents were presented with the aim of the research and given a short instruction how to fill in the questionnaire.

PSYCHOMETRIC VALUE OF INVENTORY

In order to test the utility of the inventory and to assign the items to the sub-scales/sub-inventories an exploratory factor analysis EFA was performed in the first sample (211 respondents). The scree plot indicated the presence of two or three factors. The two- and three-factor versions were tested using oblimin rotation assuming the possibility of factors correlation. The two-factor analysis was more accurate. The total explained variance was 40%. Cronbach's alpha for the first factor consisting of 15 items was 0.83, and for the second factor of 10 items it reached 0.88.

Next, internal accuracy was tested in the second sample (239), by means of the confirmatory factor analysis CFA (CMIN/df, RMSEA, GFI, AGFI, CFI, NFI, and AIC). The analyses performed on a model obtained following the factor analysis and free of modifications indicated a poor fit. After adding covariance paths, the indicators improved. The analysis revealed quite good fit indices of empirical data to the orthogonal factor model. Chi-square is relevant but when the distribution is inconsistent with normal distribution (to which this test is sensitive) and the sample is large, its value may rise. The remaining fit indices were good or acceptable (**Table 1**).

In the factor A (transcendental future) covariances may indicate the consistency of items and faith in life after death is presumably the hidden variable. In the factor B (transcendent future), the future is associated with: the future of generations (9–11 and 9–15), the blurring of the boundary between life and death both in personal perspective and the universe (16–17), and acceptance of the indissolubility of life and death (12–18). Negative covariance (10–16) may reveal the complexity of transcendence, where the feeling of being a particle of the universe does not mean the blurring of the boundary between life and death (**Figure 2**).

The discriminative power of inventory items was evaluated on the basis of coefficients of correlation between the results calculated for each item and the result for the sub-scale as a whole. In the first sub-scale the correlation coefficients were stronger and ranged between 0.60 and 0.76, excluding Item 1 whose discriminative power was 0.43. In the second sub-scale the discriminative powers were weaker but still acceptable and ranged from 0.40 to 0.57. According to the internal consistency of the inventory measured with Cronbach's alpha, the reliability of its final version (**Appendix**) was statistically satisfactory (**Table 2**).

The psychometric properties of the inventory are satisfactory and make it a useful research tool in the studies on the time perspective after life and on the process of going beyond the present understanding of time (including the future), of the meaning of life as well as of human relationships with other people and the world.

EXTERNAL ACCURACY

The external accuracy of the inventory was tested with the use of the scale of Krok's religious meaning system Krok's (2009), Trapnell and Campbell's rumination-reflection

TABLE 1 | Results of confirmatory factor analysis CFA.

Model	CMIN/df	RMSEA	GFI	AGFI	CFI	NFI	AIC
Model 2-czynnikowy ortogonalny	1.60	0.050	0.92	0.88	0.95	0.88	1719.73

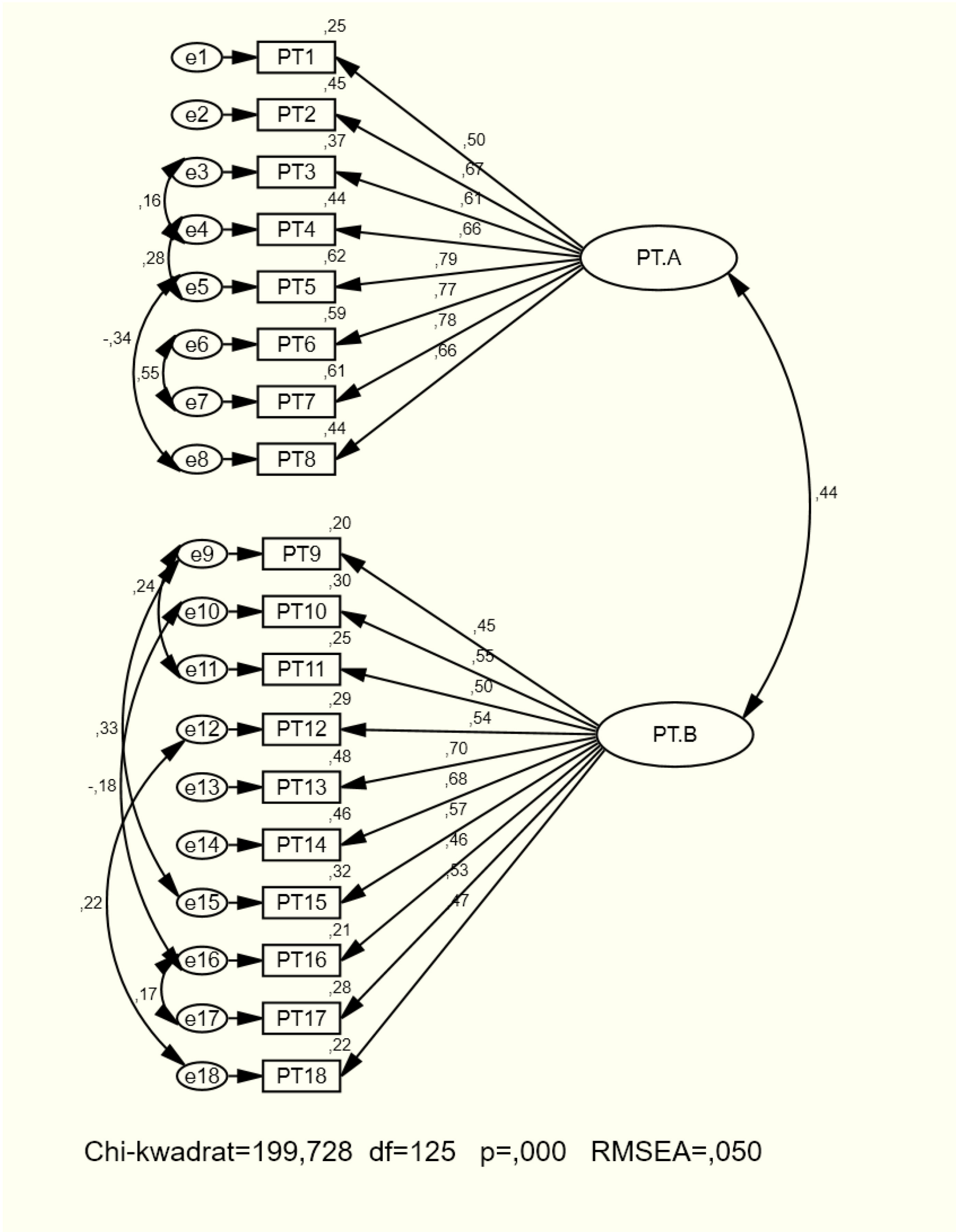

FIGURE 2 | Factor structure of TTTPI.

questionnaire Trapnell and Campbell's (1999) adapted to Polish conditions by Radoń (2014), Zimbardo and Boyd's short-form Time Perspective Inventory Zimbardo and Boyd's (1999) adapted by Cybis et al. (2012) as well as Piotrowski, Skrzypińska and Żamojtel-Piotrowska's spiritual transcendence scale (2013).

Multidimensional analyzes between the time perspective and religiosity were carried by Łowicki et al. (2018). Their study indicates that positive past and future dimension are of special importance for religiousness. Religious content helps people to explain and interpret reality in terms of meaning and purpose. For many religiously conscious people, religious beliefs manifest

TABLE 2 | Characteristics of individual TTTPI items and of scale validity.

Transcendental time perspective		Transcendent time perspective	
Inventory item	**Discriminative power**	**Inventory item**	**Discriminative power**
1	0.43	9 (16)	0.51
2	0.61	10 (17)	0.44
3	0.60	11 (18)	0.42
4	0.68	12 (20)	0.48
5	0.75	13 (21)	0.57
6	0.73	14 (22)	0.52
7	0.76	15 (23)	0.56
8	0.60	16 (24)	0.41
		17 (25)	0.53
		18 (26)	0.40
Reliability of scales			
Transcendental time perspective		Transcendent time perspective	
0.88		0.81	

TABLE 3 | Interrelations between TTTPI and SRMS (N = 308).

Scales	Scale of orientation	Scale of sense	Total
Transcendental time perspective	0.591**	0.617**	0.623**
Transcendent time perspective	0.308**	0.274**	0.299**

* $p < 0.05$; ** $p < 0.01$.

a desire to understand their position in relation to the world and other people (Krok, 2014). It was therefore decided to investigate the relationship between the religious meaning system and the transcendental and transcendent future. The scale of Krok's religious meaning system Krok's (2009) is used to measure religiousness in terms of meaning and contains two sub scales: religious orientation and religious sense. The first one refers to the understanding of the world and one's own life, while the second to the interpretation of life in terms of meaning and purpose. The study was conducted on a group of 308 people (217 women and 91 men), aged 16–86, mean age 25. The results of the correlation analysis showed strong, significant links between the transcendental future and religious orientation and religious sense, as well as with the scale as a whole. We also found weaker correlations between the transcendent future and sub scales and the overall result of the scale of the religious meaning system. This is in line with the assumption that the transcendental time perspective is linked more to faith and personal future, while the transcendent time perspective goes beyond religious beliefs and has a more holistic character (**Table 3**).

Additionally, we compared the indicators of the variables of transcendental and transcendent time perspectives in the group of practicing (141) and non-practicing (49) believers in a group of 180 respondents (130 women, 40 men) aged 60–85. Due to the disproportion in the size of the groups, the non-parametric Mann-Whitney U test was applied. The results showed that in the group of practicing believers the indicator of transcendental time perspective was higher than the group of non-practicing believers. There were no statistically significant differences in the transcendent time perspective indicator. The obtained results are consistent with the assumptions concerning the comprehension of the transcendental and transcendent future (**Table 4**).

The Rumination-Reflection Questionnaire was chosen because of the assumption that the way of thinking about the future beyond mortality may change. Ruminations may be related to a transcendental time perspective based on faith and personal dimension of time, while reflection is more related to a transcendental time perspective, which is associated with the meaningfulness of human life. The rumination and time perspective tests were conducted in a group of 179 participants (131 women and 48 men) aged 58–96, the average of 68. The choice of subjects in their late adulthood was conditioned by the fact that the inventory was designed to test the transcendent and transcendental time perspective which referred to the perspective of the end of life, death and transcendence. The rumination questionnaire is used to examine its two aspects: positive and negative. The positive aspect relates to reflection and lies in openness to experience, while the negative one relates to rumination, i.e., non-adaptive thoughts, opinions and emotions, and stems from neurotic characteristics (Radoń, 2014). The analyses of correlation showed a weak (but relevant) positive relation between the transcendental time perspective and rumination. They also indicated a medium and strong positive correlation of the transcendent time perspective and reflection (**Table 5**). Those findings may be linked to the very nature of both scales that measure the attitude to the future beyond the present

TABLE 5 | Inter-correlations between TTTPI and RRQ (N = 179).

Scales	Rumination	Reflection
Transcendental time perspective	0.162*	0.127
Transcendent time perspective	0.218**	0.385**

* $p < 0.05$; ** $p < 0.01$.

TABLE 4 | Characteristics of non-practicing believers (N = 49) and practicing believers (N = 141) in TTP (factors) – comparative analysis with non-parametric Mann-Whitney U-test.

	Rank sum *practicing believers*	Rank sum *practicing believers*	U	Z	p-level	Z corrected	p-level
Transcendental TP	3067.50	15077.50	1842.50	−4.86	0.000	−4.87	0.000
Transcendent TP	4179.50	13965.50	2954.50	−1.51	0.132	−1.51	0.131

TABLE 6 | Inter-correlations between TTTPI and TPI (N = 179).

Scales	Positive past	Negative past	Hedonistic present	Fatalistic present	Future
Transcendental time perspective	0.093	0.083	0.011	0.100	−0.051
Transcendent time perspective	0.169*	0.187**	0.275**	0.121	0.148*

*$p < 0.05$; **$p < 0.01$.

life. Transcendental future refers primarily to frequent thoughts about one's own death, to believing in what is beyond death and, finally, to an emotional attitude which is probably less functional and inhibits adaptation. Therefore, it seems that aggravated rumination that is not associated with reflection captures the essence of this kind of reference to the time perspective reaching beyond present life. The transcendent future relates to changes based on modified understanding of reality and it is associated with personal development, which in turn indicates the need of open-minded perception of the future after death. Its links with reflection and rumination reveal a particular character of this attitude to the time beyond temporality.

Other relationships were found in the course of the correlation analyses using the Polish adaptation of Zimbardo and Boyd's time perspective inventory. The absence of relevant correlations with the transcendental future indicates the discriminative accuracy of the tool (**Table 6**). The transcendental future shows the particular character of this way of perceiving time as it is not an element of the time perspective, being rather linked with believing in and focusing on what is going to happen after death. The transcendent future is related with the past, both negative and positive, with the hedonistic present as well as with the future. The correlation is the strongest with the hedonistic present which in the late adulthood means not only concentrating on pleasures, but also mindfully appreciating the life here and now (Bugajska and Timoszyk-Tomczak, 2014). This can also indirectly refer to life satisfaction that grows along with the process of gerotranscendence (Tornstam, 2011). The transcendent future is about perceiving time in its various dimensions and seems to extend the time perspective by the time after death.

The study with the use of the transcendence scale (Piotrowski et al., 2013) covered 53 subjects (30 women and 23 men) aged 50–87, the average of 65. The transcendence scale is an operationalization of Piedmont's spiritual transcendence theory Piedmont's (1999; 2001) and consists of two sub-scales: proper transcendence and spiritual openness. The proper transcendence is about finding fulfillment in prayer, faith in life as a whole, the sense of bonding with other people that transcends death as well as about ideological zeal. The spiritual openness is about tolerating paradoxes, or the capacity to think many, not mutually exclusive ways, about non-judgmental approach to other lifestyles, rejoicing every moment and about thankfulness (Piotrowski et al., 2013). Inter-correlations indicate medium positive relations of the transcendent future and the transcendental future with the proper transcendence, which may imply that each of these dimensions includes the aspect of faith, thoughts and emotions referring to the time after death. However, only the transcendent future is connected with the spiritual openness which in turn gives broader perception of not only of personal freedom but also of the future of the world (**Table 7**).

The obtained results slightly better show the character of the transcendental future that refers mainly to some form of life after death and includes an element of 'planning' what can happen beyond the current life. The transcendent future is of a more open nature as it is associated with thinking in the context of generations, a sense of life and its appreciation.

DISCUSSION

The analyses of the subjective approach to time, that are often based on studies on the time perspective, temporal orientation or attitude to time, suffer from the lack of proper tools to measure the attitude to the future transcending the current life. Theoretical analyses and the attempts to tap into the problem show deficiency and inconsistency symptoms in this matter (Zimbardo and Boyd, 2008; Ortuño et al., 2013; Seema et al., 2014; Maris Vázquez et al., 2016). Therefore, it seems essential to create such tools. The statistical analyses quoted above have proven that the proposed transcendental and transcendent time perspective inventory is an instrument that meets the requirements of reliability and accuracy. It is characterized by satisfactory internal coherence and rather good theoretical convergence. The confirmatory factor analysis has corroborated the validity of the chosen dimensions of the future beyond temporality. Therefore, it appears that the inventory is a good method for examining slightly differing attitudes to this time perspective: the transcendental future relating to faith in life after death, and the transcendent future that is focused on the man's place in the universe, on the search for meaning and acceptance of the sense of existence. The inventory can be used in studies on adults, especially the older ones. It does not have a clinical character and requires relatively good cognitive performance, i.e., it is designed for individuals without clear deficits that can inhibit understanding the reality around them.

The performed analyses showed have shown strong links with the religious system of meanings, both with religious orientation and religious sense. They also revealed that believers score higher

TABLE 7 | Inter-correlations between TTTPI and STS (N = 53).

Scales	Proper transcendence	Spiritual opennnes
Transcendental time perspective	0.542**	−0.088
Transcendent time perspective	0.510**	0.422**

* $p < 0.05$; **$p < 0.01$.

on the scale of transcendental future than non-believers. What is more, they also indicate the weakness of correlations between the transcendental future and a propensity to non-adaptive rumination, no links with the time perspective dimensions and a medium relationship with the proper transcendence. This indicates a specific nature of the transcendental future which is primarily associated with believing in any form of life after death. It is a way of thinking about the future beyond the limits of life that expresses the fear of future events, the recurrent contemplation of death and the lack of acceptance of the order of life. On the other hand, the transcendent future is more weakly correlated with the religious system of meanings as well as with rumination and, even to a larger extent, with reflection which has an adaptive character. It is also connected with diverse aspects of the time perspective, with the proper transcendence and spiritual openness. This may mean that the domination of this kind of thinking about the time after death is a part of the process of gerotranscendence (Tornstam, 2005, 2011). It encompasses stronger appreciation of what life is bringing as well as the openness to redefining one's own experience. It does not exclude negative emotions and attitudes, but opens up to appreciation and to the search for meaning.

The study findings are merely an attempt to broaden the views on the time perspective and its specific character when it reaches beyond current life. It is a subject that pertains to existential fears and to the mystery of life, thus exceptionally difficult to explore. It would be interesting to examine the relationships of the transcendent and transcendental futures with the dimensions of personality and with religious attitudes. It would also be worthwhile to analyze the future beyond present life juxtaposed with mystical experience and a range of other aspects of human functioning.

On a practical level, the tool for measuring the attitude to the future after life can be used to support people who are at the end of their existence. Having learnt their approach to the time after life, it will be easier to effectively support them and their carers who often feel helpless when facing pain and fear of death.

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CT-T contributed to preparation and development. BB contributed to consultation.

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APPENDIX

Transcendental and Transcendent Time Perspective Inventory

Read and decide to what extent the questions below are in line with your opinions, feelings and everyday practices. There are no good or bad answers here. What is important is what you think and feel. Mark your answer on the scale 1–5 and put in the number in a square next to the question. Choose the answer:

1 – I totally disagree, 2 – I disagree, 3 – I neither disagree nor agree, 4 – I agree, and 5 – I totally agree.

1. I think about the time after my death.
2. My future is not only what is temporal, but also what is beyond temporality.
3. I envision my life as eternal.
4. I believe that human life takes a different form after death.
5. I believe that there is something out of our body that will preserve after our death.
6. I believe that after death I will meet people close to me.
7. I think about meeting a Superior Being after my death.
8. I have my own important „goals-values" that I would like to realize after my death.
9. (16) When I am thinking about the future, I am thinking about future generations.
10. (17) I have a sense of being a part of the stream of life, what has been and what will be.
11. (18) I feel a bond with past and future generations.
12. (20) When I am thinking about the end of life and beyond, I feel acceptance. Gdy myślê o kresie życia i tym co poza nim to czuje akceptacjê.
13. (21) For me the future is about finding the sense of existence.
14. (22) For me thinking about the future is associated with thinking about the role of the man in the universe.
15. (23) When I am thinking about the future, I start thinking about people who will be living after me.
16. (24) When I am thinking about life and death, the boundaries between these two are blurred.
17. (25) For me the future is about crossing the boundaries of not only my own life but of the universe.
18. (26) For me the time of life and the time of death are inseparable.

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Possession in Football: More Than a Quantitative Aspect – A Mixed Method Study

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The aim of the present study was to identify and differentiate the factors that determine the possession times of successful and unsuccessful elite football teams, with the purpose of identifying a more effective possession model. For this, match corresponding to the round of eighth-finals, quarter-finals, semi-finals and final of the 2016 UEFA Euro France in which 2,636 offensive sequences occurred, were analyzed. Video recordings of matches were analyzed and coded post-event using systematic observation. The performance indicators recorded and analyzed were: phase; match period; type of start-up; interaction context; intention; field zone; possession time, passes, attack outcome; match status and final outcome. An ANOVA was performed to analyze data in order to study the influence of a set of variables. A Box–Cox transformation was applied on the variable explained to achieve normal conditions. A study of the main effects and significant interactions was also carried out, complemented with a set of predictions with the variables that were more significant. It is hypothesized that possession analysis from a *mixed methods* perspective will identify a more effective offensive playstyle. Results show how, in successful teams, possession time is influenced by: Type of start-up, intention and field zone. On the other hand, in unsuccessful teams, possession time is determined fundamentally by intention and match status. In terms of the results of the predictive models, in the case of successful teams, they will have longer possessions in the offensive zone with the score in favor and, in the defensive zone with a draw score, in both situations, initiated with the intention of progressing by means of a transition. For unsuccessful teams, possessions will be of longer duration in the defensive zone with a draw score, regardless of the type of start-up and, in the offensive zone, losing and initiating the play by means of a set ball action and winning by means of a transition. Results obtained in this work identify key factors that determine possession time in teams and allow to differentiate the possessions of successful and unsuccessful teams, identifying a more effective ball possession model. This information can be used to design a possession model with greater probabilities of success and increase the offensive performance of teams.

Keywords: performance analysis, football, possession, UEFA Euro France, observational methodology, mixed methods

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INTRODUCTION

Ball possession, in recent years, has acquired transcendental importance in the offensive game model of many football teams. This circumstance was mainly caused by the success of teams such as the FC Barcelona, Manchester City, FC Bayer München or the Spanish and German national teams. All these teams are characterized by an offensive game model, based on the initiative of the game, through ball possession. Numerous previous works have confirmed that it is a performance indicator that makes it possible to differentiate high-level teams. Grant et al. (1999b) analyzed the 1998 World Cup, concluding that greater ball possession is linked to the team success. The work of Hook and Hughes (2001) showed how successful teams in the UEFA Champions League, World Champions and Europa Cup maintained longer possessions than unsuccessful teams. Bloomfield et al. (2005) reported that the three best teams of the English Premier League in the 2003–2004 season (Chelsea FC, Manchester United FC and Arsenal FC), maintained longer possession time than their opponents. Jones et al. (2004) found significant differences in possession time between successful and unsuccessful teams in the English Premier League. Carling et al. (2005) analyzed the same competition but in the 1996–1997 season, obtained the same results. Casal et al. (2015) analyzed Euro 2008, concluding that a longer duration of the offensive phase predicts a greater success of it. The analysis of possession in the 2016 UEFA Euro France made in the work of Casal et al. (2017), also corroborate the close relationship between longer possession time and team success.

In previous works quantitative analysis of possession are carried out, arriving in some cases to identify the zone in which it takes place (Casal et al., 2017), but in none of them the factors that modulate team possession time are identified, nor are they compared to acknowledge if these are the same in successful and unsuccessful teams. Therefore, a study that allows to create relationships between the quantitative and qualitative aspects of possession is justified, and that is not limited to describing and quantitatively comparing team possessions, but that tries to identify which are the performance indicators related to possession time and, describe an offensive playstyle that allows to guarantee greater longer possessions. Unlike most of the previously mentioned works, we intend to perform a novel analysis, from a *mixed methods* perspective. In this work, in addition to a quantitative analysis, we intend to carry out a qualitative analysis to study the quality of team possessions. The study of possession quality must be undertaken from a qualitative perspective, and the ideal option is systematic observation (Anguera et al., 2000, 2017), which guarantees a perfect balance between flexibility and rigor, and which must be integrated with conventional quantitative information in the study of possessions. Thus, this study is considered from the *mixed methods* perspective, which implies a novel treatment of possessions, which were usually studied only from a quantitative perspective, taking into account parameters obtained in many cases through computer programs oriented exclusively to a description of the competitions from element frequency (serves, shots on goal, penalties, etc.) of different nature along the game sets. We start from the *mixed methods* perspective because it represents a third emerging paradigm of research (Johnson et al., 2007) that offers an alternative to purely qualitative or quantitative studies which has expanded rapidly over the last two decades (Tashakkori and Teddie, 1998, 2003, 2010).

Through the application of this methodology we will try to achieve the following objectives: determining possession times of successful and unsuccessful teams, identifying performance indicators that influence possession times in both groups of teams, describing differences between possession patterns of successful and unsuccessful teams and, finally, find more effective possession models. Our hypothesis is that possession analysis from the *mixed methods* perspective will make possible to identify a playstyle that guarantees a more effective possession of the ball. If the hypothesis is confirmed, obtained results can be used by technicians and players to model training and competitions, allowing to increase the offensive performance of teams.

MATERIALS AND METHODS

Observational Design

The specific design corresponding to this systematic observation, according to Anguera et al. (2011), is a combination of a nomothetic/puntual/multidimensional (N/P/M) and nomothetic/follow up/multidimensional (N/F/M) design. The reason is that some teams (nomothetic) are recorded in several matches with different opposite team (puntual), but also that these teams participate in the rounds until the final match (follow up); in all matches we have considered several performance indicators and time measures (multidimensional). Moreover, the recording used an intrasessional follow-up (frame-by-frame analysis of different matches), and was captured using the *ad hoc* observation instrument in different matches. Data analyzed is of type IV (Bakeman, 1978).

Participants

To control some of the situational variables that can potentially affect tactical and strategic team behavior, such as quality or level of opposing teams and the match location (Kormelink and Seeverens, 1999; Carling et al., 2005), 14 teams and 12 matches corresponding to the round of eighth-finals, quarter-finals, semi-finals and final of the 2016 UEFA Euro France have been selected in which 2,636 offensive sequences occurred. Belgium, Croatia, Eire, England, France, Germany, Hungary, Iceland, Italy, Northern Ireland, Portugal, Slovakia, Spain, and Wales were the teams analyzed.

Three games Switzerland vs. Poland; Poland vs. Portugal and Germany vs. Italy have been excluded from the analysis since the match outcome was a draw having in account regular time and extensions, which makes impossible to label the teams as successful or unsuccessful.

This sample ensures that all matches are played on neutral ground, the teams have a similar level and, by eliminating the games of the group phase, we also make sure that the teams look for the victory in their matches, since defeat will mean elimination. In the group phase matches, it may happen that some team is more interested in drawing or losing any of their matches, to avoid a particular opponent in the following phases, this would lead to incorrect results in the study.

Observational Instrument

Four national coaches and experts in football research designed an *ad hoc* observation instrument combining a field format and category systems (Anguera et al., 2018a,b) was created (**Table 1**). Indicators that represent the qualitative side of this study have been selected based on previous studies (Casal et al., 2015, 2016, 2017), which have demonstrated their relationship with team performance.

Data were recorded and coded in the LINCE software program (Gabin et al., 2012), and the MASS packages have been used (Venables and Ripley, 2002), and CAR (Fox and Weisberg, 2011) from the R software (v. 3.4.1).

Procedure

Matches were recorded from TV emitted images and were registered and analyzed post-event. Because the video recordings were public, confidentiality was not an issue and authorization was not required from the players observed or their representatives. Furthermore, the information cannot be considered either personal or intimate, as the research consisted solely of naturalistic observations in public places, and it was not anticipated that the recordings would be used in a manner that could cause personal harm (The American Psychological Association's [APA's], 2010). No experimental analysis involving human studies is performed in the study. Also, according to The Belmont Report (1978) the use of public images for research

TABLE 1 | Observational instrument (field format combined with category systems).

	Criterion	Definition	Categories
Identification	Team	Analyzed team	
	Phase	Match classification phase	o: round of 16
			c: quarterfinals
			smf: semifinal
			f: final
Classification	Final Outcome	Final match result regardless of attack sequence	w: win
			d: draw
			l: loss
Performance indicators	Match period	Part of the match in which the attack sequence was collected	ft: first time
			st: scond time
	Type of start-up	Way to start the attack sequence	sp: set pieces
			t: dynamic transition
	COI	Start interaction context	ar: advanced versus delayed
			am: advanced versus average
			aa: advanced versus advanced
			mm: average versus average
			mr: average versus delayed
			ma: average versus advanced
			ra: delayed versus advanced
			rm: delayed versus average
			pa: goalkeeper versus advanced
	Intention	Observed team intention when recovering the ball	p: progress
			k: keep
	Passes	Total observed passes that the team's attack sequence had	Numeric
	Match Status	Team's partial marker observed in the attack sequence	wn: winning
			dr: drawing
			ls: losing
Possession	MD	Time in SECONDS that the observed team keeps the ball in its DEFENSIVE zone	Seconds
	MO	Time in SECONDS that the observed team keeps the ball in its OFFENSIVE zone	Seconds
	ZC	Area in which the ball stayed longer in each offensive sequence	1: middle defensive zone
			2: middle offensive zone offensive
	Possession time	Total time the possession lasted (MD + MO)	Seconds
Outcome	Attack outcome	Final result of the team's observed attack sequence	goal: goal
			sh: shot
			sta: sent to area
			ne: no success

purpose does not required informed consent or the approval of an ethical committee. An ethics approval was therefore not required as per applicable institutional and national guidelines. Criteria used for the division of the teams into two groups, successful and unsuccessful, has been the outcome of the match (Lago-Peñas et al., 2010), excluding penalties. This way, all the teams that won their matches during reglementary time or extensions were classified as successful and teams who lost their matches as unsuccessful.

Data Quality Control

To try to ensure data reliability, all matches were registered and analyzed by four observers, all of them national soccer coaches with more than 10 years of experience in the field of training, teaching and research in football through observational methodology. In addition, the following training process was carried out: First, eight observing sessions were conducted on teaching the observers following the Losada and Manolov (2015) criteria and applying the criterion of consensual agreement (Anguera, 1990) among observers, so that recording was only done when agreement was produced. To ensure inter-reliability consistency of the data (Berk, 1979; Mitchell, 1979) the Kappa coefficient was calculated for each criterion, it revealed a strong agreement between observers, which means high reliability (0.92), taking Fleiss (1981) as a reference, who establishes a classification for the Kappa values where it characterizes as regular values found between 0.40 and 0.60, good between 0.60 to 0.75 and excellent above 0.75. Moreover, the procedure was repeated after 2 weeks (to exclude any learning effects) to check intraobserver reliability (Mitchell, 1979).

Statistical Analysis

A complete factorial design was applied to verify which were the factors that most influenced "Possession time" in successful and unsuccessful teams. The analysis of the variables and their interactions was carried out using the ANOVA technique. The residuals conditions were verified to check that normality conditions are met. In the case of non-compliance, a transformation of the response variable, "Total possession time" was performed, using a Box–Cox transformation where the parameter λ was estimated, by maximum likelihood.

After adapting the regression model and checking the adjustment to normality by calculating the Shapiro–Wilk statistic, the main effects and interaction relationships between the model's significant variables were calculated. Finally, a set of predictions was calculated between the interactions that were significant, accompanied by their graphic representation, to compare successful and unsuccessful teams.

RESULTS

Analysis started with data selection and filtering, using the variables: *Type of start-up*, *Intention*, *Zc (field zone)*, *Pt (possession time)* and *Match Status*.

The model proposed for successful teams:

$$\begin{aligned}\text{Pt} = \mu &+ \beta_1\text{Type of start-up} + \beta_2\text{Intention}\\ &+ \beta_3 Zc + \beta_4\text{Match status} + \beta_5\text{Type of start-up:}\\ &\quad \text{Intention: Zc: Match status}\end{aligned}$$

Results obtained from the variance analysis in successful teams are presented in **Table 2**.

Significant effects in this analysis were: the simple effects, *Type of start-up, Intention, Zc*. No significant second-order effects, and only a significant third-order effect *Type of star-up-Zc-Match Status.*

The transformation of the response variable made with the *Box–Cox* method, offers the best maximization of the *likelihood* profile, estimating the λ value that in this case is around 0.02020202.

This transformation allows to obtain a *Shapiro–Wilk* test of normality of W = 0.99669 with a *p*-value = 0.2821, verifying the normality test of the residuals in the model.

The ANOVA was again calculated with the transformation, and the following results were obtained (**Table 3**):

The significant effects in this analysis with the transformation applied were: simple effects, *Type of start-up, Intention, Zc*. Significant second-order effects, *Type of start-up-Intention; Type*

TABLE 2 | ANOVA results for successful teams.

	Df Sum	Sq Mean	Sq *F*	value	Pr(>*F*)
Type of start-up	1	1580	1580	6.638	0.01013*
Intention	1	34303	34303	144.104	<2e-16***
Zc	1	1872	1872	7.863	0.00515**
Match Status	2	251	125	0.527	0.59046
Type of start-up: Intention	1	617	617	2.591	0.10783
Type of start-up: Zc	1	626	626	2.629	0.10528
Type of start-up: Match Status	2	534	267	1.121	0.32646
Intention: Zc	1	284	284	1.193	0.27503
Intention: Match Status	2	742	371	1.558	0.21104
Zc: Match Status	2	625	312	1.312	0.26977
Type of start-up: Intention: Zc	1	265	265	1.115	0.29131
Type of start-up: Intention: Match Status	2	698	349	1.466	0.23148
Type of start-up: Zc: Match Status	2	1645	823	3.456	0.03197 *
Intention: Zc: Match Status	2	496	248	1.043	0.35287
Type of start-up: Intention: Zc: Match status	2	894	447	1.879	0.15339
Residuals		938	223284	238	

*Significant codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "." 0.1 " ".*

TABLE 3 | ANOVA with transformation.

	Df Sum	Sq Mean	Sq F	Value	Pr(>*F*)
Type of start-up	1	10.6	10.56	19.654	1.04e-05***
Intention	1	95.8	95.79	178.370	<2e-16***
Zc	1	7.4	7.44	13.852	0.00021***
Match Status	2	0.4	0.20	0.373	0.68898
Type of start-up: Intention	1	3.2	3.16	5.880	0.01550*
Type of start-up: Zc	1	1.8	1.81	3.378	0.06638.
Type of start-up: Match Status	2	2.1	1.07	1.991	0.13717
Intention: Zc	1	0.4	0.37	0.690	0.40653
Intention: Match Status	2	0.5	0.25	0.465	0.62805
Zc: Match Status	2	0.4	0.21	0.396	0.67295
Type of start-up: Intention: Zc	1	0.1	0.13	0.245	0.60243
Type of start-up: Intention: Match Status	2	0.6	0.32	0.590	0.55468
Type of start-up: Zc: Match Status	2	3.9	1.97	3.659	0.02612*
Intention: Zc: Match Status	2	0.2	0.12	0.225	0.79858
Type of start-up: Intention: Zc: Match status	2	0.8	0.39	0.730	0.48213
Residuals		938	503.8	0.54	

*Significant codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "." 0.1 " ".*

of start-up-Zc. Finally, a third-order interaction *Type of start-up-Zc-Match Status* was significant.

Main Effects in Successful Teams

The main effects of the three significant simple factors were represented, with their values related to possession time (**Figure 1**). In this way, possession time with respect to Type of start-up was obtained, and was slightly greater when the start is given in a set piece than in transition. With respect to the *Zc* a greater possession of the ball was observed in the offensive zone. Regarding the factor *Intention* of the observed team, when it recovers the ball, it was observed that the greatest possession time was given in an intention to progress with the ball *(p: progress*), and somewhat less when the intention was to preserve the ball (*k: keep*). The combination of the three factors with the maximum time of possession would be: in offensive zone, starting from a set pieces and with the intention of progressing the ball.

Interactions in Successful Teams

The significant interactions of the model (*Type of start-up-Intention; Type of start-up-Zc)* were shown (**Figure 2**). In the case of the *Type of start-up-Intention* interaction, it could be seen how, both in the plays that started at set pieces and in transition, the greatest possession time occurred when the team intended to keep the ball.

In the *Type of start-up-Zc* interaction, a greater possession time was observed, both in the offensive zone, and the defensive zone, when the offensive phase was initiated by means of a transition.

Successful Teams Predictions

Predictions of the significant interactions in the model were established, based on *possession time*, obtaining the prediction's most adjusted values, accompanied by their confidence intervals (**Table 3**).

A first prediction was formed by the *Type of start-up-Intention* factors. The values of the categories of the beginning of the sequence were presented in relation to team intention. In **Table 4** it can be observed, how a greater possession of the ball will be produced when the play begins by means of a transition.

A second prediction configured by the factors *Type of start-up-Zc*, indicates that there will always be greater possession of

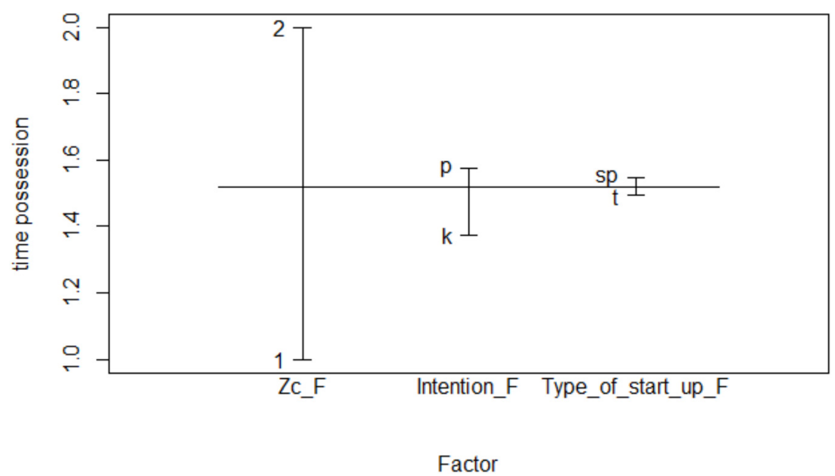

FIGURE 1 | Main effects in successful teams.

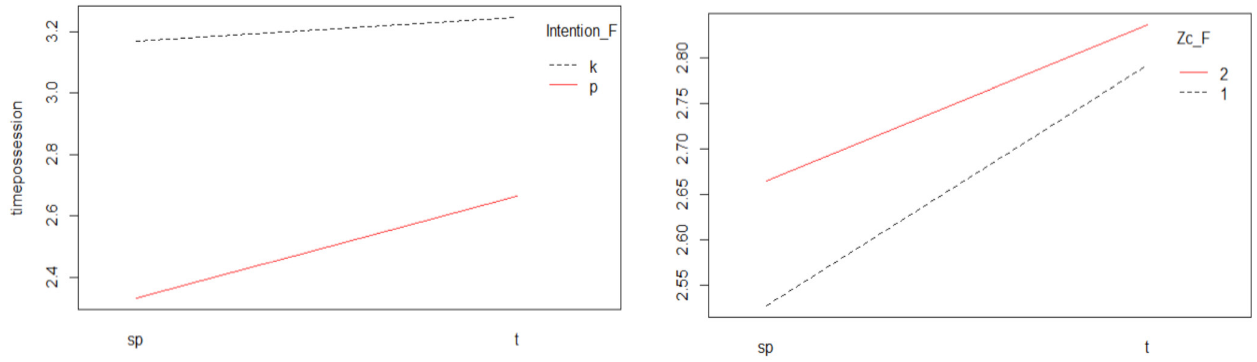

FIGURE 2 | Interaction Type of start-up-Intention and Type of start-up-Zc.

the ball, both in the defensive and offensive zones, if initiated by means of a transition.

For the prediction of three factors *Type of start-up-Zc-Match Status* the following situations were collected (**Table 5**):

TABLE 4 | Predictions based on possession time.

Intention	Type of start-up	Fit	lwr	upr
Keep	Sp	3.168067	3.042380	3.293754
	T	3.248004	3.126791	3.369216
Progress	Sp	2.332448	2.245356	2.419540
	T	2.664055	2.592382	2.735727
Zc	**Type of start-up**	**Fit**	**lwr**	**upr**
Defensive zone	Sp	2.528168	2.412159	2.644176
	T	2.792668	2.696641	2.888695
Offensive zone	Sp	2.665467	2.560275	2.770659
	T	2.837030	2.743069	2.930992

TABLE 5 | Three factor prediction.

Type of star-up		Set pieces		
Zc	**Match status**	**fit**	**lwr**	**Upr**
Defensive zone	Wn	2.331815	2.177045	2.486584
	Dr	2.712268	2.561506	2.863030
	Ls	2.520898	2.097975	2.943821
Offensive zone	Wn	2.571334	2.427036	2.715632
	Dr	2.746415	2.601379	2.891451
	Ls	2.730275	2.422766	3.037783
Type of star-up		**Dynamic transition**		
Zc	**Match status**	**fit**	**lwr**	**Upr**
Defensive zone	Wn	2.753987	2.620310	2.887663
	Dr	2.828626	2.698067	2.959185
	Ls	2.796901	2.470895	3.122908
Offensive zone	Wn	2.877259	2.758385	2.996132
	Dr	2.746526	2.594403	2.898650
	Ls	2.890032	2.631293	3.148770

If the play is started at set pieces actions, there will be a longer possession time with a tied score, both in the defensive and offensive zones.

In the case of a start with transition. There will be a longer possession time in the defensive zone with the score tied and in the offensive zone with the marker losing.

The model proposed for unsuccessful teams was the same as for successful ones:

$$\begin{aligned} \text{Pt} &= \mu + \beta_1 \text{Type of start-up} \\ &\quad + \beta_2 \text{Intention} + \beta_3 \text{Zc} + \beta_4 \text{Match Status} \\ &\quad + \beta_5 \text{Type of start-up: Intention: Zc: Match Status.} \end{aligned}$$

Once the lack of normality adjustment to residuals was verified and the transformation of the explained variable was carried out applying the Box–Cox transformation, with a value $\lambda = 0.1414141$, which allows obtaining a Shapiro–Wilk coefficient. $W = 0.9974$, and a p-value $= 0.1798$, justifying the adjustment of the residuals of the model.

Table 6 shows the results obtained in the variance analysis, with the new adjustment.

The following significant values were observed: simple effects: *Intention ($p < 0.001$) y Match Status ($p < 0.001$)*. Second order effects: *Type of start-up- Intention ($p < 0.05$); Type of start-up-Zc ($p < 0.01$); Type of start-up-Match Status ($p < 0.05$); Intention-Match Status ($p < 0.001$)*. Third order significant effect: *Type of start-up-Zc-Match Status ($p < 0.01$)*

Main Effects for Unsuccessful Teams

The main effects were represented, of the two significant simple factors and their values related to the time of possession (**Figure 3**). In this way, it was observed that the greatest possession time with respect to the *Intention* factor occurs when there was an intention to keep the ball (*k: keep*), and much less when the intention was to progress (*p: progress*). In the factor score (*Match Status*), the greatest possession time was given when the team was losing, while the shortest possession time was given when the team was winning. The combination of the two factors indicate that the maximum possession time is achieved, based on an intention to keep the ball, when the team is losing.

TABLE 6 | ANOVA results with transformed dependent variable, for non-successful teams.

	Df Sum	Sq Mean	Sq *F*	value	Pr(>*F*)
Type of start-up	1	0.7	0.66	0.644	0.422456
Intention	1	151.1	151.06	148.180	<2e-16***
Zc	1	0.0	0.02	0.018	0.8903189
Match Status	2	17.7	8.84	8.671	0.000185***
Type of start-up: Intention	1	5.7	5.72	5.613	0.018019*
Type of start-up: Zc	1	10.3	10.34	10.140	0.001496**
Type of start-up: Match Status	2	8.1	4.04	3.961	0.019340*
Intention: Zc	1	1.9	1.85	1.819	0.177760
Intention: Match Status	2	33.0	16.52	16.200	1.19e-07***
Zc: Match Status	2	0.9	0.44	0.436	0.646832
Type of start-up: Intention: Zc	1	1.0	0.99	0.975	0.323739
Type of start-up: Intention: Match Status	2	1.2	0.61	0.597	0.550505
Type of start-up: Zc: Match Status	2	10.1	5.06	4.966	0.007144**
Intention: Zc: Match Status	2	0.6	0.30	0.298	0.742660
Type of start-up: Intention: Zc: Match status	2	2.5	1.25	1.222	0.294964
Residuals		993	1012.3	1.02	

*Significant codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "." 0.1 " ".*

Unsuccessful Teams Interactions

Figure 4 shows the significant interactions of the model, according to the type of start-up. In the case of the *Type of start-up-Intention* interaction, it could be observed that, in both types of starts of the play, the longest possession time occurred when the intention was to keep the ball.

In the *Type of start-up-Zc* interaction, the longest possession time was given in the case of starting with a set piece in the defensive zone. In the case of start with transition, possession time was the same in both zones.

In the *Type of start-up-Match Status* interaction, it was observed how the greatest possession time occurred when the team started the play on set pieces and was losing. The shortest time of possession occurred, both in the start of set actions and transition, with the score in favor. With the score drawing there were hardly any differences in possession time regardless of the form of start of the play.

If we analyze the *Intention-Match Status* interaction, we can observe how two intersections occurred (**Figure 5**). The draw marker interacted with the winning and losing markers. This is because possession time with a draw score was much greater when the intention was to keep the ball, whereas when the intention was to progress it decreased considerably. When the score was favorable (winning) shorter possession times occurred, regardless of the team's intention. With the score losing, the longest possession time occurred with the intention of keeping the ball with a descent when the intention was to progress.

Unsuccessful Teams Prediction

Table 7 shows the results corresponding to the significant interactions with the Type of start-up. We can observe how a longer possession time will be produced when the play is initiated by means of a transition, whether it is intended to keep or progress.

We can also observe how, in the defensive zone, greater possession will occur if it is started by means of a set pieces and, in the offensive zone, if it is initiated by means of a transition.

Finally, A greater possession time with the score winning will occur when the play is initiated by means of a transition. Both with the score losing and drawing, there will be a longer possession time when set pieces actions start.

In **Table 8**, we present the significant predictions based on Match status. If we analyze the predictions based on team

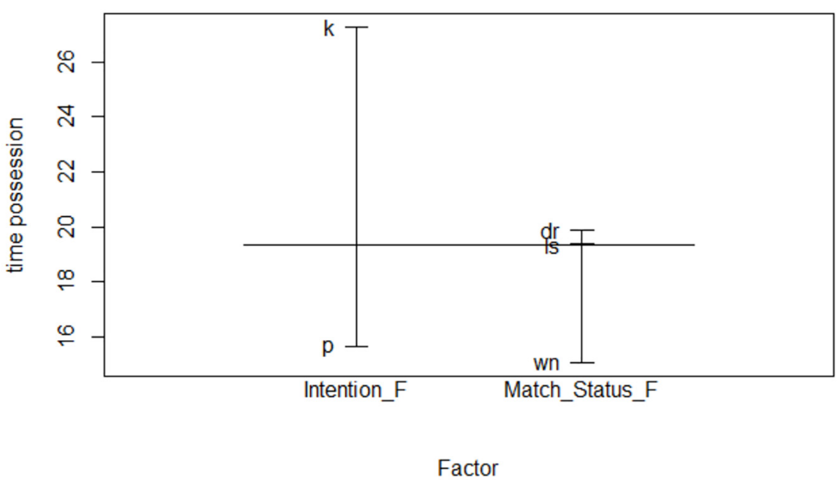

FIGURE 3 | Main effects for unsuccessful teams.

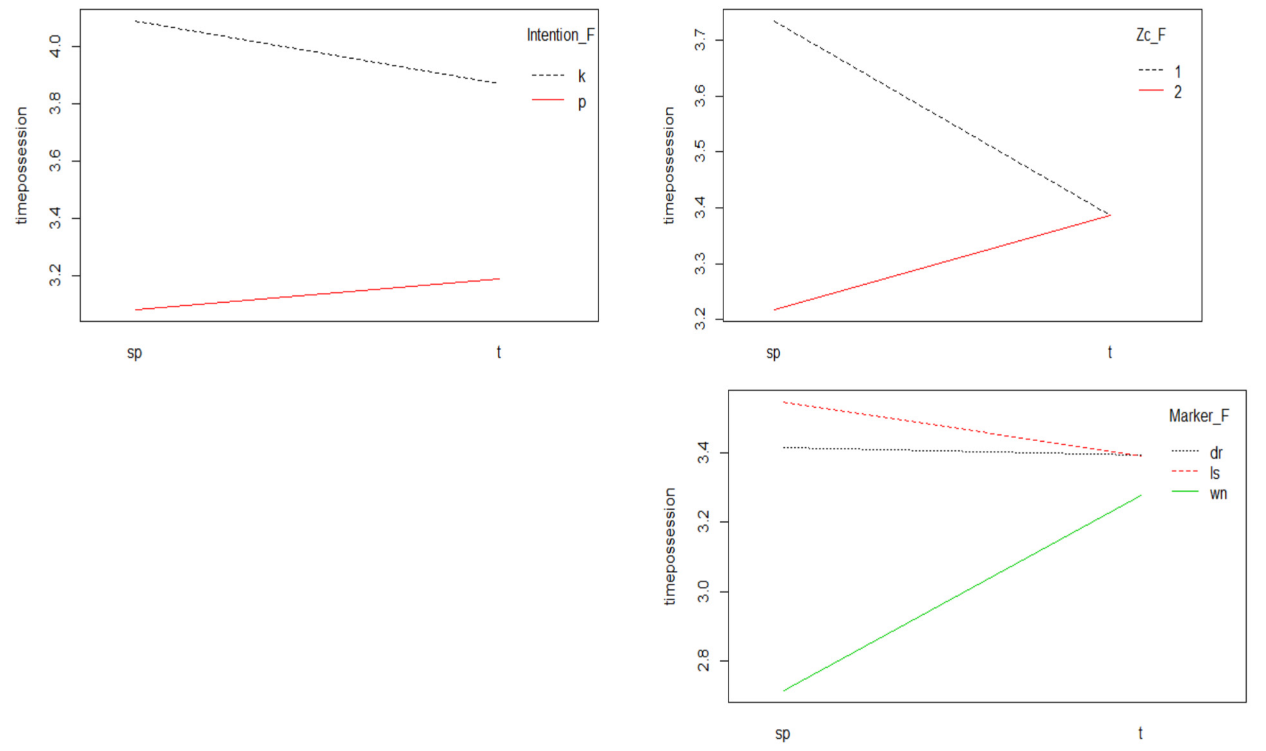

FIGURE 4 | Interaction Type of start-up-Intention; Type of start-up-Zc and Interaction Type of star-up-Match Status.

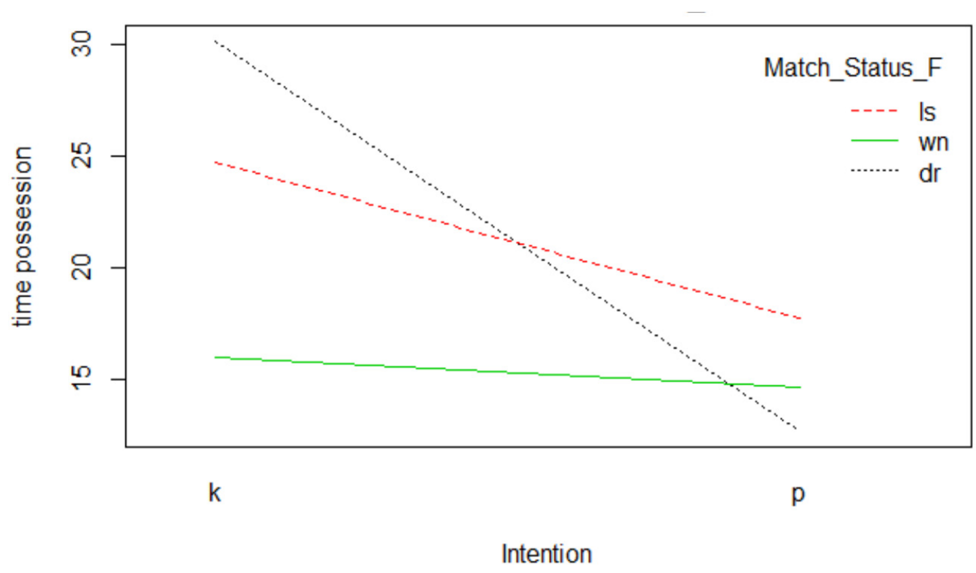

FIGURE 5 | Interaction Intention-Match Status.

intention and partial result we can see how, with the score drawing, there will be a longer possession time if you try to keep the ball and, with the result of losing, there will be a greater possession if you try to progress.

For the prediction of three factors (*Type of start-up-ZC and Match Status*), the following situations may be possible (**Table 9**):

In the defensive zone will be greater possession when the score is drawing, whether the play is initiated by means of a transition or set pieces.

There will be greater possession of the ball in offensive zone when the set piece starts with the score losing, and, if it starts with a transition, with the score winning.

TABLE 7 | Predictions in function to Type of start-up.

Intention	Type of start-up	Fit	lwr	upr
Keep	Sp	3.080707	2.958752	3.202662
	T	3.187973	3.087256	3.288690
Progress	Sp	11.58845	9.752692	13.42420
	T	16.09780	14.587048	17.60855
Zc	**Type of start-up**	**fit**	**lwr**	**upr**
Defensive zone	Sp	3.735140	3.576295	3.893985
	T	3.386873	3.256824	3.516921
Offensive zone	Sp	3.218056	3.081412	3.354700
	T	3.386374	3.262865	3.509883
Match status	**Type of start-up**	**fit**	**lwr**	**upr**
Winning	Sp	2.714127	2.287977	3.140278
	t	3.279219	2.917061	3.641377
Drawing	Sp	3.416937	3.264049	3.569826
	T	3.395566	3.256741	3.534390
Lossing	Sp	3.549402	3.398372	3.700433
	T	3.392165	3.266919	3.517412

TABLE 8 | Prediction according to tactical intention – marker.

Intention	Match status	fit	lwr	upr
Conservar	Wn	3.067949	2.607933	3.527966
	Dr	4.127844	3.980021	4.275666
	Ls	3.880861	3.698573	4.063149
Progresar	Wn	3.030887	2.725103	3.336672
	Dr	2.899664	2.776021	3.023308
	Ls	3.323472	3.221544	3.425401

TABLE 9 | Prediction field zone-type of start-up-marker.

Zc		Defensive zone		
Type of start-up	**Match status**	**fit**	**lwr**	**upr**
Sp	Wn	2.726720	2.146522	3.306918
	Dr	3.798074	3.594471	4.001677
	Ls	3.773970	3.561142	3.986798
T	Wn	3.147875	2.752974	3.542777
	Dr	3.503992	3.321563	3.686422
	Ls	3.325186	3.147818	3.502555
Zc		**Offensive zone**		
Type of start-up	**Match status**	**fit**	**lwr**	**upr**
Sp	Wn	2.707461	2.236707	3.178214
	Dr	3.091747	2.901043	3.282452
	Ls	3.399087	3.218663	3.579510
T	Wn	3.620713	3.056228	4.185197
	Dr	3.289762	3.109245	3.470280
	Ls	3.442400	3.286265	3.598534

DISCUSSION

Ball possession has been identified as a differentiating performance indicator between successful and unsuccessful teams (Grant et al., 1999a,b; Hook and Hughes, 2001; Jones et al., 2004; Bloomfield et al., 2005; Carling et al., 2005; Hughes and Franks, 2005; Casal et al., 2015, 2017). This work was proposed with the intention of discriminating possession time qualitative and quantitatively in successful and unsuccessful teams from a *mixed methods* perspective, to try to identify an effective ball possession model. The results have allowed us to identify significant differences between ball possession models of both groups of teams.

Specifically, based on the results of the simple effects, we have detected that in successful teams possession time is influenced by, the form of start of the offensive phase, the intention of the team once possession is recovered and possession zone. Successful teams are characterized by having longer possessions in the offensive zone when they start at set pieces actions and with the intention of progressing. On the other hand, in unsuccessful teams possession time of the offensive phase is influenced by team intention, once the possession of the ball has been recovered, and by the match status. In the latter case, our results corroborate those obtained in previous studies (Sasaki et al., 1999; James et al., 2004; Jones et al., 2004; Bloomfield et al., 2005; Lago-Peñas and Martín, 2007; Taylor et al., 2008; Lago-Peñas, 2009). These teams will have longer possessions when they are losing, results in line with some previous works (Sasaki et al., 1999; Jones et al., 2004; Bloomfield et al., 2005; Lago-Peñas and Martín, 2007; Lago-Peñas, 2009) and with the intention of keeping the ball. Of these results, perhaps the most significant is to indicate how the partial result, in successful teams, does not influence possession time. Indicating, in this case, that these teams do not vary their game model based on match status, while unsuccessful ones do, coinciding with the results of Bloomfield et al. (2005). These data differ from some of the previously mentioned works since, their results show the same pattern of ball possession, for both groups of teams, depending on the evolution of the match status. This circumstance may indicate an evolution of the game of successful teams toward more stable possession models, and less influenced by the evolution of the match status.

If we analyze the results obtained when studying the interaction of the different variables selected with possession time, we can observe how in the second order interactions there are also significant differences between both groups of teams. While successful teams are characterized by having longer possessions in the offensive zone, when they start possession through a transition, unsuccessful teams have longer possessions in the defensive zone, initiating the attack through set pieces ball actions and, above all, when they are losing. We cannot compare these results with previous works, since we have not found any study that performs a multivariate analysis with the indicators selected here. Some previous works (Casal et al., 2017) have also found that successful teams are characterized by possessions of longer duration in the offensive zone and unsuccessful ones, on the contrary, in the defensive zone. This can be explained because successful teams are supposed to have a higher technical-tactical level, and are able to overcome the greater defensive pressure and accumulation of players near the opposing goal and, on the contrary, unsuccessful teams will only be able of maintaining possession in those areas of lower defensive pressure that, in general, are close to your goal.

Finally, observing the data obtained in third-order interactions, which will allow us to make predictions about how possession time of the team will be, according to the relationships between the selected variables. In this case, we can check how the main differences between both teams occur in the following cases:

Successful teams will always have greater possession time, both in defensive and offensive zone in the event that the play is initiated by means of a transition. These data are in line with what was previously stated when finding that successful teams have longer possession times than unsuccessful ones, indicating that higher-level teams try to control the game, and take the initiative, through ball possession, helped by the high individual performances of their players. In the case of unsuccessful teams, if the offensive phase starts on set pieces actions, the greatest possession will occur in the defensive zone and, if the play is initiated by means of a transition, in the offensive zone. This can be explained because, in a set pieces action, the opposing team has enough time to organize defensively and, therefore, lower level teams will have greater difficulties to advance toward areas closer to the opponent's goal. On the contrary, if they start the offensive phase after a recovery of the ball, it may be easier for them to progress to more advanced zones, due to the defensive disorganization of the opposing team, since this is in an open disposition, with greater inter and intra-line space.

If we take into account the type of start-up and the match status, successful teams will produce their greatest possession with a score draw and starting the play by means of a set pieces ball action. This data shows, once again, the control of the game performed by higher level teams, maintaining possession of the ball. In the case of unsuccessful teams, if they are winning, they will have greater possession initiating the play through a transition. As we discussed earlier, in this circumstance of the game, the opposing team will perform a defensive pressure, because of their need to score as much, and the lower level of unsuccessful teams will not allow them to maintain possession for a long time unless they initiate the attack through a dynamic transition, without leaving time for the rival team to organize defensively. If they find themselves losing or drawing, the possession will be longer if the play starts at set pieces actions. In this case, the rival team does not have the need to press defensively, which will facilitate the team possession.

If we consider the type of start-up, the match status and field zone. In this case, we see how successful teams will always have longer possessions initiating the offensive plays by means of a transition and this possession will be more extensive in the defensive zone if they are drawing and in the offensive zone if they are winning. In the first case, it can be considered a normal behavior, since not having the need to score so much, can give up on counterattacks and its main objective can be focused on keeping the ball, as a defensive method. The second behavior is somewhat contradictory, since, if they are winning, it is normal for the opposing team to perform defensive pressure and this pressure will be greater near their goal, so maintaining possession in this zone will be more difficult that to do it near the own goal, where the pressure of the adversary team is smaller. This behavior could be explained by the need to keep the ball as far as possible from the own goal, to avoid a possible chance of an opponent's goal, in the case of losing the ball to the opponent. On the other hand, unsuccessful teams, in the case of being drawing, will always have more extensive possessions in the defensive zone, regardless of the type of start of the play. In addition, in spite of being able to have the will to progress toward the rival goal, it lacks the technical-tactical mechanisms necessary for it, hence that it passes great moments of the game in the initial gestation phase of the offensive game. Adversary teams, in this situation, do not have the need to quickly recover the possession of the ball, and may allow it to be in the power of the opposing team, but away from their own goal. For these teams possessions will be of greater duration in the offensive zone, losing, and initiating the play by means of a set pieces action and winning, by means of a transition. In the first case, the need to score as much, will provoke a more advanced defensive pressure and possession of the ball closer to the area of the opposing team's goal. The second situation has already been explained previously, in this case the defensive pressure of the rival team will only allow to have the ball a minimum of time in control, until they are able to make a counterattack.

Based on the results obtained, we can prove how our hypothesis regarding possession analysis from the mixed methods perspective was confirmed, which would allow us to differentiate the possessions of successful and unsuccessful teams and describe a more effective possession style. The application of the results of this study in the field of intervention will affect the tactical-strategic aspects of the team's game. This knowledge will allow the elaboration of intervention strategies to optimize team possession. However, the results of this work cannot be generalized to all matches and competitions, because only national teams have been analyzed and in a specific competition. As some previous works indicate (James et al., 2004; Bloomfield et al., 2005; Tucker et al., 2005; Lago-Peñas and Martín, 2007; Lago-Peñas, 2009; Collet, 2013), the type of competitions influences team possession, therefore, it will be necessary to continue investigating with different samples that cover different competitions to try to generalize the results and try to identify which are the key elements that differentiate or characterize the offensive possessions of successful teams, with the objective of trying to identify a more effective possession model.

CONCLUSION

This work has been carried out with the intention of identifying which are the performance indicators that influence possession time in elite soccer teams, check if these indicators differ between successful and unsuccessful teams and finally, identify a more effective possession model.

It has been possible to verify the existence of differences between the performance indicators that influence possession time between successful and unsuccessful teams. Specifically, in successful teams possession time is influenced by: *Type of start-up, intention and field zone*. On the other hand, possession time of unsuccessful teams is determined fundamentally by *intention and match status*. We have also noted how the phase of the tournament in which the match is played, the match period, the interaction context and the number of passes do not influence team possession time. Finally, the models to execute the offensive phase that guarantee a greater possession of the ball have also been different for both groups of teams.

DATA AVAILABILITY

The datasets generated for this study are available on request to the corresponding author.

AUTHOR CONTRIBUTIONS

CC developed the project, review the literature, and wrote the manuscript. JL was responsible for performed analysis and the method section. MA wrote part of the manuscript and revised the content critically and RM revised the content and supervised the drafting of the manuscript.

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The Communicative Modes Analysis System in Psychotherapy From Mixed Methods Framework: Introducing a New Observation System for Classifying Verbal and Non-verbal Communication

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Communication represents the core of psychotherapy. The dynamic interaction between verbal and non-verbal components during patient-therapist exchanges, indeed, promotes the co-construction of meanings bringing about change within a process of reciprocal influence of participants. Our paper aims to illustrate the building of a new observational instrument of the therapeutic discourse, the Communicative Modes Analysis System in Psychotherapy (CMASP), and its reliability study from Mixed Methods framework. The CMASP is a single classification system analyzing the communication features within therapeutic exchanges. Born to overcome the limits of traditional psychotherapy research which considers verbal and non-verbal dimensions of communication as in polar opposition, the CMASP building was based on the performative function derived from the Speech Act Theory. We used this function as a comprehensive theorization to interpret the communication components in psychotherapy as an integrated and interacting system. In fact, the instrument detects and classifies, at the overall and dimension level, the verbal and extra-linguistic components of psychotherapeutic communication implemented by the therapist and patients in the form of communicative modes. From the observational methodology framework, it was built an instrument able to record and analyze verbal, vocal and interruption behaviors by combining elements of qualitative and quantitative research approaches. The sample consisted of 30 psychotherapy audio recordings and verbatim transcripts of psychotherapy sessions (for a total of 8327 speaking turns). Four main dimensions were elaborated (Verbal Mode-Structural Form, Verbal Mode-Communicative Intent, Vocal Mode, and Interruption Mode) according to the agency role of communication components. The instrument is a field format combined with category systems. For each dimension, we built a category system that is exhaustive and mutually exclusive. From all dimensions, we have a total of 33 categories. Intra-and inter-judge reliability among four independent judges was computed on a total of 503 speaking turns coded through Cohen's κ and Krippendorff's canonical agreement coefficients (Cc), respectively. The CMASP showed high intra-and inter-judge agreement at the global, dimensional, and categorical level providing researchers and professionals with a single and flexible classification system, able to give multiple and concurrent information about the psychotherapy process.

Keywords: psychotherapeutic communication, verbal and non-verbal communication, performative language, observation system, mixed methods approach

INTRODUCTION

Psychotherapy, as an asymmetric help-relationship focused on the patient, represents an experience of sharing and communication (Molina et al., 2013). During psychotherapy session, therapist and patient implement a specific type of communication in the form of therapeutic conversation, as mutual research and exploration through dialogue (Soares et al., 2010). Participants, through language, co-construct meanings that continually evolve promoting the change (Soares et al., 2010; Dagnino et al., 2012). Speech content (verbal dimension) and the different channels conveying it (non-verbal dimension) are the core ingredients of communicative exchanges (Ephratt, 2011). Nevertheless, Weick (1968) claims that linguistic content, in the form of verbal behaviors, constitutes only a small portion of human communication and most of it rests on extra-linguistic behaviors. In particular, voice and interruption behaviors (Mahl, 2014) are important indicators of the underlying psychological processes in communicative exchanges (Weick, 1968).

Historically, verbal and non-verbal components of psychotherapeutic communication have been considered and studied separately, as though they were independent and in polar opposition to each other, leading to the development of separated theorizations and investigations (Westland, 2015). Nevertheless, recent research underlines the need for an integrated communication approach since verbal and non-verbal behaviors are co-occurring and interrelated phenomena that show mutual influences (Jones and LeBaron, 2002). As Jones and LeBaron (2002) claim, "Mutual influence is especially complex and subtle in face-to-face situations because visible forms of communication occur simultaneously with one another and with vocal messages, and exchanges among persons can occur both sequentially and instantaneously" (p. 512). Therefore, the study of mutual influence represents a focal point in comprehending the interpersonal communication in psychotherapy, justifying the integration of verbal and non-verbal components.

The integrated system reflects the complexity of the therapeutic relationship in which verbal and non-verbal dimensions influence each other and interact regulating its co-construction, although they are separate components (Westland, 2015). Precisely, their interaction determines the building of *therapeutic discourse*, a specific type of conversation with an asymmetric structure in which the mutual influence of verbal and non-verbal communication affects the intersubjective processes implemented by both participants (Leahy, 2004; Westland, 2015).

Traditional psychotherapy research, focusing on either verbal or non-verbal communication through separate theories, impedes to bridge these dimensions and to deepen the processes underlying their reciprocal influence. To overcome such a limit, in agreement with the convergence process of natural and human science (Damasio et al., 2001), we derived the performative (or pragmatic) function of the Speech Act Theory (SAT; Searle, 2017) from the linguistic research to explain how verbal and non-verbal dimensions in psychotherapy influence each other despite being separate, underlining the need for an integrated system. Precisely, compared to scholars who based their investigations on this function to study specific aspects of psychotherapeutic communication (e.g., Valdés et al., 2010; Tomicic et al., 2011; Talia et al., 2014), we assumed the performative function as the global theory to describe the mutual influence of communication components within an interactive system, emphasizing the essential role of integration in analyzing the therapeutic actions.

In line with the performative function, language is a part of reality and not its reflection; it represents a tool to perform actions according to which *by saying something, we do something* that in psychotherapy is an aspect connected to change (Krause et al., 2006; Reyes et al., 2008). Such a function integrates the traditional concept of language as merely constative (or propositional) and overcomes the notion of communication as a mechanic process of encoding-transmission-decoding of messages in which sender and receiver represent the ends of the process itself (Ellis and McClintock, 1990).

Within a process of mutual regulation turn-by-turn (*interactive communication*), which can be studied objectively through systematic observation, a speaker who expresses a speech performs an action that is something different from the act of saying *per se* and in which verbal and non-verbal messages interplay conveyed through different sensory systems. Verbal and non-verbal dimensions have an impact on the listener of communication who, in turn, decodes them and implements a communicative act that affects the first speaker (Jones and LeBaron, 2002; Sbisà, 2009).

During the psychotherapeutic encounter, the patient and therapist share and influence their reciprocal internal realities by transmitting information (contents) through recordable verbal behaviors. These verbal messages are expressed in the form of propositional acts (that is to refer and predicate) connected to both the speaker's communicative intent and the object of the therapeutic work (Arístegui et al., 2009; Valdés et al., 2010). Therefore, within a reciprocal coding and decoding process by both participants, each linguistic act has an impact on the recipient of communication determining, on the one hand, the mutual regulation and co-construction of meanings through conversational sequences and, on the other hand, changes in the internal representations of each participant (Arístegui et al., 2009).

However, each speech emitted is influenced by reciprocal prosodic modulations implemented by patient and therapist during the therapeutic interaction (*intersubjective approach to voice*; Campbell, 2007) and changes in the emotional state of each participant are affected by mutual and observable variations in communicative exchanges, according to the principles of universal recognition of emotions (Thompson and Balkwill, 2006; Tomicic et al., 2011, 2015b). Voice quality and its acoustic parameters (tone, intensity, duration, and timbre) influence the co-construction of meanings by transmitting psychological meanings and emotional messages apart from the verbal content, but verbal and vocal dimensions feel the effects of each other's action (Jones and LeBaron, 2002; Tomicic et al., 2011). The integration of vocal dimension to speech content is at the basis of regulatory behaviors as any experience of therapeutic interaction (Jones and LeBaron, 2002). Patient and therapist implement a mutual regulation process in the form of coordination sequences of vocal behaviors which are connected to change (Tomicic et al., 2011). Precisely, this process determines a reciprocal influence in the internal organization of both participants and transforms the individual internal functioning in a more complex state (Campbell, 2007; Tomicic et al., 2015b).

Communicative exchanges in psychotherapy, as every kind of human communication, are organized in a speaking turn alternation that patient and therapist can influence through reciprocal interruptions (Li et al., 2005). They represent linguistic acts supplied with intentionality (Wallis and Edmonds, 2017) that violate the turn-taking rules allowing the interrupter to encroach on speaker's communicative and elaborative space, supporting or hindering the co-construction of meanings and the communicative relationship (Murata, 1994; Li, 2001; Sacks et al., 2015). Therefore, the communicative intent of the interruption enriches the meaning and strength of the speech emitted by the interrupter through the mutual influence with the other verbal and non-verbal dimensions that constitute the speech itself (Jones and LeBaron, 2002). At the same time, within a mutual coding and decoding process, these non-verbal interactive behaviors (Mahl, 2014) impact on the speech of the one who is interrupted producing changes in the interactive dynamics between verbal and non-verbal components (Jones and LeBaron, 2002). Thus, interruptions orient the mutual regulation of participants through coordination sequences that influence the co-construction of meanings and therapeutic discourse (Van Eecke and Fernández, 2016).

According to this performative model of communication, "People not only utilize structural forms, but they also co-construct and negotiate meanings and rules in their ongoing interactions" (Jones and LeBaron, 2002, p. 504). Hence, the interplay of verbal and non-verbal dimensions increases the complexity of communicative exchanges in psychotherapy through mutual influence and regulation processes arising during patient-therapist interactions. The co-occurrence of these communication components models the co-construction of meanings and the unfolding of the therapeutic dialogue pointing out the need for integration.

These processes can be best studied through systematic observation because it represents the most appropriate method to capture the reality of communication exchanges and components in the natural context of the therapeutic setting (Anguera et al., 2018b). Therefore, we need observational instruments for recording and analyzing behaviors which can integrate verbal and non-verbal dimensions and fill the gap of the existing literature (such as the one we are about to introduce), since none of the present tools can keep the components of communication together.

Over the years, various research lines developed around the therapeutic intervention respectively focusing on psychotherapy manualization (e.g., Craske and Barlow, 2006), non-specific factors of change (e.g., Krause, 2005), and psychotherapy process and outcome (e.g., Wampold, 2005), while psychotherapeutic communication area has received less attention (Valdés et al., 2010). However, many scholars (e.g., Bucci, 2007; Lepper, 2009, 2015; Valdés et al., 2010; Tomicic et al., 2011; Weiste and Peräkylä, 2014; Buchholz and Reich, 2015) support the importance of studying the communicative patterns, especially in successful psychotherapeutic encounters, underlining their fundamental role in comprehending patient-therapist interactions.

During the decades, a wide variety of methods arose to study the intersubjective processes between patient and therapist, often involving problems in the field of methodology which increased the complexity and difficulty of studying communication in psychotherapy (Lepper, 2009, 2015). Nevertheless, systematic observation proved to be as the best way to analyze these communication processes.

Scholars in this field have developed various observational tools to analyze verbal and extra-linguistic components of communication in psychotherapy, but they are based on separate theorizations of the communicative dimensions and are not exempt from limits. For example, the Comprehensive Psychotherapeutic Interventions Rating Scale (CPIRS), developed by Trijsburg et al. (2004), considers only the classification of interventions implemented by a therapist resulting from the analysis of common factors to the main psychotherapy orientations (client-centered, group psychodynamic, behavioral, cognitive and systemic orientations). The Client Behavior System (CBS), developed by Hill et al. (1992) as a revised version of the Client Verbal Response Category System (CVRCS; Hill et al., 1981), focuses in particular on patient's verbal behaviors, distinguishing eight nominal and mutually exclusive categories derived from different theoretical perspectives. Finally, the Therapeutic Activity Coding System (TACS-1.0), developed by Valdés et al. (2010), is a single system based on the notion of performative language which classifies only verbal communicative actions of patient and therapist by micro-analyzing each speaking turn during relevant episodes of the psychotherapy process.

As for voice and interruptions in psychotherapy, research is not as extensive (e.g., Weiste and Peräkylä, 2014; Buchholz and Reich, 2015; Oka et al., unpublished) as the research on verbal communication. Observational systems to classify voice in the psychotherapeutic context are not so many, while those to observe interruptions are not present, to our knowledge. With regard to the study of voice, for example, the Client Vocal Quality (CVQ) and Therapist Vocal Quality (TVQ) are two classification systems developed by Rice and Kerr (1986) to separately detect the client's vocal style in any given utterance and the therapist's vocal qualities affecting the client's participation in the therapeutic work, apart from speech content. Finally, the Vocal Quality Pattern (VQP) was developed by Tomicic et al. (2015a) as a single coding system to classify patient and therapist's vocal quality, apart from the content of speech considering specific acoustic parameters of voice, during relevant episodes of the psychotherapy process. Such a system includes four vocal quality patterns (Reporting, Connected, Affirmative, Introspective, and Emotional) and three non-coding categories of vocal patterns, but it does not distinguish the positive and negative emotions of speech. Referring to the study of interruptions, systems for classifying this kind of behaviors are not traceable in psychotherapy framework. In psychotherapy research as well as in intersubjectivity and self-regulation models, distinct detection of positive and negative emotions and interruption behaviors is extremely important because they affect the change and psychotherapy process (Carver and Scheier, 1990; O'Reilly, 2008; Stalikas and Fitzpatrick, 2008; Schutte, 2013).

Although all these classification systems contribute to studying the communicative components of the therapeutic discourse, they do not consider the mutual influence of verbal and non-verbal dimensions and often focus on a specific participant or aspect of the communicative exchange. Moreover, although some classification systems are built as single systems to analyze speech of both therapist and patient, they do not go deep in the study of some aspects of communication (for example, the VQP includes only the Emotional category, not distinguishing between positive and negative emotions, or emotions with and without verbalizations). Furthermore, they often may segment a speaking turn to micro-analyze the communicative behaviors but not providing information at a more global level (e.g., TACS-1.0; Valdés et al., 2010). Finally, as we mentioned previously, there is a lack of systems for classifying interruptions in psychotherapy.

To overcome these limitations, we consider the need for a comprehensive classification system able to study and describe verbal and extra-linguistic behaviors implemented reciprocally by patient and therapist turn-by-turn during communicative exchanges. Furthermore, this system must be able to understand the mutual influence and evolution of such communicative behaviors during psychotherapy. For these reasons, inspired by an interdisciplinary perspective (Damasio et al., 2001) and starting from the performative function of language (Searle, 2017), we have developed -within an exploratory and descriptive design- the Communicative Modes Analysis System in Psychotherapy (CMASP), that we introduce in this paper.

The CMASP is born as an attempt to solve the problem of studying communication in psychotherapy according to a comprehensive theory. It has been developed to be a single and flexible observational system able to detect and classify (together or separately) both verbal and extra-linguistic components of communication expressed by the therapist and patient during the therapeutic exchange. Furthermore, the instrument allows identifying a communication profile for each participant and their interaction by integrating the communicative modes implemented. It provides valuable support in increasing knowledge about patient-therapist exchanges by detecting the communicative profiles able to build change during the psychotherapy process, and this is impossible using existing tools.

To describe patient-therapist communicative interactions and to analyze their mutual influence at the verbal and extra-linguistic level, the CMASP building is based on the performative function of language (Searle, 2017), which is connected to change in psychotherapy (Krause et al., 2006; Reyes et al., 2008), combined with Campbell's theorization (Campbell, 2007) and the principles of universal recognition of emotions (Thompson and Balkwill, 2006). Moreover, its constituent categories are derived from previous works adapted to the goals of our investigation (Hill, 1978; Goldberg, 1990; Stiles, 1992; Murata, 1994; Li, 2001; Valdés et al., 2005, 2010; Krause et al., 2009; Tomicic et al., 2015a) and from the building process of the classification system itself.

Specifically, as a single system, the CMASP permits a rigorous and systematized analysis of verbal and non-verbal communicative modes implemented by both patient and therapist in each speaking turn during the psychotherapeutic discourse. All this allows realizing comparative and sequential analyses which provide knowledge of the participants' mutual interaction process, the way communication evolves, and the communicative actions which affect the change during the psychotherapeutic process.

In recent years, a growing interest in integrating qualitative and quantitative methods has been developing in psychotherapy research. This integration provides a more comprehensive view of the patient-therapist interaction as it is supported by objective measures through a complementary perspective (Lutz and Hill, 2009), the search for mixed methods, which offers both rigor and flexibility in approaching the reality of the therapeutic relationship (Anguera and Hernández-Mendo, 2016; Anguera et al., 2018a).

The purpose of this paper is, firstly, to introduce the building of the CMASP by describing the methodology used to realize it and showing its ability in detecting and coding multiple aspects of communication in psychotherapy through its constituent dimensions and categories. Secondarily, we would present its first reliability psychometrics, for both inter-and intra-rater values, and its applications in the form of descriptive statistics of the subscales trend and an example of coding.

MATERIALS AND METHODS

The CMASP is founded on the systematic observation (Anguera et al., 2001) of verbal, vocal and interruption behaviors in patient-therapist communicative exchanges; this methodology, in turn, is based on a mixed methods approach (Plano Clark et al., 2015) integrating qualitative (QUAL) and quantitative (QUANT) data according to an exploratory sequential design (Fetters et al., 2013). Therefore, in line with a non-participant and indirect observation of natural language (Anguera et al., 2018b) within the ecological and not structured context of the therapeutic setting, patient and therapist's communicative behaviors were subjected to qualitative and quantitative analyses. In particular, verbal behaviors were converted into documentary material to analyze the content of each speech; to analyze vocal and interruptions behaviors, the acoustic characteristics of speech and the impact of these on the listener of the patient-therapist communicative exchanges were observed through a careful listening of therapeutic session recordings, apart from the content of messages. Although this methodology is intensive and implies working with a reduced number of participants, it permits the collection of a large number of records with high rigor (Castañer et al., 2016, 2017; Arias-Pujol and Anguera, 2017; García-Fariña et al., 2018; Rodríguez-Medina et al., 2018; Suárez et al., 2018) through the use of an observational instrument (the CMASP in this research).

Mixed methods research represents "a new movement, or discourse, or research paradigm (with a growing number of members) that has arisen in response to the currents of qualitative research and quantitative research" (Johnson et al., 2007, p. 113). The concepts and technicalities of quantification and data transformation are a recurrent theme in works written by eminent figures in the field of mixed methods research (Sandelowski, 2001; Creswell et al., 2003; Bazeley, 2009, 2018; Sandelowski et al., 2009; Onwuegbuzie et al., 2018; Schoonenboom et al., 2018). Several options are possible, and we select that one more suitable, considering the qualitative nature of data.

Quantification in observational methodology (in this study performed by using the CMASP) is particularly robust because, apart from simple frequency counts, contemplates other essential primary parameters, such as order and duration (Bakeman, 1978; Anguera et al., 2001; Bakeman and Quera, 2011; Quera, 2018), thereby providing the researcher with the means to map the different components of a behavior as it occurs.

In observational methodology, primary parameters are frequency, order, and duration; they are structured in the form of levels that follow a *progressive order of inclusion* (Anguera and Blanco-Villaseñor, 2003) according to which the corresponding data progressively acquire greater power. In particular, frequency provides the least information, while order gives information on both frequency and sequence of behaviors; finally, duration supplies information on frequency and order by adding the number of time units for each occurrence of a behavior.

The specific consideration of the order parameter is crucial for detecting hidden structures through the quantitative analysis of relations among different codes in systematized observational datasets. Precisely, since the initial dataset -deriving from a notably rich qualitative component- contains information on the order, it can be analyzed using a wide range of quantitative techniques working with categorical data (e.g., lag sequential analysis, polar coordinate analysis, and detection of T-Patterns) and producing a set of quantitative results which are then qualitatively interpreted, bringing about a seamless integration. Therefore, such quantitative techniques aim at searching invisible structures and studying how these evolve.

According Creswell and Plano Clark (2011), "there are three ways in which mixing occurs: merging or converging the two datasets by actually bringing them together, *connecting the two datasets by having one build on the other*, or embedding one data set within the other so that one type of data provides a supportive role for the other data set" (p. 7; the emphasis is our). Just based on the second option (*Connecting*) of integration of qualitative and quantitative elements, we perform this connection starting from systematic observation and transforming usual qualitative data of records in another dataset (here recorded by the CMASP). This last one allows including the record parameters of order and duration, being possible to obtain a matrix of data which are analyzable through quantitative techniques (Anguera et al., 2018b). Each session record will generate a matrix of codes (generally not regular) in the dataset, and each row will express the co-occurrences (corresponding to the various dimensions) carried out in each of the successive units.

The wide range of opportunities, available for processing data derived from observation, supports the idea that purely observational studies should be considered as mixed methods research studies (in which *connecting* represents an integration form implying to quantitize the qualitative records), even though they constitute a special case and do not follow traditional patterns (Anguera et al., 2017).

Design

Within the mixed methods perspective, the observational design (Blanco-Villaseñor et al., 2003) represents an empirical model of organization of the study connected to the research aims and in line with the systematic observation used which lead the decisions about data collection, organization, and analysis. The intersection of three dichotomous criteria (the unit of study, the continuity of recording, and the number of dimensions) provides eight different observational designs distributed in four quadrants (**Figure 1**).

The *unit of study* is divided into the Idiographic option (one unit corresponding to one participant or various participants with a stable bond) and Nomothetic option (different units). The *continuity of recording* is divided into the Punctual option (one session recorded) and Follow-up option (different sessions recorded over time). This last one, in turn, can be specified in inter-sessional (the recording obtained along different sessions) and intra-sessional (the recording obtained from the beginning to the end of a session). Finally, the *number of dimensions* is divided into the Unidimensional or Multidimensional options, depending on the number of response levels considered and connected to the study aims. On several occasions, one

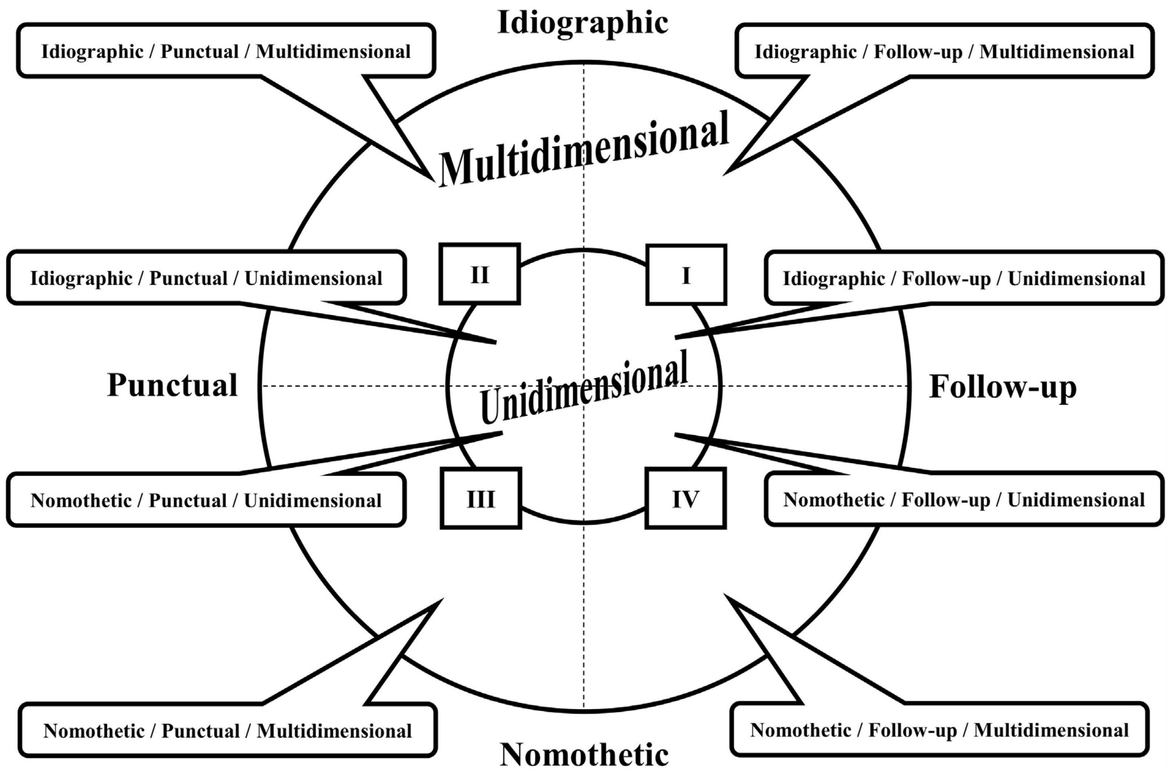


FIGURE 1 | Representation of the observational designs (adapted from Blanco-Villaseñor et al., 2003, p. 115). The intersection of the three dichotomous criteria (the unit of study, the continuity of recording, and the number of dimensions) brings about eight possible combinations, corresponding to the eight observational designs distributed in the four quadrants.

or more dimensions can be developed in subdimensions (Blanco-Villaseñor et al., 2003).

Given the complexity of this study, the most suitable observational design, among those involving a low level of intervention (Chacón-Moscoso et al., 2014), was the Nomothetic/Follow-up/Multidimensional (N/F/M; Anguera and Izquierdo, 2006) included in the Quadrant IV of the systematic observation designs representation as it presents the most wealth of information and a higher complexity (**Figure 1**; Blanco-Villaseñor et al., 2003). Specifically, the study was *nomothetic* because it was focused on a plurality of units in which different patients, in interaction with the same therapist, were analyzed independently. Moreover, intra-and inter-session analyses were performed, reflecting the *follow-up* recordings. Finally, the evaluation of verbal, vocal and interruption behaviors corresponded to the observation of multiple channels of communication, typical of the *multidimensional* design. As it is possible to notice, there is a full correspondence between the observational design selected for this study and the structure of the CMASP.

Participants and Material

We developed the CMASP at the Dynamic Psychotherapy Service belonging to the Interdepartmental Laboratories for Research and Applied Psychology (LIRIPAC), a recognized research center of the University of Padua (Italy). The ethics committee of psychology faculty of the University of Padua approved the collection of the research material (informed consents, the audio recording of sessions, and confidentiality modes of procedures) which followed the ethical guidelines and procedures of the LIRIPAC, based on the Italian law about privacy and confidentiality (n. 196/03). We discussed the specific research practice and ethical procedure of this investigation with the Director of the Centre who approved them before the research began in 2016.

We followed the ethical standards for research outlined in the *Ethical Principles of Psychologists and Code of Conduct* (American Psychological Association [APA], 2017). Therefore, we assured confidentiality by replacing the participants' personal information. As for listening to the audio recordings, we guaranteed confidentiality not providing personal data of the speakers to the trained coders who were in charge of their listening and transcription. We did not award incentives, and we emphasized voluntary participation. In line with the Declaration of Helsinki, we collected the informed consents of the therapist (verbal consent) and each patient (written consent), finalized to research aims, before realizing data collection and audio recording. In other words, we conducted the study after the end of the psychotherapy treatments.

For the CMASP development, we selected 10 weekly individual psychotherapies among those of patients self-referred to the Dynamic Psychotherapy Service (DPS) of the University of Padua. Psychotherapy sessions collection was managed, in respect with patients' recruitment, according to the following criteria: (a) each patient agreed to participate and signed the informed consent; (b) all participants completed the entire psychotherapeutic assessment phase; (c) each patient, by a previous screening to the assessment, completed the depressive scale of the Beck Depression Inventory-II (BDI-II; Italian version, Ghisi et al., 2006) and the Symptom Checklist 90 Revised (SCL-90-R; Italian version, Sarno et al., 2011), obtaining scores greater than or equal to the 85° percentile and the *T*-score of 60, respectively; (d) the audio recording of each session was complete. Moreover, patients met the following exclusion criteria: (a) absence of psychiatric diagnosis; (b) absence of ongoing pharmacological treatment for depression; (c) absence of previous psychological treatment.

The choice of selecting depressed patients was due to (a) the prevalence of this kind of patient who self-referred; (b) research reasons for obtaining a sample as uniform as possible; (c) the specific communicative features of this kind of patients which represent an expression of their symptoms. In fact, patients with depressive symptoms tend to speak more slowly and monotonously with less volume and voice modulation (Rottenberg and Gotlib, 2004), moreover, they tend to show high variation in prosody connected to the severity of symptoms (Yang et al., 2013).

Patients consisted of 10 university students (5 men and 5 women; age M = 26 years, SD = 3.91, Min = 22 years, Max = 32 years), residing in urban and rural areas of Italy; all of them were in care by the same female therapist (aged 39 years) with 13 years of expertise in the psychodynamic approach. By the administration of the BDI-II (Italian version, Ghisi et al., 2006) and SCL-90-R (Italian version, Sarno et al., 2011), all the patients showed depressive symptomatology. Specifically, they showed positive scores in the Total Score (M = 93.86, SD = 7.15, Min = 80, Max = 99), Somatic-Affective Area (M = 95.00, SD = 2.77, Min = 90, Max = 99), and Cognitive Area (M = 94.71, SD = 5.74, Min = 85, Max = 99) of the BDI-II. Moreover, they showed positive scores in the Global Severity Index (M = 61.14, SD = 8.15, Min = 53, Max = 75) and Depression Scale (M = 67.86, SD = 6.09, Min = 60, Max = 75) of the SCL-90-R. For each patient, the audio recordings (50 min each) and their verbatim transcriptions of the first three psychotherapeutic sessions were considered, for a total of 30 psychotherapy sessions. Afterward, we eliminated one session since it did not satisfy the inclusion criteria (the audio recording interrupted 10 min after the beginning) obtaining a sample of 29 psychotherapy sessions (29 audio recordings and 29 verbatim transcripts). Each transcription and the corresponding audio recording were divided into speaking turns.

To build the CMASP, we drew 3 cases of psychotherapy (each one consisted of 3 sessions) from the 10 cases considered, for a total of 9 sessions. Afterward, we randomly selected and observed audio recordings and their transcriptions of six sessions from the three cases of psychotherapy, for a total of 2095 speaking turns (1048 therapist speaking turns + 1047 patient speaking turns). These 3 cases of psychotherapy were excluded from further analyses, obtaining a definitive sample of 7 cases (4 men and 3 women) for a total of 6232 speaking turns (3121 therapist speaking turns + 3111 patient speaking turns). Finally, two sessions and their audio recordings, for a total of 503 speaking turns (252 therapist speaking turns + 251 patient speaking turns), were randomly selected among the remaining 20 sessions to perform data quality control.

Judges and Training Process

Three undergraduates and one Ph.D. students in psychology were recruited as judges and trained for the CMASP. Training consisted of 3-h classes 3 times a week (for a total of 35 h). During such a period, the judges learned the verbatim transcription norms as well as the usage of the Audacity® recording and editing software (version 2.2.1; Audacity Team, 2017) for observing and coding the audio recordings. Moreover, they studied the coding and training manual of the CMASP (Del Giacco et al., 2018) as well as they done exercises -rating 11 extracts of psychotherapy sessions audio recordings and transcripts for a total of 550 speaking turns coded (275 therapist speaking turns and 275 patient speaking turns)- and participated in discussion groups about encodings attributed.

Instruments

In systematic observation, recording instruments (e.g., to record and coding data) and observation instruments (that is purpose-designed *ad hoc* instruments) are differentiated (Anguera et al., 2018b).

Recording Instruments

Each 50-min therapeutic session was recorded in the therapist's room through an MP3 audio recorder, positioned at an equal distance from the therapist and patient to reduce and control reactivity biases. Trained undergraduates realized a verbatim transcription for each audio recording of psychotherapy sessions to observe verbal behaviors during patient-therapist communicative exchanges. Moreover, they used the Audacity® recording and editing software (version 2.2.1; Audacity Team, 2017) to perform the extra-linguistic behaviors observation. Such software is a support instrument to listen to audio tracks which shows the sound wave and enables the observer to stop, segment, trace, and code the audio recording for applying the categories according to the coding manual. The dataset was built using Excel.

Data quality control analyses were performed through the Tool for the Observation of Social Interaction in Natural Environments (HOISAN, v. 1.6.3.3.4; Hernández-Mendo et al., 2012) and Sequential Data Interchange Standard-Generalized Sequential Querier computer program (SDIS-GSEQ, v. 4.1.3; Bakeman and Quera, 2011).

Finally, descriptive statistics were performed through SPSS v. 23.0 Statistics statistical software.

Procedure

Development of the CMASP

The CMASP was elaborated within the observational methodology framework as an *ad hoc* indirect observation system of the therapeutic discourse (Anguera et al., 2018b) able to detect, record and classify verbal, vocal and interruption behaviors implemented turn-by-turn by patient and therapist, in the first phases of psychotherapy.

Based on this type of observation, the instrument building took place by implementing a recurrent process which oscillated between the observation of psychotherapeutic reality through audio recordings and transcripts and the theoretical framework that supporting the knowledge of that reality. To this end, the CMASP derived from the combination of two main instruments of the observational method, the field format and category systems, which were elaborated *ad hoc* for this specific observational study, exploiting the advantages of each to understand the reality of the therapeutic dialogue. Their combination rests on the theoretical framework of the observed reality and provides the instrument with the flexibility and dimensionality of the field format as well as with the consistency of the category systems (Anguera et al., 2007, Anguera et al., 2018b).

In the CMASP building, the recording process -leading up to a systematized recording of verbal and extra-linguistic behaviors with maximum external control- was divided into two different phases: the exploratory or passive phase (pre-scientific) and the active phase (scientific; Anguera et al., 2007). These phases were realized using the audio recordings of six sessions randomly selected from the three cases of psychotherapy previously drew.

During the pre-scientific phase, firstly we defined the structural criteria of the observation tool starting from the theoretical framework of the performative function of verbal and non-verbal behaviors (Krause et al., 2006; Reyes et al., 2008; Searle, 2017), reciprocally performed by patient and therapist through speech to co-construct the communicative relationship and meanings. The criteria were deduced after an analysis of the characteristics of communication in psychotherapy from related scientific literature and the variables studied in other research paper. To this end, we have carried out a review of databases (Google Scholar, Scielo, Dialnet, PsycINFO, PsycARTICLES, PsycCRITIQUES, and PubPsyc) using the following keywords: "verbal communication and performative language"; "non-verbal communication and performative language"; "psychotherapy and communication and performative language"; "psychotherapy and Speech Act Theory." We reviewed the abstracts and papers to select the studies related to the analysis of communication components according to the performative function of language (Hill, 1978; Goldberg, 1990; Stiles, 1992; Murata, 1994; Li, 2001; Valdés et al., 2005, 2010; Krause et al., 2009; Tomicic et al., 2015a). After discussing a preliminary list, we established core criteria and their definitions characterizing four dimensions: Verbal Mode-Structural Form (VeM-SF), Verbal Mode-Communicative Intent (VeM-CI), Vocal Mode (VoM) and Interruption Mode (IM). In particular, two dimensions were defined to analyze verbal behaviors: the VeM-SF, concerning the propositional content and corresponding to the structure by which speech expressed the communicative mode; the VeM-CI, concerning the performative content and corresponding to the communicative intent of the speaker's speech.

In this exploratory phase, three audio recordings were chosen at random from the six sessions so that they respectively corresponded to the first, second and third session of different individual psychotherapies. These audio recordings were listened through Audacity® software (version 2.2.1; Audacity Team, 2017) and verbatim transcribed. Such a step was fundamental for improving the training to observation, reducing biases (e.g., reactivity or expectation biases), as well as defining the norms for verbatim transcription, and elaborating a narrative recording (that is the first description of behaviors observed in the natural context with little constraints; Anguera et al., 2018b) at the root of the systematic observation process of communication.

To realize the narrative recording and observing verbal and extra-linguistic behaviors, we first unitized verbatim transcriptions and audio recordings in line with Krippendorff's (2013) procedures; they were structured in text blocks and audio blocks, respectively. We defined a text block as the whole speech in the transcript included between the opening and closing sentences of each therapy session. The audio block corresponded to that of the transcription, and it was marked in the audio recording through Audacity® software (version 2.2.1; Audacity Team, 2017). Afterward, we organized the text and audio block in speaking turns according to patient and therapist's communicative exchanges. One speaking turn corresponded to the piece of speech emitted by one speaker from the moment he/she began to speak until the other speaker took the floor. Given the correspondence between the audio and text block, we marked the speaking turn in the audio recording through Audacity® software at the change of speaker (therapist or patient) who emitted the speech (Tomicic et al., 2011).

We assumed the speaking turn as the unit of analysis of communicative exchanges, and it was equivalent in both the transcription and the audio recording. To facilitate a microanalytical observation and to perform subsequent comparative analyses, each transcript and audio recording was divided into ten segments according to the procedure defined by Colli et al. (2014) for the Collaborative Interaction Scale-Revised (CIS-R). This choice permitted to obtain the same number of pairs of therapist–patient turns in all the segments as well as it allowed segmenting the CMASP in the same way as other tools for psychotherapy process analysis do (e.g., the CIS-R). Finally, speaking turns were sequentially numbered and named with T and P to differentiate the speech of therapist and patient, respectively.

After carrying out the unitizing process, we observed the audio recordings and transcripts of the psychotherapy sessions and elaborated a list of communicative behaviors for each dimension. Each dimension was exhaustively observed until we detected and listed all possible communicative behaviors that represented the core criterion.

During the scientific phase, we deduced a list of possible categories for each dimension, adapted to the study goals, from the previous works selected. With the list of communicative behaviors for each dimension of the exploratory step, we performed a grouping process around concepts of the theoretical framework characterizing each provisional category. During this process, we improved the definitions and features of each category. Contemporarily, we performed a thematic grouping process of a series of communicative behaviors detecting new categories for each dimension. We defined provisional lists of categories systems that were discussed and modified until we achieved an agreement on each one.

As a result, we obtained a set of exhaustive and mutually exclusive (E/ME) categories of communicative behaviors for each criterion dimension (Anguera et al., 2018b), ensuring a good flexibility degree of the classification system. In other words, within the therapeutic discourse, each speech of patient and therapist could be evaluated according to the four dimensions of the instrument, while each communicative behavior identified could be assigned to one (exclusivity condition) and only one (mutual exclusivity condition) category within the category system of the corresponding dimension (Anguera and Izquierdo, 2006).

Once the categories were defined, an evidence check was performed on three new psychotherapeutic sessions - randomly selected among those of the three cases drew- to verify that new behaviors could not emerge, confirming the exhaustiveness of category systems after the instrument building. In this stage, the manual of the observational instrument (Del Giacco et al., 2018) was developed.

Coding Manual

A coding and training manual (Del Giacco et al., 2018) was elaborated to present the organization of the CMASP, the norms for the verbatim transcription, and the explanation of the Audacity® software usage (version 2.2.1; Audacity Team, 2017). Inside it, we described the categories of the CMASP dimensions. We illustrated each category definition through textual (and audio) examples and counter-examples, extrapolated from the observation of verbal and extra-linguistic psychotherapeutic communication, to identify and discriminate verbal, vocal and IMs, respectively. Furthermore, we showed and explained the procedure for unitizing the transcription and its audio recording as well as detecting the minimal unit of analysis for each dimension. For VeM-SF, VeM-CI, and VoM coding, we explained in the manual both the criteria for segmenting each speaking turn when a coder detected multiple categories for one dimension and the norms to be used to annotate these. Steps for coding verbal and extra-linguistic modes in the transcription and audio recording were defined. In the case of speaking turn segmentation due to VeM-SF, VeM-CI, and VoM coding, we described the rules for obtaining a global encoding. This aspect allows realizing comparative and sequential analyses as well as obtaining a systematized record in the form of a dataset (that is systems of codes structured as matrices) in which each speaking turn expressed multiple event codes.

Given the correspondence in the unitizing procedures of verbatim transcription and audio recording, we assumed the former as the coding sheet to note the observation and coding of verbal dimensions and extra-linguistic dimensions, respectively. Afterward, encodings -detected and transcribed for each dimension- were reported in a global coding sheet to obtain multiple event codes for each speaking turn.

Rigorous Data Quality Control of the CMASP

After the evidence check, control analyses were implemented through two quantitative statistical techniques to verify and ensure the data quality and the reliability of the instrument. The first one, the intra-observer reliability, was computed through Cohen's kappa coefficient (κ; Cohen, 1960) to verify the degree to which one observer's encodings of the same transcript and audio recording remained constant at two different times (in this study, we realized the second coding of the same transcription and audio recording after 1 month). The second one was the inter-observer reliability to verify the agreement level of at least three observers' encodings of the same transcript and audio recording at the same point in time. It was computed, at the global and dimensional level, through Krippendorff's canonical agreement coefficient (Cc; Krippendorff, 1980) -an adaptation of Cohen's kappa- while, at the categorical level, as an average value of all the Cohen's kappa coefficients (κ; Cohen, 1960) calculated on different couples of observers (all the possible combinations of the four observers). These analyses were performed on the encodings of four judges -trained for the CMASP and its coding procedure (Losada and Manolov, 2015; Anguera et al., 2018b)- who observed 503 speaking turns, corresponding to the material of 2 psychotherapy sessions (1 verbatim transcription + 1 audio recording each one) randomly selected from the seven cases of the definitive sample. Although we observed only two sessions, the number of speaking turns was adequate to consider the material at a microanalytic level.

The four judges realized the coding independently, applying the CMASP on one selected psychotherapy session at a time. An observer chief was selected among the four judges to compute the intra-observer reliability.

Each reliability was computed for the CMASP, at the overall and dimensional level, through HOISAN v. 1.6.3.3.4 (Hernández-Mendo et al., 2012) and, at the categorical level, through SDIS-GSEQ v. 4.1.3 (Bakeman and Quera, 2011).

RESULTS

Firstly, we present a general description of the CMASP. Afterward, we discuss the reliability study results and, finally, we report the CMASP applications to the sample (descriptive statistics of subscales trend and an example of coding).

General Presentation of the Classification System

The CMASP is an *ad hoc* classification system for the indirect observation of communication in psychotherapy, as a combination of a field format system for each criterion dimension and category systems, which analyzes (together or separately) patient and therapist's verbal, vocal and interruption behaviors turn-by-turn.

The instrument consists of four dimensions (VeM-SF, VeM-CI, VoM, IM), two of them referred to two aspects of verbal behaviors and the others related to vocal and interruption behaviors of communication, respectively.

A total of 33 categories describes patient and therapist's verbal and extra-linguistic behaviors, respectively. Each dimension comprises a set of these categories in the form of exhaustive and mutually exclusive category system, as described below. Each speaking turn can present one and only one communicative mode for each dimension, but it can show co-occurrent communicative modes belonging to different dimensions.

Concerning the analysis of verbal modes, six categories constitute the VeM-SF dimension (Courtesies, Assertion, Question, Agreement, Denial, and Direction), while the VeM-CI dimension consists of eight categories (Acknowledging, Informing, Exploring, Deepening, Focusing, Temporizing, Attuning, and Resignifying). Concerning the VoM dimension, it consists of eight categories (Reporting, Connected, Declarative, Introspective, Emotional-Positive, Emotional-Negative, Pure Positive Emotion, and Pure Negative Emotion). The communicative intent of each category is associated with both a peculiar acoustic parameters combination and specific mode of the speaker's speech affecting the listener of communication, apart from the verbal content. Moreover, the "emotional" categories (Emotional-Positive, Emotional-Negative, Pure Positive Emotion, and Pure Negative Emotion) are defined and described according to the principles of universal recognition of emotions (Thompson and Balkwill, 2006). Concerning the IM dimension, eleven categories are detected and specified in cooperative, intrusive, neutral and failed interruptions (Cooperative-Agreement, Cooperative-Assistance, Cooperative-Clarification, Cooperative-Exclamation, Intrusive-Disagreement, Intrusive-Floor taking, Intrusive-Competition, Intrusive-Topic change, Intrusive-Tangentialization, Neutral Interruption, Failed Interruption).

These categories are characterized by a description derived from the application of the observational method as well as from the previous works mentioned. Moreover, each definition of the VoM categories is supported by the description of the combination of acoustic parameters associated. Finally, a code for each category is established (for a detailed description, see "**Appendix I**. Description of the CMASP dimensions and categories").

Reliability Study of the CMASP

As shown in **Table 1**, results obtained at the overall, dimensional and categorical level of the CMASP are all greater than or equal to 0.81 in both psychotherapy session encodings, indicating an almost perfect level of the intra-judge reliability ($\kappa \geq 0.81$; Cohen, 1960). It is possible to notice that some categories are present only in a psychotherapy session but not in the other one (e.g., Courtesies, Cooperative-Assistance); however, their scores show an almost perfect agreement ($\kappa \geq 0.81$) in the session in which they were detected. Finally, some categories are not present since they do not appear in either session (e.g., Direction, Temporizing, Pure Negative Emotion). It does not represent a negative aspect of reliability, but on the contrary, it means that the judge shows a total agreement in not coding these categories in each session at two different times.

As we mentioned above, the inter-judge reliability was computed, at the global and dimensional level, through Krippendorff's Cc and, at the categorical level, as an average value of all the Cohen's kappa coefficients derived from the four judge's encodings of the two psychotherapy sessions considered (220 and 283 speaking turns, respectively), for a total of 503 speaking turns coded. As shown in **Table 2**, results obtained at the overall and dimensional level of the CMASP are percentages greater than or equal to 81%, indicating an almost perfect level of the inter-judge reliability ($Cc \geq 81$; Krippendorff, 1980). At the categorical level, percentages show an inter-judge agreement level which varies between substantial ($61\% \leq \kappa \leq 80\%$) and almost perfect ($\kappa \geq 81\%$; Cohen, 1960). The categories detected by computing the intra-judge reliability also appear in one session, but not in the other one, by the inter-judge reliability computation. These categories present an agreement level varying between substantial ($61\% \leq \kappa \leq 80\%$) and almost perfect ($\kappa \geq 81\%$) in the session in which they were detected. Finally, the same categories not detected by computing the intra-judge reliability computation neither appear by the inter-judge reliability computation. Here again, this expresses a total agreement by the four judges in not coding these categories in either psychotherapy session.

The CMASP reaches from high to very high intra-and inter-judge reliability for those categories expressing objective aspects of communication (the VeM-Structural Form categories) as well as for those categories based on the communicative intent (the categories of the VeM-Communicative Intent, VoM, and Interruption Mode dimension) which stimulate the subjectivity of the coder.

CMASP Applications: Descriptive Statistics of the Subscales Trend and an Example of Coding

As it is possible to see in **Table 3**, by the application of the CMASP on the 20 psychotherapy sessions (for a total of 6232 speaking turns), the VeM-Structural Form dimension shows the highest percentage of codes indicating high participation in communicative exchanges through speech contents with a clear structure. Precisely, speakers mainly expressed verbalizations in the form of statements (Assertion), recognition of the truth of the other's statements (Agreement) and requests for information (Question). A high percentage of communicative intents (VeM-CI) accompanied such structural forms, mainly characterized by asking for/providing contents (Exploring), taking the other's viewpoint (Acknowledging), deepening contents (Deepening),

TABLE 1 | Intra-judge reliability of the CMASP (*N* = 503 speaking turns).

CMASP	1st session (*n* = 220)	2nd session (*n* = 283)	*M*	*SD*
Overall	0.97	0.99	0.98	0.01
Verbal Mode-Structural Form (VeM-SF)	0.97	0.99	0.98	0.01
Courtesies (SF1)	1.00	TANC		
Assertion (SF2)	0.93	0.98	0.96	0.04
Question (SF3)	0.94	0.97	0.96	0.02
Agreement (SF4)	0.93	0.99	0.96	0.04
Denial (SF5)	TANC	1.00		
Direction (SF6)	TANC	TANC		
Verbal Mode-Communicative Intent (VeM-CI)	0.93	0.98	0.96	0.04
Acknowledging (CI1)	0.99	0.99	0.99	0.00
Informing (CI2)	0.87	TANC		
Exploring (CI3)	0.88	0.93	0.91	0.04
Deepening (CI4)	0.70	0.95	0.83	0.18
Focusing (CI5)	0.69	0.95	0.82	0.18
Temporizing (CI6)	TANC	TANC		
Attuning (CI7)	1.00	1.00	1.00	0.00
Resignifying (CI8)	1.00	0.92	0.96	0.06
Vocal Mode (VoM)	0.97	0.94	0.96	0.02
Reporting (VM1)	1.00	TANC		
Connected (VM2)	0.91	0.93	0.92	0.01
Declarative (VM3)	0.96	0.91	0.94	0.04
Introspective (VM4)	0.71	1.00	0.86	0.21
Emotional-Positive (VM5)	0.91	0.90	0.91	0.01
Emotional-Negative (VM6)	0.95	0.66	0.81	0.21
Pure Positive Emotion (VM7)	1.00	1.00	1.00	0.00
Pure Negative Emotion (VM8)	TANC	TANC		
Interruption Mode (IM)	0.91	0.96	0.94	0.04
Cooperative-Concurrence (IM1)	0.95	0.97	0.96	0.01
Cooperative-Assistance (IM2)	TANC	1.00		
Cooperative-Clarification (IM3)	0.83	0.95	0.89	0.08
Cooperative-Exclamation (IM4)	TANC	1.00		
Intrusive-Disagreement (IM5)	1.00	1.00	1.00	0.00
Intrusive-Floor taking (IM6)	TANC	0.91		
Intrusive-Competition (IM7)	TANC	1.00		
Intrusive-Topic change (IM8)	TANC	TANC		
Intrusive-Tangentialization (IM9)	TANC	TANC		
Neutral interruption (IM10)	0.94	0.80	0.87	0.10
Failed Interruption (IM11)	TANC	0.89		

TANC, Total Agreement in the Not Coded Category; the intra-judge reliability was computed through Cohen's kappa (κ); κ: insufficient (lower than or equal to 0.60), substantial (between 0.61 and 0.80), satisfactory (greater than or equal to 0.81).

Resignifying, and Attuning (even if at a lesser percentage). It expresses the typical characteristics emerging in the initial phases of psychodynamic psychotherapy, although the CMASP brings added value since it is possible to integrate information corresponding to co-occurrences of behavior in all dimensions.

During sessions, a fairly high percentage of VoM, spreading the underlying intentions apart from the verbal content, enriched speakers' speech. Compared to the expressed content, the voice of participants above all presented an elaborative speech in connection to oneself and oriented to the other (Connected); moreover, it transmitted positive/negative emotional states (Emotional-Positive and Emotional-Negative), positive non-verbal emotions (Pure Positive Emotions) and expressed certainty and conviction (Declarative), filling contents of new meanings.

Finally, the IM dimension shows the lowest percentage of codes compared to the 6232 speaking turns considered. As we mentioned, these modes represent an interactive aspect of communication as violations of the other participant's communicative space by an interrupter. Therefore, such a percentage do not indicate a negative aspect but, on the contrary, it expresses good self-regulation and coordination capacities of both participants during communicative exchanges. Generally, participants interrupted to show concurrence (Cooperative-Concurrence), neutrally take the floor (Neutral Interruption), or intrusively develop the topic of the current

TABLE 2 | Inter-judge reliability analysis of the CMASP (*N* = 503 speaking turns).

CMASP	1st session (*n* = 220)	2nd session (*n* = 283)	*M*	*SD*
Overall	93**	94**	93.50**	0.71**
Verbal Mode-Structural Form (VeM-SF)	95**	95**	95.00**	0.00**
Courtesies (SF1)	96*	TANC		
Assertion (SF2)	93*	92*	92.50*	0.01*
Question (SF3)	95*	94*	94.50*	0.01*
Agreement (SF4)	92*	95*	93.50*	0.02*
Denial (SF5)	TANC	79*		
Direction (SF6)	TANC	TANC		
Verbal Mode-Communicative Intent (VeM-CI)	87**	92**	89.50**	3.54**
Acknowledging (CI1)	93*	97*	95.00*	0.03*
Informing (CI2)	65*	TANC		
Exploring (CI3)	86*	86*	86.00*	0.00*
Deepening (CI4)	75*	82*	78.50*	0.05*
Focusing (CI5)	79*	82*	80.50*	0.02*
Temporizing (CI6)	TANC	TANC		
Attuning (CI7)	70*	90*	80.00*	0.14*
Resignifying (CI8)	100*	82*	91.00*	0.13*
Vocal Mode (VoM)	93**	87**	90.00**	4.24**
Reporting (VM1)	100*	TANC		
Connected (VM2)	87*	89*	88.00*	0.01*
Declarative (VM3)	75*	77*	76.00*	0.01*
Introspective (VM4)	80*	100*	90.00*	0.14*
Emotional-Positive (VM5)	83*	85*	84.00*	0.01*
Emotional-Negative (VM6)	88*	61*	74.50*	0.19*
Pure Positive Emotion (VM7)	100*	100*	100.00*	0.00*
Pure Negative Emotion (VM8)	TANC	TANC		
Interruption Mode (IM)	81**	92**	86.50**	7.78**
Cooperative-Concurrence (IM1)	89*	96*	92.50*	0.05*
Cooperative-Assistance (IM2)	TANC	100*		
Cooperative-Clarification (IM3)	100*	85*	92.50*	0.11*
Cooperative-Exclamation (IM4)	TANC	100*		
Intrusive-Disagreement (IM5)	87*	83*	85.00*	0.03*
Intrusive-Floor taking (IM6)	TANC	89*		
Intrusive-Competition (IM7)	TANC	100*		
Intrusive-Topic change (IM8)	TANC	TANC		
Intrusive-Tangentialization (IM9)	TANC	TANC		
Neutral interruption (IM10)	93*	81*	87.00*	0.08*
Failed Interruption (IM11)	TANC	90*		

*TANC, Total Agreement in the Not Coded Category; scores are expressed in percentage; *Inter-judge reliability through Cohen's kappa (κ); **Inter-judge reliability through Krippendorff's canonical agreement coefficient (Cc); κ and Cc: insufficient (lower than or equal to 60%), substantial (between 61 and 80%), satisfactory (greater than or equal to 81%).*

speaker (Intrusive-Floor taking). Moreover, they interrupted generating a battle to take the floor and express one's speech (Intrusive-Competition), or they could interrupt to understand the other's speech (Concurrence-Clarification).

The separate analysis of the CMASP categories aims to show the trend of each categorical system within the instrument. The integration of the communicative modes of the different dimensions occur at the interpretative level according to the values that these assume in line or not with the expected distributions; this makes it possible to determine different communication profiles that participants carry out. Assume that a speaker 1 shows the following communicative modes that are higher to the expected distribution: Assertion (VeM-SF), Exploring (VeM-CI), and Emotional-Positive (VoM). Moreover, assume that a speaker 2 shows the following communicative modes that are higher to the expected distribution: Assertion (VeM-SF), Exploring (VeM-CI), Emotional-Negative (VoM), and Intrusive-Floor taking (IM). It is possible to notice that, although both speakers use the same verbal communication modes, non-verbal modes convey speech in different ways, determining two distinct communication profiles. Speaker 1, indeed, refers to a certain state of things (Assertion) by reporting his/her inner experience (Exploring) that is modulated by a positive emotional state (Emotional-Positive). Speaker 2, on the

TABLE 3 | Descriptive statistics of the CMASP communicative modes on the definitive sample (*N* = 6232 speaking turns).

CMASP	*f*	%
Verbal Mode-Structural Form (VeM-SF)	5748	92.23
Courtesies (SF1)	52	0.90
Assertion (SF2)	3299	57.39
Question (SF3)	752	13.08
Agreement (SF4)	1516	26.37
Denial (SF5)	80	1.39
Direction (SF6)	49	0.85
Not coded	484	7.77
Verbal Mode-Communicative Intent (VeM-CI)	5171	82.97
Acknowledging (CI1)	1275	24.66
Informing (CI2)	196	3.79
Exploring (CI3)	2285	44.19
Deepening (CI4)	568	10.98
Focusing (CI5)	181	3.50
Temporizing (CI6)	26	0.50
Attuning (CI7)	227	4.39
Resignifying (CI8)	413	7.99
Not coded	1061	17.03
Vocal Mode (VoM)	3832	61.49
Reporting (VM1)	10	0,26
Connected (VM2)	1521	39.69
Declarative (VM3)	214	5.58
Introspective (VM4)	151	3.94
Emotional-Positive (VM5)	965	25.18
Emotional-Negative (VM6)	588	15.34
Pure Positive Emotion (VM7)	333	8.69
Pure Negative Emotion (VM8)	50	1.30
Not coded	2400	38.51
Interruption Mode (IM)	1144	18.36
Cooperative-Concurrence (IM1)	314	27.45
Cooperative-Assistance (IM2)	32	2.80
Cooperative-Clarification (IM3)	83	7.26
Cooperative-Exclamation (IM4)	18	1.57
Intrusive-Disagreement (IM5)	50	4.37
Intrusive-Floor taking (IM6)	185	16.17
Intrusive-Competition (IM7)	94	8.22
Intrusive-Topic change (IM8)	19	1.66
Intrusive-Tangentialization (IM9)	3	0.26
Neutral interruption (IM10)	286	25.00
Failed Interruption (IM11)	60	5.24
Not coded	5088	81.64

other hand, interrupts intrusively to take the floor (Intrusive-Floor taking IM) reporting his/her inner experience filled with negative emotions (Emotional-Negative).

Considering that each patient assumes an interactive role with his/her therapist and that for each one it is possible to detect the specific communicative modes, it results that we can have a detailed and "individualized" profile for the patient, therapist, and their unique interaction.

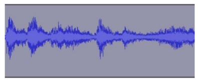
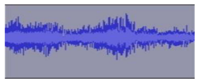
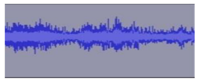
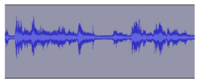
It is important to underline that some speaking turns were not coded due to the sensitivity of the classification system in coding certain communicative behaviors (e.g., VoMs cannot be detected in a speech less than 2 s). Moreover, some categories showed a lower percentage than others, not because they were not present, but because the CMASP attributes a predominant communicative mode to a speaking turn for most of the dimensions (VeM-SF, VeM-CI, VoM). As we mentioned, this classification system micro-analyzes each speaking turn which can be segmented when changes occur in the communicative modes. Therefore, although these categories (e.g., Courtesies, Denial, Direction, Temporizing, Reporting) could occur in a segment at a micro level, the attribution of the predominant category decreased their probability of being coded at a speaking turn level. On the contrary, other categories (e.g., Pure Negative Emotion, Cooperative-Assistance, Cooperative-Exclamation, Intrusive-Topic change, Intrusive-Tangentialization) could present a lower percentage, although not being based on the predominance coding procedure, due to the specific characteristics of the communicative interactions with depressed patients.

Hereunder, we present an example of the CMASP coding to show its capability to analyze the complexity of the psychotherapeutic exchange and giving information about the psychotherapy process (**Table 4**). Such a segment is extrapolated from the second session of psychodynamic psychotherapy, belonging to the final sample of seven cases, and it is related to communicative exchanges between a male patient with depressive symptomatology and the female therapist.

A trained coder, using both the audio recording and the verbatim transcript, realized the classification of patient and therapist's verbal and extra-linguistic communicative modes. Following the coding manual, he used the verbatim transcript to detect the different structural forms and communicative intents of verbal modes turn-by-turn. Moreover, he employed the transcript as support to note the extra-linguistic modes, emerging in each therapist and patient's speaking turn, detected by a careful listening of the audio recording. If two or more communicative modes of the same CMASP dimension occurred in a speaking turn, the coder assigned the predominant one according to the coding rules of the manual.

Table 4 represents an illustration that shows the added value of the CMASP by integrating the information from several components. As it is possible to notice, in speaking turn no. 195 and no.197, the therapist asks for information (VeM-SF: Question) with the intent of deepening (VeM-CI: Deepening) "stimulated" by the patient's previous speech. The therapist expresses this through a positive emotion (VoM: Emotional-Positive) in speaking turn no. 195 since her speech affects the listener as filled with curiosity. According to the coding procedures, the CMASP cannot code VoMs in speaking turns less than 2 s unless they express emotional states. In speaking turn no. 195, therapist pauses her speech for a moment arousing uncertainty in the patient about her intention to continue to speak. Consequently, in speaking turn no. 196, the patient starts to speak without a real interruption (IM: Neutral interruption) to recognize the truth of the therapist's statement (VeM-SF: Agreement). He modulates his speech through a laugh (VoM: Emotional-Positive), synchronizing with the positive emotional state expressed by the therapist. In speaking turn no. 197, faced

TABLE 4 | Illustration of the CMASP coding.

Turn	Role	Transcription	Audacity® sound wave	VeM-SF	VeM-CI	VoM	IM
195	T	When did you sister. . ...(pause)// (<2″)		Question	Deepening	Emotional-Positive	/
196	P	//Yes, exactly (laugh)//(<2″)		Agreement	/	Emotional-Positive	Neutral interruption
197	T	//grow up? (<2″)		Question	Deepening	/	Intrusive-Floor taking
198	P	Yes, we are also 5 years apart, so when she got older, I started to get. . .. to be. . .to grow up me too and so to get impossible and all the rest of it.		Assertion	Exploring	Emotional-Positive	/

T, Therapist; P, Patient; VeM-SF, Verbal Mode-Structural Form; VeM-CI, Verbal Mode-Communicative Intent; VoM, Vocal Mode; IM, Interruption Mode. /, indicates the not-coded communicative behaviors. //, indicates the speaking turn interruption. (<2″), indicates speech less than 2 s.

with such communication of agreement supported by positive emotion, the therapist intrusively interrupts the patient to regain the floor (IM: Intrusive-Floor taking) with the intent to continue her question about the previous speech (VeM-SF: Question; VeM-CI: Deepening). In speaking turn no. 198, the patient starts to speak in a coordinated way, referring to a certain state of things (VeM-SF: Assertion), to provide the information required by the therapist and giving new contents in the form of past experiences (VeM-CI: Exploring).

Such a speaking turn would be segmented due to the initial structural form of agreement ("Yes"). However, Assertion represents the predominant VeM-SF expressed by the patient for the rest of the speech and, for this reason, it can be attributed as the only code to the entire speaking turn. Finally, when the patient talks about his adolescence and the relationship with the sister, his speech affects the listener of the therapeutic exchange as filled with tenderness (Emotional-Positive).

The segment shows positive communicative exchanges between the therapist and the patient in which the two participants are emotionally synchronized. The previous patient's speech stimulates the emerging of a positive emotional state in the therapist which, at the same time, transmits to the patient the recognition of his experience and sustains the therapist herself in deepening the content referred. In turn, the patient emotionally and cognitively recognizes what the therapist expresses in the therapeutic relationship and transmits receptiveness to this last one. All this generates a climate of sharing and closeness which enables the therapist to reach the internal reality of the patient who, in turn, feels understood and supported in exploring his experience. In this case, the emotional climate helps the patient to get in touch with his emotions and legitimates him to attribute new meaning to his internal world through the sharing with the therapist. Instead, the disruptive interruption of the therapist sustains the patient in maintaining the emotional and relational balance, representing a typical problem of patients with depressive symptoms.

This illustration represents an example that shows the capacity of the CMASP to provide multiple and concurrent information about the intersubjective processes implemented by the therapist and patient during communicative exchanges. What emerges is a multi-level complexity in which the mutual regulation process occurs according to multiple and simultaneous directions (verbal–verbal, verbal–non-verbal, non-verbal–verbal, non-verbal–non-verbal). All this allows us to comprehend that these aspects of communication (content, voice, and interruptions) interweave during the co-construction of the therapeutic interaction and they cannot be considered as independent elements. Naturally, the complexity and dynamicity of the psychotherapeutic exchange make difficult the complete knowledge of what occurs within the psychotherapy setting, but the CMASP provides a deeper understanding of the internal reality of each participant and their mutual regulation during the psychotherapy session. Therefore, as an integrated system, the CMASP enables the professionals and researchers to obtain consistent information about some fundamental components of communication and the way they affect the co-construction of meanings and orient the psychotherapy process.

CONCLUSION

The purposes of this study were, on the one hand, to introduce the building of the Communicative Modes Analysis System in Psychotherapy (CMASP) and its constituent dimensions and categories underlining its ability in detecting and coding multiple aspects of communication in psychotherapy simultaneously and, on the other hand, presenting its early reliability psychometrics for both inter-and intra-rater values. Inspired by the process of convergence of natural and human science, we developed the CMASP to overcome the limits of the psychotherapy research -which investigates and theorizes the components of communication as in polar opposition- and trying to interpret some fundamental elements of therapeutic exchanges (verbal, vocal, and interruption behaviors) as an integrated and interactive system through a comprehensive theory, derived from the linguistic field.

As the CMASP is developed within the mixed methods framework by building a qualitative system that is quantitized (Sandelowski et al., 2009), it shows an increased incremental validity which ensures the qualitative/quantitative dimensions of functioning. The structure of the CMASP as a coding system applicable to both therapist and patient, as well as the possibility of detecting a predominant encoding at a speaking turn level, allow overcoming the limits of many instruments and realizing comparative and sequential analysis of communicative modes implemented by both participants during the psychotherapy process, increasing the knowledge about their evolution. In particular, the instrument permits to classify verbal and non-verbal aspects connected to the effectiveness of psychotherapy and identifying the communication profiles that contribute to the process of change in patients.

Given its high reliability at the global, dimensional, and categorical level, the CMASP represents an effective instrument providing researchers and professionals with a single classification system, able to give multiple and concurrent information about patient-therapist communicative exchanges and their evolution during a psychotherapy session. Moreover, given its flexibility, this classification system allows focusing the knowledge on a specific area of communication. Precisely, the instrument can be used as a single system permitting to monitor simultaneously verbal and non-verbal changes bound up with psychotherapy, especially when it is applied together with other instruments (e.g., self-reports, clinical reports) to improve the incremental validity of the effectiveness measure. Alternatively, as the verbal and non-verbal dimensions of the CMASP can also be applied separately, the instrument can provide an objective measure of change -starting from the qualitative modes of relational exchange- in case of disorders (depression, ADHD, BPD) with marked non-verbal behaviors.

On the one hand, it could represent a useful instrument for researchers to increase the knowledge about what is occurring within the psychotherapy process reducing its complexity and, on the other hand, it could support the clinician in comprehending the patient functioning and improving the interventions tailored to each specific therapeutic interaction. Concerning to researchers, for example, the CMASP could allow them to deepen the knowledge about the interaction of communicative modes with other constructs (e.g., therapeutic alliance, attachment patterns), or different disorders (e.g., anxiety, eating disorders), or changes in patient's symptoms after and before the treatment. Concerning the clinicians, our final purpose would be to provide them with an instrument they will be able to internalize with practice, without the need for the physical support of audio recordings and verbatim transcripts, integrating it with their skills for sustaining the interaction with the patient and the psychotherapy process. For example, by recognizing the non-verbal communication underlining the expressed content (e.g., an elaborative speech, a positive emotional state, an interruption to clarify or to disrupt), the clinician may draw information about the coherence between the verbalized content and non-verbal modes associated, about the patient's resistance, or the internalized meaning he/she expresses behind and with words. In this way, the clinician can calibrate with more efficacy his/her intervention toward the patient.

Based on decades of studies on communication in the field of psychotherapeutic research, the CMASP attempts to contribute to understanding the complexity of this field by deepening the dynamic process of co-construction of meanings during patient–therapist communicative exchanges. The development of such a classification system showed the difficulty in coping with methodology problems in the communication study. These preliminary results come from the application of coding and counting approaches belonging to the tradition of research on communication, but we aim to integrate these as a part of a system in interaction in future studies (Peräkylä, 2004).

Firstly, since this paper is an early introduction of the classification system building and its psychometric properties, we aim to focus on its validation in future research. Moreover, convergent and discriminant validity studies are not available, but the CMASP segmentation procedure -elaborated through the CIS-R one- will allow performing correlational studies of validity between the communicative modes and the therapeutic alliance as well as internal correlation analyses among the categories, in future research. Finally, even though some categories of the CMASP show a low percentage, this is not a negative aspect as it may be due to the specificity of the sample (patients with depressive symptomatology), on the contrary, it provides information about the communicative characteristics of certain types of psychotherapeutic interactions, increasing the knowledge on this type of patients. Given the instrument flexibility, we aim to extend its application to other psychotherapy sessions, patients and, mostly, disorders. It is possible, for example, that a category like VOM-Declarative, with a low percentage in depressed patients, could characterize other types of disorders (e.g., narcissistic patients) predominantly.

Although the CMASP seems to solve the problem of understanding the communicative exchanges in psychotherapy through the pragmatic function of language as a global theory -increasing knowledge about what occurs during the interaction between the patient and therapist- the insubstantiality of certain distinctions between verbal and non-verbal aspects makes further studies necessary from an interdisciplinary standpoint. The CMASP development was based on the observation of psychotherapies conducted by just one therapist. At first, such a choice was made to reduce variability in the pilot research, but we know this decision could affect data because of the personal style of the therapist, or biases, or the individual communicative trends. For these reasons, in future research, it would be useful to consider the observation of more therapists to extend, improve and confirm the communicative modes analyzed. Furthermore, we observed only psychotherapies conducted by a female therapist. In future research, it would also be useful to observe psychotherapies conducted by a male therapist to verify if gender may affect the use of specific communicative modes (e.g., to examine if a female therapist may use more emotional communicative modes than a male therapist). We selected patients according to depressive symptomatology, but the purpose for future research is to extend the CMASP application to other types of disorders (e.g., anxiety, emotional dysregulation, obsessive–compulsive behaviors, eating disorders and so on) for creating a diagnostic classification system with established norms, or trends, for each diagnostic category. Finally, it would be useful to integrate the observation of video recording to extend the richness of communication in psychotherapy with other non-verbal components (e.g., facial expression or body movement observation).

ETHICS STATEMENT

We developed the CMASP at the Dynamic Psychotherapy Service belonging to the Interdepartmental Laboratories for Research and Applied Psychology (LIRIPAC), a recognized research center of the University of Padua (Italy). The ethics committee of psychology faculty of the University of Padua approved the collection of the research material (informed consents, the audio recording of sessions, and confidentiality modes of procedures) which followed the ethical guidelines and procedures of the LIRIPAC, based on the Italian law about privacy and confidentiality (n. 196/03). We discussed the specific research practice and ethical procedure of this investigation with the Director of the Centre who approved them before the research began in 2016. We followed the ethical standards for research outlined in the Ethical Principles of Psychologists and Code of Conduct (American Psychological Association [APA], 2017). Therefore, we assured confidentiality by replacing the participants' personal information. As for listening to the audio recordings, we guaranteed confidentiality not providing personal data of the speakers to the trained coders who were in charge of their listening and transcription. We did not award incentives, and we emphasized voluntary participation. In line with the Declaration of Helsinki, we collected the informed consents of the therapist (verbal consent) and each patient (written consent), finalized to research aims, before realizing data collection and audio recording. In other words, we conducted the study after the end of the psychotherapy treatments.

AUTHOR CONTRIBUTIONS

LDG documented, designed, drafted, and wrote the manuscript. Moreover, he trained and supervised the coders as well as he carried out statistical analyses. SS supervised the sample recruitment and the statistical analyses. MA supervised the method and procedure sessions as well as statistical analyses. SS and MA revised the manuscript for theoretical and intellectual content. Finally, all authors provided final approval of the version to be published.

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SUPPLEMENTARY MATERIAL

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ORIGINAL RESEARCH
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Combining Quantitative and Qualitative Data in the Study of Feeding Behavior in Male Wistar Rats

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The first step in a behavioral study is represented by the organization of a suitable ethogram, that is, a formal description of individual components of the behavior. Then, each component of such a behavioral repertoire can be *quantified* (e.g., how many times it occurs, its duration, percent distribution, latency, etc.). However, it is our contention that the possibility to describe the behavior of a living being by means of hundreds or even thousands of numbers concerning isolated components, disjointed from the comprehensive behavioral architecture, does not imply the possibility to use those numbers to reconstruct the meaning of behavior. Such a level of comprehension requires a *qualitative approach* based on the analysis of behavioral structure and its underlying dynamics. By means of synergic utilization of quantitative and qualitative data a more complete description of a given behavior becomes available. In present study we discuss results obtained from observations of feeding behavior in two groups of male Wistar rats: a control group, under standard diet, and a second group, under hyperglycidic one. Results have been presented both in terms of quantitative evaluations and in terms of structural/qualitative ones, the latter obtained by means of T-pattern detection and analysis. As to quantitative results, mean durations showed a significant reduction of Walking and Feeding and an increase of Hind-Paw Licking and Body Grooming; concerning mean occurrences, a significant increase of Front-Paw Licking, Hind-Paw Licking, and Body Grooming was present; percent distributions showed significant reductions for Walking and Feeding and a significant increase for all grooming activities. As to qualitative assessments, T-pattern analysis unveiled a clear-cut behavioral reorganization induced by the hyperglycidic diet. If on the one hand, 50 different T-patterns were detected in subjects under standard diet, on the other hand, 703 different T-patterns were discovered in animals under hyperglycidic treatment, with a highly significant increase of mean lengths and a significant reduction of mean occurrences of T-patterns. Synergic evaluation of results in terms of quantitative and qualitative aspects shows, in rats fed with hyperglycidic diet, an increased anxiety condition, likely dependent on food-related stimuli and suggestive of a pervasive *craving*-related behavior.

Keywords: feeding behavior, standard diet, hyperglycidic diet, T-pattern analysis, TPA, rat

INTRODUCTION

The word "*diet*" comes from the ancient Greek δίαιτα, meaning "*way of life*." Such a simple notion of etymological order is enough to understand the crucial role of nutrition in our daily life. However, human approach to nutrition, over the centuries, has moved from simple aspects related to survival to the point of representing, today, an instrument of personal satisfaction, often leading to unhealthy habits. When a person follows an incorrect diet it means that his food intake is not balanced, with some nutrients lacking, and others in excess. Examples in this sense abound. It is sufficient, for instance, to think of the typical menu of modern fast-food restaurants, extremely rich in salts, sugars, fats and, consequently, calories. The World Health Organization [WHO] (2018) clearly underlines how, today, there are almost 2 billion adults in the world, over the age of 18 or over, overweight. Of these, more than 600 million are obese or severely obese. The situation is even more dramatic if these already large numbers are added to the 38 million children under 5 years old who are overweight or obese (World Health Organization [WHO], 2018). Unfortunately, the problem of overweight and/or obesity is not only aesthetic. It is very well known, indeed, that an unhealthy diet increases the risk of developing numerous diseases such as those affecting cardiovascular, endocrine and osteoarticular systems; notably, a significant correlation between the intake of specific foods and the onset of certain types of cancer has been suggested as well (Scarborough et al., 2011; World Health Organization [WHO], 2018). It goes without saying that the social economic-burden related to diseases resulting from an unhealthy diet is, simply stated, incalculable (Scarborough et al., 2011). A problem studied with increasing attention only in relatively recent times concerns the relationships between addiction and nutrition. Food addictions, just like those related to substances of abuse, are dramatically common and ever-increasing (O'Brien, 2003; Sobik et al., 2005). In this context carbohydrates have a particularly important position. Nutritionists know well, concerning humans, that a hyperglycidic diet can neither be proposed nor tolerated because it has devastating effects on the body's insulin levels with serious effects, in the long run, involving various organs and systems, including the central nervous system. Carbohydrates, taken indiscriminately and excessively, induce a perennial hunger that forces them to eat continuously, in a real state of metabolic dependence (Braga, 2010). Beyond the purely metabolic aspects, even from the behavioral point of view, an unbalanced high-carbohydrate diet induces important behavioral changes that have the connotations of a *real addiction*. This is true not only for human beings, but also it has been demonstrated in rats (Grimm et al., 2007). Aim of the present paper is twofold: first, to compare possible differences between rats under normal and hyperglycidic diet; second, to show the usefulness of a synergic utilization of quantitative and qualitative analyses in providing a more complete description of the studied behavior. To these purposes, sixteen male Wistar rats, divided into two groups, fed with two different diets (standard and hyperglycidic) and tested in an open field (OF) with free access to food and water, were analyzed. As to the above-mentioned joint use of quantitative and qualitative assessments, it is important to underline that, by definition, the so-called "mixed methods" (Anguera et al., 2018) refer to a synergic utilization of both quantitative and qualitative data, in the same research project, aimed at describing a given phenomenon in a more comprehensive way (Onwuegbuzie and Leech, 2010; Anguera et al., 2018). The utilization of these approaches orbits around the study of human behavior (Johnson et al., 2007). Of course, when animal behavior is analyzed the situation radically changes. In the following section, a brief overview of our perspective on this subject will be presented.

MATERIALS AND METHODS

Quantitative and Qualitative Approaches in the Study of Rat Behavior

The behavior of a living being is structured on the basis of events flowing in time. The first and most obvious question of the researcher in the field of behavioral sciences, in both humans and non-humans, is how to study these events. **Figure 1** represents a series of hypothetical behaviors during a given observation time window. In this figure, a first and intuitive assessment is to count the number of behaviors, thirty in this example; it follows the possibility to build a distribution of occurrences, then a percent distribution for each behavioral component etc. The quantification of the observed phenomena, in this case, a string of events on an axis, is an intuitive step that the researcher in the field of behavioral sciences performs and, more generally, it is a typically human approach to interface with reality. Imagine a table with scattered pencils on it: the first and most obvious evaluation is the numerical one. How many? Then, you could count how many of a color and how many of another color etc. How many of us, seeing objects on a table, would consider how do they relate to each other?

Quantitative is that approach which, by its own nature, provides numerical measures concerning the object studied (Onwuegbuzie and Leech, 2010; Casarrubea et al., 2017c). In behavioral terms, a purely quantitative approach will be able to answer important questions concerning, for example, how many behaviors of a given type occur, their duration, their percent distribution, which behavior is more frequent, which the least frequent etc. **Figure 2** presents, in quantitative terms, the string of events illustrated in **Figure 1**. Undoubtedly, these numbers provide the reader with a great sense of exhaustiveness. However, it should be noted that a characteristic of the data shown in **Figure 2** is the lack of the slightest information inherent possible

FIGURE 1 | Short string of 30 hypothetical behavioral components (letters) occurring during a given T0–Tx time window (*X*-axis). Two hidden sequences are present. Even so, albeit the amount of components is small, the detection of such sequences is an extremely difficult task.

relationships between the various events. In other words, these quantities describe behaviors isolated from each other, separated from what is, actually, the real behavioral architecture and its intrinsic qualities. *This is not different from classifying all the single pieces of a puzzle missing the comprehensive picture*. The functional meaning of a behavior, i.e., the study of the existing interplay between an animal and the context, is a picture lying in its intrinsic structural features.

Qualitative is that approach that tends to magnify the properties of the investigated object by studying "phenomena in their natural setting" (Onwuegbuzie and Leech, 2010). In behavioral terms, a qualitative approach is able to shed light on aspects such as, for example, the greater or lesser *complexity* of a behavior, its *variability*, its *coherence* in accordance with the context, etc. Taking into consideration **Figure 3**, the bottom line of both panels is identical to that shown in **Figure 1**. However, two sequences (a-b-c) and (e-f-g-h) are present and well appreciable only if the "background noise" of the other elements is removed or, in any case, reduced (**Figure 3**, gray letters). This very simple example raises an equally simple

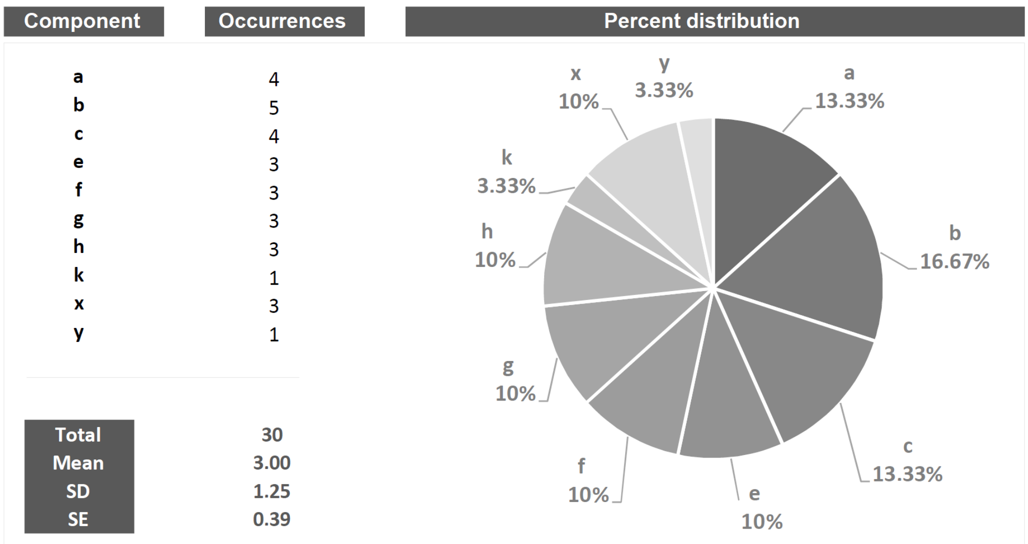

FIGURE 2 | Example of quantitative approach to the analysis applied to the string of 30 hypothetical components showed in **Figure 1**. Columns on the left show all the components in terms of their occurrences, total occurrences, mean occurrences, SD and SE. The pie chart shows the percent distribution of each component.

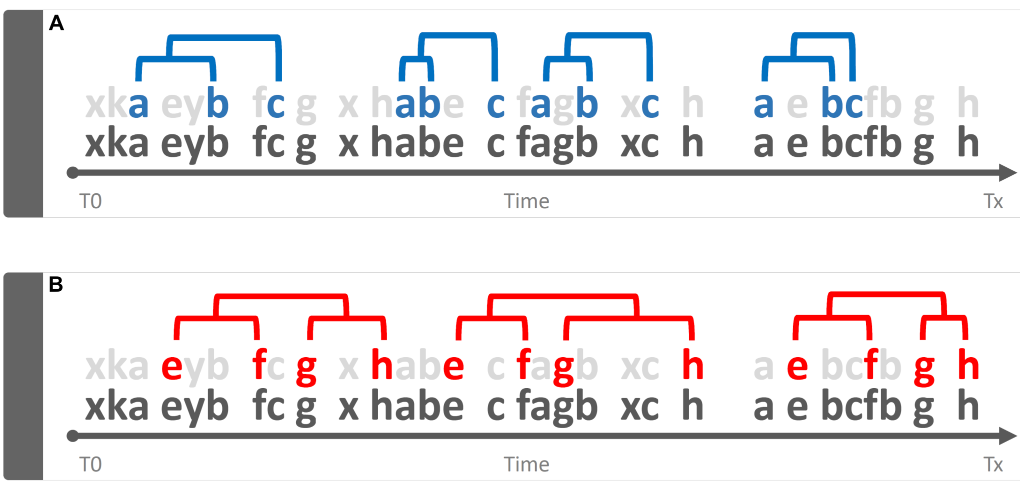

FIGURE 3 | Example of a qualitative approach to the analysis of the string of 30 hypothetical components showed in **Figure 1**. Bottom strings in both panels represent the same sequence illustrated in **Figure 1** by removing "background noise" events, two sequences a-b-c (panel **A**) and e-f-g-h (panel **B**) become evident. Concerning quality, three different issues can be mentioned here namely: *Complexity* (sequence in **B** more complex than **A**), *Recursivity* (sequence in **A** more recursive than **B**) and *Variability* (when two or more subjects are compared, the behavior of one can be considered more variable if more different sequences are performed).

question: what is the meaning of these recurring patterns? The simplest way to answer this question is: emerging phenomena characterized, as such, by qualitative aspects that cannot be inferred from the single structural elements that compose them. These structures, called "T-patterns," find their *raison d'être* in the distances between the various events in sequence: time distances, statistically evaluated, which make each of these sequences relatively self-similar (Casarrubea et al., 2015; Magnusson, 2016). A more detailed description of T-pattern detection process will be presented in Section "Data Analysis". Concerning above-mentioned qualitative features, various aspects could be highlighted. First, even at a very first glance it appears evident that T-pattern in panel B does contain more events in sequence than T-pattern in panel A. Hence, it is possible to state that the four events T-pattern on the bottom is more *complex*. On the contrary, T-pattern in panel A does occur more often than T-pattern in B. Thus, behind this perspective, it is possible to state that T-pattern A is more *recursive*. Finally, when two or more subjects are compared, the behavior of one can be considered more *variable* depending on the number of different T-patterns performed (for example, subject #1 presents 5 different T-patterns, subject #2 presents 10 different T-patterns). It is important to underline that the three qualities above mentioned, namely, complexity, recursivity and variability have meanings only if *relationships among events* in sequence are considered because, simply stated, they do arise from *structural* features of the behavior.

Animals and Housing

Sixteen male Wistar rats (Harlan Laboratories, Italy) were used. At their arrival, all rats were fed for 1 week with standard (55% carbohydrates) pellets (Mucedola, Italy). Then, animals were randomly divided into two groups, each group encompassing eight subjects. Standard laboratory pellets and water were freely accessible for the first group, used as a control; hyperglycidic (70% carbohydrates) pellets (Mucedola, Italy) and water were freely accessible for the second group. All subjects were housed in a room maintained at 23 ± 1°C with the light on 07:00 a.m. and off 07:00 p.m. They were tested, after 1 month of standard or hyperglycidic diet, when they were 2 months old.

Experimental Apparatus

Apparatus consisted of a circular (ϕ 35 cm) open-field (OF) arena made of white opaque Plexiglas with two openings, through which the rat could have free access to a pellet box and a spout for dispensing water. An outline of this experimental apparatus is presented in **Figure 4**. Animal's behavior was recorded through a digital camera (Toshiba HD-DV camcorder P10) placed in front of the OF and video files stored in a personal computer for following analyses.

Procedure

Animals were transported from the housing room to testing room within their home cages. In the testing room, to avoid possible visual and olfactory influences, all subjects were allowed to acclimate for 30 min far from observational apparatus. The temperature in the testing room, where the OF was placed, was maintained equal to the temperature in the housing room. Each animal, experimentally naïve, was placed in the OF, allowed to freely explore for 60 min and observed only once. After each observation, OF apparatus was carefully cleaned with ethyl alcohol (70%). Procedural details described in this section were carried out on the basis of our protocols (Casarrubea et al., 2011a,b, 2016b, 2017a,b).

Data Analysis

The ethogram presented in **Table 1** is based on behavioral categories previously employed (Casarrubea et al., 2009, 2011a, 2017b; Santangelo et al., 2017, 2018). It encompasses: Walking (Wa), climbing (Cl), immobile sniffing (IS), feeding (Fe), focused sniffing (FS), drinking (Dr), front-paw licking (FPL), hind-paw licking (HPL), face grooming (FG), body grooming (BG), and immobility (Im). The behavior of each subject was annotated by means of a software tool (The Observer, Noldus Information Technology bv, Netherlands) and event log files were generated for each subject. Event log files were then processed using Theme (PatternVision Ltd., Iceland), a computer program able to detect sequences of events on the basis of the existence of statistically significant constraints on the intervals separating

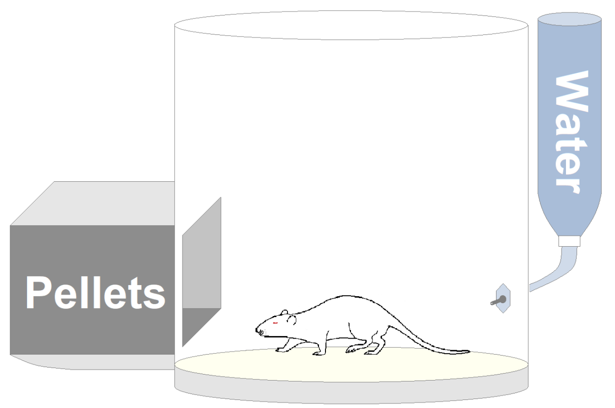

FIGURE 4 | Outline of the experimental apparatus.

TABLE 1 | Ethogram of rat behavior.

Walking (Wa)	The rat walks around sniffing the environment
Climbing (Cl)	The rat maintains an erect posture leaning against the Plexiglas wall
Immobile Sniffing (IS)	The rat sniffs the environment firmly standing on the ground
Feeding (Fe)	The rat eats from an apposite pellet-box
Focused Sniffing (FS)	The rat sniffs the border of the feeding pellet-box without inserting the head inside
Drinking (Dr)	The rat drinks from an apposite water-pipe
Front Paw Licking (FPL)	The rat licks or grooms its forepaws
Hind Paw Licking (HPL)	The rat licks or grooms its hind paws
Face Grooming (FG)	The rat rubs its face with the forepaws
Body Grooming (BG)	The rat rubs the body combing the fur by fast movement of the incisors
Immobility (Im)	The rat maintains a fixed posture

them (Magnusson, 1996, 2000, 2016; Casarrubea et al., 2015). In brief, given a distribution of events occurring within a T0–Tx observation period (**Figure 3A**, bottom row events, near *X*-axis) the program compares the distributions of each pair of the behavioral events "a" and "b" searching for a time window so that "a" is followed by "b" within that time interval. If this condition between event "a" and event "b" does occur, a two-event first level T-pattern, namely (a b), is detected (**Figure 3A**, upper row events); in a second step such first level T-pattern is considered as "a" or "b" terms for the detection of higher order temporal patterns, e.g., ((a b) c)…and so on (**Figure 3A**, upper row events). A more detailed description of theories and concepts concerning T-pattern detection and analysis can be found in our previous articles (Casarrubea et al., 2013, 2016a, 2017a), in two reviews (Casarrubea et al., 2015, 2018) or in our book (Magnusson et al., 2016). On the basis of our previous studies (Casarrubea et al., 2011a,b, 2016b, 2017a,b) the following parameters were analyzed: (1) mean duration (in sec) of behavioral components; (2) mean occurrences of behavioral components; (3) percent distribution of behavioral components; (4) number of different T-patterns detected for each group both in real and random generated data; (5) length distribution of T-patterns; (6) mean length of T-patterns detected; (7) mean occurrences of T-patterns detected and (8) percent distribution of T-patterns including each components of the behavioral repertoire; (9) structure of all the different T-patterns detected for each group (strings).

Statistics

As to quantitative evaluations, possible significant outcomes concerning mean frequencies and mean durations between groups were assessed using Student's *t*-test for independent samples; percent distribution of behavioral components in both groups were compared used Chi-square test. As to T-pattern analysis, albeit each detected sequence implies an underlying significant relationship among the events in pattern, in data with thousands of events an exceptionally high number of possible relationships exists. Such an aspect could raise the

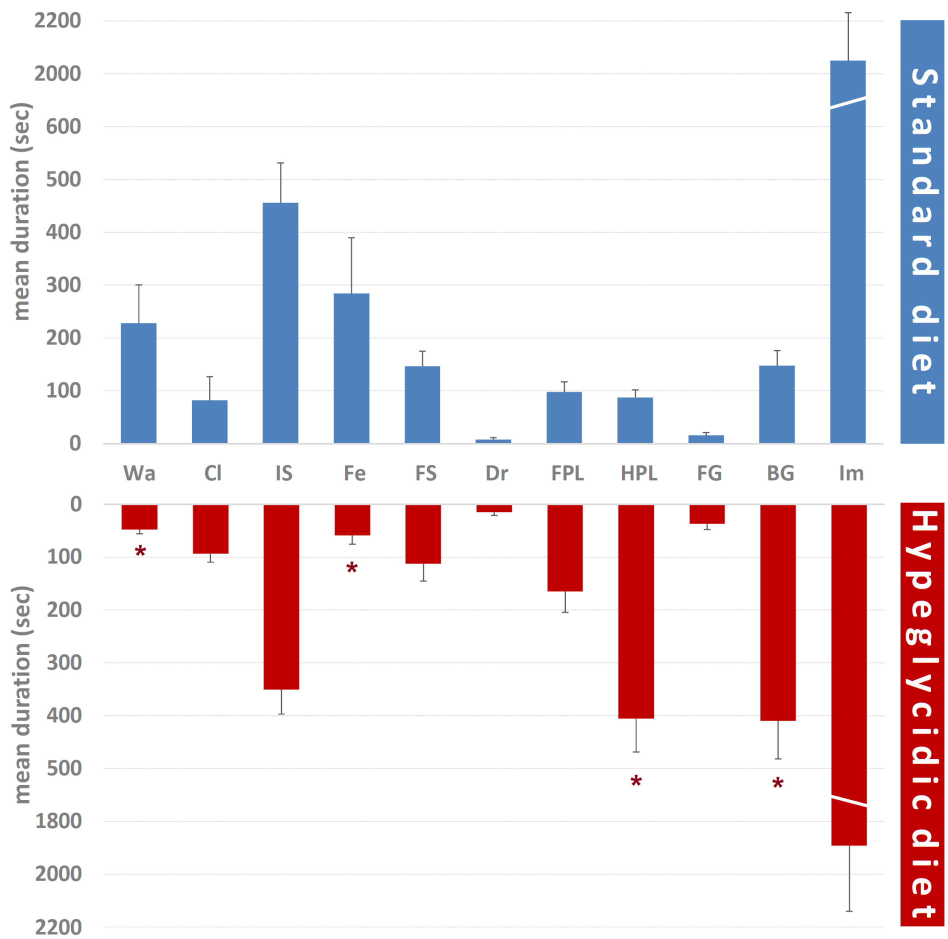

FIGURE 5 | Mean duration ± SE (in s) of each component of the behavioral repertoire in rats under standard and hyperglycidic diet. Difference between standard and hyperglycidic group, as revealed by Student's *t*-test for independent samples, *$p < 0.05$. Wa, walking; Cl, climbing; IS, immobile sniffing; Fe, feeding; FS, focused sniffing; Dr, drinking; FPL, front-paw licking; HPL, hind-paw-licking; FG, face grooming; BG, body grooming; Im, immobility. Data obtained from the analysis of sixteen subjects.

issue of whether the T-patterns are detected only by chance. Theme deals with such an important issue by repeatedly randomizing and reanalyzing the original data, using the same search parameters utilized in the detection process carried out in the real data. Then, the mean number of T-patterns of each length identified in the randomized data is compared with that obtained from the original data. Mean length and mean occurrences of T-patterns between the two groups were compared using Student's *t*-test. Finally, the percent distribution of T-patterns containing each component of the behavioral repertoire was compared using the Chi-square test.

Ethics Statement

All efforts were made to minimize the number of animals used and their suffering. Experimental procedures were conducted in accordance with the European Communities Council Directive (2010/63/EU) and approved by the official Veterinary Committee appointed by the University of Palermo.

RESULTS

Quantitative Results

Mean durations of each component of the behavioral repertoire are represented in **Figure 5**. Comparison of subjects under standard vs. hyperglycidic diet showed significant changes for Wa (t_{14} = 2.468; $p < 0.05$), Fe (t_{14} = 2.206; $p < 0.05$), HPL (t_{14} = −4.941; $p < 0.0001$), and BG (t_{14} = −3.375; $p < 0.005$). Remaining components were: Cl (t_{14} = −0.237; p = 0.816), IS (t_{14} = 1.184; p = 0.256), FS (t_{14} = 0.779; p = 0.449), Dr (t_{14} = −1.066; p = 0.304), FPL (t_{14} = −1.534; p = 0.147), FG (t_{14} = −1.737; p = 0.104), and Im (t_{14} = 0.430; p = 0.674).

Mean occurrences of each component of the behavioral repertoire are represented in **Figure 6**. Significant differences were detected for FPL (t_{14} = −2.301; $p < 0.05$), HPL (t_{14} = −4.520; $p < 0.0001$), and BG (t_{14} = −2.847; $p < 0.05$). Remaining components were: Wa (t_{14} = 1.409; p = 0.181), Cl (t_{14} = −0.269; p = 0.792), IS (t_{14} = −0.530; p = 0.604), Fe (t_{14} = 0.537; p = 0.61), FS (t_{14} = −0.706; p = 0.492), Dr

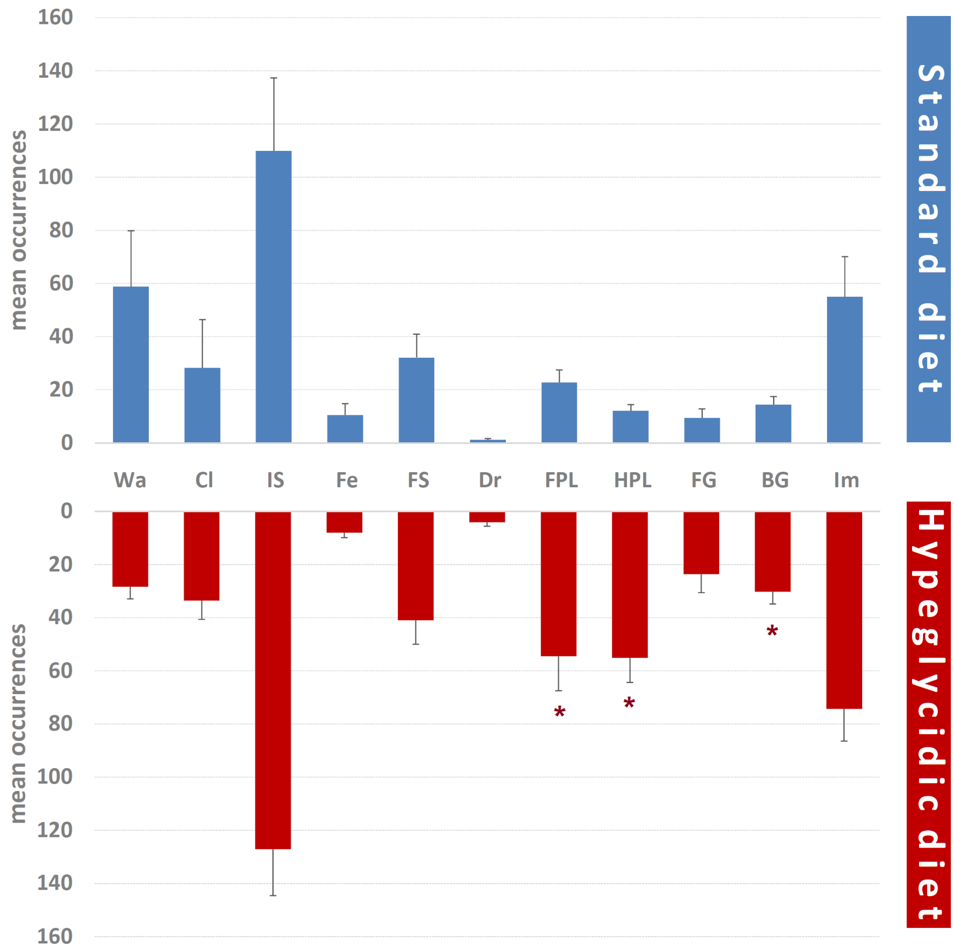

FIGURE 6 | Mean occurrences ± SE of each component of the behavioral repertoire in rats under standard and hyperglycidic diet. *$p < 0.05$ difference between standard and hyperglycidic group, as revealed by Student's *t*-test for independent samples. Wa, walking; Cl, climbing; IS, immobile sniffing; Fe, feeding; FS, focused sniffing; Dr, drinking; FPL, front-paw licking; HPL, hind-paw-licking; FG, face grooming; BG, body grooming; Im, immobility. Data obtained from the analysis of sixteen subjects.

($t_{14} = -1.959$; $p = 0.07$), FG ($t_{14} = -1.837$; $p = 0.088$), and Im ($t_{14} = -0.986$; $p = 0.341$).

Percent distributions of behavioral components are represented in **Figure 7**. Chi-square test revealed significant reductions for Wa ($p < 0.0001$) and Fe ($p < 0.005$); significant increases have been detected for FPL ($p < 0.005$), HPL ($p < 0.0001$), FG ($p < 0.005$), and BG ($p < 0.0001$).

Temporal Patterns of Behavior

Fifty different T-patterns were detected in subjects under standard diet, and 703 in animals under hyperglycidic diet. On the basis of their length, T-patterns in both groups were distributed as follows. In the standard diet group, 31 different T-patterns encompass two events, 18 three events and 1 four events (**Figure 8**, upper panel). In subjects under hyperglycidic treatment, 36 T-patterns contain two events, 46 three, 60 four, 70 five, 78 six, 111 seven, 98 eight, 93 nine, 50 ten, 39 eleven, 16 twelve, 5 thirteen and, finally, 1 T-pattern has fourteen events in sequence (**Figure 8**, bottom panel). The comparison between the mean number of T-patterns detected in random data (mean value obtained on the basis of $n = 5$ random runs) vs. real data showed a significantly higher number of T-patterns in real data (**Figure 8**, white bars).

Concerning mean length of T-patterns, a highly significant increase was detected in hyperglycidic group, in comparison with the standard one ($t_{751} = 12.502$, $p < 0.0001$) (**Figure 9**); concerning mean occurrences of T-patterns, a highly significant reduction was detected ($t_{751} = -12.399$, $p < 0.0001$) (**Figure 10**).

Overall, in subjects under standard diet, the 50 different T-patterns occurred 7475 times, while in rats under hyperglycidic diet the 703 different T-patterns occurred 20148 times. In the **Supplementary Table S1**, the complete results of T-pattern detection for both groups are shown.

Finally, as to per cent of T-patterns containing at least one time each component of the behavioral repertoire in sequence, Chi-square test revealed highly significant ($p < 0.0001$) differences between the two groups, for T-patterns containing Wa, Cl, IS, Fe, FS, FPL, BG, and Im (**Figure 11**).

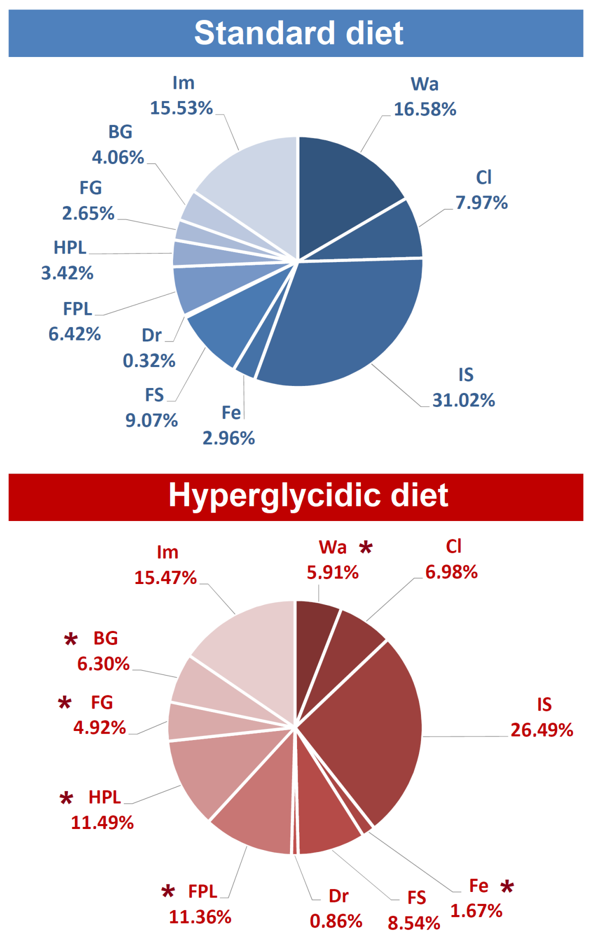

FIGURE 7 | Percent distribution of each component of the behavioral repertoire in rats under standard and hyperglycidic diet. *$p < 0.05$ difference between standard and hyperglycidic group, as revealed by the Chi-square test. Data obtained from the analysis of sixteen subjects. Wa, walking; Cl, climbing; IS, immobile sniffing; Fe, feeding; FS, focused sniffing; Dr, drinking; FPL, front-paw licking; HPL, hind-paw-licking; FG, face grooming; BG, body grooming; Im, immobility. Data obtained from the analysis of sixteen subjects.

DISCUSSION

Behavioral studies, during the last decades, have been somewhat conservative in the renewal of their approaches. In fact, even a simple search through a common scientific database, with thousands of published papers so far, will show how purely quantitative evaluations have been, by far, preferred in data analysis and description of the results. The aim of this work is to show how, through the synergistic use of a quantitative and qualitative approach, it is possible to appreciate a much more complete portrayal of behavior and make available points of view and facets otherwise not deducible from the use of a purely qualitative or purely quantitative approach.

Quantitative Assessments

Overall, all data concerning quantitative assessments (**Figures 5–7**), e.g., durations, frequencies and percent distributions show that the hyperglycidic diet induces an important change especially in grooming-related behaviors, i.e., FPL, HPL, and BG. In addition, Wa and Fe were reduced both in terms of duration and of percent distribution in subjects treated with the hyperglycidic diet. These results find support in scientific literature as it is very well known that rats under hyperglycidic diet develop a metabolic syndrome associated with severe anxiety-like behavior (Reddy et al., 2016; Rebolledo-Solleiro et al., 2017). Consistently, changes in subject's anxiety condition are known to be related with clear-cut changes in grooming behavior (Berridge et al., 2005; Kalueff and Tuohimaa, 2005; Veloso et al., 2016).

T-Patterns, Structures and Qualities

A more in-depth analysis, based on the quality of behavior in the two groups (**Figures 8–11** and **Supplementary Table S1**) shows

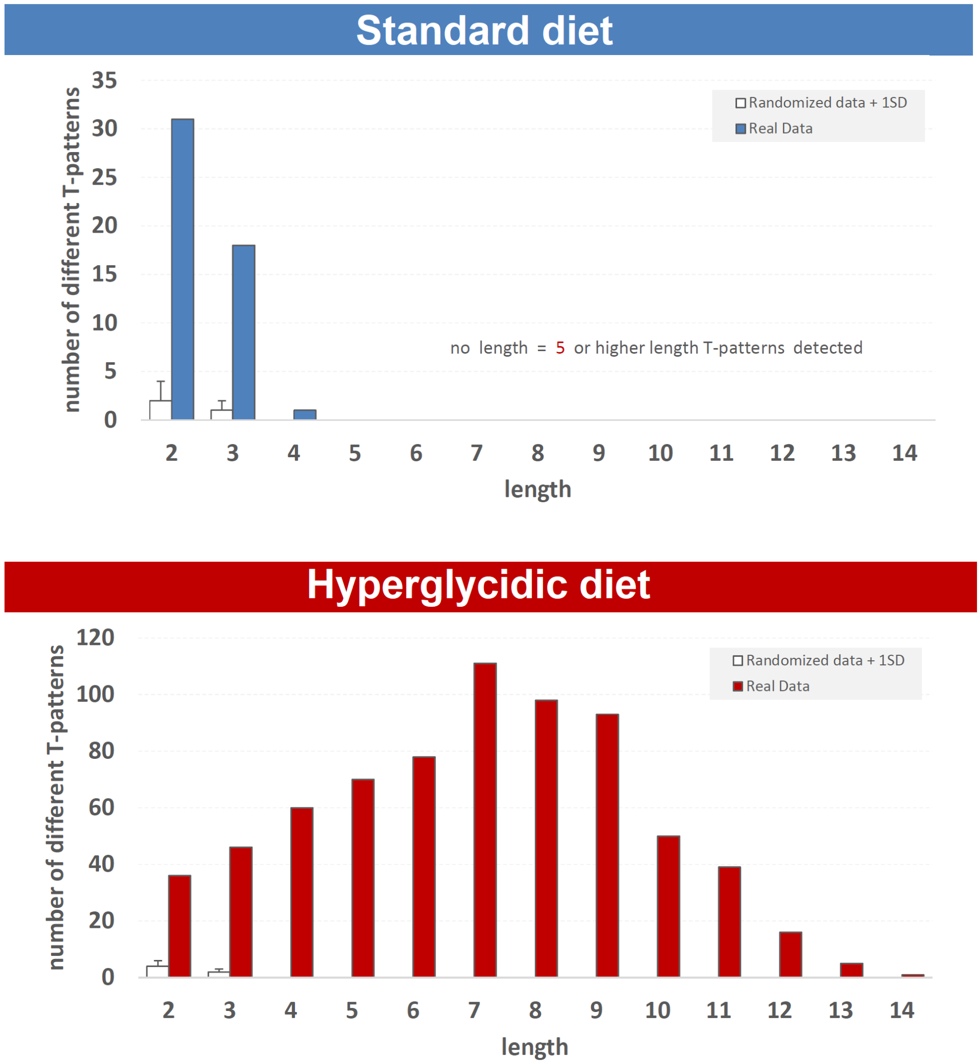

FIGURE 8 | T-pattern length distribution in real data (filled bars) and randomized data + 1SD (white bars) in standard and hyperglycidic groups. *X*-axis = T-pattern length i.e., number of events in T-pattern's structure; *Y*-axis = number of different T-patterns detected. Wa, walking; Cl, climbing; IS, immobile sniffing; Fe, feeding; FS, focused sniffing; Dr, drinking; FPL, front-paw licking; HPL, hind-paw-licking; FG, face grooming; BG, body grooming; Im, immobility. Data obtained from the analysis of sixteen subjects.

numerous additional aspects, which together with quantitative data provide a more harmonic representation of the effects of an unbalanced diet on behavior, and more in general, differences between the two groups of animals.

The T-patterns analysis shows great differences between the two groups. First of all, these differences appear in terms of different patterns identified and their length: if on the one hand the animals fed with standard diet showed a total of 50 T-patterns the longest of which contained four events in sequence, the animals with hyperglycidic diet showed a hugely more variable and complex behavior with 703 different T-patterns, the longest of which had 14 events in sequence. Consistently, the average length of the T-patterns reflects these notable differences. In contrast, the average recurrence of each T-pattern is much higher in subjects with a standard diet. Briefly, subjects with a standard diet show a behavior characterized by fewer different sequences (less *variability*) which are repeated more times than what is observed in the hyperglycidic diet group (greater *recursivity*). On the contrary, subjects with a hyperglycidic diet show a behavior characterized by a greatly higher number of different T-patterns (greater *variability*) which are, in turn, repeated much lesser than observed for sequences of the control group (less *recursivity*). These results, altogether with what traced by quantitative observations, offer a considerably expanded portrait of the behavioral dynamics elicited by the chronic exposition to hyperglycidic diet. The already reported result concerning a higher anxiety-like state following the hyperglycidic diet in rodents (Reddy et al., 2016; Rebolledo-Solleiro et al., 2017) well fits with many of the complex behavioral changes observed in our sample. In this

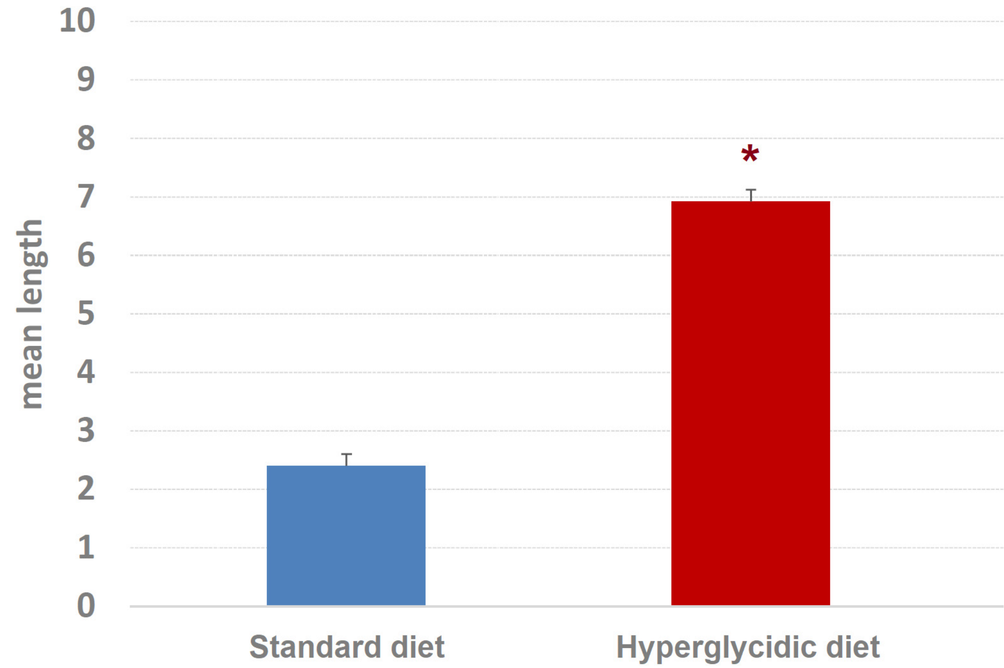

FIGURE 9 | Mean length ± SE of T-patterns detected. Difference between standard and hyperglycidic group, as revealed by Student's *t*-test for independent samples, $^{*}p < 0.05$. Data obtained from the analysis of sixteen subjects.

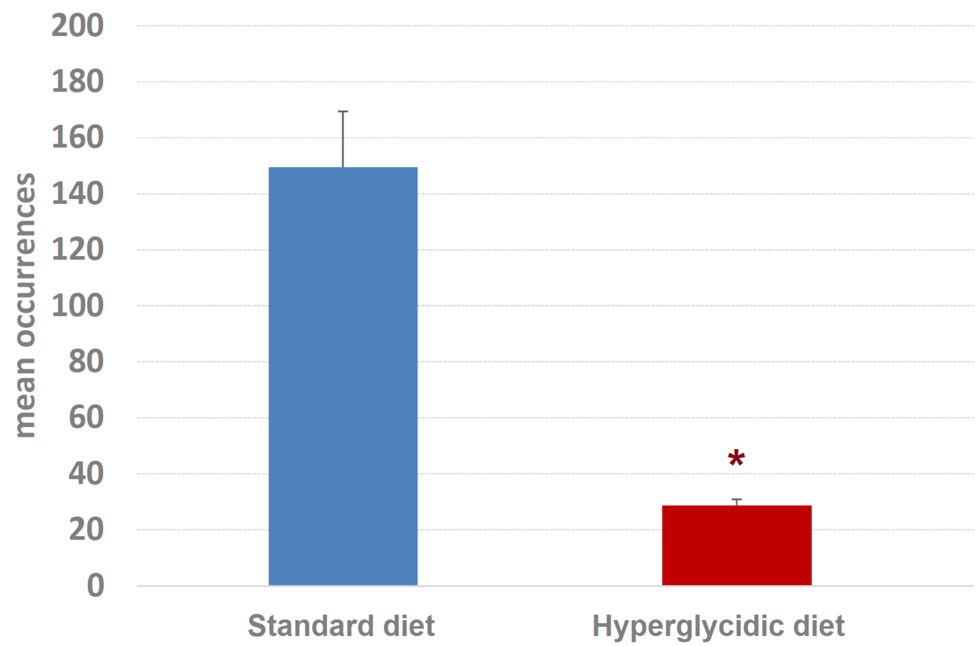

FIGURE 10 | Mean occurrences ± SE of T-patterns detected. Difference between standard and hyperglycidic group, as revealed by Student's *t*-test for independent samples, $^{*}p < 0.05$. Data obtained from the analysis of sixteen subjects.

sense, an important contribution to the interpretation of these data comes from the evaluation of the composition of the T-patterns in the two groups (**Figure 11**). The likely most salient outcome is represented by the evidence that the components Fe and FS are structured in an enormously higher percent of T-patterns in animals with a hyperglycidic diet. It is also important to notice a percent of T-patterns including Wa, Cl, and IS considerably increased. These data would seem to

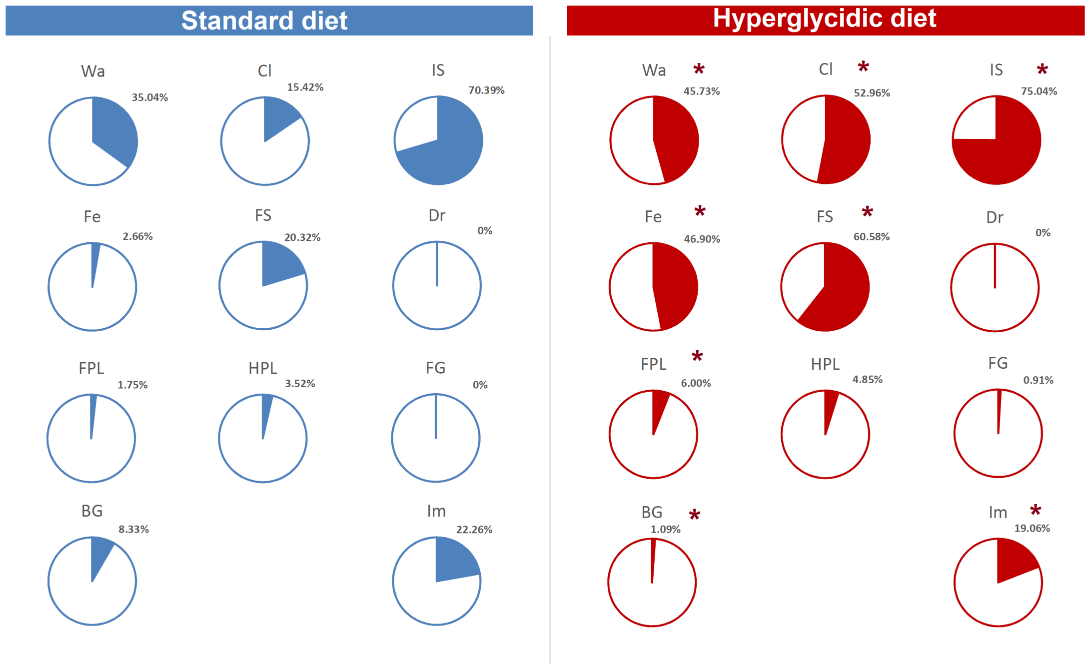

FIGURE 11 | Percent distribution of T-patterns containing each element of the behavioral repertoire (see **Table 1**). To avoid exceedingly thin slices, percent values <1% were represented together ("Others"). Chi-square test, $^*p < 0.0001$. Wa, walking; Cl, climbing; IS, immobile sniffing; Fe, feeding; FS, focused sniffing; Dr, drinking; FPL, front-paw licking; HPL, hind-paw-licking; FG, face grooming; BG, body grooming; Im, immobility. Data obtained from the analysis of sixteen subjects.

be in contrast with evaluations of durations and frequencies, where a reduction in Wa, Fe, and FS would appear, even statistically significant as regards the duration of Wa and Fe. Actually, what likely happens is that in animals treated with hyperglycidic diet, the behaviors correlated with food intake become structured in a number of T-patterns much higher than what happens with the standard diet. In this context, it is particularly interesting to observe the highly significant increase not only of Fe, but also of FS, that is the sniffing behavior of the pellet box. Taken together, these results suggest an increased salience of food-related stimuli in rats under hyperglycidic diet. Such an aspect fuels a stimulating topic of discussion concerning a putative change in the motivational drive toward obtaining and consuming food. In addition, T-pattern analysis describes how changes in food-related behaviors (Fe and FS) affect also the structural interplay with behaviors not directly related to food such as Wa, Cl, and IS. Such behavioral dynamics strongly oriented toward food stimuli are suggestive of *craving*-related behaviors. In fact, rats fed on a hyperglycidic diet show a totally reorganized behavior, structured and aimed at the continuous search for food. Interestingly, in rats, numerous tangencies have been demonstrated between the nerve circuits that mediate the craving mechanisms for opioids and carbohydrates and, in fact, the administration of an antagonist for opioids, naloxone, in these animals has proved effective in reducing the craving for sucrose (Grimm et al., 2007). From a translational perspective, this is consistent with the well-known addiction that an unbalanced high-carbohydrate diet induces in humans (O'Brien, 2003; Sobik et al., 2005; Braga, 2010), as mentioned in the introduction section. A final consideration concerns the limitation of this study. It is important to consider, indeed, that present results show the effects induced only by a hyperglycidic diet and only in male rats. These two aspects fuel interesting topics of discussion concerning possible future researches. For instance, it would be interesting to evaluate the behavioral effects induced, in rodents, also by high-protein or high-fat diets. Another interesting aspect would be the comparison of effects induced by unbalanced diets in male and female subjects and/or to assess possible sex differences under the same dietetic regime. Finally, taking into consideration the clear cut impact that hyperglycidic diet produced in terms of behavioral changes in rats, it might be interesting to evaluate also possible differences between different strains.

CONCLUSION

In the context of a behavioral study, conceptual and procedural differences underlying quantitative and qualitative approach could lead to a superficial conclusion placing them in contrast. Such a position should be avoided because through the synergistic use of qualitative and quantitative evaluations it is possible to study behavior in a much more complete way. Here we have demonstrated that the consensual evaluation of the quantitative and qualitative data allows obtaining an evaluation that neither of the two approaches, individually, is able to offer. Specifically, if on the one hand, the important modification of the duration and percent of Wa and of all grooming activities allows to formulate the hypothesis of an anxiety-related behavior, on the other hand, the evaluation of the T-patterns highlights how such an anxiety condition is, from the behavioral point of view, only the tip of an iceberg, largely submerged, consisting of the evident behavioral restructuring that the hyperglycidic diet imposes. Such a reorganization has the features of a behavior largely oriented, from a qualitative perspective, toward food-related stimuli, enormously more than what happens in animals exposed to a balanced standard diet.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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SUPPLEMENTARY MATERIAL

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TABLE S1 | Terminal strings (behavioral components in brackets) of the T-patterns detected in standard and hyperglycidic groups. Progressive numbers on the left of each string only indicate the corresponding string. Numbers on the right of each string indicate length (i.e., number of events in T-pattern's structure) and overall occurrences (Occs). Wa, walking; Cl, climbing; IS, immobile sniffing; Fe, feeding; FS, focused sniffing; Dr, drinking; FPL, front-paw licking; HPL, hind-paw-licking; FG, face grooming; BG, body grooming; Im, immobility. Data obtained from the analysis of sixteen subjects.

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Using Sensors in Organizational Research—Clarifying Rationales and Validation Challenges for Mixed Methods

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Sensor-based data are becoming increasingly widespread in social, behavioral, and organizational sciences. Far from providing a neutral window on "reality," sensor-based big-data are highly complex, constructed data sources. Nevertheless, a more systematic approach to the validation of sensors as a method of data collection is lacking, as their use and conceptualization have been spread out across different strands of social-, behavioral-, and computer science literature. Further debunking the myth of raw data, the present article argues that, in order to validate sensor-based data, researchers need to take into account the mutual interdependence between types of sensors available on the market, the conceptual (construct) choices made in the research process, and the contextual cues. Sensor-based data in research are usually combined with additional quantitative and qualitative data sources. However, the incompatibility between the highly granular nature of sensor data and the static, a-temporal character of traditional quantitative and qualitative data has not been sufficiently emphasized as a key limiting factor of sensor-based research. It is likely that the failure to consider the basic quality criteria of social science measurement indicators more explicitly may lead to the production of insignificant results, despite the availability of high volume and high-resolution data. The paper concludes with recommendations for designing and conducting mixed methods studies using sensors.

Keywords: mixed methods research, wearable sensors, Bluetooth, indicator, qualitative research, quantitative research, big data

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INTRODUCTION

Sensors are becoming increasingly widespread in social science research. Speculations regarding the potential applications and implications of "big data" are relatively frequent across the entire spectrum of scientific disciplines. However, despite the growing number of debates on the challenges and prospects of big data, and notwithstanding dedicated discussions on "digital methods" (Rogers, 2013) and "digital sociology" (Lupton, 2015; Marres, 2017), more targeted accounts of the methodological implications of using sensors are lacking. This is especially true in the case of mixed methods research (MMR) literature, in which general references to big data do exist (Mertens et al., 2016), but specific engagements from a focused methodological point of view are mostly limited to qualitative contextualization of GPS data (Fielding, 2012; Taylor and Horst, 2013; Remijn et al., 2015).

The fact that MMR debates have failed to systematically address the challenges of the "data deluge" inherent to big data research is unfortunate, since the collection and analysis of sensor data is fundamentally indebted—often without a conscious recognition of such—to key principles and concepts from the MMR field. Drawing upon the MMR literature effectively deepens our understanding of the methodological issues involved in sensor-based research. As a result we contribute to existing knowledge across several disciplines in important ways. First, we alert engineers and computer scientists developing sophisticated models with sensor measures (Fu et al., 2015; Sapru and Bourlard, 2015) to consider the quality of the underlying "raw" data from a social science perspective. Physical sensor measures are too easily equated with social or psychological constructs, thereby underestimating the context-sensitive nature of most social phenomena. Second, we provide organizational researchers concerned with the validation of sensor data (Chaffin et al., 2017; Kayhan et al., 2018) a conceptual framework that situates sensors in relation to established social science research methods. Existing validation efforts combine sensor measures with quantitative as well as qualitative data sources without clearly understanding the inherent limitations of "mixing" methods. MMR debates are here pivotal for adjusting contemporary social science research practice to the new volume and high granularity of sensor-derived data. Third, the present article goes beyond many abstract conceptual reflections regarding "big data" in the social sciences (Tonidandel et al., 2018; Wenzel and Van Quaquebeke, 2018). Our literature review of wearable sensor-based research identifies advantages and disadvantages of different sensor platforms as well as the main social and psychological constructs explored up to date. In combination with our review of the most popular devices this will allow interested scholars to gauge more precisely the relative strengths, weaknesses, and practical implications of each sensor device, for their own research.

In order to advance toward a consistent methodological framework of (wearable) sensors as an instrument for social science research, our argument develops as follows. We suggest first, to clearly separate between two measurement dimensions of sensors, namely the physical data, on the one hand, and the potential social or psychological constructs, on the other hand. On a very basic level, sensors capture changes in the physical environment such as a change of temperature, the relative strength of Bluetooth (BT) signals or the acceleration of objects among others. These physical measures are of little interest to social scientists. Only when (wearable) sensors come to represent social and psychological constructs, do they really constitute an exciting new research instrument. However, as we will argue, the potential fit between the basic physical measures and the higher-level constructs needs to be carefully considered. As our literature review will show, these two levels are often conflated, which has a negative impact on the generation of relevant research insights.

Distinguishing between the physical measurement level and higher-level constructs enables us to focus on the fit between these two levels in a second step. We therefore argue that sensor data, like any other social science indicator, involves three distinct elements: the measurement (or indicator) itself, the unobservable construct to which it refers, and the correspondence between the measurement and the construct (Meyer, 2017). The challenge that needs addressing when using sensors concerns the fact that one and the same physical measurement is expected to represent very different social constructs. Thus, "proximity" between BT enabled devices has been used as an indicator of "friendship," "advice seeking," or subjective "well-being" (Sekara and Lehmann, 2014; Matusik et al., 2018; Zhang et al., 2018). It is a key contribution of this paper to show, however, that the quality of fit between the physical measure and the social construct depends to a large degree on how sensor data is combined with additional, complementary data sources. Yet, the crucial methodological question on how to carefully plan for "complementary" data needs at the research design stage with wearable sensors has been largely ignored in the literature.

In a third step we therefore advocate that considering the literature on "mixed methods research" enables a better understanding of the ways in which the quality of fit between the sensor measurement and the targeted social/psychological constructs can be controlled and improved. While the mainstream MMR literature restricts the definition of MMR to the mere combination of qualitative and quantitative data, in this article we use a broader definition of MMR that includes "within-paradigm" combinations. This is, the mixture of several quantitative methods/data as well as the integrating of diverse qualitative methods/data (Morse and Niehaus, 2016; Flick, 2017). At the same time, the MMR literature distinguishes between two broad rationales for "mixing" quantitative and qualitative data, namely "convergent validation" and "complementarity" (Greene et al., 1989; Creswell and Plano Clark, 2007). By reviewing the existing literature on sensor research through the lens of these two MMR rationales, as summarized in **Table 1**, two important methodological issues start to emerge. First, combining sensor data with other quantitative data sources feeds into "convergent validation" as a result of which the biased nature of sensor measures is revealed. Sensor data in this context is subject to "triangulation" in order to achieve a higher validity of field efforts (Denzin, 1978; Erzberger and Kelle, 2003). Although the potential for validity by convergence has been criticized on various grounds (Fielding and Fielding, 1986; Flick, 2008), and is relatively less frequent in actual research practice (Bryman, 2006), when applied to the context of sensor data, it yields crucial insights into the bias inherent in apparently "raw," physical sensor measures. Second, important challenges emerge when combining sensor data with qualitative methods, which can follow not only the rationale of "convergent validation" but also "complementarity." Our analysis of existing approaches of "ethno-mining" (Anderson et al., 2009), "blending" (Bornakke and Due, 2018), or "stitching together" (Blok et al., 2017) sensor data with *qualitative* data shows that the validity of research results is often hampered. This is because the purpose for "mixing" data is left ambiguous, neither being concerned with "convergent validation" nor "complementarity." By insufficiently conceptualizing the gap between physical measures of behavior and the corresponding layer of social meaning, research efforts fail to deliver significant insights. The negative effects of ignoring the MMR literature for sensor-based research are accentuated

TABLE 1 | Rationales and challenges for integrating qualitative and quantitative data with sensor-based measurements and derived measures.

Sensor data combined with	Rational and purpose of data integration	Methods
+ Quantitative data	Convergent validation of physical sensor measurements	Experimental designs
+ Quantitative data	Convergent validation of higher-level constructs	Tested survey based psychometric scales. Correlation and regression analysis.
+ Qualitative data	Convergent validation of higher-level constructs	Qualitative data to improve the validity of indicators by contextual information
+ Qualitative data	Complementary insights	Ethnographic observations to complement sensor-based findings
+ Qualitative data	Anchoring of data patterns	Ethnographic observations to interpret patterns in sensor data

by the diverging granularity of the involved data sources. As a further result of our literature review, we argue that the incompatibility between the highly granular nature of sensor data and the static, a-temporal character of traditional quantitative and qualitative data has to date not been sufficiently emphasized as a key limiting factor for sensor-based research.

METHODS

This article grows out of the need to deal with- and reflect upon a concrete research experience with Sociometric badges in R&D teams (Müller, 2018). We agree largely with the growing body of critical literature that fundamental issues regarding construct validity need to be clarified before sensors can fulfill the promise of opening up new and exciting research avenues (Chaffin et al., 2017; Kayhan et al., 2018; Parker et al., 2018). In order to advance toward this goal, we carried out a scoping review of the literature on the use of wearable sensors in organizational research. The methodology for the scoping review followed the steps suggested by Arksey and O'Malley (2005). First, the two research questions guiding the review were identified: What are the strengths and the weaknesses of the different sensor platforms available in the market? What are the main methodological challenges associated with the combination of sensor data with other complementary data sources? Second, the SCOPUS database was searched for relevant publications. The search was performed in the title, abstract and keywords of the publications using terms associated with the concepts of sensor-based research (i.e., wearable sensor*, bluetooth, sociomet*, sensor-based*, wearable comput*) and MMR (mixed method*). A total of 449 publications were generated from the database search. Third, these publications were screened by title and abstract according to the following three exclusion criteria: (1) health related texts dealing with fitness monitoring, elderly care or injury rehabilitation, (2) purely technical and engineering related articles besides research targeting Human Activity Recognition (HAR) with sensors, and (3) studies related to stationary and centralized sensor systems as deployed in smart-homes. From this screening, 419 references were excluded, reducing the number of references to 30, whose eligibility was assessed by reading the full text of the publications. Using the same exclusion criteria stated above, 7 publications were discarded, leaving 23 references for inclusion in the review. Fourth, data from these references such as the types of sensors used, the challenges addressed by the authors or the validity of the reported measurements, were extracted, charted, and summarized. Additional references were identified by consulting key authors CVs, websites of relevant research groups and the tracking of publications that cite key articles on wearable sensors.

A FRAMEWORK FOR CONCEPTUALIZING SENSOR DATA

The current interest in using sensors for studying social phenomena is embedded in wider debates regarding big data in the social sciences (Savage and Burrows, 2007; Tinati et al., 2014; George et al., 2016; Tonidandel et al., 2018). Sensors constitute one source of big data when tracking, for example, mobility patterns in cities or monitoring health parameters via fitness trackers and smart-phones. Sensors are increasingly pervasive in all aspects of human life. They are widely used in health related applications as already mentioned (rehab, fitness, elderly care, occupational safety) as well as in "smart" cities and homes, tracking of consumer behavior (retail, tourism) or in the social signal processing community (Vinciarelli et al., 2009; Imani et al., 2016; Alcaraz et al., 2017; Goonawardene et al., 2017; Jiang et al., 2017; Oosterlinck et al., 2017). Out of the considerable variety of sensor types and their divergent application fields, the present article concentrates on a relatively well-defined sub-set, namely wearable sensors used in organizational research. **Table 2** provides an overview of the most widely used sensor platforms. All these platforms have in common that sensors are usually worn on the body of individual (research) participants as opposed to operating from one (or several) centrally installed, stationary sensor system(s). The platforms differ however in terms of how many individual sensors are integrated into the same system. This has consequences in terms of cost, battery life, size of devices, and data storage. Importantly, the type of sensors or combinations of sensors also conditions which social or psychological phenomena can be measured. Currently, the OpenBeacon badges deployed by the Sociopatterns project (Cattuto et al., 2010) as well as Sociometric badges developed initially by MIT (Olguin et al., 2009; Kim et al., 2012) are the most widely used wearable sensor systems in social science research. Although other technical solutions do exist, their uptake in actual research is rather limited.

Measurement Dimensions of Wearable Sensors

In order to provide a solid foundation for assessing the reliability and validity of sensor measures in social- and behavioral research, a distinction between the physical measurement level and the social and psychological constructs needs to be drawn. At the first and fundamental level, sensors measure physical phenomena.

TABLE 2 | Overview of wearable sensor systems for social science research.

Sensor platform	Sensors	Cost per unit	Availability	Observations
Sociometric badges	Bluetooth, Infrared, microphone, accelerometer	Approxmately 550 US$	Humanyze, Boston, USA	Proprietary system, including software for data export from badges. High uptake in research community; integrated solution of four sensors; no central hub required. High energy consumption; high cost; data export is "black box"
Sociopatterns/OpenBeacon	RFID	Approxmately 25 US$	Order from openbeacon.org or self-production	Build with open source hardware and software. Low cost, single contact sensor system. Used mostly in healthcare research. Low energy consumption. Central hub for (real-time) location tagging optional. See https://github.com/meriac/openbeacon-ng
Rhythm badges	Bluetooth, microphone	NA	Self-production	Open source hardware and software. This project is currently under active development. So far, no published validation studies are available. See http://www.rhythm.mit.edu/
Smartphone	Bluetooth, microphone, GPS, accelerometer	Cost of modern smartphone	Dependent upon target group	No single solution but constantly changing devices (manufacturer, operating systems) and software apps. Cheap solution due to high smartphone penetration; calibrating/testing physical measures across variety of devices problematic and easily outdated. Location (GPS) and proximity detects simultaneously available. Advantage to combine relatively easily location based measures with call-logs. Custom software install for data collection required
TelosB	RFID	NA	Discontinued	Open source software. System is not available anymore
Hitachi Business Microscope (HBM)	Bluetooth, accelerometer, microphone, infrared, temperature, illumination.	NA	NA	Proprietary system not used outside the Hitachi research. See http://www.hitachi.com/New/cnews/month/2015/02/150209.html
Opo	Ultrasonic wakeup radio	NA	Self-production or order from authors	Open hardware and open source software. Low power and extremely small sensor devices (wearable as adornment). Infrastructure free deployment; relaying of data through smartphone. See https://lab11.eecs.umich.edu/projects/opo/
Multi-sensor board	Microphone, accelerometer, Infrared, visible light, digital compass, temperature, barometric pressure, humidity	NA	Discontinued	Custom build system for research. Listed here as an early system build for social science research goals, but it was not used beyond the initial project described in Wyatt et al. (2008, 2011)

This fact, although self-evident, cannot be over-emphasized given the tendency within the literature to conflate the physical sensor measures with social phenomena. BT sensors, for example, produce a quantity called Radio Signal Strength Indicator (RSSI). Values usually range from −40 to −90, where higher numbers indicate a stronger signal which is usually produced by devices being closer together (Liu and Striegel, 2011). Captured with a certain periodicity, RSSI is a "moderate" indicator of varying physical proximity. It is "moderate" because obstacles such as walls can lower the BT signal strength, even though devices are close to each other. **Table 3** summarizes the existing literature dedicated to the validation of the physical measurement level of wearable sensors. The more or less stringent fit between the actual measurement and the physical construct it represents is indicated in the "Relational Quality" column in **Table 3**. As illustrated in the next section, the quality of sensors for certain physical constructs is not as tight as one would expect at this basic level of measurement.

At a second level, the physical indicator provides the basis for more complex social and psychological constructs. **Table 4** lists the higher level concepts that have been addressed so far with wearable sensors. The measurement of such constructs introduces further complexities into the research process, since the quality of research results not only depends upon the quality of the sensor, but also on the degree of consensus around the definition of the social concept under study. How we conceive for example notions of "creativity" or "dominance" on a purely conceptual level is not straightforward but subject to often heated debates within and across the scientific communities (Piffer, 2012). The column "Construct Quality" in **Table 4** indicates how disputed the different constructs are. "Stress" for example is relatively well-defined by the level of cortisol in

TABLE 3 | Overview of sensor types and scientific literature regarding validation of physical constructs.

Sensor	Indicator/measurement	Physical construct	Relational quality	References	Sensor platform
Bluetooth	Radio Signal Strength Indicator (RSSI)	Proximity (and derived network measures)	Moderate	Yu et al., 2016; Boonstra et al., 2017; Chaffin et al., 2017	Sociometric badges
			Moderate	Liu and Striegel, 2011; Boonstra et al., 2017	Smartphone
Infrared	Binary detect	Proximity + orientation of devices (face-to-face; derived network measures)	Moderate	Yu et al., 2016; Chaffin et al., 2017; Müller, 2018	Sociometric badges
RFID	Binary detect	Proximity + obstacles (face-to-face; derived measures)	Moderate	Cattuto et al., 2010; Smieszek et al., 2016; Génois and Barrat, 2018; Elmer et al., 2019	OpenBeacon
Microphone	Volume, frequencies (Hz)	Speech (and derived measures such as speaking duration, turn-taking)	Low	Yu et al., 2016; Chaffin et al., 2017; Chen and Miller, 2017; Kayhan et al., 2018; Müller, 2018	Sociometric badges
Accelerometer	Energy magnitude over three axes	Physical activity	High	Yu et al., 2016; Kayhan et al., 2018	Sociometric badges
Ultrasound	Time-difference of arrival RF / Ultrasound	Proximity + obstacles (and derived network measures)	High	Huang et al., 2014	Opo
GPS	Global coordinates	Physical location	High	<= 0.75 m (95% of the time) U. S. Government GPS.gov	Smartphone & other GPS enabled devices

saliva (Taylor et al., 2016). The same holds for "contagion" or "infection," as defined by the presence or absence of a virus after physical contact. Now the crucial question is to what degree the chosen physical indicators do actually measure these different social concepts. Similar to a medical diagnosis where symptoms are more or less strong indicators of a certain pathology, different sensor-derived measurements are more or less stringent indicators of higher-level constructs. The BT RSSI value is a moderate indicator of physical proximity, which is, in turn, a good indicator of "contagion" but a poor indicator of different types of social relations such as "friendship" or professional "advice." A microphone, to give another example, provides a numerical record of dominant frequencies (pitch) of the voice which then can be used as an indicator of the persons "sex" (men usually having a lower voice than women) or "stress" (Taylor et al., 2016). Therefore, it is clear that the quality of the overall sensor-based indicator is not just dependent upon the precision of its measurement, but also upon the degree of consensus around the underlying construct and the degree of correspondence between the indicator and the higher-level social- and psychological constructs. Given the variety of constructs for one and the same sensor as described in **Table 4**, one should expect different levels of validity due to different levels of fit. The fact that we can collect now BT or any other sensor-based data relatively cheaply and with unprecedented detail does not imply that the quality criteria for the measurement properties of these data (i.e., the existence of a solid correspondence between the indicator and the concept it represents) can be ignored.

The following sections will delve into some detail in summarizing the state of the art regarding the validity of sensors on the level of physical measures as well as in relation to higher level constructs. The combination of sensor-based data with qualitative and quantitative research approaches as summarized in **Table 1** is key for this next step.

COMBINING SENSOR DATA WITH QUANTITATIVE METHODS

Sensor data are often combined with other quantitative data sources and analytic techniques to validate the given metrics. As mentioned, this concerns both the physical measurement level as well as the level of social- and psychological constructs. While the exploration of the former reveals the constructed nature of sensor measures, the latter emphasizes the ambiguities that exist on the level of the social constructs themselves even before sensor devices are deployed for measurement. Work with sensors in the social sciences should not be blinded by a belief in "big data" measurements where the quantity of data is often thought to miraculously compensate for a lack of a well-argued correspondence rule between the social phenomena of interest and the available indicator.

Scrutinizing "Raw" Sensor Data in the Lab

Much of the excitement around using sensors in the social sciences probably has to do with the promise of providing "objective" measurements of the phenomena under study. Capturing data automatically without direct human intervention addresses the fundamental issue that measurements should not be affected by researchers' bias. As a mechanical form of "observation," sensors are incorruptible regarding when or what they measure and thus supposedly capable of generating "valid" data that will lead to more solid and far-reaching scientific insights. This promise is even more persuasive within

TABLE 4 | Overview of sensor types and scientific literature regarding validation of social and psychological constructs.

Sensor	Indicator/measurement	Social and psychological construct	Construct quality	Relational quality	References	Sensor platform
Bluetooth	Radio Signal Strength Indicator (RSSI) and derived (network) measures	Friendship	Moderate	Moderate	Matusik et al., 2018	Sociometric badges
					Eagle et al., 2009; Sekara and Lehmann, 2014	Smartphone
		Advice	Moderate	Moderate	Matusik et al., 2018	Sociometric badges
		Homophily (gender)	High	Moderate	Psylla et al., 2017	Smartphone
		Personality	High	Moderate	Olguin et al., 2009; Lepri et al., 2016	Smartphone
Infrared	Binary detect and derived (network) measures	Personality	High	Moderate	Olguin et al., 2009; Alshamsi et al., 2016	Sociometric badge
		Creativity	High	Moderate	Gloor et al., 2011; Tripathi and Burleson, 2012	Sociometric badge
		Leadership	High	Moderate/Low	Cook et al., 2019	Sociometric badge
		Affect	Moderate	Moderate	Alshamsi et al., 2016; Zhang et al., 2018	Sociometric badge
RFID	Binary detect and derived (network) measures	Contagion (infection, information)	High	High	Vanhems et al., 2013; Barrat et al., 2014	OpenBeacon
					Salathé et al., 2010; Guclu et al., 2016	TelosB
		Homophily (gender)	High	Moderate	Stehlé et al., 2013; Atzmueller et al., 2018	OpenBeacon
Microphone	Volume, frequencies (Hz)	Creativity	High	Moderate	Parker et al., 2018	Sociometric badge
		Stress	High	Low	Martinez Mozos et al., 2016; Taylor et al., 2016	Sociometric badge
		Dominance	High	Moderate/Low	Chen and Miller, 2017; Dietzel et al., 2018	Sociometric badge
		Affect	Moderate	Moderate	Zhang et al., 2018	Sociometric badge
		Talkativeness	Moderate	Moderate	Onnela et al., 2014	Sociometric badge
		Communication	High	Moderate/Low	Holding et al., 2019	Sociometric badge
		Team performance	Moderate/High	Moderate	Wu et al., 2008; Olguin et al., 2009; Dong et al., 2012; Daggett et al., 2017; Endedijk et al., 2018	Sociometric badge
Accelerometer	Energy magnitude over three axes (body activity)	Creativity	High	Moderate/High	Tripathi and Burleson, 2012; Gaggioli et al., 2013; Parker et al., 2018	Sociometric badge
		Dominance	High	Low	Dietzel et al., 2018	Sociometric badge
		Affect / well-being	Moderate	Moderate	Zhang et al., 2018	Sociometric badge
					Yano et al., 2015; Chancellor et al., 2017	HBM
					Doherty et al., 2014	Smartphone
		Social anxiety (mental health)	High	Moderate	Wang et al., 2014; Gong et al., 2019	Smartphone

the social sciences where sensors are poised to capture almost imperceptible but elementary behaviors that underlie human interaction. Facilitated by decreasing size and cost, sensors keep track of our behavioral "footprints" on a global scale (Golder and Macy, 2014), underscoring the dominance of numbers as "the modern fact"—simple, unbiased descriptors of phenomena that are only subject to the invariable rules of mathematics (Poovey, 2004, p. xii).

However, although sensors provide a mechanical means of measuring the social, they do not necessarily generate more objective data. Sensors need to be calibrated, have error rates, and are influenced by environmental conditions while data gets sampled, aggregated, and filtered by different algorithms before being exported as "raw" observations for downstream analysis. In fact, as some commentators have remarked, "raw data is an oxymoron" (Gitelman, 2013; Marres, 2017). As shown below, far from being a simple by-product of our activities, sensor-derived data are often an expression of the theories and instruments required for building them in the first place. Therefore, it is increasingly hard to distinguish whether we measure a social phenomenon or the underlying technological devices that mediate it (Marres and Gerlitz, 2015; Marres, 2017). One might ask if we are studying society or technology, RSSI thresholds or knowledge networks, actual friendship ties or algorithmic effects of recommender systems on Facebook? Or, to put it the other way around: to what degree are contemporary social phenomena (such as "friendship") the effect of technological devices (such as the underlying recommender algorithms in Facebook which suggest new "friends") rather than genuine social exchange?

The fact that data never "speaks for itself" (Lewis, 2015) has inspired a host of critical studies within behavioral and health sciences, which are summarized in **Table 3**. These studies are predominantly laboratory experiments where tightly controlled conditions establish the ground-truth on the basis of which sensor-derived measurements are assessed. For instance, Chaffin et al. (2017) strap Sociometric badges onto panels placed into increasing distance to each other in order to see how variability of RSSI metrics correlate with changing physical distance. As the authors report, up to 60% of the variance that BT detects is due to the experimental conditions (physical distance) with 8% of the variance being due to systematic bias of single sensors (Chaffin et al., 2017, p. 9). Next, face-to-face detects are consistently under-reported down to 50% even when placing Sociometric badges in optimal, i.e., manufacturer-specified conditions, for face-to-face detection (Yu et al., 2016; Chaffin et al., 2017). Concerning OpenBeacon sensors, only about half of the actual interactions were recorded by these tested RFID devices (Elmer et al., 2019). Microphones exhibit similar problems: in Yu et al. (2016) sociometers underestimate the duration of speech by 30–40 s while having problems to correctly identify speakers as such (Yu et al., 2016, p. 7). Kayhan et al. (2018) show, through extensive microphone tests, that badges tend to capture changes in volume and frequency accurately, but that differences exist between badges for the same experimental conditions, due to variable sensitivity of each sensor. Building further upon speech detection capacities, turn-taking has a specifically low validity, where sociometers overestimate the ground-truth (actual turns: 6) by a large margin (counted turns: +50) (Chen and Miller, 2017; Kayhan et al., 2018; Müller, 2018). Accelerometer readings provide, on the other hand, more reliable measurements, as reported by both Yu et al. (2016) and Kayhan et al. (2018). On the whole, results are less precise than one would expect at this simple level of physical measurement.

The discrepancy and variability of sensor data with respect to experimental conditions might be further exacerbated by the influence of intermediate processing and data aggregation decisions. Before any data is actually exported for downstream analysis, audio signals are processed by sophisticated algorithms to filter out "noise" from actual "speech" signals—which can substantially alter detected speaking time (Chen and Miller, 2017). Other underlying issues, such as the synchronization of the Sociometric badges internal clock, also play a fundamental role in determining the precision with which badges can measure speaking turns or mirroring activities and, therefore, the extent to which they are able to provide valid measurements. Without a precise synchronization of timestamps between badges, the ability to identify the "same" event across badges is severely impaired (Kayhan et al., 2018).

Thus, although quantitative sensor data enjoy the aura of being "objective" measurements that liberate us from any interpretative effort, upon closer inspection, BT, Infrared, microphone and accelerometer data incorporate a host of technical and measurement biases that need to be taken into account. Instead of providing an exact indicator, it seems more plausible to conceive sensors as probabilistic indicators, even on the level of physical constructs where one intuitively would expect a much more reliable functioning of sensors. This already poses an important limitation to consider before advancing to situations in which sensor data constitute indicators of more complex, social and psychological constructs.

Convergent Validation I: Social Construct Validity via Quantitative Data

While the basic, critical evaluation of sensor metrics presented during the preceding paragraphs is necessary and certainly has a sobering effect regarding their validity as indicators on a physical level, it only provides a first step in the research process. Combinations with established, quantitative measurement scales also aim to validate sensor-based measurements in relation to higher-level constructs, including "types of social relations" or "creativity," to name just two (see again **Table 4** for further examples). Since validity concerns now go beyond the pure physical construct level, the consensus regarding the underlying (social) construct, as well as the correspondence between the indicator and the construct, do enter into the equation, as the following examples will show.

Given the widespread availability of BT sensors, convergent validation of proximity data is relatively common. Sekara and Lehmann (2014) argue, for example, that by selecting a suitable RSSI threshold (at −80) one can distinguish between strong and weak links that correlate with friendship ties on Facebook (Sekara and Lehmann, 2014). The validation efforts in this case already demonstrate the problematic assumption that social network "friends" are reliable indicators of actual friendship. Matusik et al. (2018), in contrast, use self-reports among leaders in a large-scale research facility to assess the convergent and discriminant validity of BT RSSI thresholds for friendship and advice seeking networks (Matusik et al., 2018). As the authors show, self-reported "friendship" ties correlate to a certain extent with lower RSSI values indicating closer spatial proximity, while advice seeking/receiving ties map best onto more liberal RSSI signals. A further related study concentrates on the correlation between face-to-face detects and derived measures such as the diversity of social communication with positive and negative affect and thus subjective well-being (Alshamsi et al., 2016). Although correlations are found between these two elements, they are quite low (Alshamsi et al., 2016, p. 5). Parker et al., to cite another study, show that the number of speaking segments as measured by Sociometric badges and self-turns in conversations are correlated with higher perceived individual and group creativity as measured by the KEYS survey—"the best-established survey instrument for studying creativity in working environments" (Parker et al., 2018, p. 13).

While these studies provide some evidence regarding the possibilities to map various sensor types of Sociometric badges onto social constructs, they also highlight some critical issues. Sekara and Lehmann rightly contend that "proximity" is a questionable indicator of social relations: "[m]ultiple scenarios exist where people are in close contact but are not friends, one obvious example is queuing" (Sekara and Lehmann, 2014, p. 7). As already discussed, the validity of sensor-derived metrics is not just determined by the measurement precision or the fine-tuning of RSSI thresholds, but it is also framed by the relative strength of the correspondence between the indicator and the chosen construct. Now the crucial point is that in cases where this relationship is rather weak, additional contextual information can improve the quality of the indicator. In this scenario, convergent validation is not only carried out by validating sensor data with other quantitative measurement scales, but also by combining such data with qualitative data sources.

COMBINING SENSOR DATA WITH QUALITATIVE METHODS

Despite the prevalence of the "complementarity" rationale in literature on integration of sensor data with qualitative methods, as **Table 1** suggests, other motivations for combining big data with qualitative sources do exist. However, researchers, when reporting their sensor-based findings rarely distinguish between these underlying MMR rationales and consequently underestimate the methodological implications of obtaining well-founded research results. Based upon **Table 1**, in the following paragraphs, we will describe three clearly distinct rationales for combining qualitative- with sensor-based data. The resulting typology of approaches provides the first in-road to improved research planning using sensors, and improved collection- and interpretation of the obtained data.

Convergent Validation II: Construct Validity via Qualitative Data

Qualitative data sources can be combined with sensor data for the purpose of validation, i.e., to examine if measurements of the same construct with different instruments converge (or not). A recent exemplary case is available in Parker et al. (2018) where ethnographic observations are used to validate Sociometric speech measurements and body movement in relation to "creativity" in group processes. By closely reading body activity metrics of team members side by side with field notes of the actual working sessions among the environmental scientists, similarities between the two data sources are identified and matched. Thus, specific incidents where the group became "excited and engaged" produce a higher variability in the corresponding body- and speech measurements for the given time slots. Creative moments within the group "are louder on average than any other portion of the group's working day and even louder than their lively lunches and coffee breaks" (Parker et al., 2018, p. 16). Ethnographic observations do not provide complementary insights but rather sufficient contextual detail that make the body- and speech metrics accessible to a specific interpretation—in the current case in terms of a creative flow.

A similar convergent validation logic can be applied to the highly-cited BT studies described in the preceding paragraphs. Eagle et al. (2009) observe, for example, that inferring the friendship network structure through BT signals can be vastly improved when contextual information regarding work and leisure times and places is taken into consideration. Since the ratio of proximity detects outside work (hours) is much higher for friends than for non-friends, "it was possible to predict 96% of symmetric reports of non-friendship and 95% of symmetric friendship" (Eagle et al., 2009, p. 15,275). By observing broad contextual cues of the overall situations under study, qualitative accounts can improve the overall quality of the indicator. Indeed, by providing complementary data on the times and places where "friendship" is more likely to occur, the fit between the indicator and the construct can be improved.

Qualitative Data for Complementary Insights

Contrary to the "convergent validation" rationale, qualitative data might also be used to complement sensor data, i.e., to examine different facets of the same phenomena by using different (complementary) methods. A recent, exemplary case, is a study published by Bornakke and Due (2018) on the utility of bike signs in the city of Copenhagen. Researchers tracked mobility patterns of cyclists via GPS and combined these with participant observation, direct inquiries and a short questionnaire. The sensor-based information on actual bicycle journeys was thus contextualized with the cyclists' stories explaining their choice of one trajectory or another. The qualitative material explored the "why" question, based upon "what" had happened, i.e., the difference between morning vs. afternoon routes. Or, to put it the other way round, the GPS data "extends the thick observations with knowledge on the generalizability of the behavior of using multiple routes to and from one's home." (Bornakke and Due, 2018, p. 12).

The way qualitative and sensor data are combined in this example follows a strong "complementarity" rationale where qualitative observations provide a new layer of meaning to the quantitative mobility tracks. This is possible because GPS is a relatively reliable indicator of actual positions in the city; the coordinates are valid as indicators of physical routes and deliver an "autonomous" result to be used for further analysis, questioning and interpretation by researchers. Qualitative data adds here a complementary layer of meaning rather than being preoccupied with untangling the precise social situation represented by the data. Therefore, what this example shows is that only when sensor data has been established as an independent and valid source or measurement, does it make sense to "complement" it with qualitative data. The importance of the dialectic between "complementarity" and "validity" is illustrated more clearly in the example presented in the next section.

Anchoring Sensor Data via Qualitative Data?

A third approach to combine qualitative data with sensor data does not aim for convergent validation of certain constructs, nor does it provide complementary insights. Rather, it constitutes a more problematic account where qualitative insights aim to make the data interpretable as such. This approach can be illustrated by the following example. In their study at the Danish Technical University, Blok et al. (2017) tracked an entire freshman class of 800 people using BT sensors in smartphones. Ethnographic observations are part of the overall methods, used to contrast the recorded "big" interaction traces with first-person accounts of "thick" descriptions during selected events such as a student party for example. Given that BT is a relatively fuzzy indicator, the analytic work involved probing different aggregation and visualization techniques of the BT signals while constantly verifying the corresponding time slots with the ethnographers' descriptions. Digital data, as the authors explain, "allow for great plasticity" requiring a constant oscillation between extracting "interpretable occasions" from the data and cross-checking with observational accounts (Blok et al., 2017, p. 6). However, what Blok et al. identify as the "great plasticity" of digital data, is nothing but a lack of specificity and hence low quality of proximity-based indicators for social phenomena. In Blok's research, it is the fuzzy nature of proximity data that leads researchers into an endless regress of probing different aggregations levels, filters or visualizations in a hunt for significant patterns of behavior. Exploring the data without any fixed social concept in mind, these patterns mostly fail to emerge because "proximity" in itself is a very ambiguous indicator that can signify anything and nothing. When a distinct proximity/distance pattern finally does emerge and can be correctly labeled with the help of ethnographic field notes—as people leaving the party through a tunnel, at the end of which they "hug goodbye" (Blok et al., 2017, p. 8)—it is not clear that this insight contributes to the wider research question. Although satisfying to "see" this pattern of behavior in the data, it is, somehow, a rather shallow research result because it simply mirrors a broad contextual observation of the event, namely the end of the party. As Doreian and Conti (2012) argue, it is a common mistake of researchers to conflate organizational or spatial context variables with genuine social structures and individual preferences. Without a clear construct that sensor data is supposed to measure, its decontextualized nature leads to interpretations that mirror more the resources and capabilities of the observers than genuine patterns of social behavior.

Therefore, combining qualitative data sources with sensor data is unproductive when the two data sources are simply "stitched" together, without clear theoretical motivation. Although this statement is understandable from an ethnographic and inductively-based approach to data collection, it causes problems when applied to sensor data. And there is a precise reason for that, which will be largely discussed in the next section: inductively exploring sensor data easily falls prey to reproducing broad contextual observations that are first and foremost an expression of the limited observational capacities of the ethnographer rather than an expression of the inherent patterns in high-resolution, time-based sensor data.

VALIDATION AND THE PROBLEM OF "MATCHING THE RESOLUTION"

The preceding examples of combinations of sensor data with quantitative and qualitative data sources reveal an underlying, but nevertheless important, problem of mismatch between the scale (or resolution) of the sensor data and that of more conventional data collection methods. BT sensors register interaction between persons on a continuous basis. Monitoring a group of 11 people over 5 days can produce up to +100,000 detects. Although data collection methods such as participant observations, interviews, or questionnaires are able to contextualize a number of data points, its focus is, however, limited to events that are more notable and to coarse aggregation levels. Consequently, these methods fail to capture a large part of the continuous temporal information that can be obtained through sensors. Returning to Blok et al. (2017) example, it is clear from this study that the minute details of physical proximity registered by sensors between several hundred participants could not be matched with the observational accounts generated by a well-trained ethnographer. The ethnographic insights in Blok et al. (2017) study (e.g., the "high" and "low" energy of the overall party) remain coarse approximations to the phenomenon under study and, therefore, are ineffective in grasping more subtle events such as, for example, how the overall "energy of the party" emerges out of specific micro-dynamics on the group level. If big data stands for data velocity and volume, qualitative and quantitative accounts have a hard time to keep up the pace. The possibilities of addressing more fine-grained questions are indeed directly dependent on available resources which, most frequently, tend to be limited by "time, research funds, and human coding hours" (Lehmann-Willenbrock et al., 2017, p. 523).

Quantitative, survey-based approaches share a similar fate. The previously cited study by Matusik et al. (2018) ignores the temporal dimension of the proximity data as it correlates *averaged* RSSI values across a 9-day field period with advice- and friendship networks. This high aggregation level could, of course, be broken down into shorter time spans, such as daily- or hourly RSSI mean values. However, the shorter the time-slots over which the sensor data is averaged, the higher the efforts to collect the increasing number of corresponding survey measures. The cited study of Alshamsi et al. (2016) faced similar challenges when participants were asked to respond three times per day to the same questionnaire over a period of 30 days in order to validate their "affect states" with slices of sociometric face-to-face networks. The number of times that these fixed snapshots of affective moods are collected is, to a certain extent, somewhat arbitrary and clearly conditioned by the researchers' ambition to push forward the limits of taxing data collection. What all these validation studies fail to address is the fundamental problem of a mismatch of resolution between sensor-derived data and more traditional, static data types.

As with any measurement instrument, using sensors within the social sciences requires a conscious calibration effort that examines closely how tightly physical- and social constructs are bound to the available sensor metrics. Combining sensor data with other qualitative and quantitative sources confronts the dilemma of either addressing only a fragment of the behavioral measures or having to invest disproportional efforts to collect data with the comparable amount of detail using conventional methods. To say it somewhat figuratively: conventional qualitative and quantitative methods are the bottleneck through which the validation of big data has to pass. This methodological challenge is increasingly being addressed, for example by Luciano et al. (2018) who work toward new approaches to assess "measurement fit" with dynamic, time-based data.

CONCLUDING REMARKS AND RECOMMENDATIONS: TOWARD MIXED METHOD RESEARCH WITH SENSORS

In this article we argue, that in order to reliably use sensor data in organizational research, complementary data needs to be collected. The necessity of integrating sensor data with other, quantitative and qualitative methods sharply contrasts with the predominant tendency in the literature to use (wearable) sensors as a "stand-alone" research instrument (Schmid Mast et al., 2015; George et al., 2016; Tonidandel et al., 2018). The exciting new research questions made possible by the continuous, high resolution monitoring of human behavior remains dependent upon the variable "fit" between physical measurement and the targeted social or psychological constructs. Since the gap between physical sensor data and social construct level is non-negotiable, researchers need to address the validity of their sensor data in the context of their theoretical framework, research questions and by incorporating a mixed methods perspective. As Parker et al. (2018) argue: "From a sociological perspective, this research is intriguing and potentially generative, but its exclusive focus on non-verbal behavior, tendency to use sensors without triangulating methods or confirmatory data, and minimal grounding in sociological theory raise questions about its reliability, validity, and explanatory power." (p. 9). The following paragraphs provide concrete recommendations for research practice that address the inter-related nature between sensor platform, analytic interest and contextual data needs. We thereby focus on broader methodological considerations that apply to wearable sensors at large; others have provided practical tips when using Sociometric Badges (Chaffin et al., 2017; Kayhan et al., 2018; Parker et al., 2018) or Sociopatterns/OpenBeacons (Elmer et al., 2019) in research. Ethical considerations including privacy issues are discussed in Stopczynski et al. (2014); Metcalf and Crawford (2016).

First, the choice of a sensor platform needs to be adjusted in relation to the research question and a coherent theory that argues for the correspondence between the sensor-based indicator and the relevant constructs. No amount of big data can, by itself, leverage a potential misfit between sensor metrics and higher-level constructs. The overview of **Tables 3**, **4** provide a first orientation regarding diverse social and psychological concepts explored with different sensor types. "Creativity" for example has been addressed with three types of sensors, namely accelerometers, microphone, and proximity-based sensors (BT or RFID). Researchers interested in exploring "creativity" or other affect-related concepts are well-advised to use an integrated solution such as Sociometric badges or smartphones that can record proximity between participants as well as body activity and speech features. The importance of these data dimensions for monitoring "creative" behavioral markers can justify the relatively higher cost and complex field logistics involved with Sociometric badges (which require daily recharging and data download). On the other hand, researchers interested in monitoring the spread of information or contact and collaboration patterns more generally are well-advised to use simpler systems such as the Sociopatterns/OpenBeacons platform. Although this platform "only" incorporates a proximity sensor, it is the most efficient solution in terms of cost, device size and field logistics for delivering the required "contact" data. Other sensor platforms mentioned in **Table 2** cannot be recommended at this point, either because they have been discontinued (TelosB), they are not available for researchers (HBM), or they are still under active development (Rhythm badges).

A second point concerns the recommendations for increasing the validity of sensor measures. As Parker et al. remark, "most current sociometric research conducted by computer scientists and engineers accepts sociometric data at face value" thus risking to create "large datasets and performing sophisticated analysis on data of questionable quality, yielding incomplete or incorrect understandings of small group structure and process" (Parker et al., 2018, p. 25). As the following examples will show, researchers have the choice between different methodological approaches to control the coupling of physical measures, human behavior, and their social interpretation. A tighter coupling of behavior to social meaning is usually dependent upon a strict control of the experimental situation in laboratory settings. More open and complex situations in field research require the recollection of complementary, contextual cues to guarantee the validity of sensor data.

It is important to realize that much of the initial interest surrounding sensors as powerful new research instrument is based upon research carried out in the laboratory. The tight control of the experimental situation eases the interpretative burden of the sociometric data to a considerable degree, fueling hopes for capturing "honest signals" (Pentland, 2008). As sensors can capture a number of elements of body language (i.e., body posture and movement, vocal behavior such as pitch or volume) they provide access to subtle, non-verbal behaviors beyond the literal meaning of words (Hall et al., 2013; Bonaccio et al., 2016). Since these semi-automated behaviors nevertheless steer and structure social interactions on a fundamental level, it becomes conceivable to interpret the physical measurement of behavioral as "honest" signals of social phenomena. Impressive results have been reported by Alex "Sandy" Pentland's group at MIT using Sociometric badges to predict the outcome of speed dating events, elevator pitches, or salary negotiations with surprising precision (see Appendix B of Pentland, 2008, p. 113ff). However, it's worth remembering that the tight coupling of physical sensor measures to social phenomena in these initial studies has been achieved by not only setting up quasi-experimental situations but also by limiting the scope of the dependent variables of interest. By using simple, binary outcome variables (win/lose, trade business card/not, higher salary/lower), relatively high correlations between the sensor measurements and the dependent variables could be achieved. In short, it is the control of "context" that "improves" the validity of the sensor measures as a probabilistic indicator of "honest signals."

However, as soon as the outcome variables become more complex and the context of social interaction is less defined, theoretical choices regarding the social constructs of interest need to be fined tuned in relation to the type of sensors deployed and their dependency on contextual cues. As soon as sensors are embedded into real-world field settings, the defining feature of "big data"—namely, having a high (temporal) resolution while lacking contextual information (Cai and Zhu, 2015)—comes to the fore. Sensor data is "big" but also "thin" data that needs to be combined with qualitatively grounded "small data" derived from interviews, focus groups or participant observation to unlock their context and hence social meaning (Burrell, 2012; Curran, 2013; Ford, 2014). Eagle et al. (2009) study comes here to mind where the interpretation of physical proximity patterns in terms of "friendship" could be made much more precise by distinguishing between work- or leisure contexts. Complementary observations regarding people's choices when and where to be near each other provides the contextual cues to qualify their physical proximity in terms of specific social relations such as "friendship." While the observation of context is key for research about "friendship," complementary observations might be less important when exploring the spread of a contagious disease. In order to study the transmission of a pathogenic germ in a hospital ward, the observation of the physical contact pattern is enough because the validity of the physical proximity measure is a good indicator for contact-related phenomena. Researchers thus have to decide on the relation between the physical measure, the targeted construct and the contextual cues to be observed in order to achieve a better fit and validity of data.

A further example concerns the contextual observations necessary for the study of "creativity." "Creativity" is usually associated with higher agitation levels in body movement as well as speech (volume) data (Yano et al., 2015; Parker et al., 2018). However, as Parker at al. argue, "having an ethnographer in the room was critical for distinguishing between an exciting scientific episode and a coffee break or photo opportunity" (Parker et al., 2018, p. 25). The observation of the wider context anchors the interpretation of the sensor data in relation to the theoretical interest of the research. The fact that sensor-based methods apparently reduce field efforts in terms of the amount and continuous collection of data needs to be balanced in relation to the additional efforts necessary for contextualizing the collected data. In this regard, under tight research budgets, it is crucial to take into account the resources and skills needed for gathering complementary data by selecting specific events and episodes of observation or for soliciting comments from research participants.

The elaboration of a more precise understanding of observational cues necessary for working with different social and psychological constructs is an important challenge for the future of wearable sensor research. How to best distinguish "knowledge sharing" behavior in proximity data of shared office spaces or small groups for example is such a problem (Génois and Barrat, 2018). From the data it is not directly deducible if the proximity of colleagues is a product of seating order, actual collaboration or even the product of other sources of "bias" such as "people's personality, cultural background, or substance consumption" (Elmer et al., 2019, p. 16). However, addressing validity concerns of sensor data collected in the field is a first, necessary step before considering the true potential of this type of new research instruments, namely to study the temporal dimension of social phenomena (Leenders et al., 2016). Sensors can contribute for example to the study of hitherto marginally explored temporal dimension of "creativity" in organizations by providing a window on the micro-sequencing of events that are responsible of "flow" experiences (Csikszentmihalyi, 1975; Gaggioli et al., 2013). Or, to take the study of leadership emergence as another example: in combination with new analytical Relational Event Models (Butts, 2008), highly granular sensor data enables a much closer look at the "microdynamic relational processes" (Carter et al., 2015) or "micro-origins" (Cook et al., 2019) that govern leadership emergence. Given the predominance of classical, a-temporal accounts of many classical research methods, a vast landscape of sociological and psychological constructs are awaiting to be rethought by organizational researchers in terms of their genuine temporal grounding, including the path dependency between events, their duration, frequencies and cyclicality (Quintane et al., 2013; Ubaldi et al., 2017).

In this article, we have outlined the rather complex processes involved when using wearable sensors in social science research. It counters what is often blind faith in data volume, speed, and variety. As we have argued, the pitfalls of an uncritical acceptance of sensor-based data become apparent by contextualizing the usage of sensor data with MMR rationales as well as basic notions of social science indicators. To the best of our knowledge, the current article is the first to explicitly address issues of wearable sensor research in conjunction with MMR. A careful examination of available sensor types and their corresponding social and psychological constructs as outlined in **Tables 3**, **4** provides the first steps to a more beneficial deployment of sensors in field research settings. A clear alignment of research question, theoretical constructs and complementary data needs is key for successful wearable sensor research. We hope to have contributed some conceptual clarifications that will provide the framework for a more realistic assessment of these new, existing instruments for social science the potential applications of which are nothing short of exhilarating.

AUTHOR CONTRIBUTIONS

JM: conceptual development and first draft of paper. SF: methodological development and major revisions/comments. MR and EG: contribution to conceptual development, empirical fieldwork and analysis of data underlying the paper, and revisions/comments to drafts.

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A Mixed Methods Design to Detect Adolescent and Young Adults' Impulsiveness on Decision-Making and Motor Performance

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Impulsiveness in adolescents and young adults is an important aspect of psychological research. However, there still is lack of research that relates impulsiveness and motor performance in those. Thus, we aim to detect the levels of impulsiveness related to motor skills, motor laterality, spatial orientation, and individual interaction on the decision-making of adolescents and young adults across three staggered workouts. The study had 71 participants (53 males and 18 females), ranging in age from 17 to 24 years old (*M*age = 18.5 years; *SD* = 1.72) and classified as non-impulsiveness ($n = 47$), impulsiveness ($n = 17$), and attention deficit hyperactivity disorder (ADHD) ($n = 7$). A Mixed Methods research was conducted throughout four research tools (a) The Observational System of Motor Skills (OSMOS) was used to observe and detect the movement sequences patterns; (b) The Spanish version of Impulsive Behavior Scale (UPPS-P) was administered to obtain the impulsiveness profiles; (c) The Precision and Agility Tapping over Hoops (PATHoops) was carried out to observe the decision-making and temporal-spatial over movement effectiveness; (d) Motor Laterality Inventory (MOTORLAT) was applied to obtain the laterality profiles related to motor skills performance. This Mixed Methods approach has obtained useful results for impulsiveness in motor situations as the results from the different tools converge to established three clear profiles of impulsiveness. Participants with ADHD showed lack of interpersonal interaction, non-resolute decision-making, and lesser richness of motor skills patterns than non-impulsiveness and impulsiveness subjects. Additionally, impulsiveness participants also showed rich motor patterns, dyadic interactions, good decision making in spatial orientation tasks, and more versatile laterality in the lower limbs.

Keywords: impulsive actions, motor skills, behavior coding tool, T-pattern detection, methods integration

INTRODUCTION

Impulsiveness is widely investigated in adolescents and young adults mostly related to different addictions such as gambling, tobacco, drugs, and alcohol consumption (e.g., Wiers et al., 2010; Franco et al., 2016; Secades-Villa et al., 2016). Also, researchers have studied the relationships between impulsiveness and aggressive characteristics, pursuing new sensations, and risk situations (Svebak and Kerr, 1989).

Adolescence is an essential stage in the development of a human being, characterized by the evolutionary moment that individuals should consolidate personality, and are most influenced by all kinds of stimuli. Delimited between by the ages of 12 and 25, adolescence is divided into three stages: (a) early adolescence: 12–14 years; (b) middle adolescence: 15–17 years; (c) late adolescence: 18–25 years (Spear, 2013). Therefore, young adults in their twenties are nowadays considered to be in late adolescence. During the adolescent period, the control of the impulses is still regarded as immature (Casey and Jones, 2010), meaning that not only teenagers but young adults look for new, risky, and impulsive sensations (Cyders and Smith, 2008). These are critical periods in ontogenesis, which the setting of habits unbalances the personal and social dimensions (Cerkez et al., 2015).

During the teen stages, impulsiveness is an issue commonly studied with substance addiction or abuse, attention problems and attention deficit hyperactivity disorder (ADHD). (Moeller et al., 2001:1784) define impulsiveness *"as a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or to others."* The same authors recognize impulsiveness, not as an isolated act, but as a pattern of mechanisms that follow the succeeding phases: (a) *Predisposition* to react unexpectedly and quickly; (b) a fast *Response* without planning; (c) *Action* without considering the consequences.

Complementarily, the personality traits studied based on impulsiveness focus on (a) *Motor impulsiveness:* thoughtless behaviors resulted from an immediate response to a stimulus; (b) *Attentional impulsiveness:* low control over the intrusion of thoughts and difficulties for sustained care; (c) *Impulsiveness by unpredictability:* precipitate processing of information that leads to quick and unplanned decisions (Patton et al., 1995; Barratt et al., 1997); (d) *The Quest for Adventure* (Eysenck and Eysenck, 1977) individuals are carried away by the moment without being aware of the risk of their actions; (e) *The Search of novelty* (Cloninger et al., 1993): personality trait associated to an exploratory activity as response to a new stimulation and usually focused on the rewards; (f) *The search for sensations* (Zuckerman, 1990, 2007):the need to experience diverse situations that arise the sense of physical and social risk. Although the impulsiveness in risky situations is associated with the scope of Physical Activity and Sport, the binominal between impulsiveness and motor performances is scarce (Svebak and Kerr, 1989).

Impulsiveness, Decision-Making, and Goal Achievement

Dickman (1990, 2000) distinguishes two types of impulsiveness: dysfunctional impulsiveness and the functional impulsiveness. On the one hand, dysfunctional impulsiveness is disordered and unproductive behavior that does not have benefits for the teenagers and young adults. On the other hand, functional impulsiveness refers to the trend of acting rapidly with the possibility of committing errors in processing information, probably because of the inability to identify relevant elements for decision-making (Baker and Côté, 2003).

Moreover, functional impulsiveness is related to enthusiasm, risk-taking, and development of high levels of activity and audacity (Dickman, 1990, 2000). Aspects that, as a whole, represent a personality trait that allows the youngsters to process information quickly and effectively. Relating motor impulsiveness (Patton et al., 1995; Barratt et al., 1997) with functional impulsiveness (Dickman, 1990, 2000), in a Physical Activity and Sport point of view, emerges the relationship between rapid decision-making capability in the face of a stimulus (Burnett et al., 2012) and the ability to motor anticipation (Murgia et al., 2014). We consider that this relationship is fundamental given the great affluence of motor skills (Castañer et al., 2018), which can be seen in all kinds of physical activities and sports. For example, in a 1x1 team sports situation, a player must decide quickly and instantly to overcome the opponent, knowing that an improper reading of the environment could mean losing possession of the ball (i.e., dysfunctional impulsiveness). On the contrary, a correct perception and decision, but sometimes risky, could lead to successful goal achievement (i.e., functional impulsiveness).

At the sporting level, the variables speed and efficiency play a fundamental role, especially in the information processing, decision-making and motor execution (Burnett et al., 2012). From this perspective, it seems logical to reflect what role impulsiveness plays in rapid, risky and effective decision-making, and consequently in motor performances.

The review of the scientific literature leads us to raise the question about whether impulsiveness in motor execution could be considered always "negative" or prejudicial. On the line of Dickman and Meyer (1988), we hypothesize that, on many occasions, the ability to act quickly and impulsively on risky situations that require effective motor responses are fundamental, not only in the field of Physical Activity and Sport but also in everyday life. Considering the interest in the patterns' detection of impulsiveness on adolescents and young adults' motor responses, we aim to study the relationship of impulsiveness, motor skills, motor laterality (Bishop et al., 2013; Castañer et al., 2018) and decision-making (Burnett et al., 2012) in staggered situations, through a design Mixed Methods (Castañer et al., 2013). Thus, the objective of this study is to deepen how impulsiveness affects athletes' motor responses by analyzing if impulsiveness generates proactive motor behaviors.

METHOD

The Mixed Methods approaches are increasing especially in Physical Activity and Sport (Camerino et al., 2012; Castañer et al., 2013). For this reason, we conducted an embedded Mixed Methods design to merge the analysis of both impulsiveness and motor skills behaviors. As can be seen in **Figure 1**, the embedded design includes: (a) an adapted version of Observational System

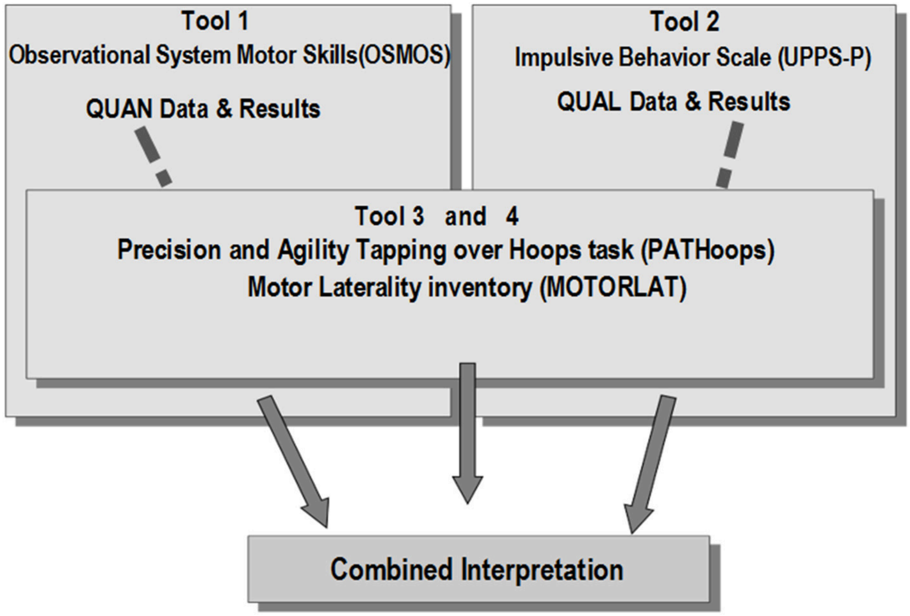

FIGURE 1 | Embedded Mixed Methods design.

of Motor Skills (OSMOS) (Castañer et al., 2009, 2016) to observe the motor behaviors; (b) The Spanish version of Impulsive Behavior Scale (UPPS-*P*) to obtain the impulsiveness profiles; (c) The Precision and Agility Tapping over Hoops (PATHoops) (Castañer et al., 2018), to observe the decision-making in the temporo-spatial organization; and (d) Motor Laterality Inventory (MOTORLAT) (Castañer et al., 2010, 2018), to get the laterality profiles of motor skills performance.

Participants

A total of 71 participants (53 males and 18 females) ranging in age from 18 to 24 years ($M_{age} = 18.5$ years; $SD = 1.72$) that regularly attended the Physical Education course were analyzed. They performed three staggered situations from closed to open motor tasks in classes. Previously, all participants were notified about the study, and they signed a written informed consent form to participate in the research. As for the observational methodology, the observation sessions were conducted in a natural context, specifically we observed the participants' development in the scholar sessions, therefore the institution has a consent form about image privacy that students enrolling at the school are required to sign. The study was approved by the ethics committee of Sports Medicine and Health of Catalan Counseling of Sport, Barcelona, Spain (code 10-2018-CEICGC).

Materials

Impulsive Behavior Scale (UPPS-P)

The UPPS-P (Cyders et al., 2014) is used to measure impulsiveness facets. The tool, comprised of five facets and 20 items in total, evidenced good internal consistency across their subscales (Cyders et al., 2014). The five facets separately assess the following dimensions: (1) *Sensation Seeking*; (2) *Lack of premeditation*; (3) *Lack of perseverance*; (4) *Negative urgency;* and (5) *Positive urgency*. Each dimension comprises four items with a Likert scale from 1 to 4 (1: Strongly Agree, 2: Agree, 3; Disagree, and 4: Strongly Disagree). Three of these facets serve to identify ADHD disorder (Geurten et al., 2018). The Spanish version of UPPS-*P* (Cándido et al., 2012) was used in this study.

Observational System of Motor Skills (OSMOS)

An adaptation of the observation instrument OSMOS (Castañer et al., 2009, 2016) was used, with a minimal optimization of criteria (**Table 1**). The instrument includes eight criteria: (1) Appropriateness of motor responses (adequateness of the participant's response); (2) Stability (motor actions without displacement of the body, i.e., turns, jumps, and balances); (3) Locomotion (motor actions that require displacement of the body); (4) Manipulation (motor actions performed with material or other participants contact); (5) Space (changes of direction or height levels); (6) Zone (area where the participant moves); (7) Time (performing pauses and changes of rhythm); (8) Interaction (including dyadic, group or both interactive behaviors). Each criterion was expanded to build an exhaustive and mutually exclusive observation system tool that included, in total, 25 categories.

Motor Laterality Inventory (MOTORLAT)

The MOTORLAT (Castañer et al., 2018) was used in the study to detect laterality profiles from motor skills performance. It consists of four criteria from OSMOS instrument (Castañer et al., 2009, 2012), but each criterion was expanded to build an exhaustive and mutually exclusive total of 30 items of fundamental and combined motor skills. The description of the four criteria are: (1) *locomotion skills*: actions that require the

TABLE 1 | An adaptation of the observation instrument OSMOS (Castañer et al., 2009, 2016).

Criterion	Category	Code	Description
Appropriateness of responses	Inappropriate motor responses	IMR	Motor actions and interactive behaviors that the participant performs unrelated to the task.
Stability	Support stability	SS	Motor skills that enable body balance to be maintained over one or several body support points, without producing locomotion (e.g., balancing actions).
	Elevation stability	ES	Motor skills that enable the body to get off the ground without locomotion (e.g., jumps).
	Axial stability	AS	Motor skills that enable body axes and planes to be varied from a fixed point, without producing locomotion (e.g., turns).
	Combination of Stability	COS	Combination of the previous criterion's categories.
Locomotion	Propulsion-stop locomotion	PSL	Motor skills that occur at the start and finish of a body movement through space.
	Sequential rebalance locomotion	SRL	Motor skills that enable displacement through the priority sequence of actions of the lower limbs segments (bipedal locomotion) or upper limbs (in inversion).
	Simultaneous coordinated locomotion	SCL	Motor skills that enable displacement through the combined action of all body segments (e.g., quadrupedal locomotion).
	Combination of Locomotion	COL	Combination of the previous criterion's categories.
Manipulation	Impact manipulation	IM	Motor skills in which certain body zones briefly contact with objects or other people.
	Conduction manipulation	CM	Motor skills in which certain segments handle (for a given period of time) objects or other people.
	Combination of Manipulation	COM	Combination of the previous criterion's categories.
Space	Change in spatial direction	CSD	Variations between the different levels of the horizontal component of displacement.
	Change of spatial level	CSL	Variations between the different levels of the vertical component of displacement (low or floor, middle or bipedal, upper or aerial work).
	Maintenance in the same space	MSS	The participant stands in the same area of the space.
	Combination of variations in body posture/gestures and spatial direction	CSP	Combination of the previous criterion's categories.
Zone	Central	CEN	The participant moves in the middle area of the space.
	Peripheral	PER	The participant moves in the external area of the space apart from the corners.
	Corner	COR	The participant moves in the vertices of the space.
Time	Change of Rhythm	CRY	When there is a clear observable tempo variation of a motor action.
	Pause	PAU	When the participant remains in a static position.
Interaction	Dyadic interaction	DYI	Synergy with a partner.
	Group interaction	GRI	Synergy with more than one other member that act together.
	Non-interaction	NIN	Inexistence of synergies.
	Combination of Interaction	COI	Combination of the previous criterion's categories.

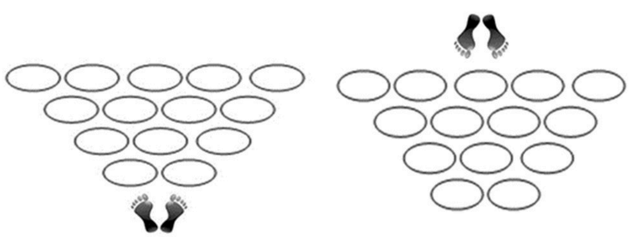

FIGURE 2 | PATHoops Task. **(Left)** Starting position from the narrow side of PATHoops. **(Right)** Starting position from the wide side of PATHoops (Castañer et al., 2018).

body to move from one point to another across space; (2) *stability skills*: actions that do not require the body to move from one point to another across space (i.e., jumping, balancing and turning); (3) *manipulation skills*: actions that require the manipulation of objects or other people with the limbs of the body; and (4) *combined skills*: actions that combine one or more of the locomotion, stability and manipulation skills criteria.

The Precision and Agility Tapping Over Hoops Task (PATHoops)

The PATHoops (Castañer et al., 2018) consists of a task in which "participants, standing on both feet, were asked to perform a path by stepping in each of 14 hoops arranged in a triangular shape on the floor. In addition, participants were asked to perform the PATHoops task from both sides" (Castañer et al., 2018, p. 4). **Figure 2** illustrates the position of the participants in front of the hoops' distribution. The task allows to observe the decision-making of participants during the entire task, that is, stepping quickly and exclusively into all the single 14 hoops.

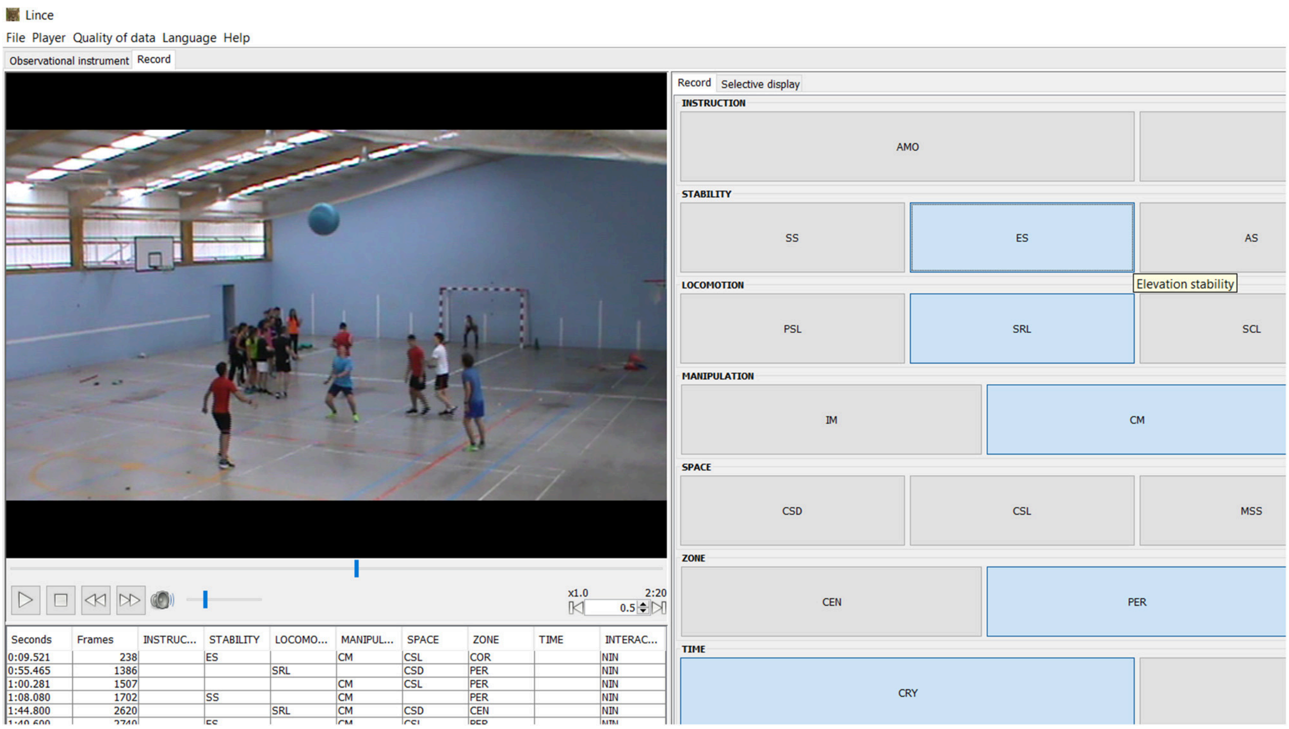

FIGURE 3 | The screen of software LINCE (Gabin et al., 2012). Written informed parental consent was obtained for the publication of this image.

For instance, previous research (Castañer et al., 2018), applied to young athletes, has demonstrated that zigzag way, which is covering from one wing to the other wing of the triangular figure, is the optimal way to perform the task skillfully.

Procedure

Firstly, we administered the short Spanish version of the UPPS-P (Cándido et al., 2012) in order to obtain the impulsiveness profiles of the participants. Likert values of the items 1, 4, 5, 7, 12, and 19 items from the short Spanish version of the UPPS-P scale were analyzed following the protocol of reverse data. Once the impulsiveness profiles were obtained, we proceed to register the staggered workouts that were introduced into three different normal Physical Education classes. The three workouts had a duration of 5 min each one and consisted of performing individual motor skills into the three following designs:

1) Different materials (e.g., balls, hoops, ropes) were placed together in different zones of the space. Participants could use these materials into the zones without interacting among them.
2) Same materials (e.g., balls, hoops, ropes) were in the same zone of the space and participants could use them and only group interaction was allowed.
3) Participants could use material and interaction in a freely way.

MOTORLAT inventory and PATHoops task were administered individually in following Physical Education classes to preserve the personal decision-making and exclude imitation on workouts' performance.

Data Analysis

The OSMOS behavior coding tool and the videos of the staggered workouts were coded using LINCEv.1.2.1 (Gabin et al., 2012) by two experts on motor behavior. Intra-observer and inter-observer reliability were calculated in LINCE software before the full data set codification obtaining a kappa statistic of 0.95 and 0.91, respectively, which guarantees the interpretive rigor of the coding process. LINCE software is a highly useful software that facilitates the systematic observation of behaviors and integrates a wide range of functions such as coding, data quality check and conversion to several data extensions, which helps the exportation to several statistical analysis software. **Figure 3** shows a screen capture of coding data in LINCE.

THEME software package (Magnusson et al., 2016) was used to T-pattern detection of observational data. THEME software is a data analysis research tool that has been increasing the interest of researchers for the last two decades to obtain T-patterns, which essentially uses an algorithm to compare all coded behaviors from the simplest to the most complex combinations. THEME software underlines the detection of a statistically significant chain of behaviors as has to deal with a great amount of behavioral events. To avoid that T-patterns are discovered only by chance, THEME works by randomizing and re-analyzing the original data repeatedly using the same search parameters (Casarrubea et al., 2015).

Laterality profiles were obtained by cluster analysis and subsequent correlational analyses were carried out as we have conducted in previous studies (Castañer et al., 2018). Internal assessment of this was done by correlational analysis between

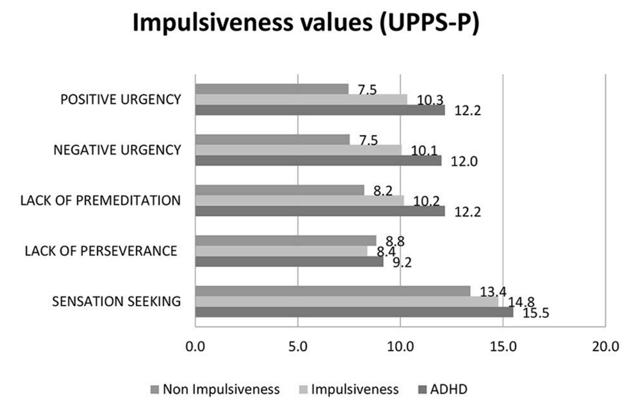

FIGURE 4 | Values of the types of impulsiveness from the five distinct facets of the Impulsive Behavior Scale (SUPPS-*P*).

the motor skills of the MOTORLAT items (**Table 3**). As that previous study (Castañer et al., 2018), a contingency analysis was used to cross the limb dominance criteria from the MOTORLAT inventory and their relationships with the spatial orientation criteria from the PATHoops task.

RESULTS

Impulsiveness Profiles

The values of SUPPS-*P*'s five facets revealed a total of 54 impulsiveness profiles of the total 71 participants. We differentiated three profiles: impulsiveness ($n = 47$); ADHD ($n = 7$); and non-impulsiveness ($n = 17$). Results showed a notable difference between impulsiveness and non-impulsiveness participants; mainly in the facets described by Geurten et al. (2018) namely lack of premeditation, positive urgency, and negative urgency (**Figure 4**).

The data obtained from item 9 of the UPPS-*P*, which refers to the joy of taking risks, and which belongs to the facet of sensation seeking, have shown that the majority of participants agreed with the enjoyment of taking risks. For instance, 71.4 and 57.4% of the participants with ADHD and with impulsiveness Strongly Agree, respectively. Moreover, impulsiveness (42.6%) and non-impulsiveness (58.9%) participants responded to Agree (**Table 2**).

Laterality Profile and Spatial Orientation

The motor skills of kicking and touching a ball with the feet, which were assessed by MOTORLAT inventory, showed differences between participants. Non-impulsiveness participants used mainly the right foot in both motor skills (94.1% for kicking a ball, and 88.2% for touching a ball). On the other hand, participants with impulsiveness and with ADHD showed greater use of the left foot. For instance impulsiveness participants reduced the use of right foot to 78.7% for kicking a ball and 70.2% for touching a ball, and ADHD participants decreased the use of right foot to 71.4% for both actions of kicking and touching a ball.

The administration of the PATHoops task revealed two interesting data, one related to the foot that the participants used to start the task (**Table 4**) and the description that they give to how to perform the entire task (**Table 5**). **Table 4** shows that non-impulsiveness, impulsiveness and ADHD participants use the right foot 76.4, 53.1, and 71.4%, respectively.

Complementarily, **Table 5** distinguishes the participants who complete the entire task by performing a zigzag way (non-impulsiveness by 58.8%; impulsiveness by 68%; and ADHD by 28.5%) from those who perform the task describing other ways (non-impulsiveness by 41.1%; impulsiveness by 31.9%; and ADHD by 71.4%).

TABLE 2 | Item 9 UPPS- *P*, I quite enjoy taking risks vs. Impulsiveness type.

		Impulsiveness type			Total
		Impulsiveness	ADHD	Non-impulsiveness	
9.- I quite enjoy taking risks.	Disagree Strongly	0	0	0	0
	Disagree	0	0	4	4
	Disagree				
	Agree	20	2	10	32
	Strongly Agree	27	5	3	35
	Total	47	7	17	71

TABLE 3 | Skilled foot vs. Impulsiveness types.

		Impulsiveness types			Total
		Impulsiveness	ADHD	Non-impulsiveness	
Foot used to kick the ball	Right	37	5	16	58
	Left	10	2	1	13
The foot that touches the ball	Right	33	5	15	53
	Left	14	2	2	18
Total		47	7	17	71

TABLE 4 | The foot that starts the Hoops task vs. Impulsiveness type.

		Impulsiveness type			Total
		Impulsiveness	ADHD	Non-impulsiveness	
Foot to start the task	Right	25	5	13	43
	Left	22	2	4	28
Total		47	7	17	71

TABLE 5 | Decision making of the way in HOOPs vs. Impulsiveness types.

		Impulsiveness types			Total
		Impulsiveness	ADHD	Non-impulsiveness	
The Way of HOOPs	Zigzag way	32	2	10	54
	Other way	15	5	7	27
Total		47	7	17	71

Motor Behavior T-Pattern Detection

From the total participants' data, we have only obtained T-patterns in the second workout. Thus, we selected the three most relevant—not due to its complexity but because of its clarity to the motor skills performed—to explain the motor behavior of each three levels of impulsiveness. We expose these three T-patterns regarding each type of impulsiveness (**Figure 5**).

DISCUSSION

The discussion section is structured following the order of the results of the different tools that have fulfilled the Mixed Methods approach (Castañer et al., 2013; Anguera et al., 2017), which was used to obtain a broader interpretation of impulsiveness profiles and workout performances of adolescents and young adults.

Impulsiveness and Motor Behavior

The results from the Spanish version of UPPS-*P* scale showed a notable difference between the impulsiveness and the non-impulsiveness participants, mainly in the facets of lack of premeditation, positive urgency and negative urgency (Geurten et al., 2018). Most participants agreed with the idea to search for new experiences and sensation seeking. While participants with ADHD agreed with taking risks without taking care of the consequences, the other participants with impulsiveness and non-impulsiveness preferred to establish premeditation. These results corroborate with the studies of Cyders and Smith (2008) and Miller et al. (2003). The latter about young adults with ADHD that showed antisocial responses with sensation seeking without premeditation.

Questionnaires have certainly made a useful contribution in detecting the facets of impulsiveness. Nevertheless, to state how participants with diverse types of impulsiveness perform motor behaviors, they must be in a natural context (Anguera, 2003). In this sense, Anguera et al. (2012), Hudak et al. (2017) from the neurosciences field, argue that protocols developed on laboratories must be translated to real-world conditions. For this reason, this study was conducted on Physical Education settings, where an inventory of motor laterality, a task of decision-making, spatial orientation and three staggered motor situations were introduced.

Decision-Making in Body Laterality Uses and Spatial Orientation

Related to motor laterality profile of participants in the uses of the upper and lower limbs, MOTORLAT inventory revealed that only the motor skills of kicking and touching a ball with a foot showed differences between participants' impulsiveness types. Specifically, non-impulsiveness subjects used more times the right foot in both motor skills, and the impulsiveness and ADHD ones showed a higher percentage of preference for the left foot. These results support the scientific literature about left- and mixed- footedness associated with ADHD (Tran and Voracek, 2016). These authors found that mixed-footedness was not only probably associated with ADHD but also related to higher inattention and impulsiveness. Furthermore, mixed laterality can be a versatile and rich skill to perform successfully in multifaceted environments (Chapple and Johnson, 2007), and of interest to optimize the athletes' complex movements performance (Loffing et al., 2016). In this regard, previous research in football concluded that Lionel Messi—a left-footed top-player—is a good example of motor versatility as he uses successfully mixed laterality in several motor skills (Castañer et al., 2016, 2017a,b).

How can we know whether the mixed laterality optimizes or not motor behaviors? We obtained the answer to this question from the analysis of participants' decision-making used in PATHoops task, as data analysis show two interesting results: (a) the foot selected by participants to start the task and (b) the way described to perform the entire task throughout the 14 hoops. On the one hand, results obtained shows the similarity between the selected foot to start PATHoops task and MOTORLAT scores for kicking and touching a ball. For instance, non-impulsiveness participants used mainly the right foot, while the other participants chose sufficiently the left foot.

On the other hand, we consider that the participants' description of the way to perform the task, explains clearly the optimal decision-making on motor behavior to solve tasks, as in this task can be observed the decision-making of participants to complete the entire task that is, stepping quickly into all the 14 hoops without repeating anyone. As we stated, previous research demonstrated that young athletes use a zigzag way that is, covering from one wing to the other wing of the triangular figure, to perform the task skillfully (Castañer et al., 2018). In our research, results have shown that non-impulsiveness and impulsiveness participants decide sufficiently this zigzag way. On the contrary a high percentage of ADHA participants decided to perform another way, which is not so optimal to decide spatial orientation according to decision-making theories (Baker and Côté, 2003; Aguilar et al., 2018).

Performing Motor and Interactive Patterns

Results from T-patterns were obtained mainly from the second workout (i.e., one T-pattern) but none from the first workout. The fact that the first workout did not provide any motor behavior T-pattern can be logically explained due to the rules of the situation: (a) the lack of interaction and (b) the constriction to use the material only in where it was placed. In these kinds of situations, participants did not know what to do and often spotted their motor actions in isolate ways without a sense. An aspect that corroborates with researches focused on motor interaction (Aguilar et al., 2018). Similarly, the third workout (based on full interaction and use of material) that appeared very creative or motor behavior enhancing, have not produced enough

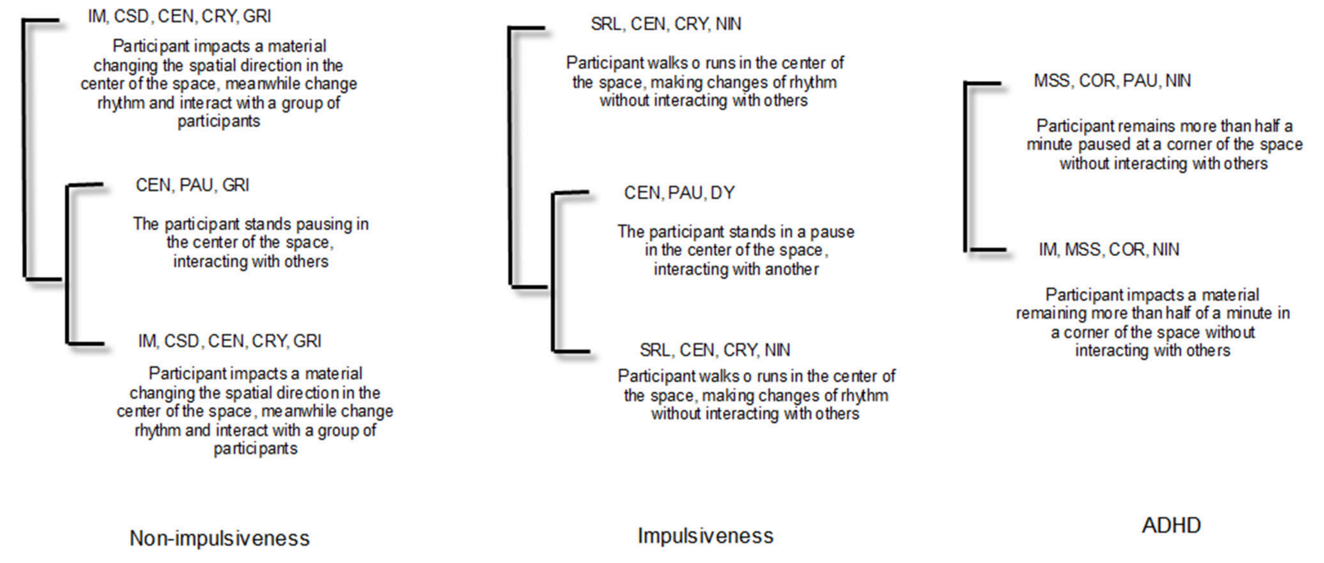

FIGURE 5 | The three most relevant T-patterns of each type of impulsiveness.

T-patterns. It seems that excess of materials, non-restrictions in the ways to use them and interacting with others are a detriment to the richness of motor behaviors (Castañer et al., 2011, 2016; Casarrubea et al., 2018).

Curiously, the T-patterns obtained from each one of impulsiveness types shows a diminishing use of interactive responses that go from (a) a continuous interaction in the group of non-impulsiveness participants; (b) a punctual dyadic interaction of impulsiveness participants to; (c) none interaction of ADHD participants. Additionally, T-patterns of non-impulsiveness and impulsiveness types offer richer combinations of motor behaviors than ADHD type. In respect to the temporal and spatial facets, non-impulsiveness and impulsiveness participants use the center of the space and perform changes of actions' rhythm. Contrarily, ADHD remained on a corner area and made pauses. All these characteristics could be related to the facet of negative urgency, which implies that impulsiveness responses are sometimes performed in an antisocial way (Cyders et al., 2007).

Merging Motor and Cognitive Processes

Cognitive processes are related to motor mechanisms and both optimize our actions. In fact, studies using neuroimaging confirmed that people with brain injuries or development disorders have a fundamental interrelationship between the motor and cognitive progressions (see Diamond, 2000, for a review). For example, brain imaging studies have shown a strong functional coupling between brain regions, which traditionally it was thought to be sustained exclusively by cognitive processes or motor ones (Stoodley, 2012). Recently, Ithas beensuggested that cognition provides the basis for many different social-cognitive skills (Gallese et al., 2009).

Moreover, studies in cognitive neuroscience have been implying the existence of a common neural mechanism that could be responsible for the actions and understandings of intention skills in both humans and non-human primates. These findings have revealed that the cortical area related to the movement of the body, which was always confined to the role of simple action, programming, and execution plays a crucial role in complex cognitive skills such as understanding the intentions and objectives of the actions.

We consider that our study adds knowledge to those research by offering a Mixed Method approach that deepens how impulsiveness can enhance optimal motor performances. However, this study has the limitation of not disposing sufficient number of ADHD participants to corroborate with more type of responses.

CONCLUSION

In this study, we pointed out a methodological and a substantive research aspect to fulfill practical implementations and theoretical approaches over impulsiveness, respectively.

Methodologically, professionals and researches should choose to apply more than a single tool (e.g., standard tests) as Mixed Methods research (Anguera et al., 2012, 2017; Camerino et al., 2012; Castañer et al., 2013) have ensured here a broader understanding of impulsiveness. In our specific case using the SUPPS-*P* scale, the MOTORLAT inventory, the PATHoops task, and the OSMOS behavior coding tool.

Related to the substantive aspect to fullfill theoretical approaches over impulsiveness, professionals such as psychologists, educators, and neuroscientists, should have in mind that impulsiveness, when not associated to deficits or disorders (e.g., ADHD), is far to be considerate negative and frequently optimize motor situations. In fact, sportsmen with impulsiveness characteristics enhance: (a) richness of motor skills and spatial interpretations (Castañer et al., 2018); (b) richness of motor patterns in open motor situations (Aguilar et al., 2018), as they enhance technical and tactical strategies in sport teams (Castañer et al., 2017a); (c) and interpersonal interaction (Kang et al., 2011). In sum, we would point out that cognitive processes are closely related to motor ones and both of them seem to improve the driving cognitive optimization that is acquired throughout evolutionary stages.

AUTHOR CONTRIBUTIONS

MC developed the project, supervised the design of the study, the method section and the drafting of the manuscript. QP was responsible for the review of the literature. JA and BE collected and codified the data. OC was responsible for the critical revision of the content and data analysis. TF supervised the drafting of the manuscript. All authors approved the final, submitted version of the manuscript.

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Educational Responses to Students With High Abilities From the Parental Perspective

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Students who have high abilities demand educational responses, both inside and outside of the classroom. The best type of educational strategy depends on the characteristics of the students, the school, the educational system, and the country. For this reason, the level of attention paid to high-ability students can vary across nations. To guarantee the efficacy of programs that are implemented both inside and outside of school, it is essential to offer to these students the support that they need. The students' parents are a fundamental component of this scenario. This study evaluates the educational support provided to students with high abilities from a parental perspective. This study's aim is to evaluate the opinions that parents in several countries hold about the educational responses to gifted students, as well as to compare the types of strategies implemented in these countries' respective educational systems. Parents of students with high abilities completed an *ad hoc* online questionnaire that was designed to identify the types of educational responses, the students' participation in enrichment programs (inside and outside of school), the parents' level of satisfaction with these programs, and any difficulties or problems that occurred. A mixed methodology was used, with both quantitative and qualitative survey questions. ALCESTE software was used to analyze the open-ended (qualitative) questions. This research, which was directed by the Network of Research, Intervention and Evaluation in High Intellectual Abilities, focused on three countries: Mexico, Argentina, and Spain. Descriptive analysis were carried out for analyzing the questions related with the educational support and demographic information. Qualitative analysis were used to analyze open-ended questions. The results provide evidence on which types of educational responses are being implemented in those countries, how they are being used, and whether they offer appropriate support for the needs of high-ability students.

Keywords: educational response, students with high abilities, parents, questionnaire, educational system

INTRODUCTION

Students with high intellectual abilities constitute a highly heterogeneous group, which is why there is no consensus about the characteristics that define them (López Andrada et al., 2000; Colangelo and Davis, 2003; Pérez, 2006; Matthews and Yun Dai, 2014). However, these students' cognitive functioning differs from that of their normative peer (Sastre-Riba and Domenech, 1999; Sastre-Riba, 2008). Researchers have confirmed that students with high intellectual abilities have cognitive activity that is characterized by high learning speed, good capacity for (and flexibility in) understanding and solving complex problems, high efficiency at generating new strategies to solve each problem, and intellectual precocity (Sastre-Riba and Domenech, 1999; Cross and Coleman, 2005; Van Tassel-Baska, 2013; Verche et al., 2018). According to Geake (2009), these traits can be explained by this group's greater plasticity and efficiency, which contribute to extensive attentional processes that facilitate the management of cognitive performance through working memory, flexibility, and inhibition (Sastre-Riba and Viana-Sanz, 2016; Sastre-Riba and Ortiz, 2018; Rodríguez-Naveiras, in preparation).

With regard to high-ability students' cognitive needs, three educational responses can be distinguished, according to the classification established by Southern and Jones (2004): acceleration, enrichment, and grouping. Researchers have described the characteristics of each of these strategies in depth (e.g., Colangelo and Davis, 2003; Colangelo and Assouline, 2009; Subotnik et al., 2011; Tourón, 2012; Elices et al., 2013).

Briefly, the acceleration response consists of promoting students' educational advancement at a higher speed than regulations typically allow; the enrichment response involves the implementation of activities or programs that add depth to certain aspects of the curriculum; finally, the grouping response consists of providing students with full-time or part-time education separate from their regular classrooms; or to create different groups within the classroom according to the level or ability of the students. These educational strategies have all been implemented in many countries for years. However, their effects on participants are still under investigation. Recently, with regard to the effects of participating in enrichment programs, researchers have reported positive results at the personal and academic levels (Borges et al., 2016a, 2017; Kim, 2016; Rodríguez-Naveiras and Borges, 2016; Cadenas and Borges, 2017; Jen, 2017; Jen et al., 2017; Rodríguez-Dorta et al., 2017). Similarly, researchers have identified the benefits of acceleration (Colangelo et al., 2004; Kulik, 2004; Jiménez et al., 2006; Hoogeveen, 2008; Colangelo and Assouline, 2009; Hoogeveen et al., 2012). Finally, full-time education in specialized centers also represents an adequate option, as it has produced positive results in terms of academic performance and development (Pérez, 2012; Tourón, 2012), with a greater presence outside Spain.

The types of strategies that should be carried out depend on the student, the school, the family, the educational system and, of course, the country's legislation. Choosing a strategy is a decision of vital importance, and it requires the rigor and scientific basis that research can provide.

All the countries involved on this research have current legislation that relates to students with high intellectual abilities. Spain's Organic Law (Ley Orgánica 2/2006, del 3 de mayo de Educación) (LOE)[1], obligates school administrations to adopt measures that allow for the optimal development of these students capacities. In addition, the Span's Organic Law (Ley Orgánica 8/2013, de 9 de diciembre)[2], relates to improving educational quality for these students; it modifies the previous law.

In Mexico, the Ministry of Education (SEP, 2006) proposed that enrichment be applied in the classroom to serve high-ability students. Subsequently, in 2013, children were allowed to attend school before the standard age or to advance by a grade level if there was reason to support such actions. In 2017, the General Education Law was modified to create a full-time education program for the gifted population.

Argentina first considered the education of children with high abilities in 1992 with the approval of the Federal Law of Education (Ministerio de Educación, 1993). Currently, the National Education Law is in force; it proposes that programs be designed for the identification, early evaluation, monitoring, and orientation of high-ability students, as well as to allow those students greater flexibility.

It is worth highlighting that, in these countries, even though there are laws that regulate the attention provided to these students, there is still a long way to go before every student receives the education they need. A previous study confirms this idea (Borges et al., 2016b) where 274 parents from different nationalities with children with high abilities completed a survey about the type of educational intervention received. Results obtained showed that the 57% of the sample responded their children did not receive any sort of educational response at school. Specifically, in Spain in the 2016–2017 school year, out of all 8,135,876 students enrolled from preschool through high school, only 27,133 (0.33% of the total enrolled) received such an intervention (Ministerio de Educación y Formación Profesional, 2017). Similarly, in Mexico in the 2017–2018 academic year, there were 14,020,204 primary-school students, but only 107,365 pupils received educational support, that is, 0.7% (SEP, 2018). These are striking figures considering that the proportion of gifted students—understood as being those with an intellectual quotient $\geq$130—should be approximately 2%; this proportion increases to between 10 and 20% if the focus is on talents instead of intellect (Hernández and Gutiérrez-Sánchez, 2014).

The family plays a fundamental role in the development of children with high intellectual abilities. One of the most prominent and relevant models in this framework is Brofenbrenner's (1976) ecological model (see also Bronfrenbrenner and Morris, 1998; Arranz, 2005; Bronfenbrenner, 2005). This model identifies the systems that can affect both a person's development and his or her behavior. Of special relevance is the microsystem, which is defined by a

[1] Ley Orgánica 2/2006, 3 de Mayo de Educación (LOE), BOE, n°106, 4 de mayo de 2006.

[2] Ley Orgánica 8/2013, de 9 de diciembre, para la mejora de la calidad educativa, BOE, n°295, 10 de diciembre de 2013.

person's interaction with his or her family and close friends. Within the family context, this model distinguishes between two types of influential variables: ecological (e.g., socioeconomic status or parental age) and interactive (e.g., parental educational style). Researchers have studied how factors such as culture and socioeconomic level relate to the diagnosis of high capacities (Miller and Gentry, 2010; Castellanos Simons et al., 2015), and they have found that students from medium and medium-high socioeconomic status are more likely than those of lower status to be diagnosed with high intellectual abilities. The family context is also of great relevance in the theoretical models that seek to explain the origin and development of high intellectual capacities from a systemic perspective (Tannenbaum, 1986; Mönks, 1992; Ziegler, 2005; Ziegler and Phillipson, 2012; Gagné, 2015). However, only a few researchers have addressed the education of high-ability students from the parental perspective (Garn et al., 2010, 2012; Cadenas and Borges, 2012; Weber and Stanley, 2012; Garn and Jolly, 2015; Rodríguez-Naveiras and Borges, 2016; Borges et al., 2017; Rodríguez-Dorta et al., 2017).

This work is intended to address parents' opinions of the educational responses that their children receive. The specific objectives of the study are (1) to examine parents' understanding of educational responses; (2) to detect which types of educational responses are implemented and what parents believe about them; and (3) to identify the problems that both parents and children have in relation to the children's schools.

TABLE 1 | Description of the participants.

	N	%
Gender		
Male	31	12.8
Female	212	87.2
Country		
Spain	128	52.7
Mexico	86	35.4
Argentina	29	11.9
Highest level Of education completed		
Primary school	11	4.5
High school	62	25.5
Undergraduate degree	109	44.9
Master's degree	45	18.5
PhD degree	16	6.6
Number of children diagnosed		
1	66	27.2
2	149	61.3
3	24	9.9
4	3	1.2
5	1	0.4

%, percentage.

MATERIALS AND METHODS

Methodology and Design

This research used a mixed methodology (Johnson and Onwuegbuzie, 2004; Denscombe, 2008). The data were collected using a cross-sectional design based on a survey composed of open-ended questions that allow for qualitative analysis.

Participants

The participants in this research comprised 243 Spanish-speaking parents. Most of the participants were from Spain (52.7%), and the remainder were from Mexico (35.4%) or Argentina (11.9%). The mean (standard deviation) age of the participants was 41.42 (5.49) years, and 87.2% of the parents were female. Regarding the participants' educational level, 44.9% had an undergraduate university degree but not a graduate degree, and another 25.5% went to High School. Finally, 27.2% of the participants had one child who had been diagnosed with high abilities, and 61.3% had two such children. The data for gender, nationality, level of education, and number of children diagnosed are shown in **Table 1**.

Instruments

An *ad hoc* online questionnaire was designed to collect the data; it consists of 68 open-ended and closed-ended questions on the following aspects: the diagnosis, the type of educational response, the children's participation in intra- and extracurricular programs, the degree of satisfaction with the intervention programs, and the difficulties encountered. For this study, 16 of the 68 total items were selected for analysis. The complete version of the survey in Spanish and the translation of each item into English is presented in **Table 2**. The quantitative and qualitative items analyzed are presented in **Table 3**.

Procedure

The University of La Laguna's Ethics Committee of Research and Animal Welfare has approved this research (registration number CEIBA2018-0300). In addition, the Network for Research, Intervention and Evaluation in High Intellectual Capabilities-REINEVA (http://reineva.gtisd.net/) participated in the dissemination of the questionnaire; this group's objective is to integrate specialists who are interested in studying high-ability children. The data-collection process began in May 2018 and ended in October of the same year.

The questionnaire was answered by adults over the age of 18 who are parents of children with high capacities. The questionnaire was filled in online; by answering it participants gave informed consent. Additionally, the aim of the research was included before completing the survey. This questionnaire is totally anonymous and no personal information was requested. We asked the parents' opinion of the educational response to their diagnosed children.

Once the data were collected, the participants were selected based on the filter question, "Which of the following labels has the school applied to your child?" Only the parents who listed a label of gifted on this question were considered.

After the data collection the analysis previously described were carried out with the answers of the participants in their mother tongue (Spanish). After the analysis, the results were translated into English.

TABLE 2 | Survey items.

Dimension	Spanish survey	English survey
Identification variables	Edad	Age
	Sexo	Gender
	País	Country
	Nivel de estudio	Educational level
	Profesión/ocupación	Profession/Occupation
	Número de hijos/as	Number of children
Definition	¿Qué entiende usted por alta capacidad/superdotación/talento?	What do you understand by high capacity/giftedness/talent?
Diagnosis	¿Se ha diagnosticado a alguno de sus hijos con alguna de estas etiquetas (señalar la que se le haya dado)? Altas capacidades Superdotación Sobredotación Alumno/a sobresaliente Talento No Otro	Have any of your children been diagnosed with any of these labels (indicate which of them)? High capacities Giftedness Outstanding student Talented None Other
	1. ¿Cómo considera usted que debería hacerse el diagnóstico de altas capacidades/ superdotación/talento?	1. How do you consider the diagnosis of high abilities/giftedness/talent should be made?
	2. ¿A cuántos de sus hijos se ha diagnosticado de alta capacidad/superdotación/talento?	2. How many of your children have been diagnosed with high ability/giftedness/talent?
Educational response	3. ¿Considera que debería recibir una atención dentro de la escuela acorde a sus capacidades? Si No	3. Do you think you should receive care within the school according to your abilities? Yes No
	4. En caso afirmativo, ¿de qué tipo?	4. If the answer is yes, please mention what kind
Diagnosis	5. Edad del primer hijo/a diagnosticado	5. Age of the first diagnosed child
	6. Sexo del primer hijo/a diagnosticado Varón Mujer	6. Gender of the first diagnosed child Male Female
	7. ¿Qué profesional (incluir la titulación) realizó el diagnóstico?	7. What professional (please include the degree) did the diagnosis?
	8. ¿Qué opinión le merece el diagnóstico realizado a su hijo/a?	8. What is your opinion of the diagnosis made to your child?
	9. En cuanto al tiempo transcurrido desde la detección (cuando alguien consideró que podía ser de altas capacidades, hasta que se le pasaron las pruebas para determinar el diagnóstico), usted está: 1. Nada de acuerdo 2. En desacuerdo 3. Ni de acuerdo ni en desacuerdo 4. De acuerdo 5. Totalmente de acuerdo	9. Regarding the time elapsed since the detection/diagnosis (when someone considered that he/she could be of high abilities, until he/she passed the tests to determine the diagnosis), what are your feelings: 1. Totally disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Totally agree
	10. En cuanto a la capacidad profesional de quienes realizaron el diagnóstico, usted está: 1. Nada de acuerdo 2. En desacuerdo 3. Ni de acuerdo ni en desacuerdo 4. De acuerdo 5. Totalmente de acuerdo	10. Regarding the professional capacity of those who carried out the diagnosis, what are your feelings: 1. Totally disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Totally agree
	11. En cuanto a las pruebas pasadas para diagnosticar las altas capacidades, usted está: 1. Nada de acuerdo 2. En desacuerdo 3. Ni de acuerdo ni en desacuerdo 4. De acuerdo 5. Totalmente de acuerdo	11. As for the tests and exams to diagnose the high capacities, you feel? 1. Totally disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Totally agree

(Continued)

TABLE 2 | Continued

Dimension	Spanish survey	English survey
	12. En cuanto a la claridad del informe del diagnóstico, usted está: 1. Nada de acuerdo 2. En desacuerdo 3. Ni de acuerdo ni en desacuerdo 4. De acuerdo 5. Totalmente de acuerdo	12. Regarding the clarity of the diagnosis report, you feel: 1. Totally disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Totally agree
Parent's problems with the school	14. ¿Ha tenido usted problemas con la escuela referidos a su hijo/a? Si No	14. Have you had problems with the school regarding your child? Yes No
	15. ¿Qué tipo de problema?	15. What type of problems?
	16. ¿Con quién? Equipo de orientación del centro educativo (o equipo de psicopedadagogía USAER) Dirección Profesorado Tutor/a Compañeros/as Otros progenitores Otro	16. With whom? Orientation team of the educational center (or USAER psychopedagogical team) Principal Faculty Tutor Companions Other parents Other
Children's problems at school	17. ¿Ha tenido su hijo/a problemas con la escuela? Si No	17. Has your child had problems with school? Yes No
	18. ¿Qué tipo de problema?	18. What type of problems?
	19. ¿Con quién? Servicio de orientación Dirección Profesorado Tutor/a Compañeros/as Otros progenitores Otro	19. With whom? Orientation team of the educational center (or USAER psychopedagogical team) Principal Faculty Tutor Companions Other parents Other
Educational response within the school	20.¿Ha recibido una respuesta educativa dentro de la escuela acorde a sus necesidades? Si No	20. Have you received an educational response within the school according to your needs? Yes No
	21. ¿En qué consiste la respuesta educativa que se le da en la escuela? Aceleración Agrupamiento total (todas las clases las recibe con alumnado exclusivamente de altas capacidades) Agrupamiento parcial (algunas clases las recibe con alumnado exclusivamente de altas capacidades) Enriquecimiento Adaptación curricular Otro	21. What is the educational response that is given in school? Acceleration Total grouping (all classes receive them with exclusively high-ability students) Partial grouping (some classes receive them with exclusively high-ability students) Enrichment Curricular adaptation Other
	22. ¿Cuánto tiempo tardó en tener una respuesta educativa (especificar meses o años)?	22. How long did it take to have an educational response (specify months or years)?
	23. ¿Cuánto tiempo hace que comenzó la respuesta educativa que ha recibido su hijo/a? (Especificar meses o años)	23. How long ago did the educational response your child received begin? (Specify months or years)
	24. ¿Lo sigue recibiendo aún?	24. Do you still receive it?
	25. ¿Por qué?	25. Why?
	26. Fecha de finalización (mes y año)	26.Date of completion (month and year)
	27. En cuanto a la temporalización (cuándo se desarrolla) 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	27. Regarding timing (when it develops), you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied

(Continued)

TABLE 2 | Continued

Dimension	Spanish survey	English survey
	28. En cuanto al profesorado que lo implementa 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	28. In terms of the faculty that implements it, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	29. En cuanto a los contenidos que recibe 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	29. Regarding the contents received, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	30. ¿El programa le ayuda a obtener mejores calificaciones escolares? Si No	30. Does the program help you get better grades? Yes No
Educational response out of the school	31. ¿Participa (o ha participado) en algún programa extra escolar? Si No	31. Do you participate (or have you participated) in any extra-curricular program? Yes No
	32. Tipo de programa Cognitivo Socioafectivo Ambos No sabe	32. Type of extra-curricular program: Cognitive Socio-affective Both Do not know
	33.Nombre del programa	33.Program name:
	34. ¿Quién lo organiza?	34. Who organizes it?
	35. ¿Cuánto tiempo hace que comenzó a asistir al programa extraescolar (meses o años)	35. How long since you started attending the after-school program (months or years)?
	36. ¿Aún participa? Sí No	36.Are you still participating? Yes No
	37. ¿Por qué?	37. Why?
	38. Fecha de finalización (mes y año)	38. End date (month and year)
	39. En cuanto a la temporalización (cuándo se desarrolla): 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	39. Regarding timing (when it develops): 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	40. En cuanto al profesorado que lo implementa 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	40. Regarding the teaching staff that implements it 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	41. En cuanto a los contenidos que recibe 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	41. In terms of the content received 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	42. ¿El programa le ayuda a obtener mejores calificaciones escolares? Si No	42. Does the program help you get better grades? Yes No
	43. ¿Lo recomendaría a otras familias? Si No	43. Would you recommend it to other families? Yes No

(Continued)

TABLE 2 | Continued

Dimension	Spanish survey	English survey
	44. ¿Por qué?	44. Why?
	45. ¿El programa tiene también un programa para progenitores? Si No	45. Does the program also provide a parent program? Yes No
	46. En cuanto a la temporalización (cuándo se desarrolla) 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	46. Regarding timing (When it develops), you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	47. En cuanto al profesorado que lo implementa 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	47. Regarding the faculty that implements it. You feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	48. En cuanto a los contenidos que recibe 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	48.As for the content received, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	49. En cuanto a la aplicación del programa en su labor como progenitor 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	49.Regarding the application of the program work as a parent, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	50. ¿Participa en otro programa extraescolar para altas capacidades? Si No	50. Do you participate in another after-school program for high abilities? Yes No
	51. Tipo de programa Cognitivo Socioafectivo Ambos No se sabe	51. Type of program? Cognitive Socio-Affective Both Do not know
	52. Nombre del programa	52. Program name:
	53. ¿Quién lo organiza?	53. Who organizes it?
	54. ¿Cuánto tiempo hace que comenzó a asistir al programa extraescolar (meses o años)	54. How long ago did you start attending the after-school program (months or years)?
	55. ¿Aún participa?	55. Are you still participating?
	56. ¿Por qué?	56. Why?
	57. Fecha de finalización (mes y año)	57. End date (month and year)
	58. En cuanto a la temporalización (cuándo se desarrolla) 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	58. Regarding timing (when it develops), you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	59. En cuanto al profesorado que lo implementa 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	59. Regarding the faculty that implements it, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied

(Continued)

TABLE 2 | Continued

Dimension	Spanish survey	English survey
	60. En cuanto a los contenidos que recibe 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	60. Regarding the contents received, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	61. ¿El programa le ayuda a obtener mejores calificaciones escolares? Si No	61. Does the program help you get better grades? Yes No
	62. ¿Lo recomendaría a otras familias? Si No	62. Would you recommend it to other families? Yes No
	63. ¿Por qué?	63. Why?
	64. ¿El programa tiene también una sección para padres? Si No	64.Does the program also have a section for parents? Yes No
	65. En cuanto a la temporalización (cuándo se desarrolla) 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	65. Regarding timing (when it develops), you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	66. En cuanto al profesorado que lo implementa 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	66. Regarding the teaching staff that implements it, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	67. En cuanto a los contenidos que recibe 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	67. Regarding the contents received, you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied
	68. En cuanto a la aplicación del programa en su labor como progenitor 1. Nada satisfecho 2. Insatisfecho 3. Ni satisfecho ni insatisfecho 4. Satisfecho 5. Totalmente satisfecho	68. Regarding the application of the program work as a parent you feel: 1. Not satisfied 2. Dissatisfied 3. Neither satisfied nor dissatisfied 4. Satisfied 5. Completely satisfied

Data Analysis

The quantitative analysis was carried out using SPSS software (version 23). To determine the relationship between the variables and the participants' country, Cramer's *V* coefficient was also calculated.

The qualitative analysis was performed using ALCESTE software (Reinert, 2003). Use of this program has been widely described (Illia et al., 2014; Courtinat-Camps et al., 2017; Zambrano, 2017).

ALCESTE is a software developed by Reinert in 1986 which uses statistical procedures to perform textual analysis to extract the essential information from a text. The aim is to identify and quantify the strongest structures from a text. The program uses a statistical procedure which clusters groups of text through chi square. Additionally, it extracts a correspondence factorial analysis.

This methodology focusses in the statistical distribution of series of words which composes the statements of a text, taking into account the co-ocurrence, that is, the simultaneous presence of several words (nouns, adjectives and verbs), removing the analysis of prepositions or conjunctions, etc. The objective is to differentiate the most significant lexical worlds (main groups of words which have a repetitive pattern throughout the text and with a similar meaning).

The unit of analysis is the Unit of Elementary Context (UEC) which corresponds with the main idea of the sentence with 8 or 20 words by UEC (De Alba, 2004). This procedure permits to

TABLE 3 | List of selected quantitative and qualitative items.

Number	Question and possible responses
QUANTITATIVE QUESTIONS	
Filter question 3	Have any of your children been diagnosed with any of these labels (indicate which of them)? Answer: High capacities/ Giftedness /Outstanding student/Talented/None/Other.
3	Do you think you should receive care within the school according to your abilities? Answer: yes/no
14	Have you had problems with the school regarding your child? Answer: yes/no
17	Has your child had problems with school? Answer: yes/no/no answer
20	Have you received an educational response within the school according to your needs? Answer: yes/no/no answer
21	What is the educational response that is given in school? Answer: Acceleration/Total grouping (all classes receive them with exclusively high-ability students)/ Partial grouping (some classes receive them with exclusively high-ability students)/ Enrichment/ Curricular adaptation/Other
22	How long did it take to have an educational response (specify months or years)?
27-29	What is your degree of satisfaction with the support that your child receives (or has received) with regard to each of the following? timing faculty content Answer: Not satisfied/Dissatisfied/Neither satisfied nor dissatisfied/Satisfied/ Completely satisfied
30	Does the program help you get better grades? Answer: yes/no/no answer
31	Do you participate (or have you participated) in any extra-curricular program? Answer: yes/no/no answer
32	Type of extra-curricular program: Answer: Cognitive/Socio-Affective/Both /Do not know
Number	**Question**
QUALITATIVE QUESTIONS	
4	Do you think you should receive care within the school according to your abilities? If the answer is yes, please mention what kind
15	What kind of problems? (parent)
17	What kind of problems? (child)

discover relations between lexical universes. The co-ocurrence is by association of proximity.

One of the advantages of this software is that it is not a person who codifies, like in other programmes as Atlas-ti. On the contrary, it is the software which establishes connections using statistical procedures (Bauer, 2003). The main advantages of ALCESTE (Illia et al., 2014) are: a researcher does not impose his/her interpretation of which part of the text is different from or similar to others. For this reason, human bias is controlled. It is really useful when it is necessary to analyze large passages of text. This procedure has been used in different topics like the study of diagnosis of Down Syndrome (Torres and Maia, 2009), in health psychology (Parrello and Osorio-Guzmán, 2013) and, specifically in gifted education (Villate and De Leonardis, 2012; Courtinat-Camps et al., 2017).

TABLE 4 | Educational responses to high-capacity students, by country.

Country	Educational response	
	Yes	No
Spain	98	30
Mexico	63	23
Argentina	22	7

RESULTS

To answer the first objective of this research, two questions have been posed: if they consider that they should have a specific educational response and, if so, what they think it should be. In response to the first question, the parents mostly consider that these students should receive a specific educational response, since only 4 of the 244 interviewees (1.6% of the total) disagree.

Once the parents' opinions on the educational response that their children of high abilities have been analyzed, it was asked if their children had received an educational response according to their needs. Only 60 responded affirmatively, representing 24.7% of the sample interviewed. There is no significant association between educational response and country of origin (Cramer's $V = 0.36$, $p = 0.857$). The distribution of educational response according to the countries studied is presented in **Table 4**.

To know the opinion that parents have regarding the educational response that their children should receive, we carried out two analyses using ALCESTE, one for which their children receive specific training and those that do not.

In the first case, the analysis yields three classes, which classify 41 Elementary Contextual Units (ECUs), explaining 65% of the corpus. A dendrogram is shown in **Figure 1**. There are two different types of class: class 1, more unspecific, and class 2 and 3, related with common educational interventions in the education of students with high intellectual abilities.

The class that groups the most ECUs is 1, with 17 ECUs, which represents 41.46% of the ECUs, called Way of Working. The most representative word is *work*. Examples:

La forma de trabajar para estos niños es importante. no puede ser algo repetitivo, se aburre. debiera tener motivación para centrarse en el trabajo

The way of working for these children is important. it cannot be repetitive, he/she gets bored. should be motivated to focus on work ($chi^2 = 9$)

importante integrarlo en trabajo en grupos, que pueda ver que otras personas les pueden aportar cosas

important to integrate him/ her in working groups, that he/she can see that other people can contribute ($chi^2 = 9$)

Class 2 groups 14 ECUs, which represents 34.15% of them. It is called Curricular Adaptation and the most representative word is *adaptation*. Examples of phrases are:

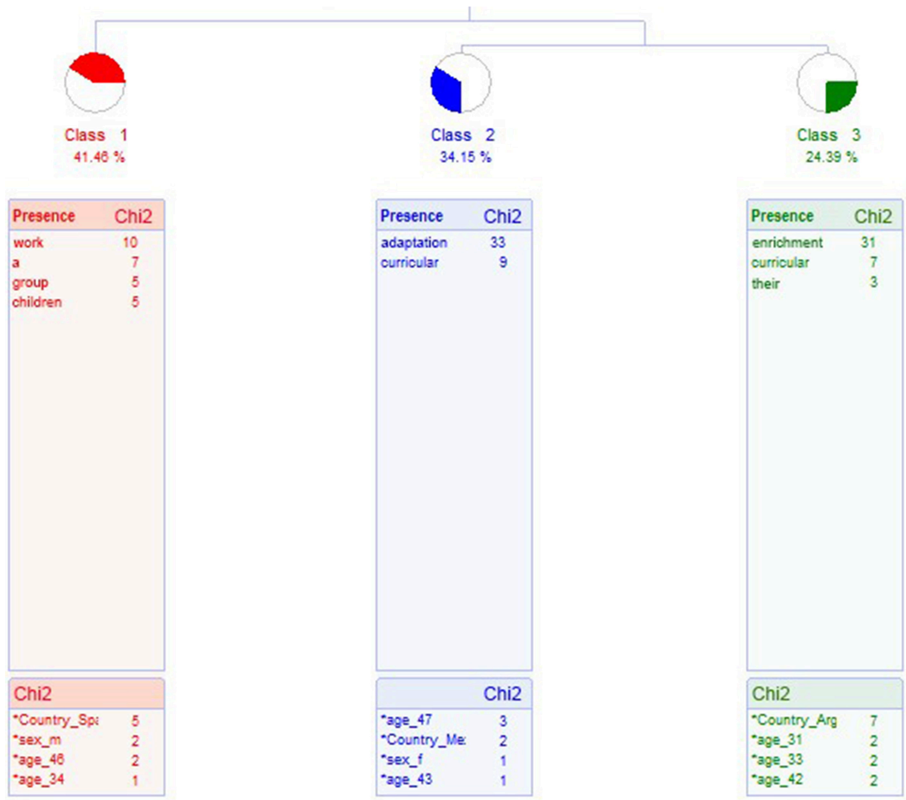

FIGURE 1 | Dendrogram about what may be the educational response for high ability. Parents whose children receive an educational response for their talent.

todo esto aparte de la flexibilizacion y la adaptación curricular

all this besides flexibilization and the curricular adaptation ($chi^2 = 6$)

adaptación curricular

curricular adaptation ($chi^2 = 6$)

Class 3 groups 10 ECUs, which represents 24.39% of them. It is called Curricular Enrichment and the most representative word is *enrichment*. Examples of ECUs are:

enriquecimiento curricular y flexibilizacion en areas concretas

curricular enrichment and flexibilization in concrete areas ($chi^2 = 3$)

enriquecimiento curricular

curricular enrichment ($chi^2 = 3$)

Parents were asked about the type of educational response received by their children, the time elapsed between the diagnostic and the educational response, as well as the assessment made by both the teachers who implement the programs and the content they receive. The results by countries, as well as the relationship between the variables analyzed, are presented in **Table 5**.

Educational Response

In the case of parents whose children do not receive an educational response, the analysis of ALCESTE yields five classes, which classifies 141 ECUs, which constitutes 76% of the corpus (see the dendrogram in **Figure 2**). There is a first axis with class 1, which is related specifically to class 2, with class 3, which links with classes 4 and 5.

Class 1 groups 54 ECUs, which explain 38.30 % of the ECUs. The most representative word is curricular, and is called Traditional Educational Response in Talent. Examples of this class are the following phrases:

adaptacion curricular y/o aceleracion de curso.

curricular adaptation and/or acceleration of year ($chi^2 = 11$)

adaptacion curricular, enriquecimiento.

curricular adaptation, enrichment ($chi^2 = 11$)

Class 2, Special Pace, groups 17 ECUs, which represents 12.88% of the ECUs. The most representative word is *Pace*, gathering phrases of which the following are examples:

necesitaría otra forma de aprender y poder relacionarse con sus iguales intelectuales además de ampliar materia

would need another way of learning and being able to relate to their intellectual equals in addition to expanding subject ($chi^2 = 10$)

poder crecer intelectualmente a su ritmo

to be able to grow intellectually at his/her own pace ($chi^2 = 8$)

Class 3 groups 15 ECUs, and represents 7.8 % of them. It is called Boredom and the most representative word is *boredom*. Examples of phrases are indicated below.

adaptar las tareas, ya que el niño/a se puede llegar a aburrir en clase.

adapt the tasks, since the child can get bored in class ($chi^2 = 25$)

TABLE 5 | Characteristics of the educational response.

	Country				
	Spain	**Mexico**	**Argentina**	**Cramer's V**	***p***
TYPE OF EDUCATIONAL RESPONSE					
Acceleration	4	2	0	0.224	0.419
Enrichment	9	6	0		
Full gifted education	2	1	0		
Several	15	14	7		
TIME REQUIRED TO RECEIVE AN EDUCATIONAL RESPONSE					
Less than 1 month	16	6	4	0.211	0.498
Up to 3 months	3	4	1		
3 to 6 months	2	3	1		
More than 6 months	9	10	1		
EVALUATIONS OF THE TEACHERS WHO IMPLEMENT THE EDUCATIONAL RESPONSES					
Strongly disagree	4	1	0	0.177	0.876
Disagree	1	1	0		
Neither agree nor disagree	5	6	2		
Agree	14	9	4		
Strongly agree	6	6	1		
ASSESSMENTS OF THE CONTENT OF THE EDUCATIONAL RESPONSES					
Strongly disagree	3	0	0	0.315	0.157
Disagree	1	3	0		
Neither agree nor disagree	8	2	3		
Agree	10	14	3		
Strongly agree	8	4	1		

si ya sabe hacer algo explicarle otra cosa aun no se haya dado todavía. mayormente porque se aburren (Individu n° 48 *sex_f *age_43 *Country_Spain)

If he/she already knows how to do something, explain something else that has not happened yet. mostly because they get bored (chi^2 = 25)

Class 4, Encourage Interest, groups 23 ECUs, which represents 16.31 % of the ECUs. The most representative word is *interes*t. Phrases that are collected in this class are presented below.

un enriquecimiento suficiente para q el alumno mantenga su interés por ir a la escuela.

enough enrichment for the student to maintain interest in going to school (chi^2 = 15).

involucrándole en un estilo de aprendizaje que estimule su interés.

involving him or her in a learning style that stimulates their interest (chi^2 = 15).

Class 5, Special Needs, include 17 ECUs, representing 12.06% of the corpus. The most representative phrase is *case*. Below are phrases belonging to this class.

cada niño tiene unas necesidades diferentes. adaptarse a ellas.

each child has different needs. adapt to them (chi^2 = 18)

aquella que necesite cada niño, no todos son iguales, ni necesitan la misma atención.

the one that each child needs, not all are equal, nor need the same attention (chi^2 = 18).

Out of School Educational Response

Other educational response is implemented out of school. In terms of attendance at out of school programs, more than half have received this type of intervention (58%, 141 of the participants). In 30% of the cases, they combine the enrichment programs within the classroom without the school programs as educational response, while 11.93% only receive intra-school programs. It should be noted that 12.75% of those interviewed said they did not receive any type of educational response.

With regard to participation in out of school programs analyzed by the three participating countries (see **Table 6**), there is a significant relationship (Cramer's V = 0.248, $p = 0.001$), since in Spain and Mexico it is more frequent to participate in these programs, unlike in Argentina.

Parents' Problems With the School

Seventy percentage of the parents have had problems with the school, with no relationship between this variable and the country of origin: (Cramer's = 0.133, $p = 0.117$). The results by country are shown in the **Table 7**.

The problems with the school have occurred even when there has been an educative response: of the 170 parents who reported having problems with the school (69.67%), 26 of them received an educational response (10.66%).

Answering about with whom or who have had problems, most often it has been with several members of the school. The relationship between who has had problems and country is significant Cramer's V = 0.215, $p = 0.047$, since Spaniards are the ones who present a higher frequency of problems with several members of the school (see **Table 8**).

To know the type of problems, an open question was carried out, analyzed with ALCESTE. It resulted in 7 classes, classifying 78% of the ECUs, which supposes 161 ECUs. A first axis is given, which links classes 1, 2 and this one with 4 and 7. Contents are related with problems with the school. The second axis relates class 3, which at the same time links to 5 and 6, to relate problems referred to the student. The dendrogram is presented in **Figure 3**.

Class 1 groups 27 units, corresponding to 16.77% of ECUs, being the most representative word *boredom*. It's called Boredom at School. Examples of phrases are:

se aburre cuando ven un tema conocido no presta atención y cuando pasan a otro el ya está distraído, le parece que todo va lento (Individu n° 41 *sex_f *age_34 *Country_Mexico)

he gets bored when they see a known topic he does not pay attention and when they pass to another he is already distracted, he thinks everything goes very slowly (chi^2 = 15)

mi hijo se aburria mucho, s portaba mal en clase, y la culpa era nuestra

my son got bored, he behaved badly in class, and it was our fault (chi^2 = 12)

Class 2 groups 26 UEC, representing 16.15% of the total of ECUs. It is called Lack of Attention to High Capacities, being the most representative word is *High*. Examples of phrases are presented below.

no atienden las altas capacidades (Individu n° 43 *sex_f *age_42 *Country_Spain)

Unité textuelle n°19 de Khi2 = 17

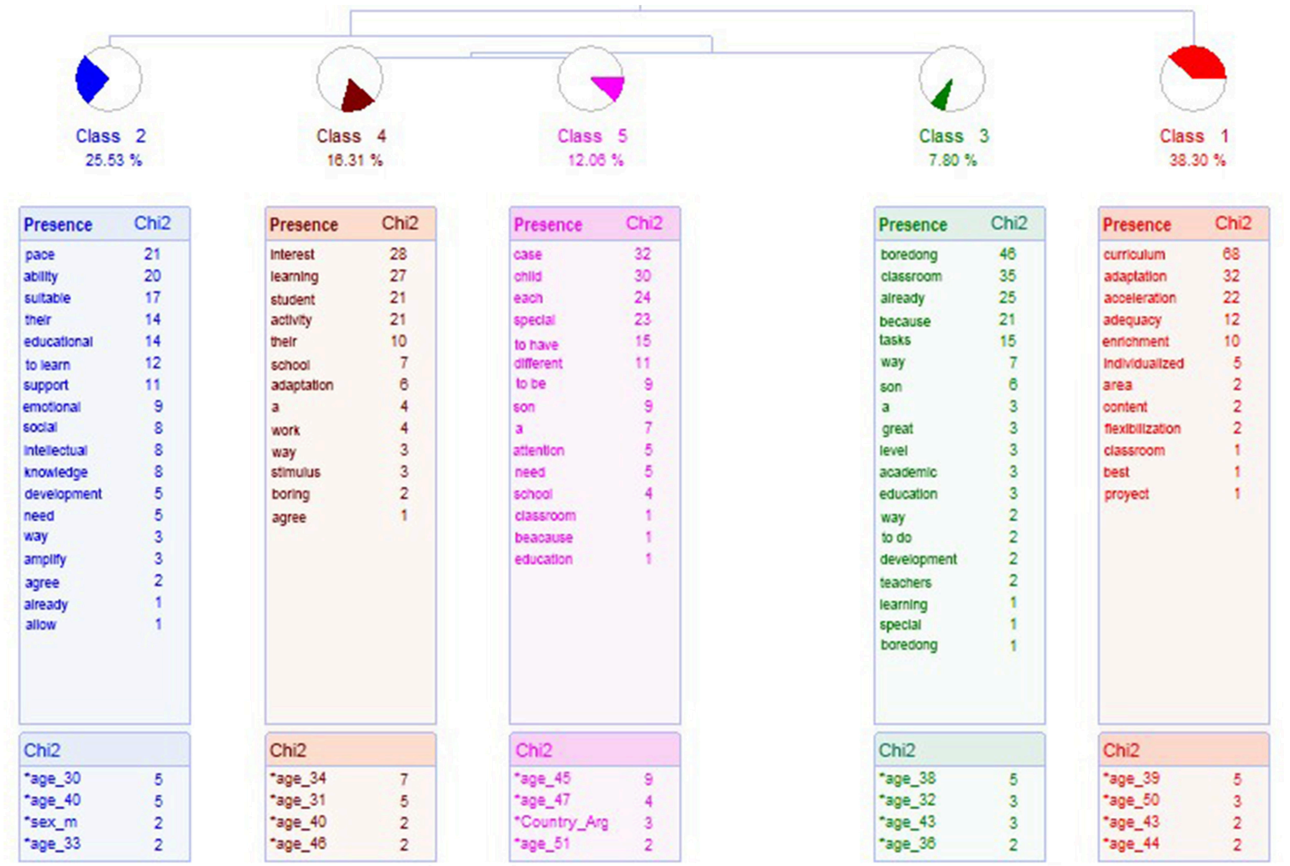

FIGURE 2 | Dendrogram about what may be the educational response for high ability. Parents whose children do not receive an educational response for their talent.

they don't take care of high abilities (chi^2 = 25)

no lo consideran alta capacidad.

they do not consider it high capacity (chi^2 = 17)

From class 2 comes an axis which connects class 4 and 7. Class 4 groups 30 ECUs, representing 18.63 of the total ECUs, resulting in the highest weight. It is denominated Lack of Interest on the Part of the School, being the most representative word is *School*, being examples of phrases the ones that are shown next.

baja disposición de una tutora. no se dio cuenta de las habilidades del niño (Individu n° 28 *sex_f *age_35 *Country_Spain)

Unité textuelle n°17 de Khi2 = 16

en la primera escuela omitir el informe privado y no entregarlo a su debido tiempo en la segunda, dar por válidas las pruebas privadas y no intervenir porque el niño va bien y no da problemas.

low disposition of his tutor. he did not realize the child's abilities (chi^2 = 20).

in the first school omit the private report and not deliver it in due time in the second, validate the private tests and not intervene because the child is doing well and does not cause problems (chi^2 = 16).

Class 7, called Lack of Attention to Student Needs. Groups 11 ECUs, that is, 6.83 %. The most representative word is *Girl*. Examples of phrases are presented below.

solo en primer y segundo grado atendieron sus necesidades (Individu n° 105 *sex_f *age_32 *Country_Argentina)

Unité textuelle n°8 de Khi2 = 26

no atendían al niño según sus necesidades y derivo en una mala conducta que le llevo a un principio de depresión.

only in the first and second grades did they meet their needs

They did not take care of the child according to their needs and it led to a bad behavior that led to a beginning of depression.

The axis that starts from class 3 connects with classes 5 and 6 and 7. Class 3 is called Bullying, group 25 UEC, which represents 15.53%. The most representative word is *Bullying*. Examples of phrases are shown in the following paragraphs.

acoso escolar por parte del alumnado. inatención y rechazo por parte del profesorado (Individu n° 73 *sex_f *age_44 *Country_Spain)

Unité textuelle n°5 de Khi2 = 29

acoso por parte de compañeros, profesores y padres.

bullying by students. Inattention and rejection by teachers (chi^2 = 36)

bullying by mates, teachers and parents (chi^2 = 29)

TABLE 6 | Participation in out-of-school programs, by country.

Country	Out-the-school programs	
	No	Yes
Spain	57	71
Mexico	25	61
Argentina	20	9

TABLE 7 | Problems that parents had with schools, by country.

Country	Problems of parents with the school	
	No	Yes
Spain	40	88
Mexico	29	57
Argentina	4	25

TABLE 8 | Members of the school community with whom the parents had problems.

Country	Problems				
	1	2	3	4	5
Spain	2	2	12	72	0
Mexico	1	1	16	37	2
Argentina	1	3	3	17	1

1: Educational and vocational services; 2: Principal; 3: Teacher or tutor; 4: several; 5: peers/other parents.

The last axis is formed by classes 5 and 6. Class 5, Lack of Attention, groups more UEC, 24, which represents 14.91% of them. The most representative word is *Lack*. The sentence examples are shown below.

no he recibido atención (Individu n° 1 *sex_f *age_50 *Country_Mexico)

Unité textuelle n°84 de Khi2 = 18

falta de respuesta y falta de rapidez.

I have not received attention ($chi^2 = 18$)

lack of response and lack of speed ($chi^2 = 18$)

Class 6 meets 18 ECUs, named Behaviors problems, represent 11.18% of the corpus, with the most representative word being *Problem*. Below are two examples of phrases of this class.

aburrimiento y problemas de conducta.

problemas con el centro, no vemos que avance adecuadamente.

boredom and behavior problems ($chi^2 = 30$).

problems with the center, we do not see-that he/she progresses properly ($chi^2 = 20$).

Children's Problems With the School

Regarding whether their children have had problems with school, 184 (75.7%) of the participants respond affirmatively. Analyzing this response by countries, it is observed that the relationship is significant: Cramer's V = 0.277, $p = 0.001$, the frequency in Mexico of problems with parents and peers being higher and in Spain with several members of the school. Results are showed in **Table 9**.

To analyze the type of problems mentioned by the children, an analysis was made with ALCESTE. It threw 7 classes, showed in the **Figure 4**, that allowed to classify 128 ECUs, which represents 68% of the corpus. First class connects to the rest with a hierarchical structure, connecting the second class with others. They are divided into the other two axes, one of them connects classes 6 and 7 and the second axis related to class 3 with a secondary axis in classes 4 and 5.

Class 1, Lack of Curricular Adaptation, groups 10 ECUs, which represents 7.81% of the corpus. The most significant word is *Curricular*. Examples of this class are shown below.

Unité textuelle n°28 de Khi2 = 37

no hicieron la adaptación curricular (Individu n° 27 *sex_f *age_35 *Country_Spain)

Unité textuelle n°127 de Khi2 = 37

no se hace adaptación curricular.

they did not do the curricular adaptation ($chi^2 = 37$)

no curricular adaptation is made ($chi^2 = 37$)

Class 2 is called Bullying, and groups 18 ECUs, which represents 14.06% of the corpus. The most representative word is *lack*. Examples of this class are presented below.

Unité textuelle n°30 de Khi2 = 24

acoso escolar, desprecio, dejadez (Individu n° 29 *sex_f *age_43 *Country_Spain)

Unité textuelle n°99 de Khi2 = 24

acoso escolar.

bullying, contempt, sloppiness ($chi^2 = 24$)

bullying ($chi^2 = 24$)

Class 3, named Behaviors Problems, include 22 ECUs (17.19% of the corpus) and the most representative word is *Behavior*. Below are two examples of phrases of this class.

Unité textuelle n°22 de Khi2 = 13

problemas de conducta (Individu n° 21 *sex_f *age_37 *Country_Spain)

Unité textuelle n°40 de Khi2 = 13

problemas de conducta.

Behavioral problems ($chi^2 = 13$)

Behavioral problems ($chi^2 = 13$)

Class 4, which is connected with class 5, is named Lack of Attention to their Needs. It has 31 ECUs, that represents 24.22% of the corpus. The most representative word is *Their*. The sentence examples are shown below.

Unité textuelle n°58 de Khi2 = 11

va al mismo ritmo de sus compañeros y se aburre (Individu n° 57 *sex_f *age_39 *Country_Spain)

Unité textuelle n°65 de Khi2 = 11

el típico ninguneo en clase y no atenderle sus necesidades.

He/she goes at the same pace as his/her mates and gets bored ($chi^2 = 11$)

the typical do not pay attention to him/her in the classroom and not attend to his needs ($chi^2 = 11$)

Class 5, teacher disinterest, represents 14.06% of the corpus, with 18 ECUs, being the main word *a. Two* examples are showed below.

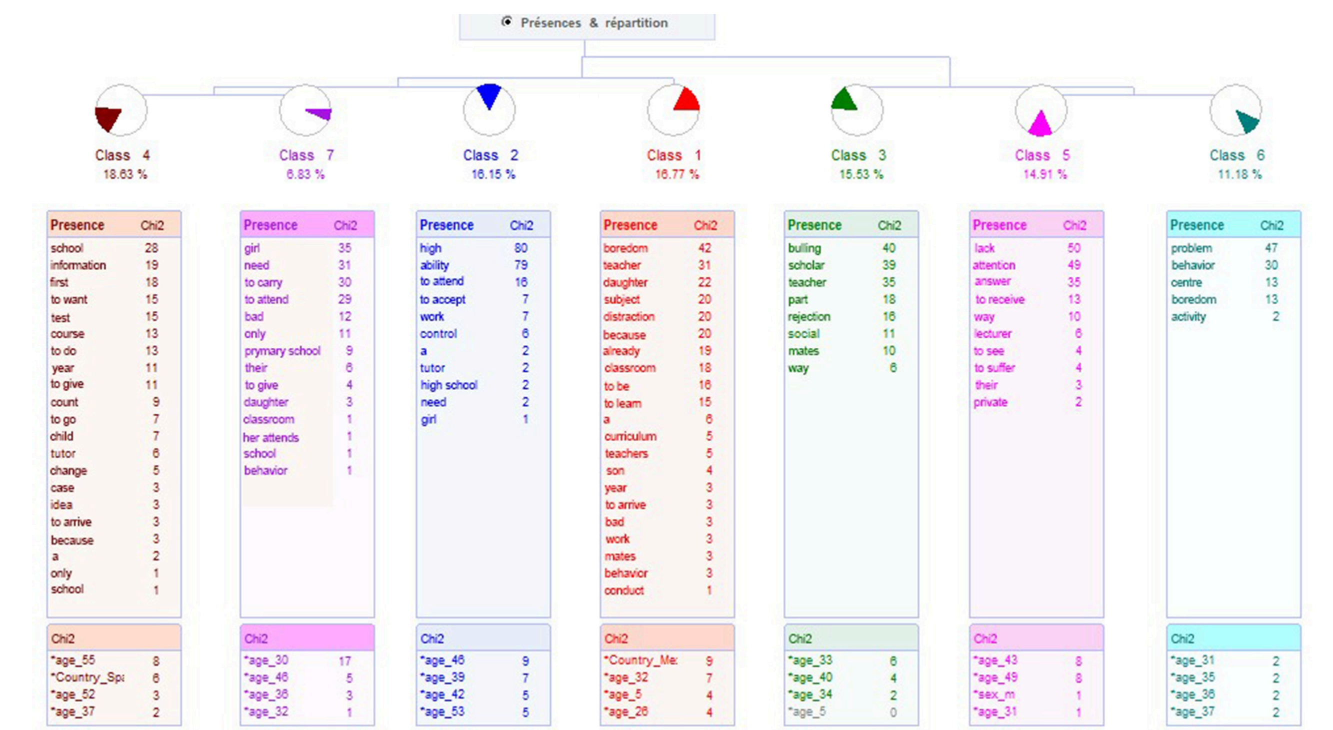

FIGURE 3 | Dendrogram about parents' problems with the school.

TABLE 9 | Children's problems with the school.

Country	Problems				
	1	2	3	4	5
Spain	4	2	15	73	1
Mexico	2	3	17	31	10
Argentina	1	3	1	19	1

1: Educational and vocational services; 2: Principal; 3: Teacher or tutor; 4: several; 5: peers/other parents.

Unité textuelle n°7 de Khi2 = 15

los profesores no me creen, me han hecho sentir como la madre tonta que cree que su hijo es mejor que los demás (Individu n° 7 *sex_f *age_48 *Country_Spain)

Unité textuelle n°81 de Khi2 = 15

al cambiar de escuela, la orientadora considera que no es necesario hacer nada, es-cierto-que el método en el nuevo centro permite a mi hija ir a su ritmo, pero (Individu n° 79 *sex_f *age_38 *Country_Spain

the teachers do not believe me, they have made me feel like the foolish mother who believes that her son is better than the others ($chi^2 = 15$)

when changing schools, the counselor considers that it is not necessary to do anything, it is true that the method in the new center allows my daughter to go at her own pace ($chi^2 = 15$)

The last axis is formed by the classes 6 and 7. Class 6, named Lack of Interest, includes 18 ECUs (14.06 % of the corpus). The most representative word is *Lack*. Examples of phrases are shown in the following paragraphs.

Unité textuelle n°12 de Khi2 = 14

falta de información, falta de atención, falta de interés (Individu n° 11 *sex_f *age_41 *Country_Spain)

Unité textuelle n°31 de Khi2 = 14

falta de comprensión y falta de interés (Individu n° 30 *sex_f *age_47 *Country_Spain)

lack of information, lack of attention, lack of interest ($chi^2 = 14$)

lack of understanding and lack of interest ($chi^2 = 14$)

Class 7 is named Unawareness of the High Abilities, represents 7.81 % of the corpus, with 10 ECUs, and the most significative word is *High*. Examples of phrases are:

Unité textuelle n°4 de Khi2 = 24

nunca han aceptado sus altas capacidades y solo ven el asperger (Individu n° 4 *sex_f *age_40 *Country_Spain)

Unité textuelle n°51 de Khi2 = 24

falta de conocimiento en altas capacidades.

they have never accepted their high abilities and only see the Asperger ($chi^2 = 24$)

lack of knowledge in high abilities ($chi^2 = 24$).

DISCUSSION

This work deepens the understanding of parents' assessments of the educational responses that their high-ability children receive. The specific research questions of the study are (1) to

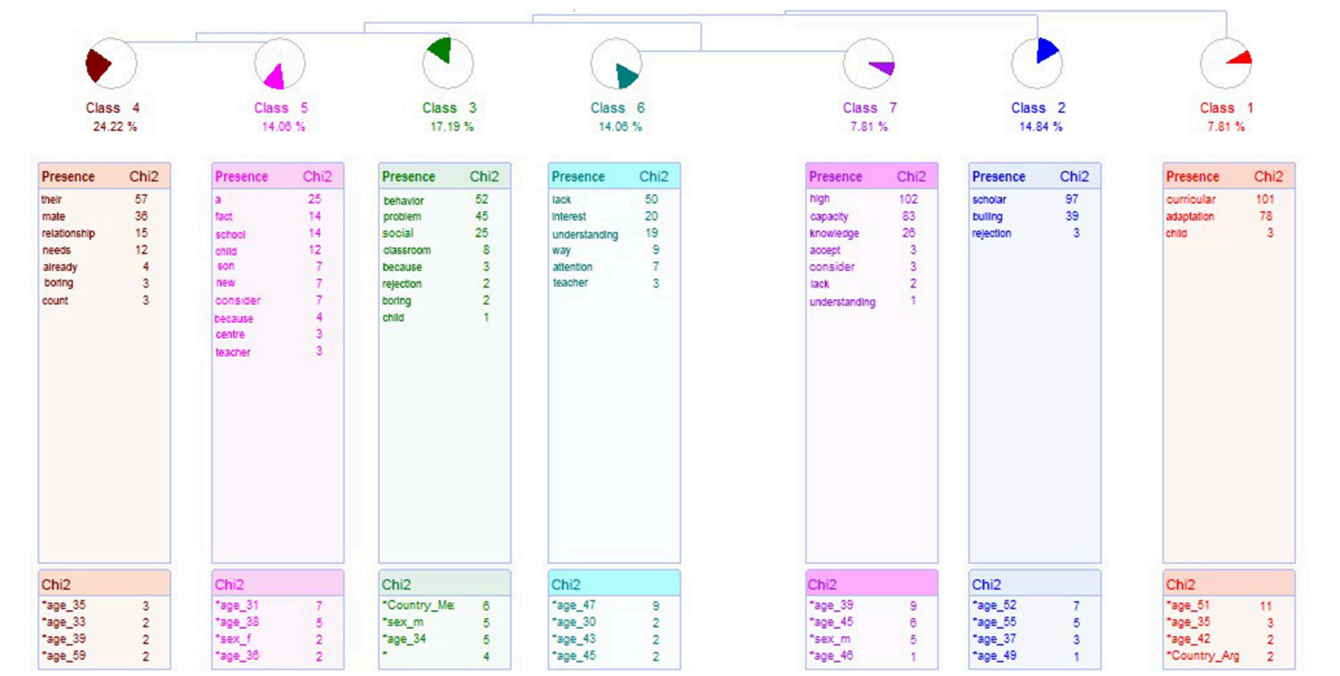

FIGURE 4 | Dendrogram about children's problems with the school.

examine parents' understanding of educational responses; (2) to detect which types of educational responses are implemented and what parents believe about them; and (3) to identify the problems that both parents and children have in relation to the children's schools.

Regarding research question 1, the study's analysis separates parents whose children received an educational response from those whose children did not. Clear differences appeared; for instance, the answers of the first group involved two classes, but the answer of the second group had seven classes. In both groups, one of the classes corresponded to the traditional educational response for these students. This was the most common type of response for children who did not receive an educational response that matched with their high abilities, but it was less common among those who did receive an appropriate response.

However, the parents in each group had non-traditional ideas that involved empowering their children's capacities through education that addresses emotional and social aspects.

In reference to research question 2, the first aspect that should be highlighted is that only about a quarter of the participants reported that their children received educational responses that fulfilled their needs. These results are consistent with these students' school situations, as previously noted; in particular, many fewer Spanish and Mexican school children received educational responses than would be expected: 0.33% of Spanish schoolchildren (at all levels, from preschool to the university level) and 0.7% of Mexican primary-school students. This study deals with families whose high-ability children have strong educational involvement; nevertheless, three quarters of the sample did not receive in-school educational responses.

It is also important to emphasize that this study provides a positive assessment of in-school programs. These programs are carried out in a short period after identification, and parents value them highly in terms of both the teachers and the content. Regarding the type of program, it is striking that most parents in this study reported that their children received various educational responses.

The rate of extracurricular responses was much higher than that of in-school responses, and the two types were sometimes combined. This shows that parents sought solutions that would meet their children's educational needs when the educational system did not do so. This is not surprising, as it is common for parents to create associations and to seek alternatives. There is a clear lack of attention paid to these high-ability students, in terms of both applying existing laws and providing institutional monitoring that can allow for appropriate responses for these students.

With regard to the third research question, this study identified the educational problems that the parents and their children experience. For the parents, the schools' inability to deal with their children was based on a wide range of problems, as is evident in the seven classes ALCESTE produced for this area. The problems parents have with the school, both specific for parents and for children, gathers a wide sort of problems divided in three types. Parents perceive lack of interest and knowledge about high intellectual abilities which has consequences in their children like behavioral problems or bullying. It would be necessary to study this issue more in depth this situation between parents and the school in order to avoid conflicts and improve the educational response for these children. On that sense the knowledge of the teachers on this field is essential.

Clearly, parents collect their own complaints regarding their relationship with the school in addition to complaints related to their children's problems.

The problems reported in this study include a wide range, including absence of educational response (which is a well-documented reality, as indicated in the introduction); lack of attention and consideration given to high-ability students; and even the children's disruptive behaviors, which can be partly explained by the absence of adequate educational responses. However, although some researchers have reported a high rate of bullying in this student population (e.g., Soler, 2017), bullying was not a frequent complaint among the parents in this study's sample.

One limitation of this study is the size of its sample. Although the number of participants is high, it would ideally be higher, as it covers three countries. However, given the lack of a policy that ensures the identification of all high-ability students, it is difficult to obtain samples with an adequate frame of reference for a probabilistic sampling to be carried out. Therefore, it is highly recommended for other researchers to replicate this study with a larger sample and to expand the research to other countries. For example, the study is being replicated with Portuguese-speaking parents in Portugal and Brazil. Also, it would desirable to include the perception of teachers on this type of studies, in order to analyze their perception about the educational interventions available in the schools for this population.

Finally, the use of mixed-methods research (MMR) is the strongest point of this investigation. Directly analyzing the respondents' responses without the need to restrict the survey to the usual closed-ended questions, allows for a greater understanding of exactly what the respondents think. For instance, in this study, the mixed-methods survey helped determine that the participants' expectations were far from the usual educational responses that they received.

ETHICS STATEMENT

The University of La Laguna's Ethics Committee of Research and Animal Welfare has approved this research (registration number CEIBA2018-0300).

AUTHOR CONTRIBUTIONS

ER-N and MC have participated in theoretical review and method. ÁB and DV has participated in the analysis. ÁB has participated in discussion. All authors have participated in the study planning, writing and revision of the article.

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Is It Possible to Predict an Athlete's Behavior? The Use of Polar Coordinates to Identify Key Patterns in Taekwondo

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Match analysts and sport psychologists can help elite athletes develop planned competition strategies from a technical-tactical perspective by analyzing of previous performances. The aim of this study was to analyze the behavioral patterns used to score points in the 2012 London Olympic Games by a mixed observational methodology and polar coordinate analysis. This analysis is a representation of four quadrants of the relationships between focal behavior [i.e., scoring, (SC)] and conditioned behaviors as key factors in taekwondo before and after focal behavior of two lags (−2, +2). A total of 151 combats, with a total of 24,940 actions were analyzed by the Taekwondo Observational Tool, which consists of 24 categories grouped into seven criteria (tactics, techniques, kicking zone, laterality, kicking leg, guard, and score). Our analysis confirms 49 significant associations (21 in females and 28 in males) between different types of scoring actions (SC1: to the trunk, SC2: to the trunk with a previous spin, SC3: to the head and SC4: to the head with a previous spin) and a variety of technical-tactical aspects. Females SC1 after cut, direct attacks with circular techniques to the chest, with back right leg; SC2 after direct attacks to the head, and SC3 after cuts, posterior counterattacks with the back leg. Males SC1 after spin anticipate counterattack with back leg and dodges, SC2 after simultaneous counterattacks (SCAs) to the head, SC3 after cuts and posterior counterattacks with back leg while SC4 after blocks and SCAs in close guard with the forward right leg. The observed relationships provide objective data regarding successful behavioral patterns, and are important for coaches and psychologists to train and develop psychological strategies to prepare athletes. For instance, they can be used to individualize training sessions, including visualization of specific combat situations. Coaches and psychologists could use these findings for specific tasks related to technical-tactical improvement of scoring effectiveness or defensive strategies against these specific actions.

Keywords: taekwondo, behavioral patterns, Olympic Games, observational methodology, mixed methods

INTRODUCTION

Psychology has a growing interest in the study of natural contexts and spontaneous behavior to discover and analyze behavioral patterns (Anguera et al., 2018). Analysis in natural contexts is especially important in elite sport for planning future competitive strategies. Previous performances can be visualized to detect underlying structures and behavioral patterns, assuming that similar patterns are usually repeated (Hernández-Mendo and Anguera, 2001, 2002). The analysis of natural contexts and sports behavioral patterns is also important for planning psychological training (i.e., visualization) in a wide range of competitive behaviors. There is evidence that visualization training activates the same muscles with almost the same intensity as real training (Folland and Williams, 2007). This analysis has been used in the mixed method approaches (for a review of a different studies see Anguera and Hernández-Mendo, 2014, 2015), which combine elements from both qualitative and quantitative research approaches (Johnson et al., 2007). Mixed method approaches are characterized by using systematic observation and qualitative data collection, stringent data quality controls and quantitative analysis, in a combination of qualitative and quantitative methods (Anguera et al., 2018).

Systematic observation has been used to collect information on key parameters in taekwondo based on their frequency of occurrence as tactics (Menescardi and Estevan, 2017), techniques (González, 2011; O'Donoghue, 2010), the kicking zone (Tornello et al., 2014), laterality or the kicking leg (Tornello et al., 2014), guard (López-López et al., 2015) or score (Tornello et al., 2014). The frequency (number of occurrences) provides the basic information on the behavioral tendencies. However, considering the order parameter takes the analysis one step further by providing not only the frequency, but also information on the order in which the behaviors occur (Anguera et al., 2018), so that strategic decisions regarding technical-tactical aspects can be made (Hernández-Mendo and Anguera, 2001). However, this information is difficult to transform into practical training applications. Relevant information has to describe tactics in a specific technique, toward a specific zone and with a given laterality in order to score a specific number of points.

To extract information that can be used by coaches and psychologists, a specific analysis (e.g., polar coordinates analysis) needs to be carried out. The polar coordinate analysis aims to detect behavioral patterns between focal (behavior of interest) and conditioned behaviors (those that precede or follow focal behavior), which occur with a higher probability than by chance (Anguera, 2003, 2008). The analysis is carried out in two steps: the first matches frequency tables with conditioned (observed) and unconditioned probabilities (by chance) (González-Prado et al., 2015). When conditioned probabilities exceed unconditioned ones, excitatory relationships appear in a technique known as lag sequential analysis (Anguera, 2008). The second step involves creating a vector map of four quadrants (see **Figure 1**) containing information on both retrospective and prospective perspectives (Anguera, 2000, 2001). This technique has also been used as a data reductionism technique, synthesizing the existing relationships and isolating those that occur most frequently (Hernández-Mendo and Anguera, 1999; Gorospe and Anguera, 2000).

Polar coordinates have been used on the sports field in disciplines such as soccer, tennis, Basque pelota and taekwondo (Hernández-Mendo and Anguera, 1998; Castellano and Hernández-Mendo, 2003; Castellano et al., 2007; Perea et al., 2012; López-López et al., 2015; Menescardi et al., 2016). Specifically, only two studies have applied the technique to investigate the relationship between technical-tactical actions and the different ways male Olympic taekwondo athletes use to score (López-López et al., 2015; Menescardi et al., 2016). In particular, a relationship between anticipatory counterattacks (ACAs) and effective one- and two- point actions to the chest (López-López et al., 2015), and sequences of attacks followed by counterattacks actions (Menescardi et al., 2016) were revealed, in line with the peculiarity of this sport (Joseph, 2012).

However, these studies did not analyze the whole competition and did not consider differences that occur during its phases (Menescardi et al., 2014); in fact, the entire competition should be analyzed. The literature on Olympic taekwondo match analysis mainly focuses on the frequency of technical-tactical actions (González, 2011; Kazemi et al., 2014; Tornello et al., 2014; González-Prado et al., 2015), whereas scant information is given on the match sequences of elite male and female taekwondo athletes. In this regard, previous studies have shown that males performed more actions than females in the Olympics (Kazemi et al., 2009), elite (Kwok, 2012), college (Menescardi et al., 2012), or youth (Casolino et al., 2012) competitions. The differences between genders were pointed out, showing that females won more bouts by superiority than males. Also, more warnings were given to female medalists than non-medalists as compared to males, concluding that male athletes had a more dynamic fighting style than the females (Matsushigue et al., 2009). These results highlight the impossibility of extrapolating inter-gender data.

The aim of the study then was to analyze the relationships between technical-tactical behaviors (i.e., tactics, techniques, the kicking zone, the kicking leg, laterality, and guard) that occur before and after a point is scored (i.e., one, two, three, or four points) by introducing an observational methodology into the mixed methods framework. Based on the theoretical framework and literature, we expected to find technical-tactical patterns that would allow coaches and athletes to explain successful behaviors and also some of the differentiated patterns between female and male athletes. This analysis allows researchers to extract behavioral patterns suitable for use by coaches and psychologists to enable them teach effective tactics for competitions.

MATERIALS AND METHODS

Experimental Approach to the Problem

The present study is based on an observational methodology inserted into the mixed method approach. Mixed methods involve the collection, analysis and combination of quantitative and qualitative data with rigor and have the flexibility required to study behaviors in a natural context (Anguera et al., 2014). The observational methodology collects data directly from training

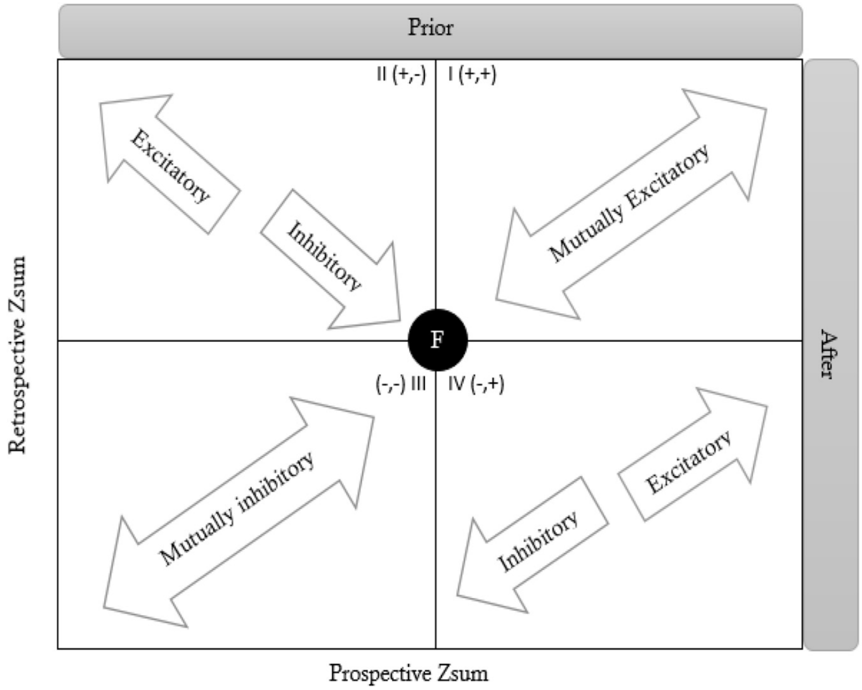

FIGURE 1 | Graphic depiction of relationships between conditional and given behaviors in polar coordinate maps according to quadrant in which vector is located and their occurrence prior or after the focal behavior (F) (Modified from Castañer et al., 2016).

sessions and/or competitions and has the advantage of observing spontaneous behavior (Anguera and Hernández-Mendo, 2016). It non-intrusively assesses physical and psychological demands during competition (Anguera et al., 2014). The data can be used to build research models and for the purposes of physical and psychological training (Anguera et al., 2014). Specifically, polar coordinate analysis is a powerful technique for studying tactical behaviors in the field of sport (Aragon et al., 2017). Several studies have used this technique to analyze the relationships (Aragon et al., 2017; Maneiro and Amatria, 2018) between key behaviors and improve coaching decisions. It also enables coaches and psychologists to suggest both offensive and defensive strategies (Maneiro and Amatria, 2018). To test the hypothesis of technical-tactical patterns that explain successful behaviors, this study describes behaviors (i.e., tactics, techniques, kicking zone, kicking leg, laterality, and guard) that occur before and after points are scored (i.e., one, two, three, or four points) by a polar coordinates analysis. As applied to taekwondo, this provides information on the event before (QI and QII), and after scoring (QI and QIV) or on those that prevents (QIII) scoring.

Methodology and Design

An observational methodology was used to collect and analyze data (Castellano and Hernández-Mendo, 2003; López-López et al., 2015). The N/S/M design was used in the present study (Arias-Pujol and Anguera, 2017), N refers to nomothetic (focusing on 128 athletes), S refers to inter-sessional follow-up (151 bouts were recorded) and intra-sessional follow-up (continuous recording of specific moves), and M refers to multidimensional (analysis of multiple criteria, or levels of response, using the purpose-designed TDKOT observational instrument).

Participants and Sample

A total of 151 bouts (male; n = 75, and female; n = 76) in the Olympic tournament (2012 London Olympic Games) were coded (one male semi-final bout was not analyzed due to the injury of one athlete) from public television broadcasts. From these bouts a total of 24,940 actions (M = 173.3 actions per bout) were registered and codified. The action inclusion criterion was to have clear observability of each action (Castañer et al., 2016). When the action was unclear or impossible to fully identify, it was not codified. This research was carried out in accordance with the Declaration of Helsinki and the Belmont Report. A review by an ethics committee and written informed consents were not required in this study as: (a) it involved the observation of people in public places (competition area) where the athletes targeted for observation had no reasonable expectation of privacy; (b) it did not include any intervention by the researcher; and (c) it did not collect personal information disseminated through photographic, film or video footage in the research results (National Institutes of Health, 1978; American Psychological Association, 2002).

Materials

To code the athlete's behavior, the TKD observational tool, validated by Menescardi et al. (2017) was used (**Table 1**). This tool contains seven exhaustive category systems (criteria) and 24 mutually exclusive categories distributed within each criterion.

TABLE 1 | Categories, codes and categorical core of the observational tool used.

Criteria	Categories	Code	Categorical core or description
Tactics	Block	BLO	Defensive actions to avoid the impact of a kick by placing one arm or leg between the protector and the leg of the opponent. This does not have a scoring objective.
	Dodge	DOD	Defensive actions to avoid the impact of a kick by placing one arm or leg between the protector and the leg of the opponent. This does not have a scoring objective.
	Cut	CUT	Defensive forward movement to avoid being beaten by a close opponent, and to prevent the attacking action from being completed. This does not have a scoring objective.
	Opening	APE	Movement to control the distance from the opponent or bridge the gap between both competitors.
	Direct attack	DIA	Offensive action with the objective of scoring, ending with impact on the opponent but without previous movement.
	Indirect attack	INA	Offensive action in order to score, ending with impact on the opponent and with previous movement such as a step, skip, opening, guard change, kicking trajectory modification, etc.
	Anticipated counterattack	ACA	Action that starts during the opponent's attack with the purpose of scoring. The athlete kicks the attacker during the preparatory phase (guard) and/or initial phase (when the opponent's knee is being raised).
	Simultaneous counterattack	SCA	Action that starts at the same time as the opponent's attack and has a scoring purpose. The athlete kicks at the same time as the opponent. Thus, the counter attacker kicks at the end of the attacker's initial phase (leg raised) or during the impact momentum (impact phase) of the attacker's kick.
	Posterior counterattack	PCA	Action that begins after the opponent's attack (during the descending phase, or when attacker's leg touches the ground) with a scoring purpose. Athletes kick at the same time. This action (sometimes) includes a previous backward displacement to dodge the opponent's attack.
Techniques	Linear	LIN	The kicking leg is directed toward the front of the opponent's body with a pushing motion in an attempt to kick the opponent with the sole of the foot.
	Circular	CIR	The kicking leg is directed toward the opponent's side, with a circular movement in an attempt to kick the opponent with the instep.
	Spin	GIR	Action performed with a previous rotation, at least 180° from the initial position, before kicking the opponent.
Height target	Trunk	CHE	Kick to permitted areas of the trunk.
	Head	HEA	Kick to permitted areas of the head.
Laterality	Right	RIG	Kick performed with the right leg.
	Left	LEF	Kick performed with the left leg.
Kicking leg	Front	FRO	Kick performed with the leg closest to the opponent.
	Back	BAC	Kick performed with leg furthest from the opponent.
Guard	Open	OPE	The front leg of each opponent differs (i.e., one of them has the left leg advanced and the other the right leg).
	Close	CLO	The front leg of both opponents is the same (e.g., both opponents have the left leg advanced).
Score	0 points	SC0	Action does not impact on the permitted areas, or impacts in these areas but not with enough force to score.
	1 point	SC1	Score obtained by a valid action performed to the trunk with a linear or circular technique.
	2 points	SC2	Score obtained by a valid action performed to the trunk using a spin beforehand.
	3 points	SC3	Score obtained by a valid action performed to the head with a linear or circular technique.
	4 points	SC4	Score obtained by a valid action performed to the head using a spin beforehand.

HOISAN software (Hernández-Mendo et al., 2012) was used for codifying data and carrying out the polar coordinate analysis.

Procedure

Each action (kick) was analyzed from the time the athlete's foot started the movement, (i.e., raising the foot off the ground) until the kicking leg returned to the floor. Actions were analyzed by different, qualified observers; a procedure was developed for training observers (Menescardi et al., 2017) in accordance with the approach set forth in Anguera (2003). Six observers, divided into two groups (groups A and B), were involved in the reliability analysis of the data and evaluating inter-observer reliability. Each observer analyzed six combats. To evaluate intra-observer reliability, two observers analyzed the same six combats twice in a row. Cohen's Kappa (κ) was used to calculate intra and inter-observer reliability. The inter and intra-observer results showed Cohen's kappa values to be above 0.85, confirming an almost perfect conformity (Landis and Koch, 1977; Blanco-Villaseñor et al., 2014; López-López et al., 2015; Miarka et al., 2015). HOISAN v1.3.6.3 (Hernández-Mendo et al., 2014), was used to perform a lag sequential analysis of behaviors, followed by a polar coordinate analysis. HOISAN software integrates the analysis of the prospective (Sackett, 1980) and retrospective lag sequential analysis, specifically, the genuine retrospectivity (Anguera, 1997) of successive behaviors. The retrospective perspective of lag sequential analysis, in its genuine aspect, considers retrospectivity from the focal to the conditioned behavior. It considers negative lags and detects when conditional behaviors prior to focal behavior are revealed as preparatory to the occurrence of focal behavior (Anguera, 2008). The prospective perspective, however, is based on considering the conditioned behaviors as occurring subsequent to the focal behavior (Castañer et al., 2016). The relations between the behaviors were represented on a vector map on MATLAB software (Perea et al., 2012).

Statistical Analysis

Several negative (−1 and −2) and positive lags (+1 and +2) were used to identify behavioral associations between focal and conditioned behaviors. ±2 lags (corresponding to actions) have been used in previous works to determine the last and second-to-last actions prior to focal behavior (score) and the first two actions following the focal behavior (Anguera, 2008). Although, team sports studies normally use ±5 lags (Anguera et al., 2018), in adversary sports five actions before and after the focal behavior would not give a clear scenario of what occurs during a kicking sequence in competition. In combat sports it is more appropriate to use a restricted lag interval, as for example ±2 lags for the actions included in the tactical schema of taekwondo (**Figure 2**) as proposed by Menescardi (2017). The adjusted residual values obtained in the lag sequential analysis (excitatory and inhibitory actions) were then subjected to polar coordinate analysis (Sackett, 1980), considering both the retrospective and prospective perspectives.

The resulting polar coordinate maps show the associations between each focal behavior (as given behaviors are known in polar coordinate analysis) and all the conditional behaviors were analyzed (represented as vectors through the Z_{sum} parameter) (Santoyo and Anguera, 1993; Gorospe and Anguera, 2000). Every Z_{sum} parameter was understood as follows (Cochran, 1954; Sackett, 1980): $\text{Zsum} = \frac{\Sigma z}{\sqrt{n}}$, where n represents the number of lags analyzed. Three main points should be considered when interpreting the associations: (a) the quadrant location of the vector; (b) the length or module of the vector; and (c) the angle (φ) of the vector with respect to the horizontal axis (Castañer et al., 2016, 2017; Arias-Pujol and Anguera, 2017). To calculate the length and angle of the corresponding vector and corresponding representation, the retrospective (Y-axis) and prospective (X-axis) Z_{sum} values for each conditional behavior are required (López-López et al., 2015; Arias-Pujol and Anguera, 2017). This determines the association between focal and conditioned behaviors. The length of the vector is calculated by the $\sqrt{(\text{ZsumProspective})^2 + (\text{ZsumRetrospective})^2}$ (López-López et al., 2015; Arias-Pujol and Anguera, 2017). Finally, the angle is determined by dividing the retrospective Z_{sum} arcsine by the radius ($\varphi = \frac{arcsine\ of\ Y}{radius}$), giving rise to four relationships (López-López et al., 2015) according to the quadrant, in which the vector is located:

(a) Quadrant I (0-90°). Indicates that the focal and conditional behaviors are mutually activated in both perspectives; that is, the conditioned behaviors occur before and after the focal behavior (+, +).
(b) Quadrant II (90–180°). Indicates that the focal behavior inhibits the conditional behaviors but is also activated by them, that is, the conditioned behavior precedes but does not follow the focal behavior (+, −).
(c) Quadrant III (180-270°). Indicates that the focal and conditional behaviors are mutually inhibited, that is, the conditioned behavior neither precede nor follow the focal behavior (−, −).
(d) Quadrant IV (270-360°). Indicates that the focal behavior activates the conditional behaviors but is also inhibited by them, that is, the conditioned behavior does not precede but follows the focal behavior (−, +).

These relationships were represented with the focal behavior in the center of each vector map and the conditional behaviors in one of four quadrants. Although all the relationships appear on the vector representation of the polar coordinates map, only those whose module or radium vector length > 1.96 are considered significant ($p < 0.05$) (Hernández-Mendo and Anguera, 1999; Castellano and Hernández-Mendo, 2003; López-López et al., 2015; Arias-Pujol and Anguera, 2017; Castañer et al., 2017) and included in the results. A total of eight

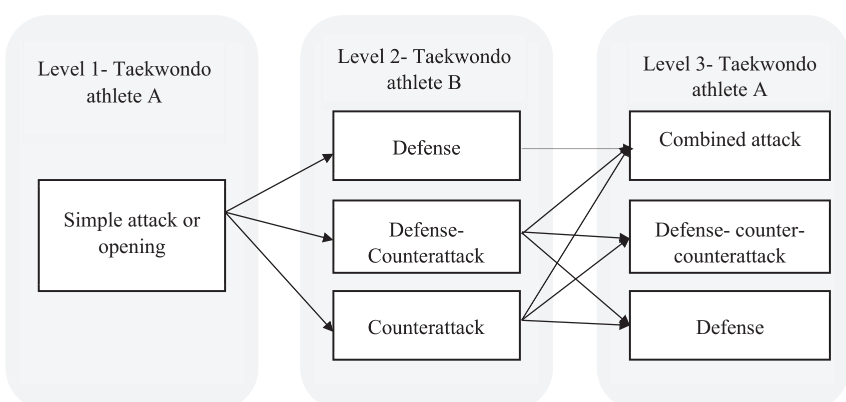

FIGURE 2 | Offensive-defensive tactical schema in taekwondo (Menescardi, 2017).

polar coordinates analyses were conducted, considering gender (two options: male or female) and the score criteria (four options: SC1, SC2, SC3, and SC4).

RESULTS

The results of the vector maps are shown in **Figures 3–6** and the polar coordinates analysis for each category of the score criteria (as focal behaviors, i.e., SC1, SC2, SC3, and SC4) are shown in **Tables 2–5**. Females and males showed a total of 21 and 28 excitatory relationships between behaviors, respectively. For males, relationships were found in every focal behavior (SC1–SC4), however, for females, they were found in SC1, SC2, and SC3 (no relationship was found in SC4).

DISCUSSION

The main findings of the present study are the relationships extracted for each score in each gender. The results showed a total (females and males) of 49 significant excitatory relationships (25 before -QI and QII- obtaining a point, and 24 after -QI and QIV-gaining a point), and 13 that are inhibited before and after (QIII) gaining a point. Of the 25 excitatory relationships, 11 explain female successful and 14 male successful patterns. Females used to score a point after a cut, used to shorten the distance with the opponent, and after a direct circular attack with the back right leg to the chest. A high probability of scoring two points was also found after direct attacks to the head, while scoring three points is probable after a cut, or a posterior counterattack with the back leg. For females, there is little probability of scoring one and three points by dodging, opening, linear actions or anticipatory kicking counterattacks with the front leg. Males often score one point after a dodge and a spin or an anticipatory back leg kicking counterattack. Two points are scored after a simultaneous counterattack (SCA) during a spinning kick to the head, while three points are scored after a block or a kick with the back leg. In addition, four points were scored after a block or a SCA with the front left leg in close guard position. Finally, no scoring points are obtained either before or after an opening with the front leg or with a linear kick in an open guard position. The relationships found can help coaches and psychologists to plan strategies for winning points (in QI and QII) and avoiding those that prevent points from being scored (QIII). The discussion will focus on the relationships in QI, QII and QIII, which were found to be related to scoring points. The QIV was found to be irrelevant for scoring, in agreement with previous studies that also analyzed the results of interest (Castañer et al., 2017).

Elite Female Athletes' Relationships

A total of 21 excitatory relationships between focal and conditioned behaviors have been found. From those excitatory relationships, 11 occurred before gaining a point (QI = 9; QII = 2), 12 occurred after (QI = 9; QIV = 3), while seven were inhibited before and after gaining a point (QIII). From a technical-tactical perspective, there is a high probability of scoring a point (SC1) after a cut (CUT), and after a circular (CIR) direct attack (DIA), with the right (RIG) back leg (BAC) to the chest (CHE) (QI and QII). This is in line with previous studies that found a preference for direct actions and circular techniques (Menescardi et al., 2012; Menescardi and Estevan, 2017), right back leg and actions to the chest in competition (Tornello et al., 2014). A high

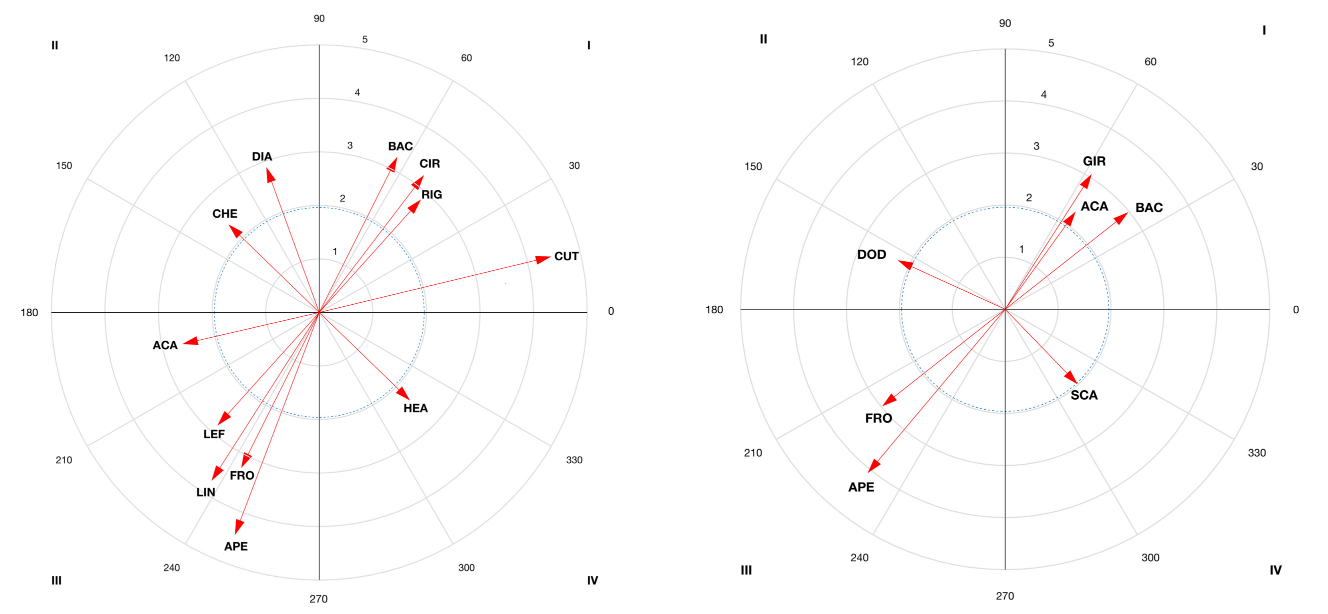

FIGURE 3 | Representation of behavioral maps for SC1 category as focal behavior in female competitors **(Left)** and males **(Right)**. The behavioral map was represented divided into four quadrants, with each of the conditioned categories as vectors in the axis *X*-/*Y*- and their respective coordinates Z_{sum} prospective (*X*-) and Z_{sum} retrospective (*Y*-).

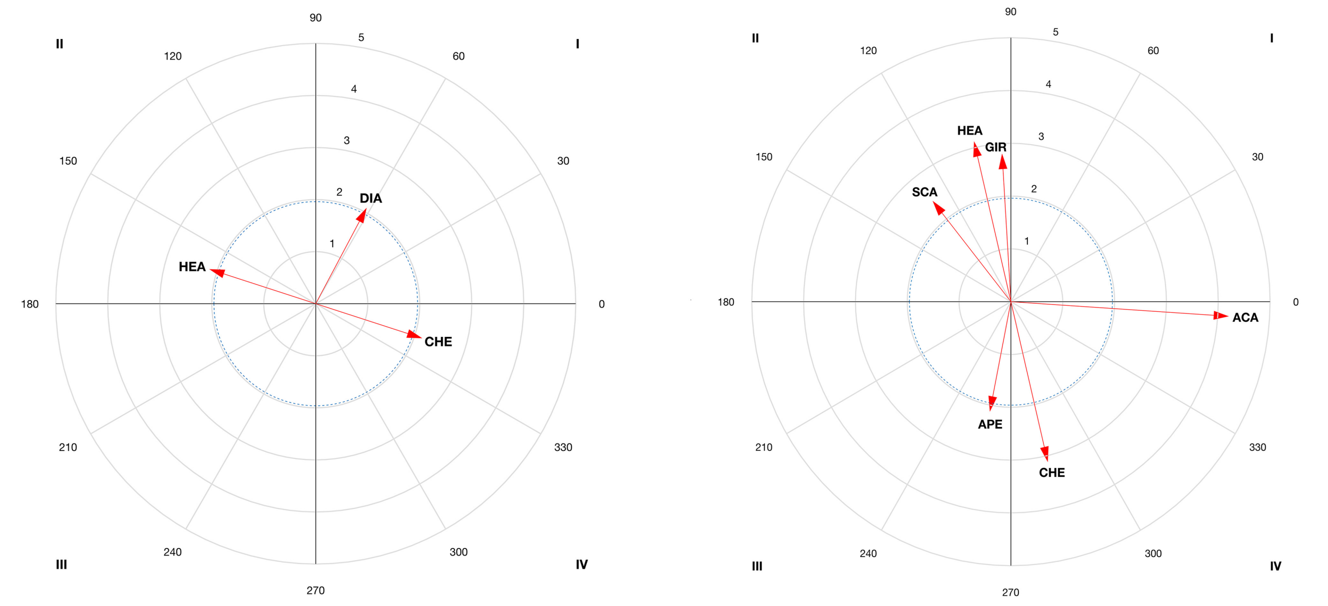

FIGURE 4 | Representation of behavioral maps for SC2 category as focal behavior in female competitors **(Left)** and males **(Right)**. The behavioral map was represented divided into four quadrants, with each of the conditioned categories as vectors in the axis *X*-/*Y*- and their respective coordinates Z_{sum} prospective (*X*-) and Z_{sum} retrospective (*Y*-).

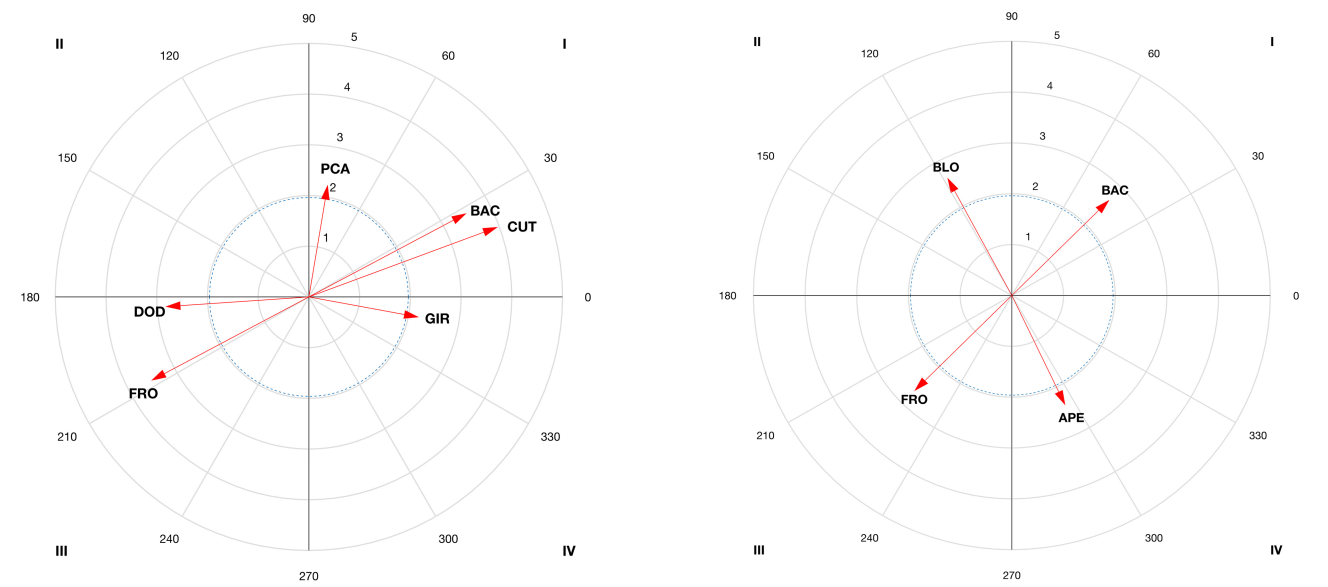

FIGURE 5 | Representation of behavioral maps for SC3 category as focal behavior in female competitors **(Left)** and males **(Right)**. The behavioral map was represented divided into four quadrants, with each of the conditioned categories as vectors in the axis *X*-/*Y*- and their respective coordinates Z_{sum} prospective (*X*-) and Z_{sum} retrospective (*Y*-).

probability of scoring two points (SC2) was found after a direct attack (DIA) to the head (HEA). This might be due to an effective spinning action to the chest to counteract attacks to the head. In this sport, both spinning actions and actions to the head are given an additional score for their difficulty of execution (World Taekwondo Federation, 2012), then athletes used to perform one in order to counterattack the other one. Finally, a high probability of scoring three points (SC3) was found after a cut (CUT), or a posterior counterattack (PCA) with the back leg (BAC). The frequent use of actions with the back leg could be due to their involving a longer path than front leg actions (Menescardi, 2017), thus making it possible to kick to the head, required to gain three points. The relationship with cuts and posterior counterattacks is due to this tactical aspect being used by female competitors to

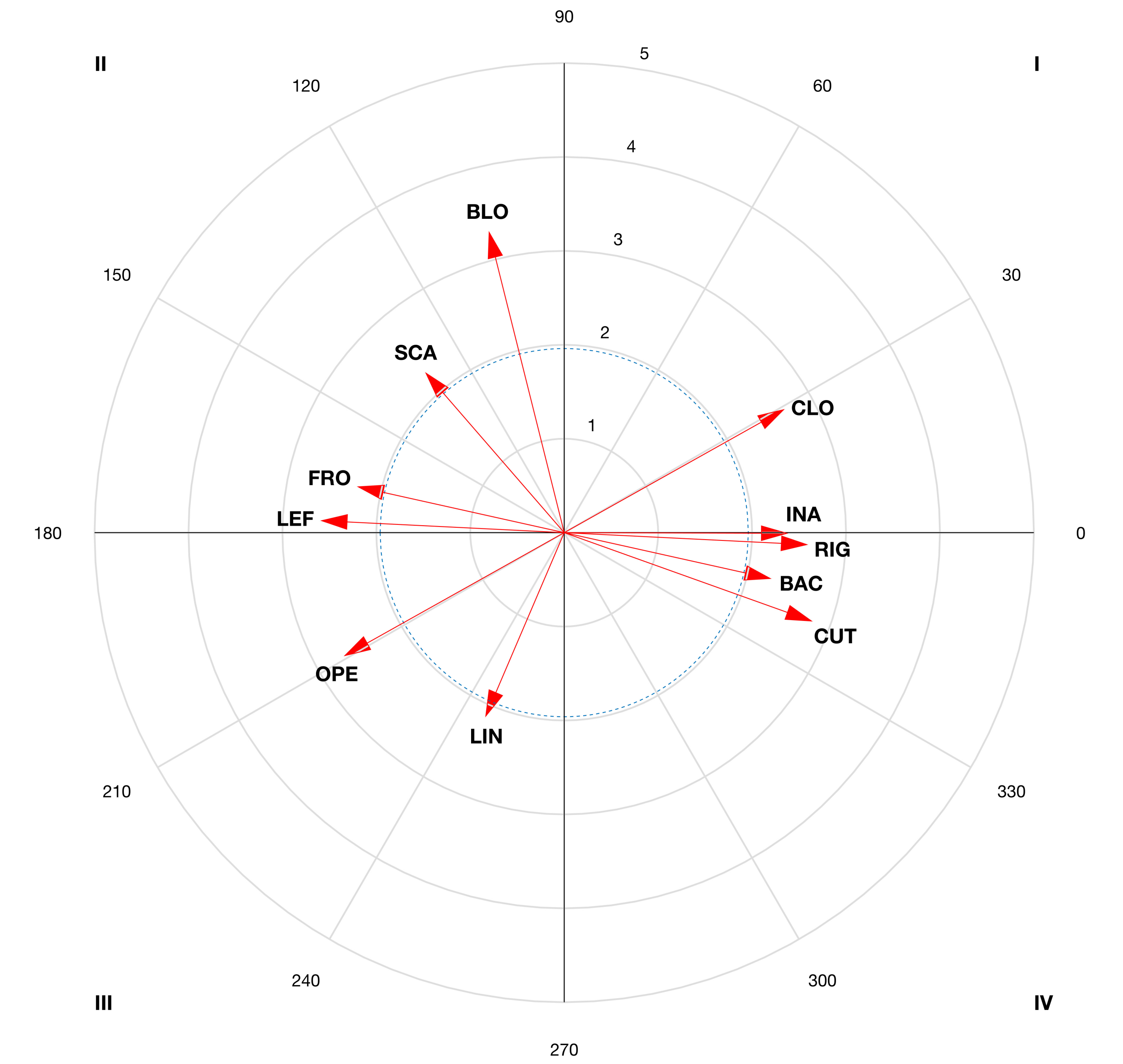

FIGURE 6 | Representation of behavioral maps for SC4 category as focal behavior in male competitors. The behavioral map was represented divided into four quadrants, with each of the conditioned categories as vectors in the axis *X*-/*Y*- and their respective coordinates Z_{sum} prospective (*X*-) and Z_{sum} retrospective (*Y*-).

shorten the distance and counterattack by cutting and kicking to the opponent's head.

Regarding the behaviors in QIII, in females an inhibitory relationship existed between the focal and conditioned behaviors. The probability of scoring one and three points (SC1 and SC3) after a dodge (DOD) and an opening (APE) or a linear (LIN) anticipation counterattack (ACA), with the front, left leg (FRO/LEF) is limited. This is due to the opponent avoiding a point being scored, for instance, by moving away or dodging (Fargas, 1990) or by performing an ACA with the front left leg.

An interesting interpretation of behaviors is when the behavior's vector angle (φ) is close to the limit between quadrants (for instance, when the vector is in QIII close to QII or QIV). This is the case for the counter-attack action (ACA) to score one (SC1, see **Figure 3**) and a dodge (DOD see **Figure 5**) to score three (SC3), both are close to QII (193,2 and 183,9 degrees, respectively). The counterattacking action occurs when athlete use an underdeveloped strategy to score. In the case where the angle of the behavior would be placed in QII, an association between the score and the preceding counter-attack exist. Polar

TABLE 2 | Results of the polar coordinates' analysis for SC1 focal category.

	Females						Males					
Cond.	**Q.**	**Pros.**	**Retr.**	**Ratio**	***R***	**φ**	**Q.**	**Pros.**	**Retr.**	**Ratio**	***R***	**φ**
BLO	IV	0.40	−0.57	−0.81	0.69	305.47	II	−0.33	1.07	0.96	1.13	107.18
DOD	II	−1.20	1.39	0.76	1.83	130.77	II	−2.02	0.93	0.42	2.22*	155.15
CUT	I	4.31	1.04	0.23	4.44*	13.55	IV	1.93	−0.33	−0.17	1.95	350.44
APE	III	−1.57	−4.14	−0.94	4.43*	249.25	III	−2.59	−3.13	−0.77	4.06*	230.44
DIA	II	−0.98	2.7	0.94	2.87*	110.00	II	−0.23	0.49	0.91	0.54	114.57
INA	II	−0.01	1.33	1.00	1.33	90.61	I	0.88	1.32	0.83	1.59	56.45
ACA	III	−2.54	−0.59	−0.23	2.61*	193.02	I	1.32	1.86	0.81	2.28*	54.59
SCA	IV	1.50	−1.13	−0.60	1.88	322.96	IV	1.36	−1.43	−0.72	1.97*	313.55
PCA	IV	0.23	−1.05	−0.98	1.07	282.20	I	1.17	0.39	0.31	1.24	18.33
LIN	III	−2.00	−3.13	−0.84	3.72*	237.43	III	−1.94	−0.12	−0.06	1.94	183.55
CIR	I	1.94	2.55	0.80	3.21*	52.70	IV	0.88	−1.36	−0.84	1.62	302.72
GIR	II	−0.07	0.86	1.00	0.86	94.72	I	1.63	2.58	0.85	3.05*	57.78
CHE	II	−1.68	1.63	0.70	2.35*	135.86	IV	0.60	−1.04	−0.87	1.20	300.04
HEA	IV	1.68	−1.63	−0.70	2.35*	315.86	II	−0.60	1.04	0.87	1.20	120.04
RIG	I	1.89	2.10	0.74	2.82*	48.04	III	−1.44	−0.91	−0.54	1.70	212.43
LEF	III	−1.89	−2.10	−0.74	2.82*	228.04	I	1.44	0.91	0.54	1.70	32.43
FRO	III	−1.45	−2.89	−0.89	3.24*	243.38	III	−2.31	−1.85	−0.63	2.96*	218.7
BAC	I	1.45	2.89	0.89	3.24*	63.38	I	2.31	1.85	0.63	2.96*	38.7
OPE	III	−0.86	−1.28	−0.83	1.54	236.24	I	0.84	0.85	0.71	1.20	45.24
CLO	I	0.86	1.28	0.83	1.54	56.24	III	−0.84	−0.85	−0.71	1.20	225.24

Means significate vectors (radium > 1.96). Z_{sum} values, prospective (pros.) and retrospective (retr.), quadrants (Q), radium length (R), and ratio and vector angle (φ) are represented. BLO, blocks; DOD, dodges; CUT, cuts; APE, opening; DIA, direct attack; INA, indirect attack; ACA, anticipatory counterattack; SCA, simultaneous counterattack; PCA, posterior counterattack; LIN, linear technique; CIR, circular technique; GIR, spin technique; CHE, action to the chest protector; HEA, action to the head; RIG, right leg; LEF, left leg; FOR, forward leg; BAC, backward leg; OPE, open guard; CLO, close guard.

coordinates analysis can thus be used by coaches to examine whether the athletes' behavior activates or inhibits his/her effectiveness according to the type of score and technical-tactical aspects. Training can thus be oriented toward developing new strategies used to defeat the opponent and void his/her attacks. Not only the length of the vector (the longer the vector the stronger the relationship expressed in *z*) but also the angle should be considered in polar coordinates. This is because in cases where the vector is close to changing the quadrant (less than 45 degrees to change to QII and QIV), researchers and sports teams could follow these behaviors to detect possible changes in behavioral tendencies (Castellano and Hernández-Mendo, 2003).

No significant relationship was found between technical-tactical actions and those that precede four-point score (SC4). This could be because females use heterogeneous methods to obtain four points. As the analysis did not find a pattern, the probability of obtaining four points was attributed to chance. A second explanation, as has also been suggested by previous studies (González, 2011; Menescardi, 2017), is that performing few actions allows them to obtain four points. Female athletes should thus create their own strategies and tactics according to their opponent's strategy.

Elite Male Athletes' Relationships

In males, we found a total of 28 significant excitatory relationships, 14 before obtaining a point (QI = 5; QII = 9), 13 after scoring (QI = 5; QIV = 8) and six inhibited (QIII) before and after obtaining a point (21 relationships were found in females). This difference could be due to males using more behavioral patterns to score, while females use fewer patterns more frequently, indicating their different ways of competing and scoring, which could have implications for training (Menescardi et al., 2012).

From a technical-tactical perspective, males have a high probability of scoring one point (see **Figure 3**) after a dodge (DOD) and a spin (GIR) or an ACA with the back (BAC) leg. This is in line with previous studies (Kazemi et al., 2014) that highlighted that males use attacking actions to score one point (SC1), which contrasts with obtaining a point after a dodge, since the sequence is ended and a new sequence starts (with an attack). Other studies have pointed out the advantage of using the longer time needed to carry out a spin (Cheng et al., 2015; López-López et al., 2015) as compared to linear or circular kicks (Serina and Lieu, 1991). Actions with the back leg may possible unbalance the opponent (González, 2011) and have greater impact force (Pieter and Pieter, 1995; Pêdzich et al., 2006). This is important for achieving a point with the use of the electronic chest protector system. The possibility of scoring before and after an anticipated counterattack has also been pointed out in previous studies (Falco et al., 2014) due to its difficult timing. A high probability of scoring two points (SC2; see **Figure 4**) has been found after a SCA during a spinning kick (GIR) to the head (HEA). The scenario of performing spin-actions by both counterparts has been proven previously, showing spin-counterattacks as effective

TABLE 3 | Results of the polar coordinates analysis for SC2 focal category.

	Females						Males					
Cond.	**Q.**	**Pros.**	**Retr.**	**Ratio**	***R***	**φ**	**Q.**	**Pros.**	**Retr.**	**Ratio**	***R***	**φ**
BLO	II	−1.52	1.05	0.57	1.85	145.46	IV	0.91	−0.4	−0.4	0.99	336.53
DOD	II	−0.80	0.13	0.17	0.81	170.46	III	−0.41	−1.2	−0.95	1.26	251.06
CUT	IV	0.42	−0.17	−0.37	0.46	338.2	IV	0.30	−0.3	−0.71	0.42	315.00
APE	IV	0.37	−0.81	−0.91	0.90	294.74	III	−0.40	−2.06	−0.98	2.10*	258.95
DIA	I	0.97	1.82	0.88	2.07*	62.03	II	−0.65	0.29	0.41	0.71	155.98
INA	III	−0.06	−0.96	−1.00	0.96	266.21	I	0.31	1.00	0.95	1.04	72.67
ACA	IV	1.25	−0.95	−0.6	1.57	322.87	IV	4.19	−0.28	−0.07	4.20*	356.23
SCA	III	−0.13	−0.83	−0.99	0.85	260.85	II	−1.50	1.90	0.78	2.42*	128.35
PCA	III	−0.04	−0.06	−0.87	0.07	240.95	I	0.24	0.70	0.95	0.74	71.05
LIN	III	−1.07	−0.93	−0.66	1.42	220.97	IV	0.13	−1.05	−0.99	1.06	276.89
CIR	I	1.04	1.37	0.80	1.72	52.85	III	−0.01	−0.62	−1.00	0.62	268.68
GIR	III	−0.02	−0.94	−1.00	0.94	268.71	II	−0.17	2.79	1.00	2.79*	93.49
CHE	IV	2.03	−0.66	−0.31	2.13*	342.05	IV	0.71	−3.02	−0.97	3.10*	283.18
HEA	II	−2.03	0.66	0.31	2.13*	162.05	II	−0.71	3.02	0.97	3.10*	103.18
RIG	IV	0.68	−0.73	−0.73	1.00	312.99	I	0.71	0.16	0.21	0.72	12.41
LEF	II	−0.68	0.73	0.73	1.00	132.99	III	−0.71	−0.16	−0.21	0.72	192.41
FRO	III	−1.70	−0.04	−0.02	1.70	181.19	III	−0.04	−1.29	−1.00	1.29	268.43
BAC	I	1.70	0.04	0.02	1.70	1.19	I	0.04	1.29	1.00	1.29	88.43
OPE	IV	0.86	−1.60	−0.88	1.82	298.36	II	−0.83	0.24	0.28	0.86	163.8
CLO	II	−0.86	1.60	0.88	1.82	118.36	IV	0.83	−0.24	−0.28	0.86	343.8

**Means significate vectors (radium > 1.96). Z_{sum} values, prospective (pros.) and retrospective (retr.), quadrants (Q), radium length (R), and ratio and vector angle (φ) are represented. BLO, blocks; DOD, dodges; CUT, cuts; APE, opening; DIA, direct attack; INA, indirect attack; ACA, anticipatory counterattack; SCA, simultaneous counterattack; PCA, posterior counterattack; LIN, linear technique; CIR, circular technique; GIR, spin technique; CHE, action to the chest protector; HEA, action to the head; RIG, right leg; LEF, left leg; FOR, forward leg; BAC, backward leg; OPE, open guard; CLO, close guard.*

(López-López et al., 2015). The relationship with actions to the head could be explained by the necessity of increasing the score, not only by doing spin-actions but also performing actions to the head, as occurred in female bouts. A high probability of scoring three points (SC3; see **Figure 5**) was found after a block (BLO) or a kick with the back (BAC) leg. These results are especially relevant in clench situations (body–body situations) in which athletes try to continue the tactical sequence, chaining various actions with kicks to the head. The chaining of actions, although rarely used by male competitors (González, 2011), is revealed as an effective tactic if the opponent is distracted. Finally, a block is the behavior with the highest probability of scoring four points (SC4; see **Figure 6**), or a SCA with the front (FRO) left (LEF) leg in close guard position (CLO). The relationship found with blocks, actions performed with the front left leg and SCAs are revealed as favorable scenarios for spinning actions to the head and scoring four points. In addition, the relationship between scoring four points and close guard could be due to this being the most frequently used guard by males in competition (González, 2011; López-López et al., 2015).

Regarding the behaviors grouped in QIII, males obtained no scoring points either before or after an opening (APE) (SC1 or SC2, **Figures 3**, **4**, respectively), with the front (FRO) leg (SC1 or SC3), or with a linear kick (LIN) in an open guard (OPE) position (SC4, **Figure 6**). This 'no relationship with openings', we speculate, reflects the use of those actions to test the opponent by performing movements like the *miro chagui*. This is usually performed with the front leg, which, by definition does not allow scoring (Menescardi et al., 2017) and therefore the relationship is in the third quadrant. The inclusion of linear actions in this quadrant (QIII) could occur because the circular and spinning actions already appear in QIV. Considering that only four points can be achieved by spin-action, in terms of probability, linear actions are infrequent before and after obtaining four points (SC4).

The present study has two limitations: the first is the fact that the results should be interpreted according to the characteristics of the polar coordinates analysis, in terms of the probability of each type of behavior, that is, the probability of one of the categories in the same criterion. This means, that if one category (i.e., the left leg) is found in one quadrant, the other (i.e., the right leg) should appear in another. This is because it is improbable that similar actions be performed before and after scoring (according to the exhaustive and mutually exclusive characteristics of the observational tool). It should also be noted that this type of analysis provides information on what happens before and after scoring (SC1, SC2, SC3, or SC4), but not on how the point was achieved. The lack of classifying data in relation to match outcomes (Gómez et al., 2016a,b) could also be seen as a limitation. Future studies should consider using the same methodology to analyze taekwondo performance including the discrimination of winning and losing close and unbalanced matches, which

TABLE 4 | Results of the polar coordinates analysis for SC3 focal category.

	Females						Males					
Cond.	Q.	Pros.	Retr.	Ratio	*R*	φ	Q.	Pros.	Retr.	Ratio	*R*	φ
BLO	III	−0.33	−0.75	−0.91	0.82	246.09	II	−1.24	2.3	0.88	2.61*	118.30
DOD	III	−2.81	−0.19	−0.07	2.81*	183.89	IV	1.63	−0.84	−0.46	1.84	332.74
CUT	I	3.71	1.37	0.35	3.95*	20.32	II	−0.73	0.16	0.21	0.74	167.94
APE	IV	0.52	−1.44	−0.94	1.53	289.69	IV	1.03	−2.14	−0.90	2.38*	295.57
DIA	II	−1.66	0.15	0.09	1.67	174.89	II	−0.95	1.29	0.81	1.60	126.36
INA	I	1.55	0.45	0.28	1.61	16.05	III	−0.47	−0.07	−0.15	0.48	188.49
ACA	III	−0.86	−0.91	−0.73	1.26	226.60	III	−0.57	−0.11	−0.18	0.58	190.49
SCA	IV	1.03	−0.33	−0.31	1.08	342.04	II	−0.82	0.36	0.40	0.90	156.27
PCA	I	0.37	2.19	0.99	2.22*	80.48	IV	1.51	−0.34	−0.22	1.54	347.30
LIN	III	−1.11	−1.35	−0.77	1.75	230.58	III	0.00	−1.10	−1.00	1.10	270.00
CIR	II	−0.04	1.49	1.00	1.49	91.63	II	−0.78	1.43	0.88	1.63	118.57
GIR	IV	2.15	−0.40	−0.18	2.19*	349.56	IV	1.35	−0.71	−0.46	1.52	332.37
CHE	I	0.44	0.66	0.83	0.79	56.31	III	−0.25	−0.79	−0.95	0.83	252.65
HEA	III	−0.44	−0.66	−0.83	0.79	236.31	I	0.25	0.79	0.95	0.83	72.65
RIG	I	0.93	0.40	0.39	1.01	23.15	III	−1.22	−1.24	−0.71	1.74	225.50
LEF	III	−0.93	−0.40	−0.39	1.01	203.15	I	1.22	1.24	0.71	1.74	45.50
FRO	III	−3.09	−1.64	−0.47	3.50*	207.96	III	−1.87	−1.87	−0.71	2.65*	224.89
BAC	I	3.09	1.64	0.47	3.50*	27.96	I	1.87	1.87	0.71	2.65*	44.89
OPE	I	1.22	0.35	0.28	1.27	16.12	II	−1.24	0.15	0.12	1.25	173.20
CLO	III	−1.22	−0.35	−0.28	1.27	196.12	IV	1.24	−0.15	−0.12	1.25	353.20

Means significate vectors (radium > 1.96). Z_{sum} values, prospective (pros.) and retrospective (retr.), quadrants (Q), radium length (R), and ratio and vector angle (φ) are represented. BLO, blocks; DOD, dodges; CUT, Cuts; APE, opening; DIA, direct attack; INA, indirect attack; ACA, anticipatory counterattack; SCA, simultaneous counterattack; PCA, posterior counterattack; LIN, linear technique; CIR, circular technique; GIR, spin technique; CHE, action to the chest protector; HEA, action to the head; RIG, right leg; LEF, left leg; FOR, forward leg; BAC, backward leg; OPE, open guard; CLO, close guard.

would provide more specific data and have valuable practical applications. It would also be interesting to analyze the different championship levels (world, national, or college) and the same level over time to monitor the influence of new rules and regulations and changes in refereeing practice and performance.

From a practical point of view, we suggest designing tactical strategies to train actions that permit scoring when detecting the actions that occurred before (QI and QII), as well as defensive (QIII). In addition, these results could be relevant for estimating and describing combat tactical patterns and their psychological effect (Hernández-Mendo and Anguera, 2001). In this line, sports psychologists agree on the importance of attitude, confidence, motivation and stress control through protocols of visualization of the technical-tactical aspects to enhance strengths and exploit the opponent's weak points (Hernández-Mendo and Morales-Sánchez, 2010). For example, mental training is suggested to reduce uncertainty, tension and negative mental influences (pressure, anxiety, etc.). Confidence could also be enhanced by, for example, simulating training methods (Xiong, 2012). The results can also help in planning tactical training by mechanizing and automating tactical situations, as well as coping strategies for stress through or self-regulation work to make good decisions as well as relaxation work, imagery, attention and concentration training, self-instruction or positive reinforcement can be used to produce adaptive behaviors for motor improvement (Hernández-Mendo and Morales-Sánchez, 2010). In short, it is necessary to introduce competition situation models into training, for instance, taking into account the different scoring patterns used by males and females and to create specific strategies and tactics according to the opponent's characteristics. Sport psychologists play an essential role in helping athletes reach their maximum sports performance (Orlick, 1996; Alvarez et al., 2014).

CONCLUSION

Taekwondo research could also use the observational methodology described here which highlights the most important factors that affect the results of bouts. Sports researchers in other fields could also use this methodology and include the statistical techniques mentioned (i.e., the polar coordinate analysis) to provide objective data on competitive behavior. Future studies should investigate the relationships between behaviors according to the new regulations. Studies focusing on technical and tactical aspects of taekwondo could provide interesting and complementary insights into training aspects of this sport. For psychologists and coaches, it is important to discover the relationship between both technical and tactical actions in order to increase knowledge on interdependent behaviors and how they are produced. Psychologists and coaches can use the information obtained regarding the patterns that athletes use in competition to plan visualization sessions and tactical strategies. The results of the current study can be summarized as follows:

TABLE 5 | Results of the polar coordinates analysis for SC4 focal category.

		Males				
Cond.	**Q.**	**Pros.**	**Retr.**	**Ratio**	***R***	**φ**
BLO	II	−0.80	3.20	0.97	3.29*	104.04
DOD	III	−0.18	−1.61	−0.99	1.61	263.72
CUT	IV	2.63	−0.94	−0.34	2.79*	340.33
APE	III	−1.38	−1.38	−0.71	1.95	225.00
DIA	II	−1.07	0.33	0.29	1.12	163.16
INA	IV	2.37	−0.01	0.00	2.37*	359.83
ACA	III	−0.56	−0.56	−0.71	0.79	225.00
SCA	II	−1.47	1.70	0.76	2.25*	130.91
PCA	IV	0.88	−0.1	−0.11	0.89	353.61
LIN	III	−0.83	−1.95	−0.92	2.12*	246.85
CIR	I	1.26	1.03	0.63	1.62	39.17
GIR	II	−0.84	1.38	0.85	1.62	121.39
CHE	I	0.84	0.94	0.75	1.26	48.18
HEA	III	−0.84	−0.94	−0.75	1.26	228.18
RIG	IV	2.58	−0.13	−0.05	2.58*	357.18
LEF	II	−2.58	0.13	0.05	2.58*	177.18
FRO	II	−2.19	0.49	0.22	2.25*	167.45
BAC	IV	2.19	−0.49	−0.22	2.25*	347.45
OPE	III	−2.33	−1.31	−0.49	2.68*	209.28
CLO	I	2.33	1.31	0.49	2.68*	29.28

**Means significate vectors (radium > 1.96). Z_{sum} values, prospective (pros.) and retrospective (retr.), quadrants (Q), radium length (R), and ratio and vector angle (φ) are represented. BLO, blocks; DOD, dodges; CUT, cuts; APE, opening; DIA, direct attack; INA, indirect attack; ACA, anticipatory counterattack; SCA, simultaneous counterattack; PCA, posterior counterattack; LIN, linear technique; CIR, circular technique; GIR, spin technique; CHE, action to the chest protector; HEA, action to the head; RIG, right leg; LEF, left leg; FOR, forward leg; BAC, backward leg; OPE, open guard; CLO, close guard.*

Effective actions to the trunk (SC1) were preceded and followed by spin actions with the back leg and anticipated counterattacks in males, while females opted to cut and performed circular techniques with the right back leg (QI). Direct attacks to the chest occurred before scoring in females and dodges in males (QII), while actions to the head in females and SCAs in males occurred after scoring (QIV). While there is probability of scoring one point in actions with the front leg and openings in both genders, anticipating counterattacks with a linear technique and the left leg in females is limited (QIII).

Effective spin-actions to the trunk (SC2) were preceded and followed by direct attacks in females (QI) and only preceded by actions to the head in both genders and SCAs in males (QII). Those behaviors were followed by actions to the trunk in both genders and anticipated in males (QIV). The probably of scoring two points when openings are performed is limited in males (QIII).

Effective actions to the head (SC3) were related to cut and posterior counterattacks with the backward leg in both perspectives and genders (QI) and cuts in retrospective in males (QII) and spin-actions in females and openings in males in prospective (QIV). The probability of scoring three points with front kicks in both genders and dodges, in females, is limited (QIII).

Effective spin-actions to the head (SC4) were carried out in a scenario of close guard (QI), preceded by blocks, actions with front right leg and SCAs (QII), followed by indirect actions with back and forward leg and cuts (QIV) in males. In SC4 and females, no relationships were found. The probability of scoring four points with open guard and linear kicks is limited in males (QIII).

Coaches may use these findings for specific tasks related to technical-tactical improvement of scoring effectiveness. Studies of this type could also be useful for establishing defensive strategies against specific actions. Sports psychologists could plan psychological intervention according to the athlete's and his/her opponents' characteristics. It would be interesting for future research to consider others types of contexts (world, national, and college championships) or match outcomes, to better discriminate between the motor ability patterns of successful and unsuccessful performances.

AUTHOR CONTRIBUTIONS

CM participated in the study design and data collection, conducted statistical analyses and contributed to the interpretation of the results, drafted the manuscript, and approved the final manuscript as submitted. CF, IE, and AH-M conceived the study, participated in its design and coordination, contributed to video coding, data collection and to the interpretation of results, drafted the manuscript, and approved the final manuscript as submitted. CR and VM-S participated in the study design, contributed to the interpretation of the results, reviewed and provided feedback to the manuscript, and approved the final manuscript as submitted. All authors made substantial contributions to the final manuscript.

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Mixed Methods Approach to Describe Social Interaction During a Group Intervention for Adolescents With Autism Spectrum Disorders

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Over the last 20 years, researchers have been mixing qualitative and quantitative approaches, but mixed methods research represents a new movement that arose in response to the currents of qualitative and quantitative research, considered separately. Little has been published on the use of polar coordinate analysis in psychotherapy. This type of analysis can provide detailed information and integrate the qualitative-quantitative analysis. Even less has been published on the analysis of ASD children's behavior. The main aim of this study was to implement this mixed methods methodology to analyze patterns of social behaviors in a group of adolescents with ASD during a group social competence intervention program. Moreover, we wanted to see whether an observational scale could be combined fruitfully with polar coordinate analysis and to investigate whether typical ASD behaviors show similar interrelations (prospective and retrospective sequentialities) as behaviors observed in psychotherapy. We used an adaptation from the Social Skills Training Program (UC Davis, California). We observed that each participant took a unique course, increasing or decreasing the number and quality of their social behaviors. In accordance with previous literature, results suggest some increment in the amount of appropriate social conduct. We did not detect a generalized progress pattern but agreed that there were changes between the beginning and end of the intervention. Therefore, we consider that observational methodology is useful in the field of psychotherapy and ASD, offering detailed information about changes and development that cannot be obtained with other traditional measures, such as questionnaires.

Keywords: Qual-Quan integration, mixed methods, systematic observation, polar coordinate, social skills interventions, ASD, group

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INTRODUCTION

Autism spectrum disorders (ASD) are serious neurodevelopmental disorders that involve impairments in reciprocal social interaction and social communication combined with restrictive interests, repetitive behaviors and sensory abnormalities, and a wide range of psychiatric and medical conditions (American Psychiatric Association [APA], 2013). The estimated prevalence of ASD is about 1/160 (World Health Organization [WHO], 2017).

Regarding treatment, social skills training programs (SSTP) constitute an evidence-based therapeutic approach commonly used with high-functioning adolescents with ASD. Certain specific manualized programs have demonstrated positive results in improving social competence in adolescents with ASD (DeRosier et al., 2011; McMahon et al., 2013). However, it is difficult to adequately measure improvements in social skills. Most studies that evaluate the effectiveness of group therapies commonly use questionnaires or social cognitive assessments to measure social outcomes (Kasari et al., 2014) but these evaluations have been proven to be insufficiently sensitive and other methods of evaluating these outcomes are urgently required.

According to Sánchez-Algarra and Anguera (2013), systematic, objective, serious study of human conduct is highly complex due to the spontaneity of this behavior and the natural context of the situation. Considering this complexity, integration of qualitative methods, which provide a holistic view of the person, and quantitative methods, which offer more objective information (Lutz and Hill, 2009) has been proposed. It is for this reason that observational methodology is used in the field of psychology research. Observational methodology allows analysis of spontaneous behaviors that occur in the natural environment (Portell et al., 2015) and has been shown to be useful in studying changes that take place over the course of psychotherapy (Pascual-Leone et al., 2009). Moreover, this type of methodology can directly evaluate social performance and behaviors linked to the objectives of the intervention. For instance, McMahon et al. (2013) proposed the use of an observational scale (Bauminger, 2002) to evaluate the efficacy of a group-based intervention for children and adolescents with ASD.

Observational studies are a form of mixed methods research. After researchers had been more than 20 years mixing qualitative and quantitative approaches, mixed methods research is the response to the currents of qualitative and quantitative research, and represents a new movement that has arisen. Arias-Pujol and Anguera, 2017). The mixed methods approach involves the collection, analysis, and interpretation of qualitative and quantitative data for the same purpose and within the framework of the same study (Anguera et al., 2018). Studies that use observational methodology are considered to be mixed methods research studies, as they offer a great amount of data that can be analyzed in different ways. Data obtained from observational methodology are qualitative but can be transformed into quantitative data using different techniques, such as sequential analysis and polar coordinate analysis. These quantitative data can also be analyzed from a qualitative perspective. This integration of qualitative and quantitative methods is coherent with a mixed methods perspective (Anguera et al., 2017). In mixed methods studies we can perform various types of analysis. A study by Arias-Pujol et al. (2015) used lag sequential analysis to identify patterns of interactive behaviors between children with ASD and their therapists during psychotherapy sessions. Results show how certain behaviors exhibited by the therapist stimulated the appearance of positive behaviors in the child.

The analysis of polar coordinates is distinct from other forms of sequential analysis. Polar coordinate analysis reveals the relationships established between a behavior considered as "focal" and a number of conditional behaviors, with respect to prospective and retrospective sequentialities, and to describe different behavioral maps (Castellano and Hernández, 2003). This analysis provides information about activation or inhibition of the registered/observed behaviors through qualitative information transformed into quantitative data, allowing detailed observation of diverse behaviors.

Polar coordinate analysis is an elaborate data reduction technique that provides a vector image of the complex network of interrelationships between categories that make up the different dimensions of the observation instrument. The structure of polar coordinate analysis, which is a technique that complements prospective and retrospective sequential analysis (Bakeman, 1978), is based on complementarity between two analytical perspectives: prospective and retrospective. Therefore, this technique can detect changes in social competence behaviors in adolescents with ASD throughout therapy by combining data from prospective and retrospective viewpoints.

Little has been published on the use of polar coordinate analysis or similar analyses to examine the behavior of children (Herrero, 2000; Espinosa et al., 2004; Rodríguez-Medina et al., 2018). In ASD, the literature is even scarcer. Mixed methods analysis has been used to describe interactions in neurotypical adolescent group therapy (Arias-Pujol and Anguera, 2017). In their study, Arias and Anguera used polar coordinate analysis to analyze conversation turn-taking between therapists and six adolescents over the course of a 24-session intervention. Results show that polar coordinate analysis can offer a new focus. It could be used to study the role of the therapist, her interaction style and the effects of her strategies on participants.

In this study, we used an adapted version of the social competence intervention program developed by the Solomon Lab at the UC MIND Institute (Solomon et al., 2004). The goal of the group therapy is to improve social skills and social competence. Therapists seek to promote social interactions, such as conversation and cooperative play. Sessions include topics such as empathy, talking about feelings and resolving social conflicts.

The main aim of this study was to demonstrate how polar coordinate analysis can be useful in studying social behaviors in adolescents with ADS during an intervention. Moreover, we want to see whether Bauminger's scale could be combined fruitfully with polar coordinate analysis and to investigate whether typical ASD behaviors show similar interrelations (prospective and retrospective sequentialities) as behaviors observed in psychotherapy.

MATERIALS AND METHODS

Design

In this study, we applied systematic observation to analyze social behaviors in a group of adolescents with ASD. A total of ten sessions was conducted, although the first session was not included in the analysis as participants did not know each other and this could interfere in interactions. We only observed 15 min of each session (free play time). The observation of behavior was scientifically rigorous as the observers had a non-participatory role and only observable behavior was coded.

The observational design (Anguera et al., 2001) was nomothetic (several adolescents were observed), included follow-up (every session from the intervention was registered), and multidimensional (several dimensions of the observation instrument were considered suitable) (N/F/P). As the therapeutic process extended to several sessions, the group of adolescents was considered as a plurality of units. We worked with two levels of response: verbal and non-verbal.

Participants

Following approval from the Research Committee Review Board at Sant Joan de Déu Hospital (Barcelona) and the Ethical Committee for Clinical Research at Sant Joan de Déu Foundation (CEIC "Comitè d'Ética d'Investigació Clínica Fundació Sant Joan de Déu"), subjects were recruited by psychologists and psychiatrists from the Multidisciplinary Autism Spectrum Disorder Unit (UnimTEA), Hospital Sant Joan de Déu (HSJD). All parents provided written, informed consent and informed assent was obtained from each child. Participants were informed about the location of the camera and the period of time that would be recorded.

Participants were selected through inclusion criteria based on an age range between 13 and 17 years old, diagnosed with Autism Spectrum Disorder according to DSM-5 criteria, and evaluated with the Autism Diagnostic Observational Schedule-2 (ADOS-2; Lord et al., 2000). Subjects were also required to have a level of Verbal Comprehension within the normal range according to standardized assessment. Participants with below average cognitive or language abilities (IQ < 70), severe behavioral problems, and/or other mental psychopathologies were excluded.

A total of eight adolescents were initially enrolled and participated in ten group sessions. However, the final sample consisted of five participants as three participants did not attend all sessions (mean age 14.6; 1 Girl/ 4 boys).

The group was led by a trained psychologist and assisted by co-therapists.

Intervention Design

The intervention was based on a more extensive program developed by the Solomon Lab at the UC MIND Institute (Solomon et al., 2004). The main goal of the program was to develop and improve social competence skills, following an "inside-out" model, that is, trying to increase inner motivation to socialize. Each session consisted of separate parts: greeting time, 15 min of free play, didactic time, joke time and a take-home social experiment. Didactic time involved training abilities such as empathy, recognizing emotions, managing anxiety or anger, reciprocal conversation skills, theory of mind and problem-solving.

The adolescents included were invited to participate in a total of 10 sessions, scheduled on a weekly basis. These sessions took place in a large, specially adapted room at Sant Joan de Déu Hospital (Barcelona) and lasted for 90 min. Each session followed the same structure: introduction (open conversation), 15 min of free play, didactic time, jokes and ending. Free play time in all sessions was video-recorded.

Before the group sessions, all participant families attended an information session with therapists and general information about the study was provided. Afterward, each participant had an individual meeting with his/her therapist to set his/her own personal goals.

Participants agreed to participate in the program and informed consent was obtained from the parents of minors. All procedures were in accordance with the ethical standards of the institutional research committee and the 2000 Declaration of Helsinki.

Instruments

Diagnostic Instruments

Diagnosis of Autism Spectrum Disorder was confirmed through clinical interview and the ADOS-2 (Lord et al., 2000), which was administered to the adolescents. Cognitive abilities were measured with the Wechsler intelligence scale for children and adolescents: Fourth edition (Wechsler, 2007) or Fifth edition (Wechsler et al., 2014).

Recording Instrument

Group sessions were recorded using two video cameras. In accordance with the principles of the Declaration of Helsinki, the Spanish Official College of Psychologists General Council's Ethical Code and the Ethical Committee for Clinical Research at Sant Joan de Déu Foundation, participants were informed that they were being filmed. They were shown the location of the video cameras, which were positioned discreetly to minimize reactivity bias. Lince software (Gabin et al., 2012) was used to codify behaviors.

Observation Instrument

The observation instrument used to code social behaviors was based on an adaptation of an observational scale (Bauminger, 2002; see **Table 1**) that had previously been used to evaluate social competence groups for adolescents with ASD (McMahon et al., 2013). We adapted the scale in order to make it more adjusted to our clinical reality. Each category was described in a more specific manner so that observers could understand them better and increase inter-observer reliability. We also eliminated the Negative Interaction dimension, because we rarely observed this type of behavior. Finally, we decided to add a dimension that was very interesting and a fundamental part of communication between our participants: gestures. It is worth noting that gestures are more varied and common in Mediterranean cultures than in northern Europe or the United States.

Behavior was grouped into two categories: social initiation (the child/adolescent begins a new social sequence, distinguished from a previous sequence by a change in activity) and social response (the participant responds verbally and/or non-verbally to social stimuli directed toward him/her by peers). Subsequently, each category was organized into three dimensions, depending on the quality of social interaction: high-level positive interaction (HPI; the child exhibits verbal and non-verbal social behaviors that lead to an effective social process with peers and serves

TABLE 1 | Dimensions and category systems in the observation instrument for patients (adaptation of Bauminger, 2002).

Response Levels	Dimensions	Category systems (codes)
Social Initiation (IS): The child begins a new social sequence, distinguished from a previous sequence by a change in activity. Social Response (RS): The child responds verbally and/or non-verbally to social stimuli directed toward him/her by peers.	High positive interaction (HPI): The child exhibits verbal and non-verbal social behaviors that lead to effective social process with peers. Behaviors that serve to start or maintain social interaction.	Eye Contact (CO): The child looks into the eyes of another child. Smile (SON): The child smiles at other children. Affection (AFEC): The child expresses affection for another child, either verbally (e.g., "You're nice," "I like you") or non-verbally (e.g., hugs, touches). Sharing objects (COMOBJ): The child offers his/her objects to another child or shares an object with another child. Sharing experience (COMEXP): The child tells peers about an experience or asks them about their experiences (e.g., "What did you do over the weekend?"). Verbal social communication (COSOVER): The child approaches another child with a social (rather then functional) intention (e.g., "Let's play"). Talk that reflects an interest in another child (CMI): The child expresses an interest in another child's hobbies (e.g., "What's your favorite game/object?"), mood (e.g., "Are you sad?"), etc. Giving help (OFAY): The child offers help to another child.
Social Initiation Social Response	Low level interaction (LPI): The child exhibits behaviors that indicate social intention, but with minimal social enactment, such as close proximity to children without initiating a positive social interaction. Also includes behaviors typical of the autistic syndrome (e.g., echolalia, idiosyncratic language).	Looking: At an action or person without eye contact (MIR): The child looks at the other child's face or body, or child's action, without establishing eye contact. Looks to the side, avoiding eye contact (MOL). Close proximity (PX): The child stands in close proximity to another child (3 feet or less) but does not approach the peer. Yes and No (YES/NO): The child only nods his/her head for yes or shakes it for no. Imitation peer (IMIC) or therapist (IMIT): The child imitates the talk or activity of another child or the therapist. Idiosyncratic language (LID): The child uses utterances with no clear meaning. Repetitive behavior (COMREP): The child behaves in a repetitive manner with no clear communication intent, but in close proximity to another child. Functional communication (COMFU): The child approaches or responds to another child with an intention to fulfill his/her own needs, and with no social intention (e.g., "It's my turn on the computer now"), or just to express something related to the game, without social intent.
Social Initiation Social Response	Gestures	(GECONV): Greet, raise your hand, no / yes (with your head), come, shut up, ok, etc. (GESEN): Gestures that emphasize explanations or participants' discourse, but that do not add any further meaning. (GEDES): Gestures that indicate the quantity, the size, the form... they describe something. (GESEÑ): Point your hand, arm or finger at something to show it to another. (GEMO): Gestures that indicate an emotion (covering your mouth (surprise or laughter), covering your eyes (disbelief), raising your hands or arm (joy), etc.)

to start or maintain social interaction), low level interaction (LPI; the child exhibits behaviors that indicate social intention, but with minimal social enactment, such as close proximity to children without initiating a positive social interaction), and negative interaction (NSI).

These three dimensions involved specific conduct. HPIs included: eye contact, smiling, affection, sharing objects, sharing experience, verbal social communication, talk that reflects an interest in another child's hobbies and giving help. LPI conduct included: looking, close proximity, "yes" and "no," imitation, idiosyncratic language, repetitive behavior and functional communication.

As we observed that our sample never codified for negative interaction, we decided to remove this dimension.

Procedure

Data Quality Control Analysis: Inter-Observer Agreement

From the qualitative research perspective, systematic observation was used to obtain data that we managed as a code matrix. Two observers analyzed and coded 14 min of nine group sessions. The degree of inter-observer agreement, calculated with Cohen's (1988), ranged between 76 and 89%. To obtain this value, 20% of the material was coded and the Kappa coefficient of the A and B sessions (which were randomized) of P3, P5, P6 and P8 participants was calculated. Once we had confirmed the reliability of the data, we codified 14 min during the free play activity of each session to exhaustively record social behaviors throughout the sessions. Finally, we only codified the total material of the participants that appeared in all sessions. For each participant, the nine sessions were organized into three blocks (First block: 1-2-3, second block: 4-5-6 and third block: 7-8-9).

Data Analysis

From the quantitative perspective, data were initially analyzed in a descriptive way, showing the corresponding frequencies of the group categories from the ISP and IBN dimensions in three consecutive group sessions through polar coordinate analysis, which is a technique that shows relationships between categories.

To carry out the prospective analysis, the first step is to define a behavior, known as the focal behavior, which, depending on the aims of the study, is believed to generate or trigger a series of connections with other categories, known as conditional behaviors. To detect significant behavioral patterns, it is necessary to compute lag sequential statistics with a focus on positive lags, i.e., events or behaviors that occur *after* the focal behavior. In the case of our study, positive lags identified "forward-occurring" discursive units used by the teachers.

The retrospective, or "backward" perspective, which incorporates what Anguera (1997) referred to as the concept of "genuine retrospectivity," reveals significant associations between the focal behavior and behaviors that occur *before* this behavior (i.e., negative lags). In this study, this retrospective analysis produced a "mirror-like" image of associations between discursive units that occurred before the focal behavior; the sequence followed was last, second-last, third-last, etc.

As mentioned above, polar coordinate analysis integrates both the prospective and retrospective perspectives, and provides interpretable data through the application of an extremely powerful technique involving the calculation of the Z_{sum} statistic, described by Cochran (1954) and later proposed by Sackett (1980). This computation is possible, as both the frequency of the focal behavior (n) and the Z scores for each of the lags considered are known. These Z scores are independent of each other, as they are computed using the binomial test, which compares observed probabilities (corresponding to textual units derived from observation of the therapists' discourse) with expected probabilities (chance occurrences).

Prospective and retrospective Z_{sum} scores can have a positive or negative sign. Each conditional behavior is represented by a vector, which, in turn, is located in one of four quadrants (I, II, III, or IV) depending on the positive or negative sign of the prospective and retrospective Z_{sum} scores. These quadrants indicate whether the focal and conditional behaviors activate or inhibit each other, as follows:

> Quadrant I: Mutual excitation between focal and conditional behavior (prospective and retrospective activation).
> Quadrant II: Inhibitory focal behavior and excitatory conditional behavior (prospective inhibition and retrospective activation).
> Quadrant III: Mutual inhibition between focal and conditional behavior (prospective and retrospective inhibition).
> Quadrant IV: Excitatory focal behavior and inhibitory conditional behavior (prospective activation and retrospective inhibition).

With polar coordinate analysis technique, it is possible to generate vectors that show the relationship between the focal behavior and each of the conditional behaviors analyzed. Polar coordinate analysis thus constitutes a powerful statistical technique and a robust methodological tool for identifying all possible interrelationships between the variables of interest in a given study. In short, following a complex process of data reduction, polar coordinate analysis generates a highly informative map containing vectors showing the complex network of interrelationships between behaviors that play a central role (focal behaviors) and other, potentially related, behaviors of interest (conditional behaviors). The corresponding calculations can currently be performed in HOISAN v.1.6.3 (Hernández-Mendo et al., 2012). The first step is to calculate the adjusted residual values for lags -5 to $+5$; these values are then standardized and combined with the Z_{sum} of the prospective (positive) lags and the retrospective (negative) lags to calculate the length and angle of each vector. The vectors connect the focal behavior with the conditional behaviors. Once the vector angles have been calculated, each vector is assigned to one of four quadrants that indicate the type of relationship between the focal and conditional behaviors. All vectors with a length of 1.96 were considered to be significant ($p < 0.05$).

In order to facilitate the analysis and obtain more data for each participant, the sessions were divided in three blocks: block 1 corresponded to sessions 1, 2 and 3; block 2 corresponded to sessions 4, 5 and 6 and block 3 corresponds to sessions 7, 8 and 9.

In our study, within the HPI (positive high level interaction) dimension, polar coordinates were calculated for the three blocks of sessions considering the following categories as focal and conditional behaviors: eye contact (CO), sharing objects (COMOBJ), sharing experiences (COMEXP), verbal communication (COSOVER) and five types of gestures: conventional gestures (GECONV), emotional gestures (GEMO), emphatic gestures (GESEN), descriptive gestures (GEDES) and pointing gestures (GESEÑ). Within the LPI dimension, polar coordinates were calculated considering the following categories as focal and conditional behaviors: affirmation or denial gestures, functional communication, play and five types of gestures (as with HPI). No negative social interaction (NSI) was registered.

RESULTS

As previously explained, the final sample consisted of 5 participants with diagnosis of ASD. They all had an IQ within the normal range and presented significant difficulties in social communication and social interaction behaviors. However, the degree of impairment in social communication was distinct for each participant as they showed differences in the quality and frequency of social behaviors (**Table 2**). We also observed differences in their personal patterns. For instance, some participants exhibited more non-verbal communication behaviors (e.g., eye contact, gestures) than verbal communication while other participants showed the opposite patterns (e.g., verbal communication without eye contact).

To describe relationships between social behaviors for each participant, we applied two types of analysis. We analyzed the number of social behaviors in each block of sessions (frequency) and additionally performed polar coordinate analysis. In general, all participants showed fewer LPIs and high variability in high level positive interaction (HPI) behaviors. As described above, polar coordinate analysis offers information on the development of their interactive behaviors. There was no specific pattern that summarized the progress of all participants through the intervention, as each adolescent took a different course. In the sections below, we describe the development of social behaviors for each participant.

Focal behaviors for each participant were chosen according to the frequency with which they appeared in the sessions of each. For example, in Participant 1, functional communication (COMFU) was more frequent than other types of conduct. Therefore this behavior was selected as focal. In contrast, conditional behaviors were those that appeared more sporadically or were less frequent in the interaction.

TABLE 2 | The characteristics of the five participants were as follows.

Participant	Age	Verbal comprehension	ADOS (severity)
P1	16	88	6
P2	15	105	7
P3	14	93	DS 15 (module 4)
P4	14	116	7
P5	14	Missing data	6

Participant 1

As shown in **Figure 1**, participant 1 exhibited a high number of HPI behaviors within the first block of sessions (1-2-3). These behaviors increased during the second block, while LPI behaviors decreased. By the end of the intervention, all types of social behaviors decreased.

Polar coordinate analysis was used to analyze relationships between social behaviors. The focal behavior was functional communication. The graphs in **Figure 2** show the vectors for the different relationships distributed among the four quadrants through the three blocks of sessions (1-2-3, 4-5-6, 7-8-9). On examining the first block (sessions 1-2-3), it can be seen that functional communication does not stimulate any conduct (quadrant I is empty), whereas vectors located in quadrant IV indicate that functional communication and gestures are mutually inhibited. During sessions 4-5-6 (graph 2), functional communication and functional play activate each other (quadrant I). The third graph represents the gesture of nodding/shaking the head as focal behavior during the third block of sessions (7-8-9). Vectors in quadrant I indicate mutual activation between the gestures of nodding/shaking the head and physical proximity. These results suggest positive development of interactive play during free playtime.

The graphs in **Figure 3** show positive steps stimulated by eye contact (focal behavior). During the first block (sessions 1-2-3), vectors located in quadrant I indicate that eye contact (CO) and verbal social communication (COSOVER) were mutually activated, which indicates an appropriate strategy. In the second block (sessions 4-5-6), vectors located in the first quadrant

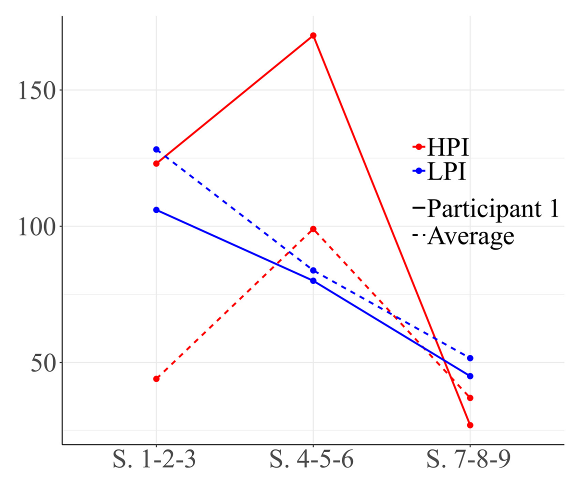

FIGURE 1 | Development of high level positive interaction (HPI) behaviors and low level positive interaction (LPI) behaviors for participant 1. Session blocks 1-2-3 from left to right.

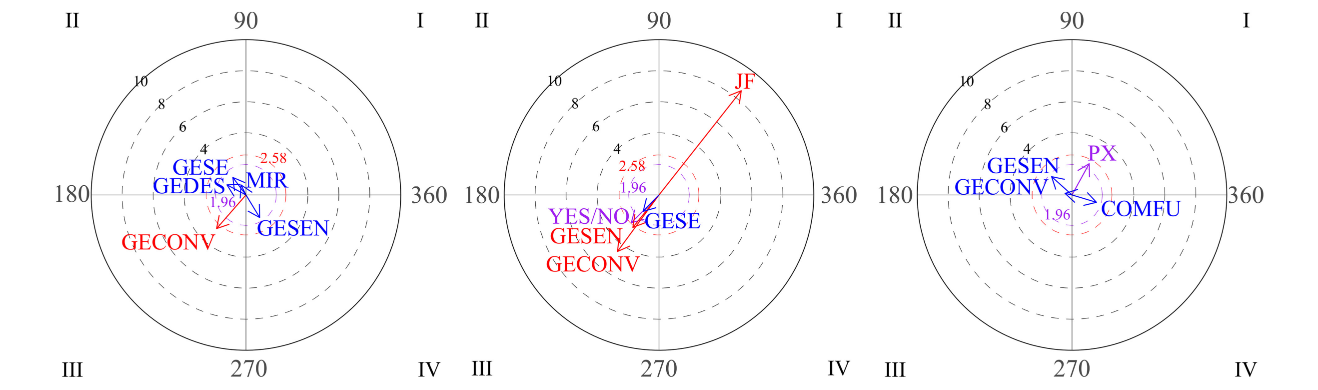

FIGURE 2 | Graphs 1 and 2 represent vectors corresponding to functional communication (COMFU) as the focal behavior during the first and the second blocks of sessions and looking, gestures and functional play as conditional behaviors. Graph 3 represents gestures of nodding/shaking head as focal behavior during the third block and proximity (PX) and functional communication as conditional behaviors.

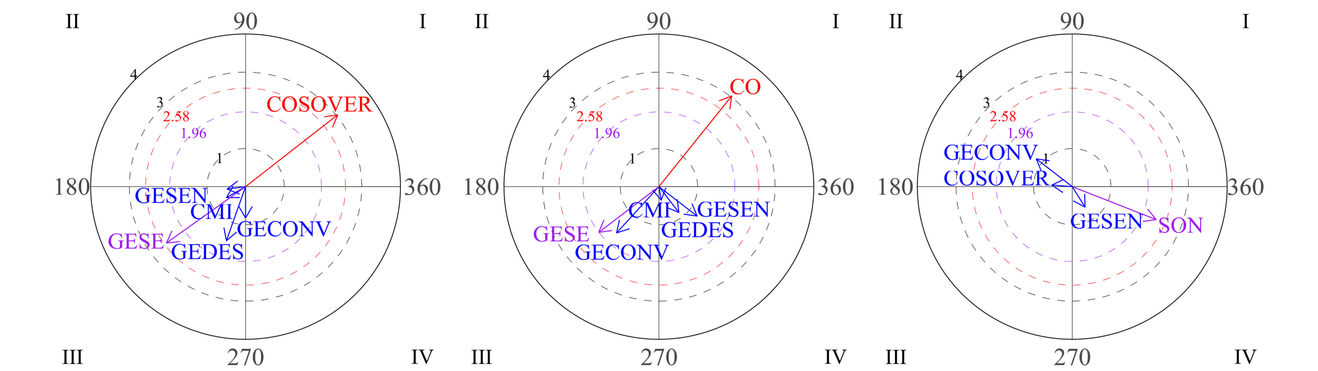

FIGURE 3 | Graph 1 represents vectors corresponding to eye contact (CO) as focal behavior during first block of sessions, and verbal social communication (COSOVER) as conditional behavior. Graph 2 represents verbal social communication as the focal behavior during the first block of sessions. Graph 3 represent vectors corresponding to eye contact as focal behavior during the second and third block of sessions, and conventional gestures and social smile (SON) as conditional behaviors.

indicate mutual activation between eye contact and conventional gestures. Finally, it can be seen that eye contact precedes social smile (SON; quadrant III).

Participant 2

Figure 4 shows the progress of social interaction frequency through the intervention for participant 2. The figure shows that the number of positive interactions increases in the second block with respect to the first block of sessions, while the number of LPIs decreases. Both types of interaction decrease by the end of the intervention.

The graphs in **Figure 5** represent the development of interactions between social behaviors for participant 2 over the course of the intervention. As shown, gestures are very frequently used by this participant. Block 1 is characterized by mutual activation of emotional gestures and emphatic gestures (quadrant I).

For the second block (sessions 4-5-6), vectors located in quadrant I indicate that verbal social communication (COSOVER) and social smile (SON) were mutually activated.

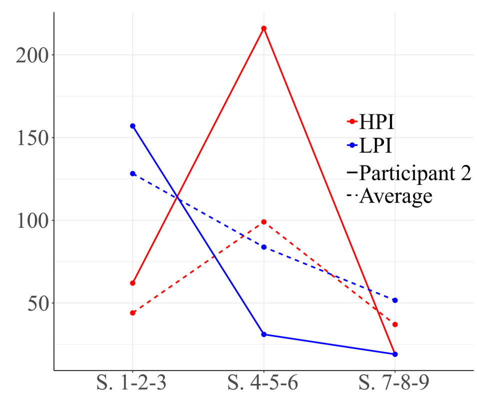

FIGURE 4 | Development of HPI behaviors and low level positive interaction (LPI) behaviors for participant 2. Session blocks 1-2-3 from left to right.

Again, mutual activation was observed between emotional gestures (GEMO) and emphatic gestures (GESEN). No significant result was observed during sessions 7-8-9.

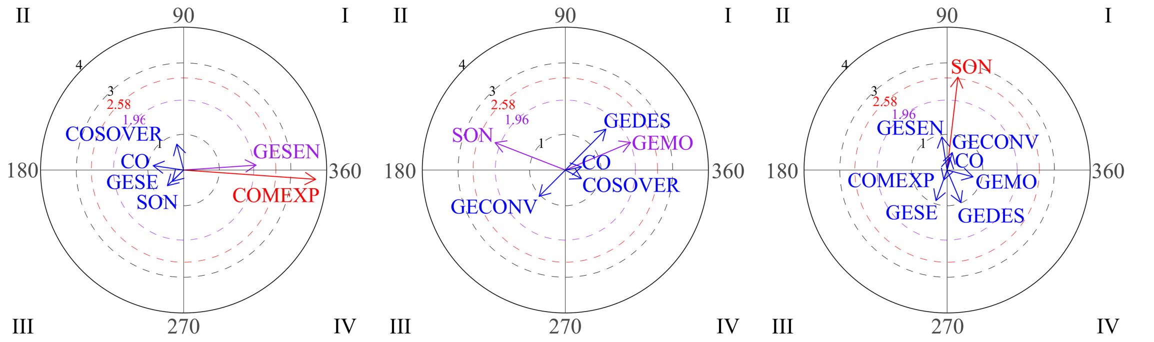

FIGURE 5 | Vectors corresponding to social behaviors of participant 2. Graph 1 and 3 correspond to sessions 4-5-6 and focal behaviors are GEMO and COSOVER. In Graph 2, the focal behavior is GESEN in sessions 1-2-3.

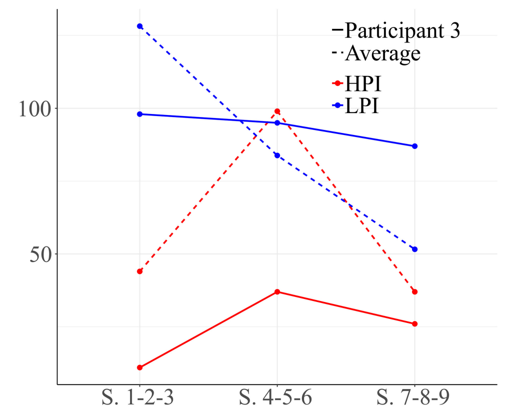

FIGURE 6 | Development of HPI behaviors and low level positive interaction (LPI) behaviors for participant 3. Session blocks 1-2-3 from left to right.

Participant 3

Participant 3 showed a different course to prior participants. As shown in **Figure 6**, he performed more LPI behaviors than HPI behaviors. High level positive behaviors increased through the intervention, indicating that the quality of his interactions probably improved.

Figure 7 represents interactions between social behaviors for participant 3. The focal behavior was functional communication (COMFU). Significant results are observed for quadrants I and II in the first block of sessions (1-2-3). Vectors located in quadrant I reflect mutual activation between functional communication and emphatic gestures. Vectors situated in quadrant II indicate that functional communication inhibits the gesture of nodding/shaking the head (yes/no), while this gesture activates functional communication. The same pattern is observed with emotional gestures. We observe that looking at an object and functional plays do not stimulate communication.

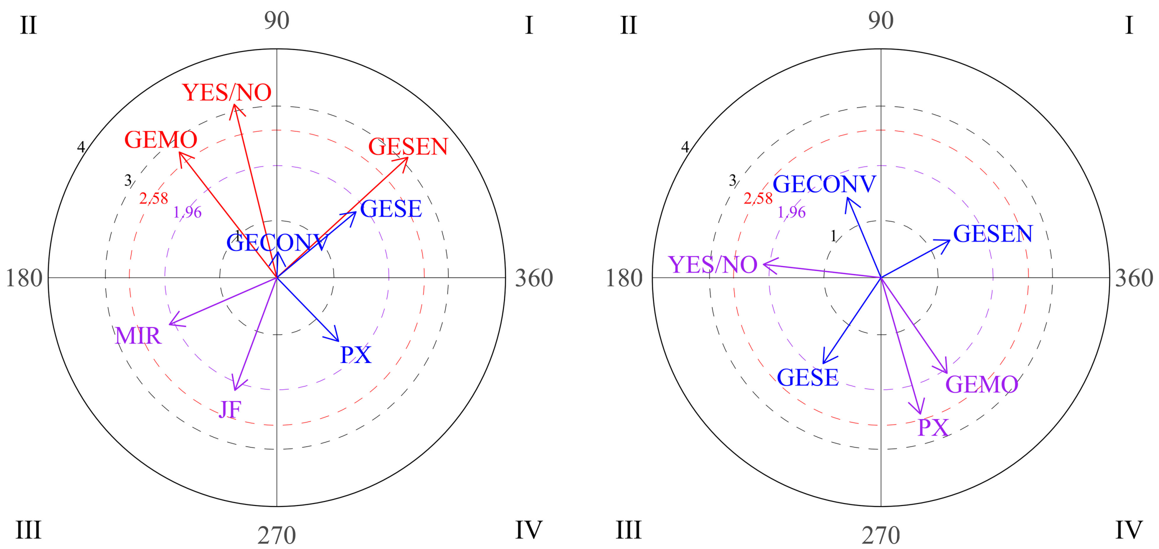

FIGURE 7 | Vectors corresponding to functional communication (COMFU) as focal behavior, and emphatic gestures, gestures of nodding/shaking the head, emotional gestures, looking at an object and functional play as conditional behaviors. Session blocks 1 and 3.

Vectors for the third block of sessions (sessions 7-8-9) show a change in the relationships between functional communication and other behaviors. In this case, the focal behavior (functional communication) stimulates physical proximity and emotional gestures, but not vice versa (quadrant IV). As in previous sessions, gestures of nodding/shaking the head activate functional communication.

Regarding high level positive behaviors, no significant result was observed in sessions 1-2-3 or 4-5-6. There were significant results in the final sessions (7-8-9). We observed that the social smile activates verbal social communication. This participant showed frequent use of functional communication to initiate and respond in free play, exhibiting more LPI behaviors than high level behaviors (**Figure 7**). We observed that during the first sessions his functional communication was more often accompanied by gestures. We observed a new component during final sessions: physical proximity to a partner or to a situation. By the end of the intervention, the amount of high level interaction behaviors had increased.

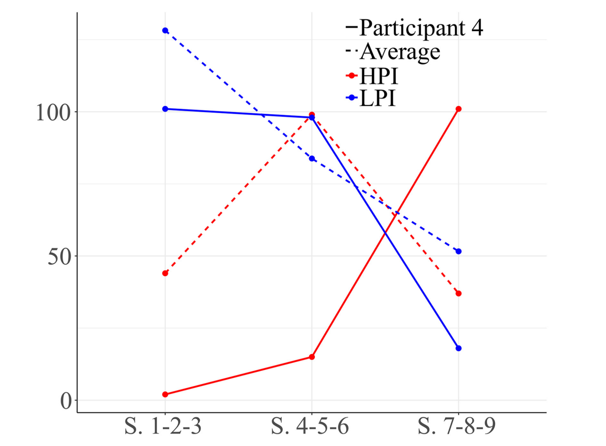

FIGURE 8 | Development of HPI behaviors and low level positive interaction (LPI) behaviors for participant 4. Session blocks 1-2-3 from left to right.

Participant 4

Participant 4 exhibited changes in the use of HPI behaviors and low level behaviors over the course of therapy. **Figure 8** shows that during the first block he manifested a high number of LPIs behaviors. However, the amount of high level interaction behaviors increased in the second and third block.

Graph 1 in **Figure 9** shows significant results for vectors located in quadrant I in block 1 (sessions 1-2-3). As can be seen, functional communication and head nodding/shaking (yes/no) gestures are mutually activated. Mutual activation is also observed between physical proximity and functional communication. These observations might offer information about the way this participant initially performs social initiations and social responses. Vectors located in quadrant IV indicate that functional play and functional communication are mutually inhibited.

Results for the second block show interactions among other behaviors (**Figure 9**, graph 2). Considering head nodding/shaking (yes/no) gestures as focal behavior, it was observed that this behavior activates physical proximity. Repetitive behaviors activate nodding/shaking head gestures.

Head nodding/shaking gestures do not activate emphatic gestures, descriptive gestures or functional communication.

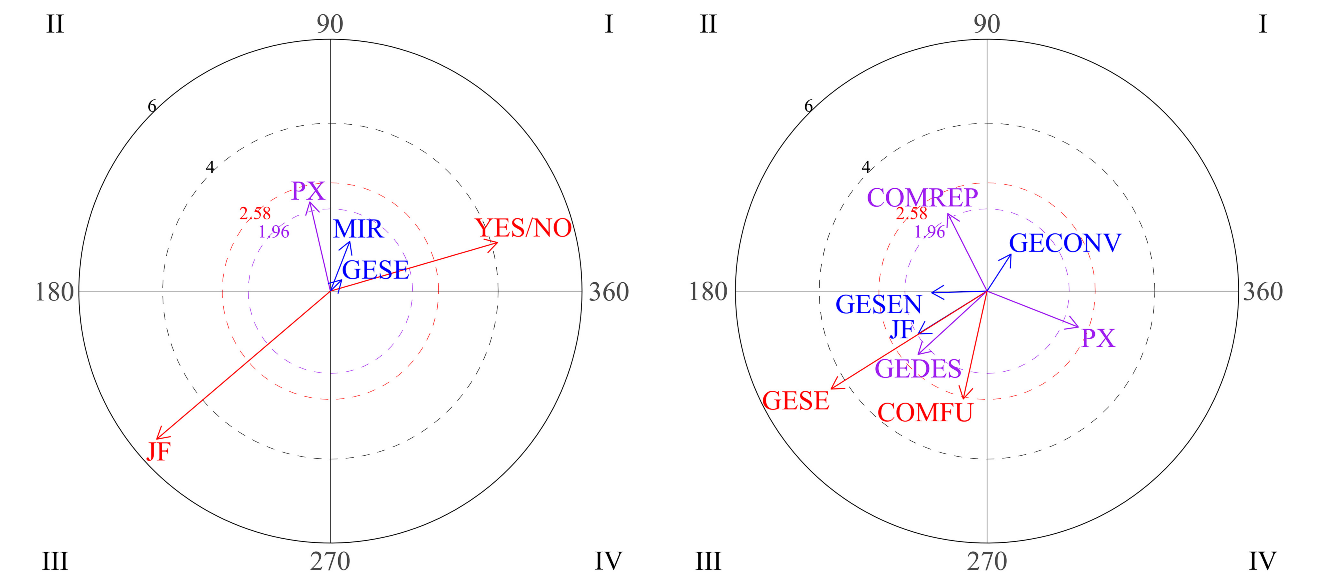

FIGURE 9 | Graph 1 represents vectors corresponding to functional communication (COMFU) as focal behavior and the gestures of head nodding/shaking, physical proximity, functional communication and functional play as conditional behaviors during the first block of sessions (sessions 1-2-3). Graph 2 represents gestures of head nodding/shaking as focal behavior and physical proximity and repetitive behaviors as conditional behaviors during the second block of sessions (sessions 4-5-6).

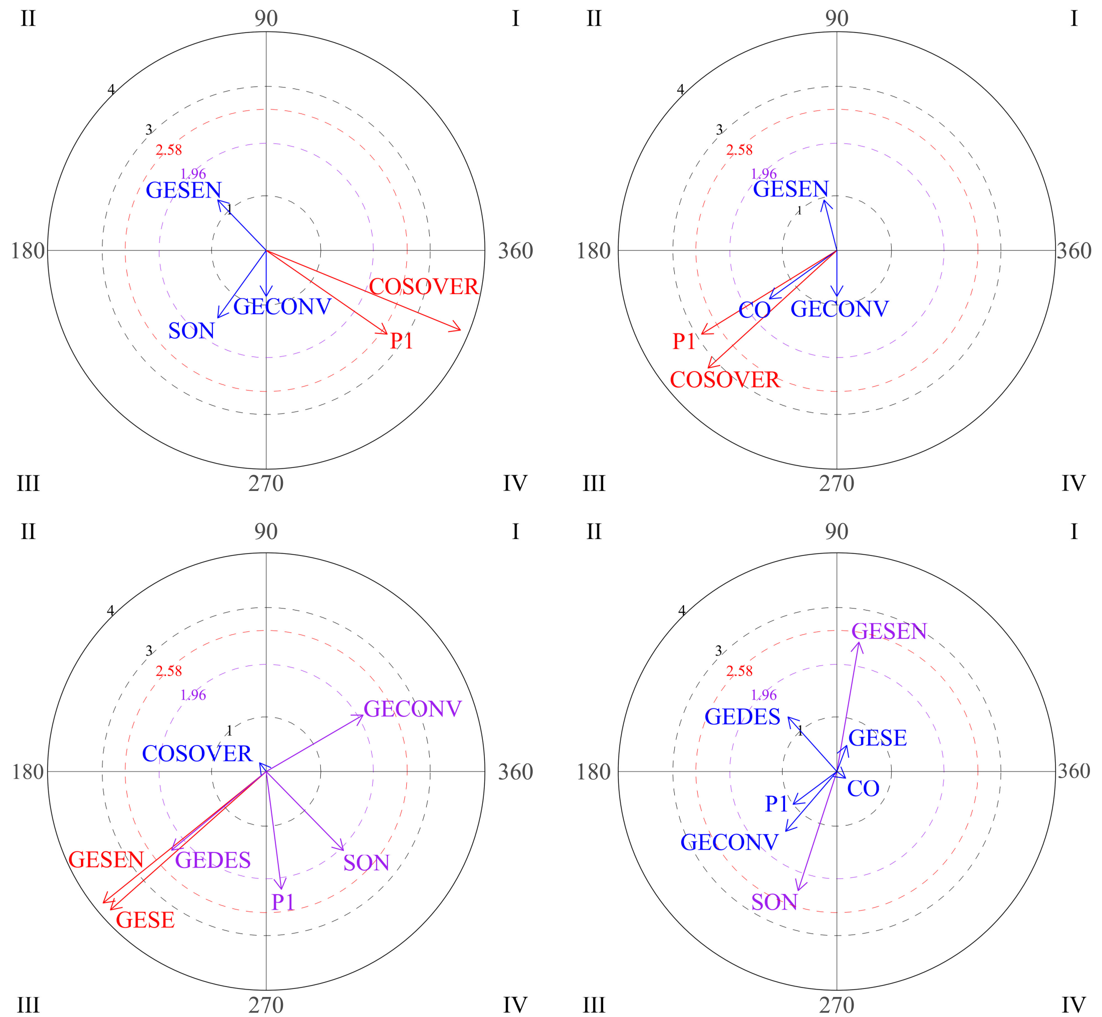

FIGURE 10 | Graph 1 represents eye contact (CO) as focal behavior and verbal social communication (COSOVER) as conditional behavior during the second block of sessions (sessions 4-5-6). Graph 2 represents the social smile (SON) as focal behavior during the second block of sessions (sessions 4-5-6). Graph 3 represents eye contact as focal behavior and social smile, emphatic gestures, descriptive gestures and pointing as conditional behaviors during the third block of sessions (sessions 7-8-9). Graph 4 represents verbal social communication as focal behavior and emphatic gestures as conditional behavior.

Significant results for high level social behaviors are also observed during the second block of sessions (sessions 4-5-6). Considering eye contact as focal behavior, vectors located in quadrant II in the first graph (**Figure 10**) show that eye contact activates verbal social communication, which is expected in any social interaction. Finally, when the social smile is the focal behavior during this second block, verbal social communication and social smile are mutually inhibited (graph 2, quadrant III).

As can be seen in the third and fourth graphs in **Figure 10**, this participant shows significant positive results in the final sessions (7-8-9). For the third graph, the focal behavior was eye contact. Quadrant I indicates that eye contact and conventional gestures are mutually activated. Eye contact also activates social smile (graph 3, quadrant IV), which is important in social interactions. Other types of gestures (emphatic, descriptive or pointing gestures) and eye contact are mutually inhibited (graph 3, quadrant III).

The last graph in **Figure 10** represents verbal social communication as focal behavior, which activates emphatic gestures.

In general, this participant showed high inhibition during early sessions and his interactions were mainly functional and not socially oriented. He demonstrated positive development and an improvement in the quality of his interactions, probably indicating more interest in social communication.

Participant 5

Figure 11 shows the changes of participant 5, manifesting the positive evolution in second block of sessions and decreasing in the final sessions. **Figure 12** represents vectors corresponding to head nodding/shaking (yes/no) gestures as focal behavior during the first block of sessions for participant 5. It can be seen that this type of gesture activates functional play (quadrant IV). Vectors located in quadrant III indicate

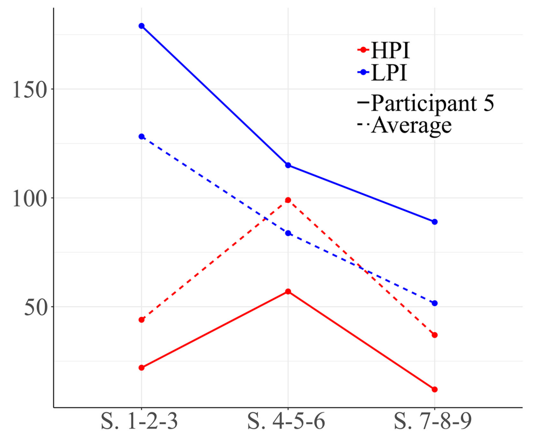

FIGURE 11 | Development of HPI behaviors and low level positive interaction (LPI) behaviors for participant 5. Session blocks 1-2-3 from left to right.

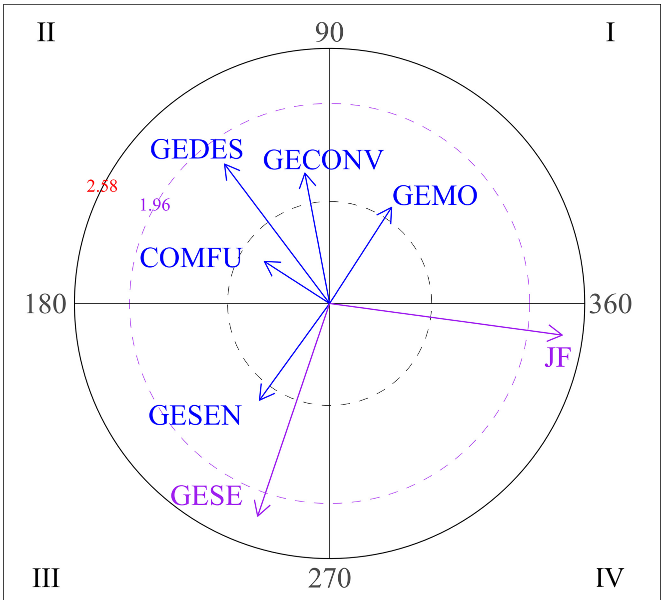

FIGURE 12 | Vectors corresponding to head nodding/shaking (yes/no) gestures as focal behavior, and functional play and pointing as conditional behaviors during the first block of sessions (sessions 1-2-3).

mutual inhibition between head nodding/shaking gestures and pointing.

The graphs in **Figure 13** show the vectors for the different relationships between social behaviors through the three blocks of sessions for participant 5. During early sessions (graph 1), vectors located in quadrant I indicate that social smile activates verbal social communication retrospectively.

Graph 2 represents eye contact as focal behavior during the second block of sessions (sessions 4-5-6). Vectors situated in quadrant I show mutual activation between eye contact and sharing objects, and between eye contact and verbal social communication. These relationships reflect appropriate use of social communication. Finally, graph 3 shows that emotional gesture activates social smile (quadrant IV).

Participant 5 shows high variability in the use of types of social interactions. He uses both high and low level social behaviors at the beginning and end of the intervention. It can be observed that this participant is able to use HPI behaviors, integrating conduct such as the social smile, sharing objects, eye contact, social communication and emotional gestures. Therefore, although the use of high level interactions is variable, this participant shows good abilities in high level social interaction behaviors.

The results show that there is considerable variability between participants, showing different courses through the sessions, improving or decreasing the number and the quality of their social behaviors. In addition, we observed that the average of HPI in the first block of sessions (1-2-3) was very low, in the second block (sessions 4-5-6) increase the number of HPI behaviors increased, and finally we observed another decrease (sessions 7-8-9).

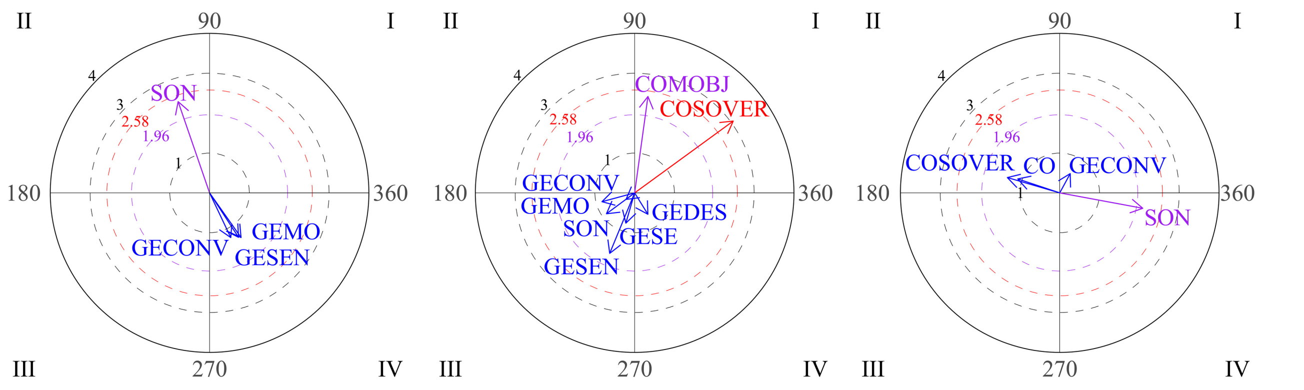

FIGURE 13 | Vectors represent verbal social communication (COSOVER) as focal behavior and social smile as conditional behavior during the first block of sessions (sessions 1-2-3). Graph 2 represents eye contact (CO) as focal behavior and sharing objects and verbal social communication as conditional behaviors during the second block of sessions (sessions 4-5-6). Graph 3 represents emotional gestures as focal behavior and social smile as conditional behavior during the final block of sessions (sessions 7-8-9).

DISCUSSION

The main goal of this study was to analyze patterns of social behaviors in a group of adolescents with ASD that participated in a group social-competence intervention program. To evaluate these patterns, we adapted a previously used observation instrument and used polar coordinate analysis, based on an integrative qualitative-quantitative perspective.

The observation instrument presented could be considered as a new tool for coding and analyzing social behaviors. Our final instrument was an adaptation of an observation scale developed by Bauminger (2002), which had already proved its utility in analysis of social behaviors through social-competence group interventions (McMahon et al., 2013). With this study, we also observed that this instrument could be useful for polar coordinate analysis. The reliability results in the data quality control analysis support the adequacy of the data obtained. This observation instrument might have future applications in the field of psychotherapy.

Regarding polar coordinate analysis, we show the potential of the application of this observational methodology in analyzing behaviors in a group of adolescents with ASD. As has already been noted, Portell et al. (2015) described observational methodology as the type of evaluation that allows analysis of spontaneous behaviors in psychotherapy. Our results show that participants exhibited highly variable patterns of social behavior and different courses of development. Therefore, it is not possible to summarize their behaviors in one single pattern that represents the whole group of adolescents. Nevertheless, we were able to observe spontaneous behavior in a semi-structured social environment, which allowed us to observe variation in behaviors for each participant.

In common with Anguera et al. (2018), we established that the use of observational methodology offers the opportunity to obtain a large amount of data that can be analyzed with different techniques. These data offer a great variety of options when analyzing behaviors in a more sensitive and detailed manner, offering information to which questionnaires are not sensitive (Kasari et al., 2014).

Similarly, Castellano and Hernández (2003) suggest that polar coordinate analysis offers the chance to observe unique qualitative details which can be subsequently transformed into quantitative data to be interpreted in a more global manner. In our study, this type of analysis offered information about bidirectional relationships that appear between the behaviors of each participant. In the field of ASD, obtaining detailed information about behaviors would be very useful for therapists, as it can provide information on the way one type of behavior might activate or inhibit another. In our study, we obtained information on how one behavior activated or inhibited another in the same person. Another type of analysis could examine interactions among different participants. For example, how a therapist activates or inhibits other participants' behaviors could be explored (Arias-Pujol and Anguera, 2017).

It is also valuable to know the type of behaviors that a person tends to exhibit. For instance, knowing whether a participant tends to display more low or high level behaviors could be important. Therapists may be interested in observing whether this tendency changes through the course of their interventions.

Similar observational methodology and polar coordinate analysis has been used to analyze behaviors in sports competitions, such as soccer (Maneiro and Jiménez, 2018) and handball (Morillo et al., 2017). These studies support the numerous possible applications of this type of methodology.

CONCLUSION AND FUTURE LINES OF RESEARCH WORK

We observed that each participant took a unique course, increasing or decreasing the number and quality of their social behaviors. In accordance with the literature, we observed some increment in the amount of appropriate social conduct. We cannot generalize to a pattern of progress but can say that there were changes and differences between the beginning and the end of the intervention. Therefore, we consider that observational methodology might be useful in the field of psychotherapy and ASD, offering information about changes and development that cannot be obtained with other traditional measures, such as questionnaires.

For future lines of research, it would be interesting to correlate the different variables of the initial evaluation (i.e., ADOS2, WISC-V) with data obtained from polar coordinate analysis. This would provide more information about the possible changes in the degree of severity or difficulties related to ASD. Furthermore, studies with a greater number of sessions are needed to obtain more data that support these findings. In addition, it is vital to conduct more studies that include observational methodology and mixed methods analysis to obtain more evidence on the real utility of this methodology. It is important to obtain reliable data that support this type of analysis, which would, in turn, allow researchers to obtain detailed information on spontaneous behaviors and then transform this information into quantitative data. Professionals in the field of ASD need new methods to evaluate their interventions and the changes in their patients. Each little change might be important in a child's development.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of Spanish Official College of Psychologists General Council's Ethical Code with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Research Committee of Hospital Sant Joan de Déu.

AUTHOR CONTRIBUTIONS

MÁM and CA developed the project, codifying the videos, running the group therapy and writing the manuscript. EA-P contributed to documenting, drafting and writing the manuscript and gave her approval to the final version to be published. MTA wrote the methods section and performed the polar coordinate analysis. MM, NE, MD-J, GB, MG-R, and JR-M contributed to documenting, drafting and writing the manuscript. JR-M designed all the figures of the manuscript.

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Support System for the Assessment and Intervention During the Manual Material Handling Training at the Workplace: Contributions From the Systematic Observation

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Efficacy of classical manual material handling (MMH) training interventions on back pain prevention at the workplace has been called into question. The way that observation (self-observation or hetero-observation) is used in other areas to create feedback addressed to modify motor activities can justify innovative components for these interventions. However, their implementation and evaluation cannot be done without tackling the methodological challenge of developing a reliable observational instrument to measure manual handling practice during the training process. The aims of this study were: (1) justify and develop an hetero-observation (H-O) instrument to assess changes in the worker behavioral patterns with a level of analysis convenient to derive a parallel version for the systematic self-observation (S-O) during training on MMH; (2) provide evidence on the inter-rater reliability of the H-O instrument; (3) provide evidence on the usability of the S-O instrument and its perceived usefulness; and (4) provide evidence on the benefits that can be derived with the use of the H-O instrument to create feedback based on T-pattern and polar coordinate analysis. A mixed method approach mainly grounded on systematic observation was used. A convenience sample composed by blue-collar workers participated in the study. Based on literature review and expert opinion, the H-O instrument proposed was composed by six dimensions (feet, knee joints, back, elbow joints, load position, and interaction between back tilt and displacement) plus a structural dimension which defined MMH phases. The inter-rater reliability of this instrument was almost perfect for all dimensions using a tolerance level of 2 s (the range of time-unit kappa was from 0.93 to 0.97 and the range of event-based kappa was from 0.82 to 0.9). The usability and usefulness of the S-O instrument was highly valued by workers. Regarding the way to use hetero-observations to create feedback, the paper shows the great potential of T-pattern and polar coordinate analysis. The observational instruments developed combined with these techniques make it possible to characterize the body positions adopted during manual handling performance, and this is crucial to create feedback on performance instead of only feedback on results.

Keywords: systematic observation, health promotion in the workplace, T-pattern analysis, polar coordinate analysis, mixed method approach, manual material handling, feedback

INTRODUCTION

Musculoskeletal disorders (MSDs) are one of the most common occupational disorders worldwide (Schneider and Irastorza, 2010; Hossain et al., 2018; Penkala et al., 2018). Lifting and handling of loads have been associated with an increased risk of back disorders, mainly developing low back pain (Bernard, 1997; Hoogendoorn et al., 2000; Thiese et al., 2014). Even though the majority of the tasks have been automated, manual material handling (MMH) is still being carried out in numerous workplaces (e.g., building sites, nursing, or the food industry), and what is more, there are plenty of daily life activities in which people may perform MMH during non-working hours (e.g., lifting or carrying people or objects such as boxes).

Throughout the last decades, there has been an increase of studies focused on developing, implementing and evaluating the efficacy of MMH training on the reduction of low back pain or back injury prevention (Punnett et al., 2009; van der Beek et al., 2017). The systematic reviews of Clemes et al. (2010), Verbeeck et al. (2011), and Hogan et al. (2014) agreed that most of MMH trainings are not effective to reduce low back pain or back injury. This lack of effectiveness has been related to the focus on a task-specific training instead of a multidimensional approach (Clemes et al., 2010). Also, it has been related to the use of interventions not based on a behavioral change theory (Verbeeck et al., 2011; Hogan et al., 2014). Most studies have focused on evaluating the effectiveness of training on long-term results, such as reduction of MSDs, and there are few rigorous evaluations of the effect of MMH training on key intermediate variables of the changing health behavior theory, such as knowledge or behavior change (Hogan et al., 2014). The inclusion of these intermediate variables is necessary to evaluate the implementation process, which in turn is necessary to identify why an intervention worked or not, and under which operating conditions these interventions are likely to be most effective (Pedersen et al., 2012). Another limitation is the lack of transferability of the intervention effectiveness from the training situation to other labor and non-labor settings; and this lack of transferability has been related to the components of those interventions (Ford et al., 1998; Clemes et al., 2010; Hogan et al., 2014). Solving some of the aforementioned constraints cannot be done without tackling a methodological challenge related to the development of reliable observational instruments to measure manual handling practice during and after training (Hogan et al., 2014).

On the transferability issue, the way that observation (self-observation or hetero-observation) is used in other areas to create feedback addressed to modify motor activities can justify innovative approaches (Kernodle and Carlton, 1992; Janelle et al., 1997; Dowrick, 1999, 2012; Wulf et al., 2010; Magill, 2011; Ste-Marie et al., 2013). Previous research provided evidence on the effectiveness of the feedback derived of self-observation in the learning of motor skills (Salmoni et al., 1984; Newell, 1991; Kernodle and Carlton, 1992; Janelle et al., 1997; Silva et al., 2016). Moreover, starting with an hetero-observation to provide information on what is well done, what should be improved, and how it should improve (these last two pieces of information are known as feedforward) has proved to have a positive effect in order to modify different behaviors in different settings (Newell, 1991; Kernodle and Carlton, 1992; Buggey, 2007; Dowrick, 2012; Mason et al., 2016). As far as we know, the combination of feedback based on self-observation (the observed and the observer are the same person) and hetero-observation (the observed and the observer are different people, e.g., worker and technician) has not been incorporated in the occupational MMH training. Based on the studies reviewed, these components could be particularly beneficial to improve the training of workers with special responsibilities in fostering safety habits in workplaces (e.g., supervisors).

On the issue of observational instruments, there are few studies specifically evaluating behavioral change in manual handling, and they generally rely on observational methods developed with the aim of assessing MSD risk (e.g., Snook and Ciriello, 1991; Daltroy et al., 1993; Waters et al., 1993; Best, 1997; Lortie and Baril-Gingras, 1998; Nygård et al., 1998; Monnington et al., 2002; Chang et al., 2003; Marras and Karwowski, 2006; Batish and Singh, 2008; Village et al., 2009). However, these kinds of instruments do not allow for the assessment of behavior change in the way of characterizing body positions adopted during the process of manual handling execution, and this is crucial to create feedback on performance instead of only feedback on results (Salmoni et al., 1984; Kernodle and Carlton, 1992; Janelle et al., 1997; Magill, 2011).

The general purpose of this study was to develop and justify observational instruments that combine two uses during manual handling training on back pain prevention. On the one hand, change assessment in worker behavioral patterns. On the other hand, its use as a source of feedback based on systematic self-observation by workers and the hetero-observation of workers by a technician. The development of observational instruments was based on observational methodology (Anguera, 2003) and will be reported following the Guidelines for Reporting Evaluations Based on Observational Methodology (GREOM) (Portell et al., 2015; included in the EQUATOR library). This methodological approach allows the systematic analysis of spontaneous behavior in a natural environment using a set of dimensions and categories to evaluate behavior changes and temporal patterns using T-pattern analysis (Magnusson, 1996, 2000, 2018; Casarrubea et al., 2018), lag sequential analysis (Bakeman and Quera, 2011; Quera, 2018) or polar coordinate analysis (Sackett, 1980; Morillo et al., 2018; Rodríguez-Medina et al., 2018). Observational methodology is well established in several fields (Blanco-Villaseñor et al., 2010; Anguera and Hernández-Mendo, 2016; Arias-Pujol and Anguera, 2017; Cerezo et al., 2017; Escolano-Pérez et al., 2017; Izquierdo and Anguera, 2018; Pérez-Tejera et al., 2018; Santoyo and Mendoza, 2018). Nonetheless, their use to provide feedback as an intervention component within an occupational MMH training, as well as their use to assess behavioral change derived from training is innovative. We use the term SsObserWork (Systematic Self-Observation of Work) to label our application of the observational methodology for workplace health promotion. The SsObserWork design and evaluation can be seamlessly integrated into the research framework for the development and implementation of interventions preventing work-related musculoskeletal disorders proposed by van der Beek et al. (2017). Specifically, the aims of this paper were: (1) justify and develop an hetero-observation instrument with a level of analysis convenient to derive a parallel version for systematic self-observation during the training on MMH technique; (2) provide evidence on the inter-rater reliability of the hetero-observation instrument; (3) provide evidence on the usability of the self-observational instrument and its usefulness perceived; and (4) provide evidence on the use of the hetero-observational instrument to create feedback based on T-pattern analysis and polar coordinate analysis.

METHODS

Concerning the methodological approach, this work is enclosed within the mixed methods perspective that are characterized by the integration of qualitative and quantitative elements. This integration was carried out from the “connect” option (Creswell and Plano Clark, 2011). Systematic observation grounded in observational methodology (Anguera, 2003) was applied, because it was suitable in relation to the proposed aim. Recently it has been considered in scientific literature that observational methodology studies, in which the QUAL-QUAN-QUAL macro stages take place, can also be considered mixed method studies in certain circumstances, as they apply unconventional approaches (i.e., not based on frequency counts) to quantitize qualitative data (Sánchez-Algarra and Anguera, 2013; Anguera et al., 2017, 2018b). Researchers have been mixing qualitative and quantitative approaches from the last 20 years. Many researchers do not mix qualitative and quantitative approaches in optimal ways, but qualitative techniques can be used to enhance the development of quantitative instruments and vice versa. Its potential is very broad, and includes instrument fidelity, “maximizing the appropriateness and/or utility of the instruments used, whether quantitative or qualitative” (Onwuegbuzie et al., 2010, p. 57).

We used systematic and direct observation. According to the possible study designs, described in observational methodology (Anguera et al., 2001; Portell et al., 2015), the design used can be classified as nomothetic, follow-up and multidimensional. It is nomothetic because we conducted a parallel analysis of a group of workers. We classify as incomplete follow-up given the observation during two training sessions and the intra-sessional follow-up (intensive or continuous monitoring of events throughout observation sessions in order to obtain behavioral dynamic indicators or sequential data). The multidimensional nature of the design was determined for the multiple criteria included in the purpose-designed observation instrument. Additionally, the quantitative approach was complemented with data collected from a cross-sectional design in order to obtain evidence of usability and usefulness.

Observation Instruments Development

The SsObserWork instruments were developed in three phases. In the first phase, a review of the scientific literature was conducted to establish the research background. We searched the Scopus, Web of Science, PubMed and Google Scholar databases for studies on the MMH training phases (Hsiang et al., 1998; Plamondon et al., 2014), and mostly studies on the effect of the back position (Anderson and Chaffin, 1986; McGill, 1997; Larivière et al., 2000; Straker, 2003b; Mörl et al., 2005; Kahrizi et al., 2007; McGill, 2007; Mawston and Boocock, 2012), feet position (Kirby et al., 1987; Authier et al., 1996; Kingma et al., 2004; Kingma et al., 2006; Demaret et al., 2007; Zhou et al., 2013), knee position (Hagen et al., 1993; Straker, 2003a,b; Kingma et al., 2004; Mörl et al., 2005), arms and load position (Hsiang et al., 1997; Marras et al., 1999; Demaret et al., 2007; Faber et al., 2009; Colombini et al., 2013) on MMH and their impact on the risk of back disorders. Based on this review and considering the objective to establish an instrument similar for hetero-observation and systematic self-observation, the granularity of the codes (Bakeman and Quera, 2011; Anguera et al., 2018a) was established. It was done considering that the procedure of modeling movements by observation with the objective of a performance description can vary from a micro to macro (or molecular to molar) level of granularity or specificity. On one side, codes can be created to capture minimum details (e.g., repeated measurement of movements during the process based on sensor-based high-resolution) while on the other end of the continuum they can be relatively broad (e.g., general assessment of balance and coordination at the end of the process). We selected a medium level of granularity for the decomposition into categories of the MMH process. With this level of granularity, the instrument for worker hetero-observation will be able to generate sequential data of their performance. Moreover, this level of granularity seems molar enough to allow us to obtain a parallel version understandable for the worker during the implementation of the systematic self-observation; we will refer to this version as self-observation instrument, hereinafter S-O instrument.

In the second phase, the observational context was established, and a pilot testing of a preliminary version of the hetero-observation (H-O) instrument was performed. The instrument was developed focusing on a standard MMH task in a training context in which attention is paid to lifting, carrying and lowering actions done spontaneously by the employee from a sagittal plane. The recording requirements were established based on a previous review (Kilbom, 1994; da Silva et al., 2014). The instrument was developed as a combination of field format and category systems, and it was created with nine dimensions. For the first eight dimensions we built category systems to codify the positions of different body segments and sub-segments: feet, feet with respect to floor, knees, back, arms with respect to legs, arms with respect to back, elbows, and shoulders. The last dimension was a catalog of codes to identify the phases. A standardized training manual was developed with definitions and diagrams for each category and code. This first version was applied in a pilot study implemented in a company in the metallurgical sector. Pilot testing of this preliminary version was performed by two observers trained in ergonomics who applied the instrument to the observation of 16 workers doing 160 MMH tasks. Data quality was evaluated by an inter-observer reliability analysis, using conventional Cohen's Kappa agreement index. The Kappa values of the dimensions ranged from 0.39 to 0.75, with a median of 0.65, indicating moderate agreement (Landis and Koch, 1977).

In the third phase, the H-O instrument and the manual were optimized and the self-observation (S-O) version was created. Four external experts in different areas took part in this process: a physiotherapist specialized in patient transfer, two specialists in occupational medicine and safety, ergonomics, psychology and industrial hygiene, and an expert in physical activity and sports science, specifically in physical activity at work. These experts participated in qualitative interviews on the appropriateness and representativeness of the dimensions, categories and training context. The interviews were organized as an iterative process whereby each interview informs the next, and subsequent interviews are used to explore the weaknesses raised in previous interviews (Brod et al., 2009). Interviews were conducted by MP and AS-M. During this phase, the number of dimensions and categories was reduced, the definitions were improved, the classification criteria to define supra-categories (recommended or non-recommended to prevent health risk) were established, recording rules were clarified, and the observers training process was improved.

Participants and Samples

A convenience sample was initially composed by 53 blue-collar workers of a food processing company in Catalonia (Spain), who were interested in participating in two sessions of a multicomponent training on health promotion in the workplace. The sample participants were 24 men (45%) and 29 women (55%), of which 4% were between 18 and 28 years old, 38% were between 29 and 39 years old, 30% were between 40 and 50 years old and 28% were more than 50 years old. Participants did not have chronic bone, muscle or joint pathology in the trunk, knees, nor chronic or acute pain diagnosed by a specialist. While attending training sessions, workers were video-recorded during box manipulation (see next section).

On the reliability study of the H-O instrument the sampling unit was the box-manipulation. From a total number of 530 boxes manipulated, 84 box-manipulations were randomly selected for the reliability study. The hierarchical stratification sampling scheme used took into account the position of the box within session and between sessions. This sampling scheme ensured that a minimum of 77% of the participants were represented on this box-manipulation sample.

Regarding the study on usability of the S-O instrument, the participants were a subsample of 27 workers who used the S-O instrument in two separate self-observation sessions. Participation in this study was voluntary, but the opportunity to take part in two self-observation sessions was randomly established. The participant subsample were 10 men (37%) and 17 women (63%), of which 41% were between 29 and 39 years old, 37% were between 40 and 50 years old and 22% were more than 50 years old; no statistically significant differences were observed on these variables regarding the general sample.

The Ethics Committee of the Universitat Autònoma de Barcelona approved the study protocol. In accordance with the principles of the Declaration of Helsinki, participants were informed that they were being filmed. They were shown the location of the video cameras, which were positioned discretely to minimize reactivity bias. Informed consent was also obtained.

Instruments

According to the GREOM (Portell et al., 2015), the reporting of systematic observation studies must clarify the distinction between observation instruments (i.e., purposed-designed instruments to analyze a given participant; where development is the main objective of this paper and it will be presented as a part of the results) and recording instruments (i.e., those used to record and code data according to the dimensions established by the observational instrument). In this study, the recording instrument was LINCE (v.1.2.1) (Gabin et al., 2012; Hernández-Mendo et al., 2014). Box manipulation was registered with Sony HD video cameras and videotapes were transferred to Toshiba Portege laptops for their codification. The following computer software was used to perform the data analysis: GSEQ (v.5.1) (Bakeman and Quera, 2011), HOISAN (v.1.6.3.3) (Hernández-Mendo et al., 2012), and THEME (v.6.0 Edu) (Magnusson, 2000).

Procedure

As a part of a multicomponent training in health promotion at the workplace, workers were video-recorded while having to lift, carry and lower 5 boxes (8 kg each). The video camera was positioned at the workers' hip height and the plane was sagittal. All observations took place in company spaces adapted to training. After MMH performance and recording, a subsample of 27 workers observed their own performance using the S-O instrument. During this self-observation task the technician provided feedback and feedforward considering the classification associated to H-O and S-O instruments (**Table 1**). These workers repeated the MMH performance recording and systematic self-observation task 3 weeks later. At the end of this second systematic self-observation task, workers were required to answer five questions on usability and usefulness perceived of the S-O instrument, which were adapted from previous studies

(Tsakonas and Papatheodorou, 2008; Zapata et al., 2015). The usability questions explore the understandability of the terminology, images, aesthetic appearance and layout. The usefulness questions explore the worker's perceptions regarding the instrument's ability to improve their knowledge on MMH technique and their behavior during MMH. A 10-point response scale was used for all questions (from 1 – very low – to 10 – very high).

For the reliability study of the H-O instrument we adapted a double approach justified by Arana et al. (2016). A first block of codes (block AB) was generated by two members (AS-M, MP) using a process of qualitative consensus agreement in the application of the H-O instrument to the 84 units. Parallel to this, a senior technician for work hazard prevention (who did not participate in the instrument development) was trained in the use of the H-O instrument for 9 h with specific materials (the box-manipulation used for this training was not included in the sample). This technician codified the 84 units, acting as an independent observer, and creating a second block of codes (block C).

Data Analysis

Time-Unit Kappas and Event-Alignment Kappas

Considering the purpose of this paper, we used a demanding approach to the agreement study, emphasizing observer agreement regarding the data collected (not with scores derived from such data). For each category system, data were recorded as time-event sequential data (Bakeman and Quera, 2011), that is, mutually exclusive and exhaustive (ME&E) codes for each dimension had been assigned to events as they unfold over time (micro-coded). We applied the agreement study algorithms for time-event sequential data proposed by Bakeman et al. (2009): time-unit kappas and event-alignment kappas. Both time-unit and event-based kappas were computed using GSEQ (v.5.1) (Bakeman and Quera, 2011; Quera, 2018). Time-unit

TABLE 1 | Dimensions and category systems of SsObserWork instruments: hetero-observation (H-O) and self-observation (S-O) version.

H-O instrument Category systems	Code	Classification[a] (Recommended -R- or Non-Recommended -NR-)	S-O instrument[b]
Dimension 1. Feet			
Symmetric feet behind the load	p1	NR, during LF and LW phases.	✓
Asymmetric feet behind the load	p2	NR, during LF and LW phases.	✓
Symmetric feet beside the load	p3	R, during LF and LW phases.	✓
One foot beside the load and the other behind it	p4	HR, during LF and LW phases.	✓
Walking	ppv		
Dimension 2. Knee joints			
Extension – slight flexion	rex		✓
Moderate flexion	rmo	R, during LF and LW phases. It is just considered NR when the highest position and the upright (0 cm) position are concurring.	✓
Maximum flexion	rsq	NR, during all MMH phases.	✓
Walking	rcv		
Dimension 3. Back			
Neutral	tne	R, during all the MMH phases.	✓
Flexion	tF	NR, during all the MMH phases.	✓
Maximum flexion	thip	NR, during all the MMH phases.	✓
Extension	tEx	NR, during all the MMH phases.	✓
Dimension 4. Elbow joints			
Extension – slight flexion	b1	R, during all the MMH phases.	✓
Flexion	b2	NR, during all the MMH phases.	✓
Dimension 5. Load position			
Close to the body	ap	R, during all the MMH phases.	✓
Separated from the body	se	NR, during all the MMH phases.	✓
Dimension 6. Interaction between back tilt and displacement			
Tilt at 0 cm	sin	R, during LF and LW phases.	
Tilt at > 0 cm	non	NR, during all the MMH phases.	
Upright at 0 cm	f13	R, during the highest position of LF and LW phases.	
Upright at > 0 cm	anda	R, only during CA phase.	

[a]*The classification as recommended (R) or non-recommended (NR) is defined in relation to the MMH code phases: LF-Lifting [with three subphases: initial position (f1a), lowest position (f1b), highest position (f1c)]; CA-Carrying (f2); LW-Lowering [with three subphases: highest position (f3b), lowest position (f3c), final position (f3d)].*
[b]*The check mark (✓) indicates the presence of the category in the S-O instrument.*

kappa examines interrater agreement in time (i.e., how long agreement and disagreement lasted). On this data we consider it acceptable not to count minor errors of timing on the order below 0.5 s and we define five levels of tolerance: 0.5, 1, 1.5, and 2 s. Event-alignment kappa examines interrater reliability on code order for timed events (i.e., onsets and durations). In this procedure, GSEQ aligns codes using a predefined algorithm (Bakeman et al., 2009) and examines agreements, omission and commission errors. We also use the mentioned five levels of tolerance and an 80% event overlap.

T-Pattern Detection and Analysis

T-pattern analysis was proposed and developed by Magnusson (1996, 2000). This analysis allows for detection of hidden or nonobvious temporal patterns in behavior that are not always visible. The detection algorithm first identifies significant (non-random) recurrences of any two events (in T-pattern analysis "event" refers to the configuration of codes from each dimension of the observational instrument) within a similar temporal configuration (critical interval) in real-time behavioral data and then proceeds to identify hierarchical relationships with any other antecedent or subsequent events. T-pattern analysis involves the use of an algorithm that calculates temporal distances between behaviors and analyzes the extent to which critical intervals remain invariant relative to the null hypothesis, that each behavior is independently and randomly distributed over time. The algorithm developed by Magnusson (1996, 2000) has been implemented in the THEME_{TM} software (Patternvision Ltd., Iceland). Data from this study was analyzed using Theme 6.0 Edu. Once T-patterns have been detected it is possible to use this new information in different ways (Casarrubea et al., 2015, 2018). One approach is based on the analysis of pattern sets and another approach is to analyze patterns individually (e.g., Castañer et al., 2017). This second approach is the one used on this paper. From that approach it is crucial to be transparent regarding the qualitative and quantitative filters used to select T-patterns to suit the objective of the analysis (Amatria et al., 2017). Considering the purpose of our T-pattern selection, which is to help employees analyze their own MMH in a better way, the filters used were first quantitative and secondly qualitative. The quantitative filters were: (1) minimum one occurrence of the pattern on each MMH, (2) frequency of occurrence higher than 3; (b) significance level of 0.005 (0.5% probability of critical interval being due to chance). The qualitative filters were (applied as a lexicographic decision rule): (1) maximum length (number of event-types in the terminal string of a pattern), (2) maximum level (number of hierarchical levels in a pattern), (3) different event-types (configuration of codes), (4) items (codes) related to recommendable position, (4) maximum duration. The results were validated by simulation, through data randomization on five occasions, accepting only patterns for which the probability of randomized data coinciding with real data is zero.

Polar Coordinate Analysis

Polar coordinate analysis, which was proposed by Sackett (1980), combines adjusted residuals from lag sequential analysis (Bakeman, 1978) and the Z_{sum} statistic (Cochran, 1954). It involves the detection of significant associations between a behavior of interest (referred in polar coordinate analysis as *focal behavior*) and other behaviors (referred as *conditional behaviors*). Polar coordinate analysis is based on the complementarity between two analytical perspectives: prospective and retrospective, concerning the focal behavior as zero point. The Z_{sum} statistic provides a representative value for a series of independent values (adjusted residuals at different prospective or retrospective lags) to produce prospective and retrospective Z_{sum} values. Prospective Z_{sum} values are represented in X axis, and Z_{sum} retrospective values in Y axis. The resulting values and their sign (positive or negative) determine the quadrant in which the different vectors are located and indicate their respective lengths and angles (Sackett, 1980). The value of angles implies a necessary adjustment of the trigonometrical value, as a function of the quadrant. Vectors provide information on the nature of the relationship (prospective/retrospective and activation/inhibition) between a focal behavior, which is equivalent to a given behavior in lag sequential analysis, and each conditional behavior that we have proposed in our study (see results section). We used the genuine retrospective approach. The concept of genuine retrospectivity (Anguera, 1997) was introduced at a later stage to improve the classic concept of retrospectivity (Sackett, 1980). This approach considers negative lags from a backwards rather than a forward perspective, i.e., it looks at what happened from lag 0 back to lag −1 rather than from lag −1 to lag 0, and the same in successive lags. Sackett (1980) recommended using the same number of prospective and retrospective lags. Based on experience to date (Sackett, 1987; Anguera et al., 2018c), five prospective lags and five retrospective lags (−5 to +5) were analyzed. The meaning of the vectors varies according to the quadrant in which they are located, and the position in one quadrant or another is determined by the combination of positive or negative signs on prospective and retrospective Z_{sum} values. In quadrant I (+ +), the focal and conditional behaviors activate each other; in quadrant II (− +), the focal behavior inhibits and is activated by the conditional behavior; in quadrant III (− −), the focal and conditional behaviors inhibit each other; and in quadrant IV (+ −), the focal behavior activates and is inhibited by the conditional behavior. Vector length indicates the strength of the association between focal and conditional behaviors. The HOISAN program (v.1.6.3.3) (Hernández-Mendo et al., 2012, 2014) was used to calculate adjusted residuals, Z-values, and vector length and angles; the program includes a feature to produce results in graph form.

RESULTS

SsObserWork Systematic Observation Tools: H-O Instrument and S-O Instrument

Based on literature review and expert opinion, the H-O instrument proposed was a combination of a field format and category systems (Anguera, 2003; Portell et al., 2015). It was composed of six dimensions (feet, knee joints, back, elbow joints, load position, and interaction between back tilt and displacement) and twenty-one categories (**Table 1**). Additionally, these six dimensions had a formal category null (empty set) which marks off an unobservable action. The set of categories corresponding to each dimension met the requirements of ME&E. Additionally, there was a structural dimension which defined MMH phases. In **Table 1**, dimensions and categories are shown (details in **Supplementary Table S1**). Based on the scientific review described in the previous section, the twenty-one categories were classified according to their effect on health. On the third column of **Table 1**, the derived classification as a recommended or non-recommended position to be adopted during MMH is summarized. This data was the base to create the modified version of the H-O instrument to construct the S-O instrument and to create feedback. The last column of **Table 1** indicates the categories included on the S-O instrument with a check mark. The S-O instrument kept all dimensions except the most complex one (interaction between tilt and displacement) and all categories were defined graphically.

Both instruments can be used to observe the MMH task in formative training addressed to improve MMH in diverse work environments at a range of industrial sites. The application requirements were: (1) a conventional video camera positioned at the workers' hip height; and (2) the instrument to record observational data. **Figure 1** shows space disposition for MMH in formative context and **Figure 2** shows the interface used to codify. The observational instruments, the record instrument to automatize codification and the training program could be facilitated upon request.

Average time required to apply the observation instruments were (time by box in the generic setting illustrated in **Figure 1**): 9 s for MMH recording, 6 min for the codification of the H-O instrument by the technician, and 3 min for the codification of the S-O instrument by the worker.

Inter-Rater Reliability Testing of the H-O Instrument

The values of agreement statistics across observers (AB register vs. C) for each dimension are summarized in **Table 2**. **Supplementary Tables S2**, **S3** list the values of agreement statistics for each category. In addition to kappa values, **Table 2** includes the kappa maximum and percentage of agreement.

Regarding the results obtained from event-based kappas for each dimension, the kappa values ranged from 0.72 (for elbow joints criterion at 0.5 tolerance level) to 0.9 (for feet criterion at 1.5 tolerance level), indicating good to very good agreement according to the criteria of Landis and Koch (1977) and Altman (1991). Regarding event-based kappas for the categories (**Supplementary Table S2**) and considering the higher demanding tolerance level (0.5 s), the kappa values ranged from 0.5 (for the "symmetric feet beside the load" category included in the feet criterion) to 0.97 (for the "walking" category included in the feet criterion), indicating moderate to very good agreement according to the criteria of Landis and Koch (1977) and Altman (1991). Values indicating moderate agreement happened in one of the 21 categories included in the H-O instrument; thus, 95% of the categories presented kappa values indicating good to very good agreement.

Regarding the results obtained from time-unit kappas for each criterion, the kappa values ranged from 0.90 (for the back criterion at 0.5 tolerance level) to 0.99 (for the knee joints criterion at 2 tolerance level), indicating very good agreement according to the criteria of Landis and Koch (1977) and Altman (1991). Regarding time-unit kappas for the categories (**Supplementary Table S3**) and considering the higher demanding tolerance level (0.5 s), the kappa values ranged from 0.53 (for the "symmetric feet beside the load" category included in the criterion feet) to 0.99 (for the "walking" category included in the criterion feet), indicating moderate to very good agreement according to the criteria of Landis and Koch (1977) and Altman (1991). The values indicating moderate agreement happened in just one of the 21 categories included in the H-O instrument; thus, 95% of the categories presented kappa values indicating good to very good agreement.

Usability and Usefulness Perceived of the S-O Instrument

Table 3 reports the median, mean and standard deviation of the usability and usefulness perceived by workers who apply the S-O instrument during two separate sessions. The last column shows the results of the one-tailed sign test using 7.5 as a cut point. For all the studied aspects, the median was statistically greater than 7.5 (on a scale of 1–10, being 10 the best).

Use of the H-O Instrument to Create Feedback Based on T-Pattern Analysis and Polar Coordinate Analysis

To illustrate the functionality of the H-O instrument to create feedback on performance, two workers were selected (we refer to them as WO1 and WO2), both males, aged between 40 and 50 years old, who have equivalent values in terms of recommended position when they are examined globally throughout the session (global values between P40 = 53.3% and P50 = 54.8% of the distribution of relative durations). Using the GREOM terms (Portell et al., 2015; Chacón-Moscoso et al., 2018), duration is a static behavioral indicator, but the granularity of the H-O instrument is be able to define additional and more complex dynamic indicators. Based on these behavioral dynamic indicators, joined with the possibilities of sequential analysis techniques, **Figures 3–5** illustrate the new information that can emerge from the observational record.

For each worker, **Figures 3**, **4** show the two most relevant T-patterns detected by applying the selection criteria described in the method section. For each T-pattern two diagrams are presented. Firstly, the tree graph pattern (**Figures 3A.1,B.1**, **4A.1,B.1**) shows which event types (configurations of concurrent codes) are included in the pattern and how they are connected. Secondly, the instance graph (**Figures 3A.3,B.3**, **4A.3,B.3**) provides information about the real-time pattern structure (the time period represented only includes the observation periods in which the worker loads, displaces, or unloads each load).

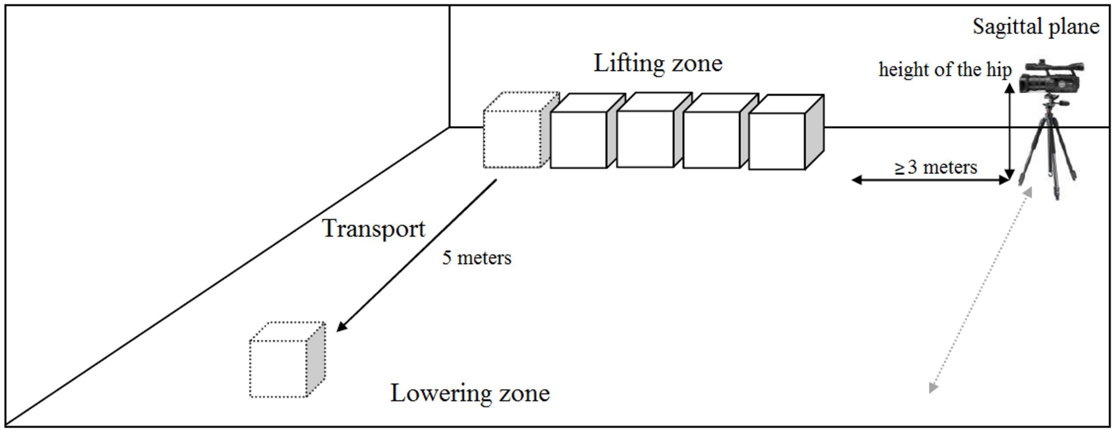


FIGURE 1 | Space disposition for MMH in formative context.

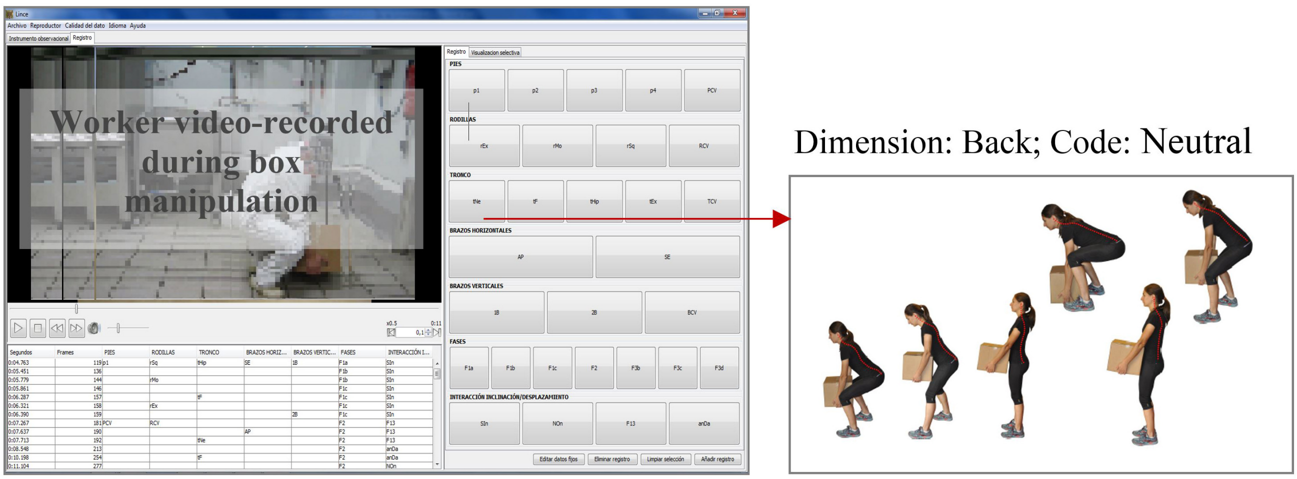


FIGURE 2 | Sample interface used to codify. Left side shows the recording instrument. Right side shows the visual part of one category definition in the H-O instrument. Written informed consent was obtained from the depicted individual for the publication of these images.

On the right side of the tree graph pattern, the pictures highlight configuration details (for confidentiality reasons the workers' images have been replaced by photographs from the H-O instrument).

Figure 5 summarizes the results of polar coordinate analysis for each worker. Each graph represents the statistically significant associations (activation or inhibition) between the focal and conditional behaviors. The focal behavior on this analysis was "neutral back position." The conditional behaviors were the categories of the dimensions feet, knee joints, elbow joints and load position, after applying two kinds of code transformations based on the classification criteria included in **Table 1**. The first was a merger of categories of the feet dimension and the second the creation of new superordinate codes combining the knee joints and phase dimensions (the new codes have been created by joining the codes of the original categories that were already defined in **Table 1**). The association is shown both quantitatively (vector length) and qualitatively (quadrant I, II, III, or IV). Under each graph, the table with the polar coordinate analysis results is presented for the statistically significant associations.

The qualitative information which can be deduced from these analyses is presented below to illustrate how they provide useful resources to improve the informative quality of the feedback and feedforward on worker performance.

Regarding worker WO1, the first T-pattern analysis was applied at 693 micro-coded observational data which were structured in 99 configurations (33 different event-types). Taking into account all the dimensions of the H-O instrument, the most complete pattern identified for 100% of the MMH performed only showed a regular structure in event-types related to the lifting phase (**Figures 3A.1,A.3**). This pattern also showed that knee joints, elbow joints and interaction are dimensions that remain in a recommended position during this regular pattern of behavior. Theme also allows more detailed analysis of a part of the dimensions. In this case, position analysis related to upper body dimensions was applied (**Figures 3B.1,B.3**). The most complex pattern obtained for this subset of configurations, which is significant for 100% of the MMH performed, connects the way of performing the lifting with load displacement, with lowering performance not being structured enough for it to be incorporated into the pattern. It is also worth noting the regularity of the co-occurrence between the neutral back position and the position close to the body detected by Theme (see the biggest picture in the **Figure 3B.2**).

Polar coordinate analysis showed that the neutral back position of the worker WO1 (**Figure 5A**) was sequentially associated with the dimensions: feet, knee joints, elbow joints and load position. From this analysis, the most interesting relationship that can be presented as feedback to worker WO1 was about the feet (code P1P2) in quadrant III, where the vector represents a mutually inhibitory sequential relationship between a neutral back position and a non-recommended position of the feet during lifting and lowering phases. In quadrants II and IV two other strong relationships can be seen, both of which are of asymmetric dependence. The first relationship pointed out is that the recommended position of the back inhibited load position close to the body, although load position close to the body activated the neutral back position. The relationship shown in quadrant IV is the mirror image: the recommended position of the back activated the load position separated from the body and this last inhibited the recommended position of the back.

Regarding worker WO2, the first T-pattern analysis was applied at 525 micro-coded observational data which was structured in 75 configurations (30 different event-types). Taking

TABLE 2 | Agreement between register AB and C for each dimension, presenting kappa based on events and kappa based on time units for each tolerance level, as well as percentage of agreement and kappa maximum.

		Based on events			Based on time units		
Dimension	**Tolerance level**	**% agreement**	**Kappa**	**Kappa max.**	**% agreement**	**Kappa**	**Kappa max.**
Feet	0.5	92	0.87	0.93	97	0.92	0.95
	1.0	93	0.89	0.94	97	0.93	0.95
	1.5	94	0.90	0.94	97	0.93	0.95
	2.0	94	0.90	0.94	97	0.93	0.96
Knee joints	0.5	89	0.86	0.97	99	0.97	0.98
	1.0	90	0.87	0.97	99	0.98	0.99
	1.5	91	0.87	0.97	99	0.98	0.99
	2.0	91	0.87	0.97	99	0.99	0.99
Back	0.5	89	0.83	0.94	94	0.90	0.97
	1.0	92	0.88	0.95	96	0.93	0.97
	1.5	91	0.87	0.95	97	0.94	0.97
	2.0	92	0.88	0.95	97	0.94	0.97
Elbow joints	0.5	86	0.72	0.88	96	0.92	0.94
	1.0	89	0.78	0.89	96	0.93	0.94
	1.5	91	0.82	0.89	97	0.93	0.94
	2.0	91	0.82	0.89	97	0.93	0.94
Load position	0.5	87	0.76	0.95	95	0.91	0.94
	1.0	91	0.81	0.94	97	0.94	0.96
	1.5	93	0.85	0.93	98	0.97	0.98
	2.0	93	0.85	0.91	99	0.98	1
Interaction between back tilt and displacement	0.5	84	0.78	0.92	97	0.96	0.98
	1.0	86	0.80	0.92	98	0.97	0.98
	1.5	87	0.82	0.92	98	0.97	0.99
	2.0	87	0.82	0.92	99	0.98	0.99

TABLE 3 | Usability and usefulness perceived of the S-O instrument.

Item[a]	***Md***	***M***	***SD***	**Sign test *p***[b]
Usability: understandability of the terminology	8	8.44	1.50	<0.0001
Usability: understandability of the images	9	8.81	1.52	<0.0001
Usability: aesthetic appearance and easy and clear layout	9	8.78	1.25	<0.0001
Usefulness: behavior improvement during the MMH	9	8.81	1.42	<0.0001
Usefulness: knowledge improvement on MMH technique	10	9.11	1.19	<0.0001

Descriptive statistics and one-tailed sign test results. [a]10-point response scale was used for all questions (from 1 – very low – to 10 – very high). [b]One-tailed sign test using 7.5 as a cut point to define dichotomy.

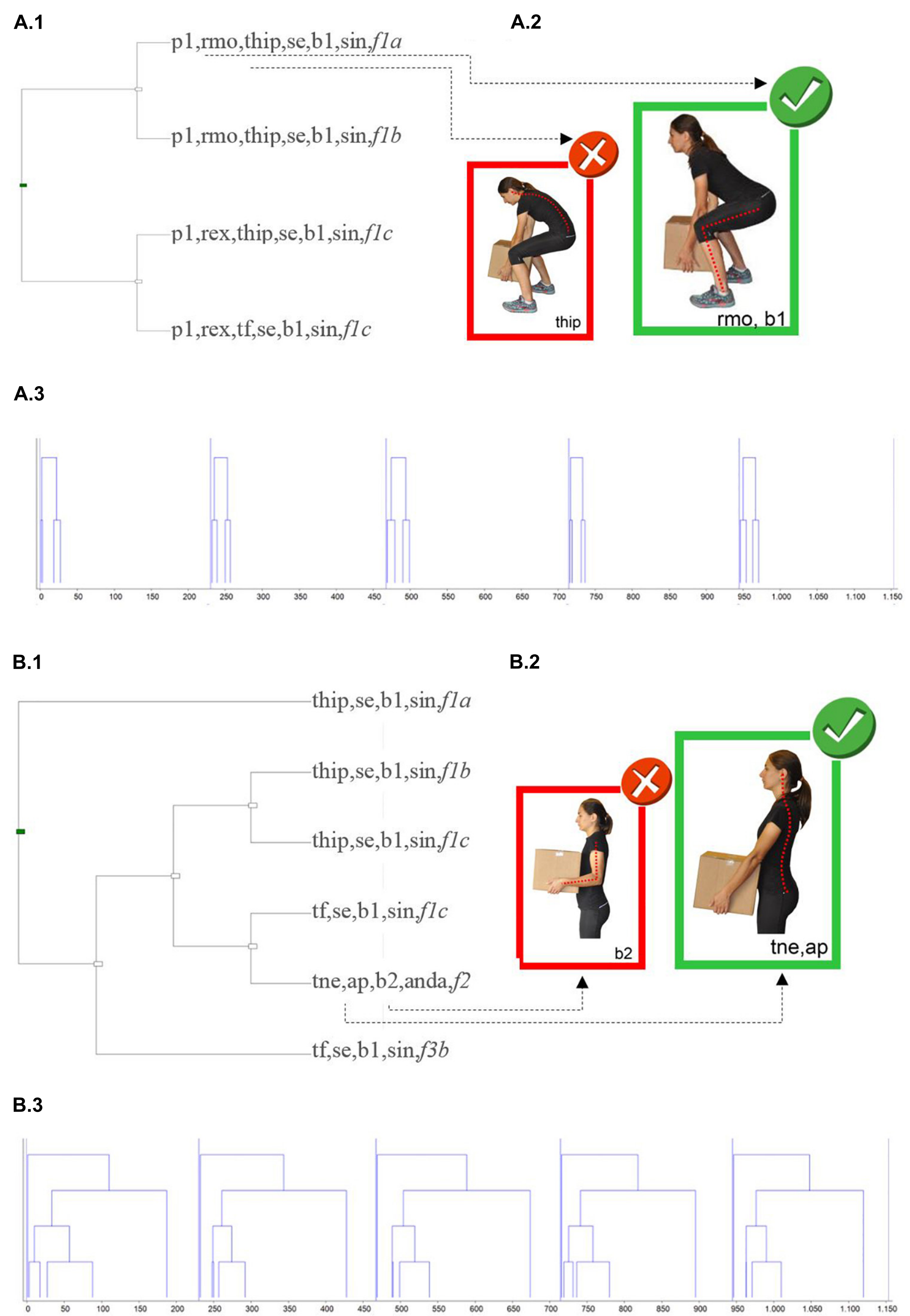


FIGURE 3 | Schematic representation of two T-patterns **(A,B)**, that occur throughout the MMH process of the worker WO1. **(A.1,B.1)** Include the pattern tree graph. **(A.2,B.2)** Include pictures highlighting details of the configurations (the recommended positions in larger sizes than those non-recommended); for confidentiality reasons, the workers' images have been replaced by pictures from the H-O instrument manual. **(A.3,B.3)** Includes the instance graph. Written informed consent was obtained from the depicted individual for the publication of these images.

into consideration all the dimensions of H-O instrument, only one common pattern was detected in 100% of the MMH performed. This very simple pattern structures behavior during the carrying phase (**Figures 4A.1,A.3**). This pattern detects regular associations between an event-type and especially non-recommended co-occurrences (starting displacement with the back tilted due to an anterior hip flexion, in the final position of the lowering phase and with the rest of the dimension in a non-recommended position) and another event-type which includes two very recommended co-occurrences (load position close to the body and neutral back position). **Figures 4B.1,B.2** show the results focusing on the search of T-patterns among

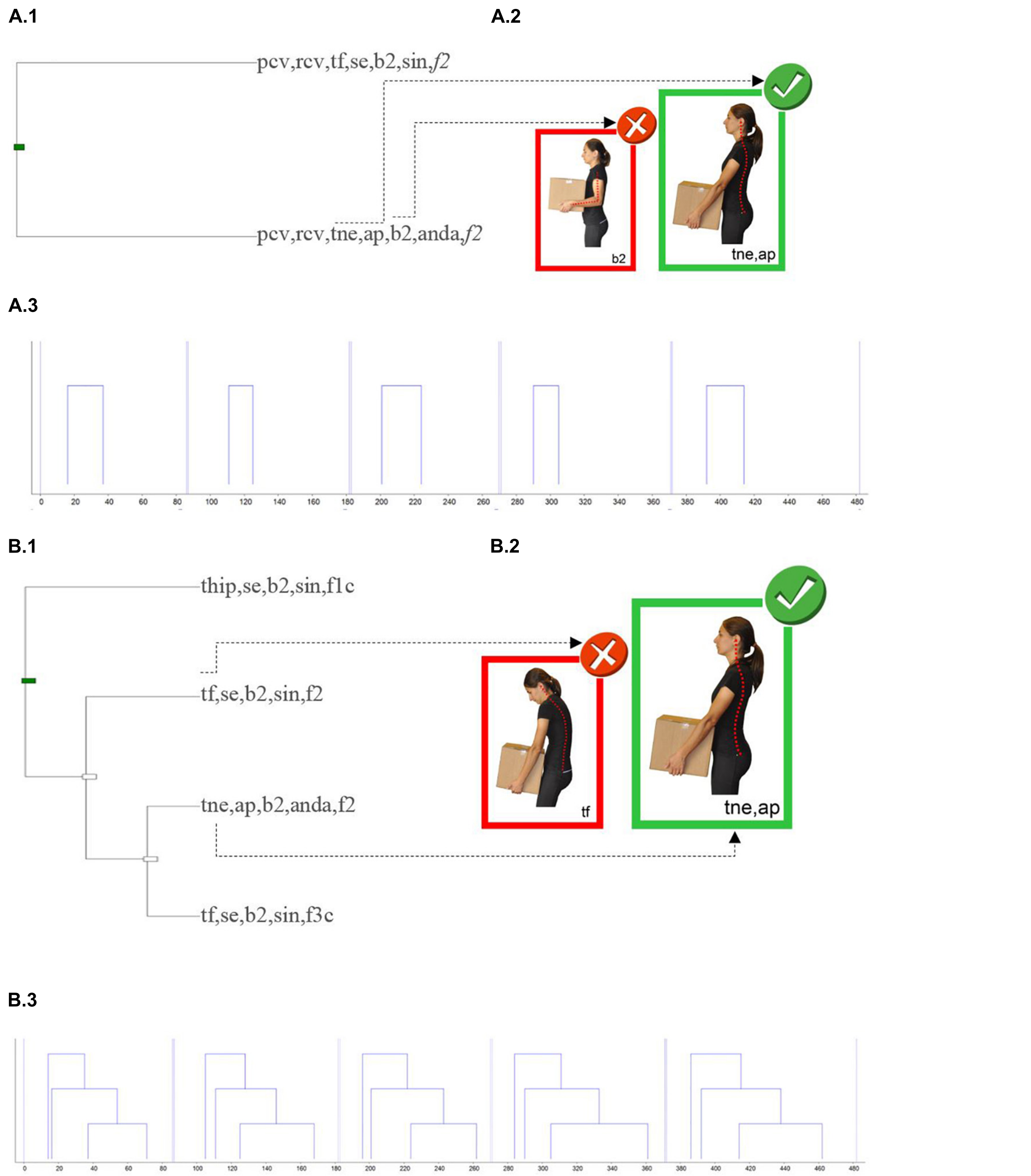
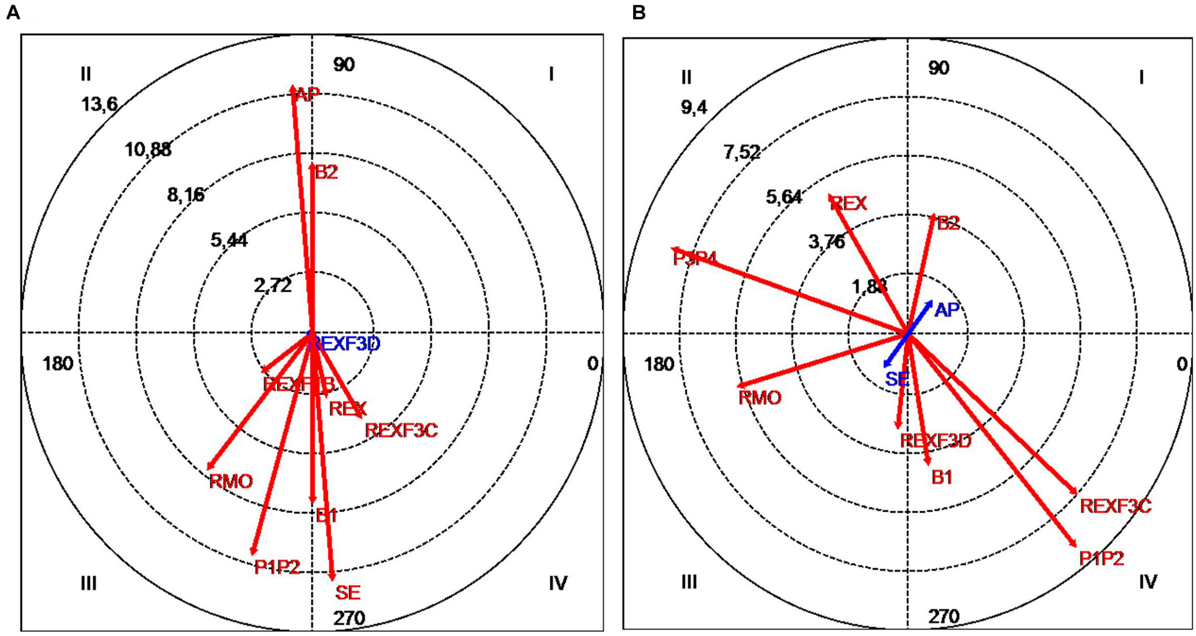


FIGURE 4 | Schematic representation of two T-patterns, that occur throughout the MMH process of the worker WO2. **(A.1,B.1)** Includes the pattern tree graph. **(A.2,B.2)** Includes pictures highlighting details of the configurations (the recommended positions in larger sizes than those non-recommended); for confidentiality reasons, the workers' images have been replaced by pictures from the H-O instrument manual. **(A.3,B.3)** Includes the instance graph. Written informed consent was obtained from the depicted individual for the publication of these images.

the subset of dimensions back, elbow joints, load position and interaction. The most complex T-pattern detected in 100% of the MMH performed, structures the temporary association previously detected (**Figure 4A.1**) with other configurations, all of which are not recommended, during the loading and lowering phases.

When the polar coordinate analysis was applied to worker WO2 data (**Figure 5B**), it was observed that the neutral back position adopted by this worker is sequentially associated with other dimensions such as feet, knee joints and elbow joints. The strongest sequential relationships were observed in quadrant IV and this indicates the following asymmetric dependence



Category	Q	P.Prosp.	P.Retro.	Radius	Angle
p1p2	III	-2.83	-10.15	10.54	254.41
rex	IV	0.66	-2.96	3.03	282.49
rexf1b	III	-2.42	-1.83	3.03	217.16
rexf3c	IV	2.32	-3.94	4.57	300.54
rmo	III	-4.93	-6.25	7.96	231.74
b1	IV	0.01	-7.79	7.79	270.11
b2	II	-0.01	7.79	7.79	90.11
ap	II	-0.94	11.31	11.35	94.75
se	IV	0.94	-11.31	11.35	274.75

Category	Q	P.Prosp.	P.Retro.	Radius	Angle
p1p2	IV	5.57	-6.81	8.8	309.29
p3p4	II	-7.85	2.74	8.31	160.77
rex	II	-2.65	4.48	5.21	120.66
rexf3c	IV	5.61	-5.13	7.6	317.57
rexf3d	III	-0.35	-3.06	3.09	263.41
rmo	III	-5.68	-1.69	5.93	196.56
b1	IV	0.68	-4.21	4.27	279.23
b2	I	0.87	3.87	3.96	77.35

FIGURE 5 | Maps of polar coordinate analysis for worker WO1 **(A)** and worker WO2 **(B)**. Under each graph the table with the polar coordinate analysis results is presented for the statistically significant associations. The focal category is the neutral back position (tne). The conditional behaviors are: non-recommended feet position (p1p2), recommended feet position (p3p4), knees flexed moderately during lifting and lowering (rmo), knees extended or slightly flexed during lifting and lowering (rex), knee joints in a non-recommended position in initial/lifting-lowest/lowering-lowest/final position (rex1a/rex1b/rex3c/rex3d), knees are flexed severely (rcv), elbow joint is extended or slightly flexed (b1), one or both elbow joints are flexed (b2), load close to the body (ap), load separated to the body (se).

relationship: the recommended back position activates non-recommended feet and knee joint positions during the middle part of the lowering, and non-recommended feet and knee joint positions inhibit the recommended position of the back. The previous relationship is not particularly useful to use as an informative feedback for the worker. From this analysis, the most interesting relationship that can be presented as feedback for worker WO2 is about the mutually inhibitory sequential relationship (quadrant III) between a recommended back position and a non-recommended knee joint position at the end of the lowering phase (the knees were bent less than what should be recommended).

DISCUSSION

Our study shows the design and implementation of two systematic observation instruments of worker behavior during MMH training for back-pain prevention in the workplace. These observation instruments address a double purpose: the behavioral change assessment and the creation of feedback under a training component that we have labeled SsObserWork. Following the research framework for the development and implementation of interventions preventing work related MSD established by van der Beek et al. (2017), we assume that the etiology of back pain is multifactorial meaning that the SsObserWork approach is suggested as a piece for use in multicomponent occupational intervention, which in turn should be designed according to the "risk control hierarchy model." We organized the discussion around two aspects. On the one hand, the novelties associated to SsObserWork instruments, and on the other, the evidence of their reliability, usefulness and usability.

The H-O instrument has been justified and developed for observing worker behavior during the MMH training process. The H-O instrument is composed of the dimensions feet, knee joints, back, elbow joints, load position, and interaction between back tilt and displacement. For each dimension an independent category system has been created; additionally, the H-O instrument includes a structural dimension related to the MMH phase. This instrument has been developed in such a way that it allows us to derive the simplified S-O instrument, whereby workers can apply self-observation during MMH. Both instruments are highly structured, and they were developed for video observation, as well as for the generation of feedback. Literature review provided the theoretical models to underpin the link between dimensions, categories and classification criteria to provide feedback. The expert judgment also provided support on the appropriateness of the dimensions and categories for the objectives established as well as their representativeness regarding the MMH training task selected.

The reliability results obtained by the H-O instrument were highly satisfactory. We have presented a thorough assessment of the agreement between the codes assigned by two research team observers and the codes assigned by a technician in occupational health and safety, previously trained in the use of H-O (Denis et al., 2002). The levels of agreement obtained provide strong evidence on the reliability of the H-O instrument. The small changes observed between kappa values when the analysis is based on time or event units are explained by the overestimation and underestimation associated with the respective algorithms used for obtaining these results, hence the recommendation has been followed to present them jointly (Bakeman et al., 2009). The results support the use of H-O (by a technician in occupational health and safety) as a reliable instrument to evaluate changes in worker behavior during an MMH training.

The use of observational techniques in ergonomics is not new at all (David, 2005). The novelty of the procedures being proposed here lies in the function of observation, in the granularity level used by the instruments, and in the connection between the instruments and the provision of feedback for the worker.

The H-O instrument has not been created for the assessment of exposure to MSD risk factors associated with a task or a workplace, it has been created for the assessment of changes in worker behavior during MMH in a formative context. This characteristic that we could call worker-centered evaluation, singularizes the H-O instrument regarding many of the observational techniques used in ergonomics (David, 2005; Takala et al., 2010).

Another remarkable characteristic of the H-O instrument arises when evaluating the effectiveness of different behavior-change-intervention approaches. Behavioral training evaluations using assessment instruments exist which focus on distal outcomes such as back injuries or wage-loss claims due to back injuries (Clemes et al., 2010). In other cases, the assessment instruments are focused on intermediate outcomes measured through self-report, such as knowledge about safe lifting and posture (Haslam et al., 2007). Back injuries are a consequence of the behavior that the training hopes to change, but it is an outcome further down the causal chain of a behavioral intervention. The assessment of a behavioral intervention should include behavioral outcomes (Michie and Johnston, 2012). The H-O instrument can remedy the detected lack of instruments addressed to the assessment of the proximal effect of manual handling training on intermediate variables that link training to distal changes in employee behavior (Hogan et al., 2014; Kay et al., 2014). Moreover, the H-O instrument can contribute to the understanding of the processes in training implementation.

There are some instruments focused on the evaluation of changes in worker behavior using video observation (Gattinger et al., 2014), but another important peculiar feature of the H-O instrument is its level of granularity. The H-O medium level of granularity requires video observations, because this allows a large number of items to be assessed, as video films can be replayed several times in order to observe the dimensions separately. A more decreased granularity could require the use of monitoring instruments such as sensors that are attached directly to the worker for the measurement of exposure variables at work. The use of these direct measurement systems can provide large quantities of highly accurate data, however the feasibility of this approach in the workplace has been highly controversial (David, 2005; Mgbemena et al., 2017). We have selected a medium level of granularity, which has been used for the modeling of complex behavior in the work setting (Neumuth et al., 2010), but as far as we know it has not been applied for training in the field of occupational risk prevention and health promotion in the workplace. The rationale for this medium level of granularity lies, firstly, in the purpose of the instrument which is the assessment of behavior change during the training intervention process, instead of the MSD risk assessment. Secondly, in the interest to enable the feasibility of the H-O assessment in different workplaces by occupational health professionals. Thirdly, in the interest to use a level of granularity that may also be used for the S-O instrument without hindering the worker's understandability.

The usability and usefulness perceived of the S-O instrument has been highly valued by workers. Among the various concepts under investigation on usefulness and usability (Tsakonas and Papatheodorou, 2008; Akin et al., 2013; Zapata et al., 2015), our questions explored understandability, aesthetic appearance and layout, worker perception regarding the instrument's ability to improve their knowledge and their behavior during MMH. Workers reported very favorable assessments toward all the usability and usefulness attributes explored and it can be interpreted as support for the selected level of granularity.

In addition to being convenient for the S-O instrument, the granularity selected allows the H-O instrument to generate suitable data to make sequential analysis able to uncover "hidden time patterns" (Magnusson, 2000) in the behavior during the training process. This paper shows how it can be used to improve the informative quality of the feedback and feedforward on worker performance. To illustrate the usefulness of the instrument for this purpose, we present the data of two workers who would receive very similar feedback if only summary indicators of the global results of their MMH are taken into account (e.g., the global proportion of time with a recommended position of the back). The results show the wealth of information that can be extracted to inform workers of different regular aspects of their execution. The feedback/feedforward build from this information combined with the self-observation made by the worker himself or herself is the base of the SsObserWork intervention component. This approach is in line with previous studies which established the importance of different forms of feedback used in combination with video feedback (Wulf et al., 2010; Ste-Marie et al., 2013; Lim et al., 2015). Systems already exist for generating feedback that informs on awkward postures adopted by workers in real time, as well as to evaluate the ergonomic risk (Mgbemena et al., 2017). However, SsObserWork is presented here as a different approach (although it would not be incompatible). Here the feedback is raised as a training component that gives the worker material to engage in systematic self-observation and reflection on his or her non-recommended position within his or her "work gesture." Results show how the combined use of the H-O instrument with sequential analysis techniques allows feedback to be completed based on static indicators (e.g., relative duration of trunk in non-recommendable position) with dynamic indications that describe the interaction of the worker with the load. Using the complementary methods of T-pattern analysis and polar coordinate analysis (Anguera et al., 2017) it is possible to detect how co-occurrences and recommended position sequences interact within gestures that globally can be deficient, thereby contributing toward the creation of positive feedback and feedforward (Ste-Marie et al., 2011). The contribution of these analyses can overcome the limitations of the positive self-review modeling (Dowrick, 1999) and it allows progress to be made in the delivery of feedforward that helps the worker construct a previously unachieved but possible future pattern of movements. This sort of individualized feedback can open new possibilities especially addressed to influential workers because of their basic structure position (e.g., supervisors) as well as in parallel structures (e.g., members of the health and safety committees, or older employees participating as mentors in intergenerational learning programs).

This study has both strengths and limitations. The main strength of this study is to provide two new connected instruments for systematic observation that make possible the assessment and implementation of new components to enrich interventions in the prevention of back pain associated with material handling tasks. The mixed method design based on systematic observation (QUAL-QUAN-QUAL phases) makes it possible to tackle the methodological complexity of the development, assessment and integration of the results provided by these instruments. We want to highlight the demanding reliability study presented and its very satisfactory results; this point seems remarkable considering the lack of reliability data in several assessment instruments noted by different authors (Village et al., 2009; Kadikon and Rahman, 2016).

Regarding the limitations and future directions of the research we will mention three points. Firstly, the number of companies and participants has been low. In the pilot study, a company from the metallurgical sector participated and the final version was applied in a food processing company. An area in which we consider that the SsObserWork approach could be of great interest is in training for the mobilization of patients in hospitals. The structure of the H-O instrument (combined field format and category systems) facilitates adaptations and extensions to include interaction dimensions that are essential to address the complexity of manual handling in healthcare settings (Kay et al., 2014). A second limitation has to do with the high time and material cost of the coding and sequential analysis process. We hope that future studies will advance in the automation of procedures since this will facilitate the application to more companies, as well as their integration into multicomponent training interventions. Thirdly, the results on usability and utility are only based on self-reported data from a small sample. It would be convenient to replicate this analysis with larger samples and complement what is presented here with qualitative techniques (e.g., in-depth interviews) in order to gain a deeper understanding of worker perception as well as technician perceptions on the application of these instruments.

CONCLUSION

In conclusion, this work introduces the SsObserWork approach and it focuses on the development, implementation and evaluation of new instruments included in SsObserWork. This detailed study has been extremely useful for the next phase of this project consisting in the evaluation of the effect of the new SsObserwork component using a randomized parallel group trial. The results presented in this work provide empirical evidence in favor of the appropriateness and reliability of these instruments. As far as we know, the approach we propose is novel in the field of MDS disorder prevention from MMH training at the workplace. A number of convergent research areas support the use of participatory approaches to health training which allow individuals to control features of their own learning environment enhancing motor learning as well as the transfer of training to different settings (Burke et al., 2006; Ste-Marie et al., 2013; Portell et al., 2014). The combined use of the S-O instrument with external feedback based on data provided by the H-O instrument opens new possibilities for these participatory approaches, always thinking on the SsObserWork approach as a piece to integrate in multicomponent occupational intervention.

DATA AVAILABILITY

The datasets for this manuscript are not publicly available for confidentiality reasons. Requests to access the datasets should be directed to mariona.portell@uab.cat.

ETHICS STATEMENT

The Ethics Committee of the Universitat Autònoma de Barcelona approved the study protocol (Reference Number 1742). In accordance with the principles of the Declaration of Helsinki, participants were informed that they were being filmed. All participants signed the informed consent form.

AUTHOR CONTRIBUTIONS

MP conceived and supervised the development of the project, drafted the manuscript and she also contributed to the design of the instruments, the data collection, the data codification, and the data analysis. AS-M implemented the self-observation intervention, collected the data, codified the data, and she also contributed to the development of the project, the design of the instruments, and the drafting of the manuscript. MTA contributed to the development of the project, the data analysis, and the drafting of the manuscript. GKJ and JLL contributed to the data analysis and the drafting of the manuscript. All authors have made a substantial, direct and intellectual contributions to the work, and approved it for publication.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01247/full#supplementary-material

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Preschool Metacognitive Skill Assessment in Order to Promote Educational Sensitive Response From Mixed-Methods Approach: Complementarity of Data Analysis

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A child's metacognitive skills contribute significantly to their learning and success. However, very few studies are focused on these skills at early education and most of them are carried out from inappropriate methodological perspectives for the characteristics of the youngest students. To overcome such limitations, it is essential to carry out observational studies that analyze children's metacognitive behaviors in the natural and habitual context of children's learning, as well as appropriate tasks for their level of development. The aim of this study was to analyze the sequential and associative structure of the metacognitive skills used by 5-year-old children throughout the resolution of a playful task (a puzzle). It was interesting to know if there were different hidden structures in the use of metacognitive skills in the children who solved the puzzle and those who did not. From the methodological approach, this work was located in the perspective of mixed methods which is characterized by the integration of qualitative and quantitative elements. This integration was carried out from the "connect" option. The integration involved developing quantitizing, as one of its possibilities. Recent scientific literature has considered systematic observation, in which the QUAL-QUAN-QUAL macro stages take place, as a mixed method itself. Consequently, systematic observation was applied, because it was suitable for our aim. A Nomothetic/Punctual/Multidimensional observational design was used. The playful activity of 44 preschool children solving the puzzle individually was coded. It allowed us to obtain data matrices that respond to the QUAL stage. Regarding the QUAN stage, once the quality of data was controlled, the records were further analyzed by differentiating two groups of participants (those who had solved the puzzle and those who did not) using three quantitative techniques of observational analysis (T-pattern detection, lag sequential analysis, polar coordinate analysis). Finally data was returned to a QUAL stage to interpret the results. The use of these three techniques allowed a detailed and in-depth analysis of the children's activity. Results reveal differences in the metacognitive abilities of the children that solved and didn't solve the puzzle. These results have important implications for educational practice.

Keywords: mixed methods, systematic observation, preschoolers, metacognitive skills, T-pattern detection, lag sequential analysis, polar coordinate analysis, educational practice

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INTRODUCTION

Metacognitive skills (also called metacognitive regulation) refer to the processes that allow us to guide, regulate and supervise our own learning activities; that is, knowing how to learn and how and when to use a series of strategies to regulate our behavior. Generally metacognitive skills are divided into three component activities that are: (1) planning: it consists in the anticipation of the sequenced actions to be used to solve the task; (2) monitoring: it implies the review of the actions that are being carried out, their verification and rectification if necessary; (3) evaluation: it is about comparing the obtained result with the goals established at the beginning of the task. It also includes aspects related to the adequacy of the process followed (Flavell, 1992; Veenman et al., 2006; Chatzipanteli et al., 2014).

Metacognitive skills play an important role in a wide variety of activities including the exchange of verbal information, comprehension, reading, writing, attention, memory, problem solving, learning, or self-control. This helps to understand that metacognitive skills have been identified as a good predictor of academic success, even better than intelligence itself (Bryce et al., 2015; Nelson and Marulis, 2017; Mari and Saka, 2018). Thus, the level of metacognitive skills and the use that students make of them are differentiating variables between successful and unsuccessful students. Students who strategically use their metacognitive skills learn more and with less effort than those who do not use them; they detect and solve problems more easily and discover the best methods to reinforce what they have learned and transfer it to other contexts. This also makes them more involved and motivated toward learning, in addition to presenting greater self-efficacy (Chatzipanteli et al., 2014; Mari and Saka, 2018).

Metacognitive Skills Development

Metacognitive skills emerge very early in life and develop during the following years (Chatzipanteli et al., 2014; Nelson and Marulis, 2017; Roebers, 2017). For example, it has been shown that children of 12 and 18 months, through their behaviors, show that they are already able to reflect on their own decisions to evaluate the accuracy of these and adapt their subsequent behaviors. Thus, they persist more in their behaviors after making a correct decision than when it is incorrect. Therefore, although complex forms of metacognition and verbal expression mature later in childhood, infants in their first year of life, through their behavior, show that they already estimate the accuracy of their simple decisions, monitor their errors, and use these metacognitive evaluations to regulate their subsequent behavior (Goupil and Kouider, 2016). Other studies have also shown that children of 18 months already use spontaneus strategies to correct their mistakes during problem solving (DeLoache et al., 1985). At 3 years, children are able to monitor their problem-solving behavior and at 4 years of using metacognitive processing in puzzle tasks (Sperling et al., 2000). Thus, there are various studies that show that, especially from 3 to 5 years of age, children show an important development in their metacognitive skills. Children are capable of solving their problems. They show different ways of planning, monitoring, and evaluation to do so, being able to monitor their behavior through different strategies (comments directed toward themselves, checking behaviors and error detection, behavior repetition to verify the accuracy of the result, use of gestures to support their activity) and establish behavior evaluation (including assessment of performance quality itself and evaluation when the task has been completed) (Whitebread et al., 2009; Bryce and Whitebread, 2012; Whitebread and Basilio, 2012; Whitebread and Pino-Pasternak, 2013). In short, the scientific evidence allows to affirm that the behavior of children already during the first year of life and during preschool years reveals basic forms of planning, monitoring and evaluation (Paulus et al., 2013; Chatzipanteli et al., 2014; Bernard et al., 2015; Roebers, 2017).

However, differences in the execution of metacognitive skills among children can be observed, which indicates the existence of different development rhythms of their metacognitive skills. Some children may not spontaneously acquire competent metacognitive skills. Veenman (2013) pointed out that those children who have metacognitive skills at their disposal but fail to produce them appropriately can be assisted by simple cues and reminders, provided by the context itself (for example, reminder posters) or by the teaching staff. However, children who do not have metacognitive skills may not benefit from simple cues and reminders, but can benefit from the effects of a specific further teaching and intervention, given that metacognitive skills are modifiable and teachable even in first ages (Whitebread and Basilio, 2012; Chatzipanteli et al., 2014).

Metacognitive Skills Assessment

An important issue in the assesment of the development of early metacognitive skills as well as in their intervention proposals is to attend to the characteristics of the tasks that the child must solve, because at these early ages metacognitive skills are highly dependent on the context (Whitebread et al., 2009; Roebers, 2017). Thus, it is necessary that children are given the opportunity to launch their metacognitive skills by providing meaningful tasks for them, that is, that fit their interests and level of understanding (Chatzipanteli et al., 2014).

It was precisely methodological questions related to the tasks used during years in metacognitive skill research for children (besides theoretical issues) that made these early skills underestimated and even denied, affirming that metacognitive skills began to emerge at around 8–10 years. Recent research has allowed us to reject that position, allowing us to conclude that the characteristics of the tests and instruments used for their assessment underestimated these children's abilities by requiring a high verbal component, being that their linguistic development does not have to be at the same level as their metacognitive development (Whitebread et al., 2010; Mari and Saka, 2018). The indiscriminate use of self-report tools and laboratory studies with minors to assess metacognitive skills has also been criticized by experts (De la Fuente and Lozano, 2010; Mari and Saka, 2018). Current studies using an observational methodology, where children are studied in their own habitual context and their free, natural and spontaneous behavior is respected (without necessarily requiring explicit verbal response) have allowed to know that already at preschool ages, children use metacognitive skills to solve everyday problems (Whitebread et al., 2009; Escolano-Pérez et al., 2014; Nelson and Marulis, 2017; Mari and Saka, 2018).

Thus, natural contexts that have a meaning and purpose for children allow the implementation of metacognitive skills at a much earlier age than when they are exposed to artificial and meaningless environments. This makes systematic observation (characterized by allowing the capture of spontaneous behaviors as they occur in a natural context) the most appropriate, and often the only methodology that captures children competencies (Anguera, 2001; Bryce and Whitebread, 2012; Whitebread and Pino-Pasternak, 2013; Marulis et al., 2016; Escolano-Pérez et al., 2017).

Observational methodology nowadays is considered in itself as mixed-method because it integrates qualitative and quantitative elements in a QUAL-QUAN-QUAL macro stages (Anguera and Hernández-Mendo, 2016; Anguera et al., 2017, 2018a,b). In an initial qualitative stage an *ad hoc* observational instrument is constructed, totally adapted to the natural context and taking into account the objectives and observational design determined for its approach. The application of this observation instrument to the reality under study allows the registration of observational data to be obtained. Subsequently, the quantitative stage follows, in which the measurement parameters are obtained, the quality control of the observational data and its analysis is carried out. Finally, the interpretation of the results returns the process to the QUAL stage, permitting seamless integration.

One of the most exciting advances in observational methodology is the new possibilities of observational data analysis techniques. These techniques allow us a deeper study of spontaneous behaviors as they occur in a natural context. The most used techniques currently are: (1) *Temporal patterns (T-patterns) detection* (Magnusson et al., 2016; Casarrubea et al., 2018): a temporal pattern (T-pattern) is essentially a combination of events that occur in the same order with temporal distances between each other that remain relatively invariant in relation to the null hypothesis that says that each component is independent and is randomly distributed over time. The basic premise is that the interactive flow or chain of behavior is governed by structures of variable stability that can't be visualized by unaided observers but can be visualized by detecting these underlying T-patterns. This data analysis technique has been used successfully in studies developed in the field of social and human sciences, although in the specific area of education, despite its potential and richness of results, its use has been less common (Herrero-Nivela and Pleguezuelos Saavedra, 2008; Santoyo et al., 2017; Suárez et al., 2018). (2) *Lag sequential analysis* (Bakeman, 1978; Bakeman and Quera, 2011): this technical analysis calculates associated relationships between categories based on the calculation of observed and expected probabilities, and to compare them using a corrected binomial test, applying the correction of Allison and Liker (1982). Starting from a certain category (criterion or given behavior), it allows us to know what other categories (conditional behaviors) precede it in lag −1, −2, −3, etc. (retrospective lag sequential analysis) and/or what categories occur in lag +1, +2, +3, etc. (prospective lag sequential analysis) with an occurrence probability greater than being random. This technique has been used by different authors to detect and explore relationships between behaviors of different nature within the scope of social and human sciences. There are researchs that have analyzed the existing relationships between different behaviors carried out by students of different educational levels within the school context (Herrero-Nivela, 2000; Santoyo et al., 2017; García-Fariña et al., 2018), although this type of educational studies is less numerous than those performed in other human contexts; (3) *Polar coordinate analysis* (Sackett, 1980; Anguera, 1997): it is a data reduction technique that involves calculating the length and angle of vectors that reflect different relationships between a behavior of interest (known as a focal behavior) and other behaviors (known as conditional behaviors). Previously, calculating the adjusted residuals for the focal and conditional behaviors using lag sequential analysis is required. Relationship between the focal behavior and the corresponding conditional behaviors can be shown in a vector map with four quadrants. Each quadrant shows the type of relationship between these behaviors: Quadrant I (+ +): focal behavior activates and is activated by conditional behaviors; Quadrant II (− +): focal behavior inhibits but is activated by conditional behaviors; Quadrant III (− −): focal behavior inhibits and is inhibited by conditional behaviors; Quadrant IV (+ −): focal behavior activates but is inhibited by conditional behaviors. As with lag sequential analysis, despite the potential of polar coordinate analysis, it has been little used in the field of child development and learning (Herrero-Nivela, 2000; López Jiménez et al., 2016; Santoyo et al., 2017; Rodríguez-Medina et al., 2018).

So, observational methodology meets the rigorous standards of scientific inquiry while at the same time offers the flexibility needed in real-life settings. It is thus an ideal methodology for studying metacognitive skills of children while they are playing (Whitebread et al., 2009; Whitebread and Pino-Pasternak, 2013). Playing is an inseparable infantile life activity, reason why it is constituted as an indispensable mean for the observation of children's progress and development (Weisberg and Zosh, 2018).

Children games have an essential role in the evaluation of children since it constitutes a ubiquitous and universal aspect of childhood. Playing is the children's natural mode of expression and provides opportunities for their development and learning. This makes the game an essential tool for the children's teaching-learning process and for the systematic observation and analysis of their progress and development (Otsuka and Jay, 2017). Thus, the game can be considered a window through which we can systematically observe the affective, social, and cognitive functioning of children, thus allowing systematic observation of their metacognitive skills (Whitebread and Pino-Pasternak, 2013). The systematic observation of the child's behavior in this ludic context offers us great information and a variety of nuances that can allow us to describe, explain, and understand fundamental aspects of the child's development and learning that can not be appreciated with other methodologies. However, despite its importance for child development, there are few studies that carry out a validated and reliable assesment and intervention based on the game (Salcuni et al., 2017). Consequently, many authors claim the need for more observational studies to identify and analyze children's metacognitive behaviors in their own natural context of child development and learning, as well as through the performance of appropriate play tasks for their level of development (Whitebread et al., 2009; De la Fuente and Lozano, 2010; Whitebread and Basilio, 2012).

On the other hand, different authors (Whitebread and Coltman, 2011) state that the activities that favor the use of metacognitive skills in children, and therefore self-regulated learning, are those that allow and encourage the child to find his/her own way of solving the task; those in which each step to execute requires prior planning and later evaluation. In relation to all this, there are several authors who defend that puzzles, since they combine all the aspects that have just been mentioned (playful activity + the need to search in a specific way for resolution), constitute one of the best activities for solving children's problems promoting the implementation of metacognitive skills by children (Robson, 2015; Nelson and Marulis, 2017).

However, despite these methodological advances that have made possible to show that metacognitive skills appear from very early ages, there are still few empirical studies that evaluate metacognitive skills in child populations while being employed naturally, which would provide more adequate and valid measures of these infantile abilities (Paulus et al., 2013; Mari and Saka, 2018). Perhaps the scarcity of this type of research is due to the complexity and difficulties involved in working with very young participants, both due to their inherent characteristics (such as the high fluctuation of their motivation and their short periods of attention and activity on one task), as well as the ethical and legal issues involved in working with minors (for example, parents may be reluctant to allow children participation in research; De la Fuente and Lozano, 2010; Clark et al., 2013).

Thus, we find a small number of studies related to early metacognitive skills, but in addition, most of them focus on positive examples of metacognitive skills and frequently, only on one of them (Bryce and Whitebread, 2012), also reducing its analysis to simple frequencies of particular behaviors. All this prevents capturing all the information that involves the use of early metacognitive skills and offers a limited and misleading view of them.

Aim

In order to overcome the limitations previously mentioned, the aim of this study is to analyze, complementing three observational data analysis techniques (T-pattern detection, lag sequential analysis and polar coordinate analysis), children records obtained to know the sequential and associative structure of the metacognitive skills that children of 5 years of age put into action during the resolution of a playful task (specifically, a puzzle). More precisely, it is interesting to know if there are different hidden structures in the use of metacognitive skills by children who solve the puzzle and those who do not, focusing on planning, monitoring, and evaluation metacognitive skills.

We hypothesize that children who solve the puzzle will use more advanced skills on planning that children who do not. That is, children who solve the puzzle will determine more accurately the steps to be taken to solve the puzzle. We predict that the determination of steps to solve the task will allow them to guide their actions. Consequently, these actions will be less hesitant and more fluid and autonomous. In addition, we expect them to be more aware and realistic than children who do not solve the puzzle when they evaluate their process followed to solve the task.

We postulate that the complementary use of these three data analysis techniques, a novel issue in the research of human behavior (Santoyo et al., 2017; Tarragó et al., 2017) and from our knowledge never used in the educational field in ages so early, will allow us to capture in depth and from different perspectives all the richness of children's metacognitive behavior.

We hope that results obtained will help education professionals to provide an educational response tailored to student needs, a key issue in any quality education system (Rodríguez-Dorta and Borges, 2017). This will help children to improve their metacognitive skills, which will imply enhancing their learning and academic success as well as their ability to solve problems throughout their lives and become competent citizens.

MATERIALS AND METHODS

Design

We applied a mixed-method approach as ongoing method of assessment. The integration of qualitative and quantitative elements (characteristic of mixed-methods) was carried out from the "connect" option (Johnson et al., 2007). More exactly, we used observational methodology.

The observational design employed, according to the observational designs described by Anguera et al. (2018a), was Nomothetic/Punctual/Multidimensional (N/P/M), which was justified by the following arguments: *nomothetic* in regard to units of observation studied because we studied the metacognitive skills of 44 children playing individually; *punctual* (with intrasessional following) regarding the temporality of the assesment given that each participant was observed in a single session analyzing behavior succession, indicating their metacognitive skills within the session, and *multidimensional* in relation to the dimensionality of observed behavior because several metacognitive skills (planning, monitoring, and evaluation) were analyzed according to the theoretical model proposed by several authors (for example: Chatzipanteli et al., 2014) and the observation instrument reflected this multidimensional structure.

The observation of behavior in this study was scientifically rigorous because the behaviors observed as indicators of preschool metacognitive skills were fully perceivable and the observers had a non-participatory role. So, systematic observation was non-participative and active and behaviors observed were fully perceivable (Anguera, 2001; Bakeman and Quera, 2011; Shaughnessy et al., 2012).

Participants

The sample used for this study was part of a wider research (Escolano-Pérez et al., 2017). The sample was composed by 44 Spanish children. They had a mean of 5.73 years old (SD Age = 0.30), 28 participants (63.6%) were women and 16

(36.4%) were men. They represented 95.65% of the last year of preschool students (last year of non-compulsory education in Spain) who attended the same educational city center in the north of Spain. All participants were of medium-high socioeconomic class, according to information offered by the center's management team.

The sample was a convenience sample formed by the preschoolers whose parents signed the informed consent authorizing the participation of their son/daughter in the study and who also fulfilled the following three inclusion criteria (Escolano-Pérez et al., 2017): (1) attendance at the targeted school since the first year of preschool education (age 3); (2) absence of the following disorders or risk factors: (a) gestational age <36 weeks and/or birth weight <2,000 g or significant pre-, peri-, or postnatal events; (b) medical/neurological conditions affecting growth, development, or cognition (e.g., seizure) and sensory deficits (e.g., vision or hearing loss); (c) neurodevelopmental disorders (e.g., attention-deficit hyperactivity disorder, autism spectrum disorder, language disorder); (d) genetic conditions or syndromes; (e) a first-degree relative with bipolar disorder, schizophrenia or related disorders; (3) an adequate IQ for their chronological age. The information to assess compliance with the first two criteria was provided by the children's parents. (In the informed consent that they had to sign authorizing the participation of their son/daughter in the study, questions were included in this regard). The information to assess compliance with the third inclusion criteria was obtained using the Spanish Battery of Differential and General Abilities Tests: level I (BADyG-I) (Yuste and Yuste, 2001).

Instruments

Different instruments were used: those of the qualitative stage (Recording Instruments and Observation Instrument) and others specific to the quantitative phase (Data Analysis Instruments) that made up the assumed mixed methods perspective. Next, each of them is specified.

Recording Instruments

To record the playful activity of each of the participants, a Sony HDR-CX115 video camera was used.

To carry out the registration of the actions indicative of preschoolers' metacognitive skills, the free software Lince was used (Gabin et al., 2012). It was downloaded from http://lom.observesport.com/.

Observation Instrument

The observation of spontaneous behaviors in a natural context required the use of an observation instrument that was built *ad hoc*. We elaborated an observation instrument that combines a field format and systems of categories (**Table 1**). The choice of this type of instrument was justified by the multidimensionality of our observational design. The instrument was elaborated based on: (a) preliminary recordings of the reality object of study; (b) theoretical proposals about metacognitive skills (Chatzipanteli et al., 2014); (c) observation instruments used by other researchers to capture children's metacognitive skills (Muñoz, 2004; Whitebread et al., 2009); and (d) characteristics of the puzzle.

The observation instrument was made up of 5 dimensions or criteria. These criteria allowed to capture metacognitive skills that the child used during the process of solving the puzzle, meaning, planning (criterion 1), monitoring (criterion 3), and evaluation (criterion 4), in addition to the specific piece of puzzle he/she used each time in these skills (criterion 2). Capturing the participation of the adult accompanying the child was also possible with the last criterion (criterion 5). The criteria 1, 2, 3, and 4 had resulted in exhaustive and mutually exclusive category systems. The criterion 5 corresponded to a structure of field format as there was no closed set of coding possibilities.

Software Instruments

Four software programs were used: (a) SAS 9.1.3 (Schlotzhauer and Littell, 1997; SAS Institute Inc, 2004) to analyze observational data quality (intra and inter observational reliability); (b) THEME v.6 Edu (Magnusson et al., 2016) for the temporal patterns (T-patterns) analysis. This software was downloaded for free from http://patternvision.com; (c) GSEQ5, v.5.1 (Bakeman and Quera, 2011) for the lag sequential analysis. This software was downloaded for free from http://www.ub.es/comporta/sg/sg_s_download.htm; (d) HOISAN v.1.6.3.2 (Hernández-Mendo et al., 2012, 2014) for the polar coordinate analysis. It was downloaded for free from the online MenPas psychological evaluation platform (www.menpas.com).

Procedure

The research project was approved by the school management team. Afterwards, teachers of the participants were informed about the aim and nature of the study. In adition, an informative meeting was held with the parents/guardians of the children. In this meeting they were given the informed consent that they had to return signed authorizing the participation of their son/daughter in the study and being recorded while playing. Parents/guardians were asked about the first two inclusion criteria in the sample: (1) child's attendance at the school since first year of preschool education (age 3) and (2) absence of certain disorders or risk factors in the child. Parents who did not attend the meeting were given information about the study and informed consent when they went to pick up their children at school.

Among those students whose parents signed the informed consent (a total of 44, representing 95.65% of all children who attended the last year of preschool), those who fulfilled the first two inclusion criteria were selected. All the children fulfilled them. To verify if these children also fulfilled the third inclusion criterion in the sample (an adequate IQ for their chronological age), the BADyG-I was administered collectively. This instrument-with adequate psychometric properties (Yuste and Yuste, 2001)-offered three scores: Verbal Intelligence, Non-Verbal Intelligence, and General Factor Intelligence. The 44 children evaluated obtained adequate scores for their chronological age, so all of them were part of the study sample.

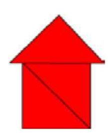
In accordance with the requirements of the observational methodology, exploratory, or preliminary observation sessions

TABLE 1 | Observation instrument.

Criterion	Category systems			Category description	Example	Category code
1. Planning	Inaccurate			The participant indicates where he/she is going to place the piece but he/she does it ambiguously and vaguely, without using specific spatial references (for example, without using references of the type "up/down," "in the roof area," "wall") .	The participant says: "*This* (points to piece 1) *goes here* (it indicates, without precision, a large space in the upper area of the table)".	plim
	Accurate			The participant indicates in a concrete and precise way where he/she is going to place the piece and how, using concrete spatial references on what will be the location of the piece, its orientation and/or its relationship with the parts of the house.	The participant says: "*This* (points to piece 1) *I will rotate and put it up here* (points to a specific space in the upper area of the table), *with this peak up* (points to the right angle of the piece), *forming the roof of the house*".	plp
	Does not know/Does not answer			The participant does not give any indication about how and where the piece will be placed.	The participant says: "*I do not know how the piece goes*".	pln
2. Planned or moved piece	One			Piece of the puzzle marked with number 1	The participant says: "*This piece* the participant points to the piece marked with number (1) *I will put it down*".	uno
	Two			Piece of the puzzle marked with number 2	The participant rotates the piece marked with the number 2.	dos
	Three			Piece of the puzzle marked with number 3	The participant tries to place the piece marked with number 3.	tres
3. Monitoring	Start	According to the planning	Success	The participant places a piece congruently to how he/she said he/she was going to do it before starting the task, being this location of the correct piece comparatively to the house model to be built.	The participant, during the planning, pointing out piece 1, its sides and vertices indicate that he/she will put the piece on the top of the table, with the vertex of the right angle upwards and the hypotenuse parallel to the bottom edge of the table. When he/she begins to perform the task, takes piece 1 and places it as he/she said. The result of this action is that piece 1 remains as a roof of the house.	acpla
			Error	The participant places a piece congruently to how he/she said he/she was going to do it before starting the task but the location of the piece is incorrect compared to the model of the house to be built.	The participant, during the planning, pointing piece 2 and its right angle, indicates that he/she will put the piece just at the bottom edge of the table, with its right angle downwards (the vertex of this angle touching the edge of the table) and its hypotenuse up (parallel to the edge of the table). When he/she begins to perform the task, the participant takes piece 2 and places it as he/she said. The result of this action is that piece 2 is not well located comparatively to the model of the house to be built. (It is displaced 180 degrees with respect to what it would be, for example, its correct location to form the roof).	acple
		Not according to planning	Success	The participant places a piece differently to how he/she said he/she was going to do it before starting the task but the location of the piece is correct comparatively to the house model to be built.	The participant, during the planning, pointing piece 2 and its right angle, indicates that he/she will put the piece just at the bottom edge of the table, with its right angle downwards (the vertex of this angle touching the edge of the table) and its hypotenuse up (parallel to the edge of the table). When the task begins, the participant takes piece 2 and places it in another way: he/she places the piece on	naca

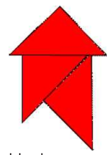
(Continued)

TABLE 1 | Continued

Criterion		Category systems		Category description	Example	Category code
					the top of the table, with the vertex of the right angle upwards and the hypotenuse downwards, parallel to the lower edge of the table. The result of this action is that piece 1 remains as a roof of the house.	
			Error	The participant places a piece differently from how he/she said he/she was going to do it before starting the task, being also the location of the incorrect piece comparatively to the house model to be built.	The participant, during the planning, pointing piece 2 and its right angle, indicates that he/she will put the piece just at the bottom edge of the table, with its right angle downwards (the vertex of this angle touching the edge of the table) and its hypotenuse up (parallel to the edge of the table). When he/she begins to perform the task, the participant takes piece 2 and places it in another way: he/she places the piece in the upper area of the table, with its right angle facing left (looking toward the model house) and with its hypotenuse perpendicular to the edge of the table.	nace
	During	Trials	Success	The participant, after a first placement of the three pieces, takes one of them and changes its position or location without giving a reason for it, proving how and where to put it. The result of this new location of the piece is correct comparatively to the house model to be built.	Having placed the three pieces, so that piece 1 and piece 2 form a square as a facade of the house and piece 3 is located at the bottom of this square with the vertex of the right angle touching the square, the participant takes piece 3 and places it on top of the square, with its hypotenuse resting on the square.	taa
			Error	The participant, after a first placement of the three pieces, takes one of them and changes its position or location without giving a reason for it, proving how and where to put it. The result of this new location of the piece is incorrect compared to the house model to be built.	Having placed the three pieces, so that piece 1 and piece 2 form a square as a facade of the house and piece 3 is located at the bottom of this square touching with the vertex of the right angle the square, the participant takes piece 3 and places it on top of the square with the vertex of the right angle resting on the square.	tae
			Turns the figure correctly	The participant, after a first placement of the three pieces, rotates in any direction the figure that has formed with the three pieces (it implies therefore to rotate the three pieces together), so that by means of this action it obtains a correct figure comparatively to the model of house to build.	Once pieces 2 and 3 are placed forming a square as a facade and piece 3 is located in the lower part of this, the hypotenuse of the piece 3 touching the lower part of the square, the participant rotates the 3 pieces together 180° toward his/her left.	tga
			Turns the figure incorrectly	The participant, once the three pieces are placed, rotates in any direction the figure that has formed with the three pieces (it implies therefore to rotate the three pieces together), so that by means of this action it obtains an incorrect figure comparatively to the model of house to build.	Once pieces 2 and 3 are placed forming a square as a facade and the piece 3 located in the lower part of this, touching with the vertex of the right angle the lower part of the square, the participant rotates the 3 pieces together 90° toward his/her left.	tge
	End	Solves		The participant correctly solves the task, that is, realizes a house equal to the given house model placing the pieces correctly: He/she places a triangle with its right angle upwards and its hypotenuse downwards, forming the roof of the house. Under		rs

(Continued)

TABLE 1 | Continued

Criterion	Category systems	Category description	Example	Category code
		this triangle he/she places two triangles joined by their hypotenuses, forming a square as a facade. This square has one of its sides stuck to the hypotenuse of the upper triangle that it gave as a roof, leaving this triangle-roof supported and centered on the caudrado-facade of the house.		
	Does not solve	The participant does not solve the task or solves it incorrectly (that is, he does not manage to make a house equal to the given house model).		nrs
4. Evaluation	Correct justified	The participant issues a response about his/her successful resolution or not (good/bad) of the puzzle, which is consistent with the reality of the product obtained and issuing criteria based on those who make such a judgment. That is, the participant truthfully argues his/her answer.	Having correctly solved the puzzle, the participant says: "*I have done well because the two houses are the same: Look at the roof of this* (the participant points to the roof of the model house) *and this* (the participant points to the roof of the house built). *They are the same, they are up, and the walls of this one* (he/she points to the model house) *and the walls of my house ... are the same, they are under the roof* ".	coj
	Correct without justification	The participant issues a response about his/her successful resolution or not (good/bad) of the puzzle, being this congruent with the reality of the product obtained but without explaining or arguing the reasons that lead him/her to make such a decision.	Having correctly solved the puzzle, the participant says: "*It's okay*".	cosj
	Incorrect	The participant issues a response about his/her successful resolution or not (good/bad) of the puzzle but this is inconsistent with the reality of the product obtained (regardless of whether he/she justifies his/her answer or not).	Having incorrectly solved the puzzle, the participant says: "*It's okay*".	inc
5. Adult	Help	The adult participates in any phase of the task suggesting and/or offering the participant explicit clues to the completion of the task.	The adult says to the participant: "*Look closely at this piece, are you sure it is well placed*?"	aday
	Intervenes	The adult participates in any phase of the task encouraging, reinforcing the child to continue his/her task.	The adult says to the participant "*That's it, very well, continue*".	adin

were held in order to gather information that would contribute to the construction process of the observation instrument as well as making subsequent decisions with guarantees. These preliminary sessions, as established by the observational methodology, were similar to the observation sessions themselves. They consisted of the following: an adult familiar with the child offered a puzzle to the participant in a classroom of the school (specifically in a classroom usually used by teachers of the center to perform individual or small group activities with children, being therefore a familiar classroom for participants). The concrete puzzle that was used in this study (and explained below) was elaborated based on the tangram and the puzzle used by Muñoz (2004) in his research with children of similar characteristics to those who composed the sample of this study. The puzzle consisted of the following (see **Figure 1**). The child had to build, from three equal pieces and in the form of a triangle (pieces 1, 2, and 3 of **Figure 1**) the house model that was presented to him/her (**Figure 1**). The three pieces were three right isosceles triangles. Their hypotenuse measured 19.8 cm and their legs 14 cm. The layout in which the participant was presented both the house model to be built and the 3 pieces with which to build it are shown in **Figure 1**. Both the house model and the pieces of the puzzle were made of

Eva rubber foam, for being a flexible material and resistant to manipulation by children.

When the child was presented with the three pieces and the house model, he/she was told: "*You have to make a house equal to the model with these pieces* (the model and the pieces were pointed out), *but before doing it you must think how you are going to do it. When you've thought about it, you'll tell me and then you'll do it.*" We made sure that he/she had understood what he/she had to do asking him/her: "*Have you understood?*". In case the child answered yes, he/she was asked to explain it to verify that it was indeed like that. In case the child answered no, he/she was explained again a second time. (No participant needed to be repeated more explanations). Once it had been proven that the child understood what he/she should do, he/she was told: "*Very well, remember: first think how to do it, second tell me and third, do it.*" The time available for the child to do any of these three actions (think about how he/she was going to solve the puzzle, tell it, and execute it) was not limited.

The moment in which the child began to tell how he/she was going to solve the puzzle was considered the beginning of the observation session. (This explanation given by the child on how he/she was going to solve the puzzle allowed to evaluate the metacognitive planning skill). Once the child had finished this explanation, he/she was told: "*Now you can do the puzzle, telling me in a loud voice what you do and why you do it.*" (With this we evaluated not only the monitoring strategy but also whether it fitted the plan and if the child was able to realize his/her mistakes in the planning and the way to solve them). When the child finished the task he/she was asked if this was good and why so that he/she could evaluate if his/her evaluation strategy was consistent not only with the final result but also with the whole process carried out. When the child finalized his/her answers to these questions, it was considered the end of the observational session. All the observational sessions were recorded so that they could be analyzed later.

There were five preliminary sessions in which five children, individually, played with the puzzle. These preliminary sessions, which lasted an average of 9.45 min, were video recorded for later viewing. With the information gathered in these preliminary sessions about the metacognitive skills used by children to solve the puzzle, in addition to the information extracted from theoretical models about metacognitive skills and from observation instruments constructed by other authors for similar purposes, the observation instrument was constructed. It was necessary to build and adjust different intermediate versions until reaching the final version (**Table 1**).

The observation sessions themselves had an average duration of 9.31 min. All the sessions were video recorded.

The video recordings were imported into the Lince software and coded using the *ad hoc* observation instrument. Two observers (who were expert in observational methodology, child development and learning, and metacognitive skills) coded. The data entered included information on the frecuency and order of behaviors. In accordance with the type of data proposed by Bakeman (1978), the data were concurrent and event-based (Type II). This type of data was consistent with the multidimensional nature of the design.

Observational data quality was assessed qualitatively through consensual agreement and quantitatively by calculating intra- and inter-observer reliability. In the first four sessions to be codified, the consensual concordance between the two observers was applied. Then, observer 1 coded all the remaining sessions and calculated intra-observer reliability in 11 sessions. Observer 2 codified another 11 sessions that were used to calculate interobserver reliability with the corresponding records made by observer 1. Intra and interobserver reliability were calculated through intraclass correlation coefficient using SAS 9.1.3 software. In all cases good reliability was obtained (intraclass correlation coefficient ≥.90).

Data Analysis

We used three techniques of data analysis in order to answer to the aim of this study: (1) T-patterns detection; (2) Lag sequential analysis; and (3) Polar coordinate analysis.

T-patterns Detection

In agreement with the aim of the study, the detection of T-pattern focuses on the analysis of the whole recording of the puzzle. Therefore, the files with the encoded data of each participant were concatenated into a single multi-sample file.

The following search parameters were set in THEME v.6 Edu for the detection of T-patterns (for further information see Reference Manual, PatternVision Ltd and Noldus Information Technology bv, 2004): (a) frequency of occurrence ≥7; (b) level of significance $p < 0.005$; (c) deactivation of fast requirement at all levels and selection of free heuristic critical interval setting; (d) validation of results through randomization of data on five occasions (i.e, detected T-patterns were only accepted if THEME detects them among all the additional randomly generated relationships).

Once the T-patterns were obtained, statistical analysis was carried out on them according to the aim of the study. It was determined to look for patterns that were significantly more frequent in children who did solve the puzzle and those who were significantly more frequent in children who did not solve the puzzle. Once these patterns were obtained, through the application of qualitative filters, those of greatest interest for the study objective were selected; that is, the patterns that reflected the complete or almost complete resolution process, implying: (a) that they started with some category related to *Planning* ["Inaccurate planning" (*plim*), "Accurate planning" (*plp*), and "Does not know/Does not answer" (*pln*), regardless of which *piece was planned* (*uno, dos* or *tres*)] and (b) finished by some category related to *End* [i.e., categories "Solves" (*rs*) and "Does not solve" (*nrs*)] or by some category related to *Evaluation* ["Correct evaluation without justifying" (*cosj*), "Correct evaluation justified" (*coj*), and "Incorrect evaluation" (*inc*)].

Lag Sequential Analysis

In this study, according to the aim, a lag sequential analysis was calculated for each children group (children who solved the puzzle and those who did not). Behaviors selected as criterion behaviors in the group of children who solved the puzzle were: (a)

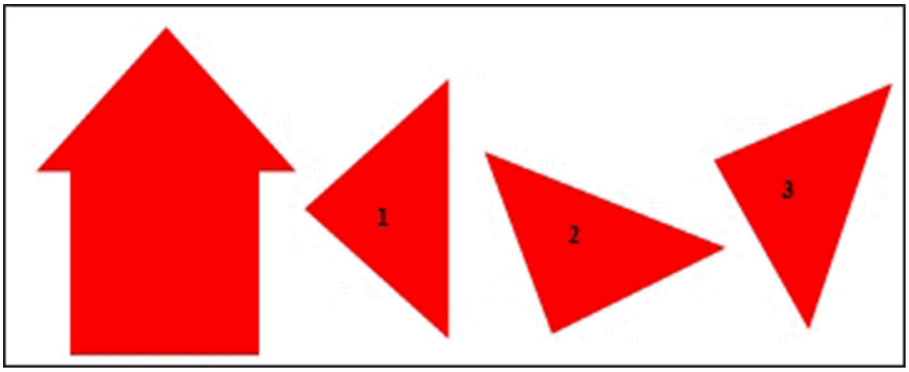


FIGURE 1 | Puzzle: Model to be constructed by participants from the three pieces.

all the categories related to the metacognitive ability of *Planning*, that is: "Inaccurate planning" (*plim*), "Accurate planning" (*plp*), and "Does not know/Does not answer" (*pln*), regardless of which piece was planned (*uno*, *dos* or *tres*); (b) the *Monitoring* category "Solves" (*rs*) and (c) all the categories referred to *Evaluation*: "Correct evaluation without justification" (*cosj*), "Correct evaluation justified" (*coj*) and "Incorrect evaluation" (*inc*). In the group of children who did not solve the puzzle, these same categories were used as criterion behaviors, except "Solves" (*rs*) that was replaced by "Does not solve" (*nrs*). In both groups of children, as conditional behaviors, we selected all the categories of the observation instrument. Given the psychological meaning of each category selected as criterion behavior (and consequently the moment of childhood activity in which each of them could appear generating prospective or retrospective patterns), from multievent sequential data (using lag sequential analysis lexicon), we looked at: 10 prospective lags (from +1 to +10 lags) that occurred immediately after the criterion behavior referred to *Planning* ["Inaccurate planning" (*plim*), "Accurate planning" (*plp*) and "Does not know/Does not answer" (*pln*)]; 10 retrospective lags (from −10 to −1 lags) that occurred immediately before the criterion behavior "Solves" (*rs*) or "Does not solve" (*nrs*) and 10 prospective lags (from +1 to +10 lags) that occurs immediately after these criterion behavior; and 10 retrospective lags (from −10 to −1 lags) that occurred immediately before the criterion behavior referred to *Evaluation* ["Correct evaluation without justification" (*cosj*), "Correct evaluation justified" (*coj*), and "Incorrect evaluation" (*inc*)]. The level of significance was set at $p < 0.05$. We used software program GSEQ5, v.5.1.

Polar Coordinate Analysis

Given the aim of this study, the analysis of polar coordinates was made, on the one hand, with the observational data of children who solved the puzzle and, on the other, with the data of children who did not solve the puzzle. We used the software program HOISAN v.1.6.3.2. The categories chosen as focal behaviors were: all the categories related to the metacognitive ability of *Planning* ["Inaccurate planning" (*plim*), "Accurate planning" (*plp*), and "Does not know/Does not answer" (*pln*)]; the category of "Solves" (*rs*) or "Does not solve" (*nrs*) depending on whether it was a group of children or another; and the *Evaluation* categories ["Correct evaluation without justification" (*cosj*) and "Incorrect evaluation" (*inc*)]. The categories chosen as conditional behaviors were all the categories that made up the observation instrument.

Given the aim of our study, which sought to analyze the sequential and associative structure of the metacognitive skills that children put into action during the resolution of the puzzle, the results obtained in quadrant I and IV were considered, quadrants in which the focal behavior activates conditional behaviors. [This is why the category "Correct evaluation justified" (*coj*) was not considered as a focal given that it implied the end of the game and therefore, it can not activate any category].

TABLE 2 | T-patterns obtained in the group that solved the task.

T-patterns	*N*	Length
(((plim,tres acpla,uno)(taa,dos rs))(adin cosj))	7	6
(plp,uno (((plim,tres acpla,uno)(taa,dos rs)) adin))	7	6
(plim,dos ((plim,tres acpla,uno)(taa,dos rs)))	7	5
((plp,uno plim,tres)((acpla,uno taa,tres) rs))	7	5
(plim,tres (acpla,uno (taa,tres rs)))	8	4
((plp,uno (acpla,uno rs)) coj)	7	4
((plim,tres acpla,uno)(rs coj))	7	4
(plim,dos ((acpla,uno taa,tres) rs))	9	4
(((plim,dos acpla,uno) taa,dos) rs)	7	4
(plp,uno (acpla,dos rs))	7	3
(plp,uno (acpla,tres rs))	7	3

RESULTS

T-patterns Detection

Table 2 shows 11 T-patterns obtained in the group of children that solved the puzzle, as well as the frequency of each of them and their length. These patterns appear ordered from greater to shorter length.

Patterns obtained show that children can reach the correct resolution of the puzzle starting from a precise (*plp*) and imprecise (*plim*) planning. Specify that precise planning (*plp*) always refers to piece one (*plp,uno*), while imprecise planning (*plim*) refers either to piece two (*plim,dos*) or piece three (*plim,tres*). The number of patterns obtained with precise planning (*plp*) (5 patterns) is very similar to that obtained with imprecise planning (*plim*) (6 patterns). Within these last patterns generated by imprecise planning (*plim*), the same number of patterns are obtained with piece two (*plim,dos*) (3 patterns) as with piece three (*plim,tres*) (3 patterns).

Although these patterns are typical of children who solved the task, only in three patterns does the evaluation (*cosj* and *coj*) appear. Therefore, the evaluation metacognitive skill is the one least used by participants. However, these evaluations are always correct (*cosj* and *coj*), and there are more numerous patterns that contain justified evaluations (*coj*, 2 patterns) than those that contain unjustified evaluations (*cosj*, 1 pattern).

The patterns obtained in the group of children that solved the task show low adult participation (*adin*). Adult intervention (*adin*) only appears as part of two patterns and also does it once the child has already solved the task (*rs*). Therefore, it seems that the adult would intervene with the intention of encouraging the evaluation of the child, although it does not always seem to achieve it: in a pattern, after the adult intervention (*adin*) there is a correct, although unjustified, evaluation of the child (*cosj*) but in another pattern, this does not happen (after *adin* no category happens).

Table 3 shows the only pattern obtained in the group of participants who did not solve the puzzle, its frequency and length.

Participants who did not solve the task planned in an imprecise way the location of piece two (*plim,dos*) and during its execution they carried out unsuccessful trials (*tae*). These children were not able to successfully perform the task despite receiving help from the adult (*aday*) during several moments of their execution. Thus, neither their planning metacognitive skill nor their monitoring metacognitive skill show adequate indicators to solve the task. There are no indicators of the evaluation metacognitive skill.

TABLE 3 | T-pattern obtained from the group that did not solve the task.

T-pattern	N	Length
(((plim,dos nrs)(tae,tres aday))((tae,dos aday) nrs))	7	7

Lag Sequential Analysis

Tables 4, **5** collect the retrospective and prospective patterns obtained in the group of participants that solved the puzzle. Patterns of interest are highlighted according to the aim of the study, which as previously indicated are the patterns that reflect the complete or almost complete resolution process. Therefore, according to the retrospective patterns, interest patterns are those that begin on some category related to *Evaluation* ["Correct evaluation without justification" (*cosj*), "Correct evaluation justified" (*coj*), and "Incorrect evaluation" (*inc*)] or by the *End* execution of the task ["Solves" (*rs*)] and finalize by some category related to *Planning* ["Inaccurate planning" (*plim*), "Accurate planning" (*plp*), and "Does not know/Does not answer" (*pln*)]. Considering the prospective patterns, those patterns that begin with one of the categories referred to *Planning* and *End* either by "Solves" (*rs*) or by some category related to *Evaluation* are of interest.

Tables 6, **7** show the retrospective and prospective patterns obtained in the group of participants who did not solve the puzzle. As in the previous case, patterns of interest are highlighted according to the aim of the study. The criteria that justify their consideration as patterns of interest are the same as those just explained for the group of participants that solved the task, except that when dealing with the patterns of children who did not solve the task, the "Solves" category (*rs*) is replaced by "Does not solve" (*nrs*).

In the group of participants who solved the task, taking into account the patterns obtained in the retrospective perspective (**Table 4**), it can be seen that: (a) taking as criterion behavior "Correct evaluation justified" (*coj*), 64 patterns are obtained up to the delay−8 which contains an "Accurate planning of piece number one" (*plp,uno*).

Considering the prospective patterns of this same group of participants (**Table 5**), it is appreciated that all the precise planning (*plp*), independently of the piece to which they refer (*uno, dos,* or *tres*) generate patterns of interest. Taking into

TABLE 4 | Retrospective patterns obtained in the group of participants who solved the task.

Lag −10	Lag −9	Lag −8	Lag −7	Lag −6	Lag −5	Lag −4	Lag −3	Lag −2	Lag −1	Criterion behavior
			adim (2.27)			tae,dos (2.07)	acpla,dos (3.84) tae,tres (3.27)	acpla,tres (2.67) taa,dos (3.35) taa,tres (4.76)	acpla,tres (3.05) acpla,uno (3.74) taa,dos (6.24) taa,tres (5.36)	rs
		acpla,uno (2.13) **plp,uno (2.64)**	**plim,dos (2.74)**	**acpla,tres (1.99)** **plim,tres (2.74)**	**acpla,tres (2.0)** **acpla,uno (2.81)** **acple,uno (2.0)** **taa,dos (2.05)**	**acpla,dos (2.1)** **taa,uno (2.1)**	**acpla,tres (4.41)** **acpla,uno (2.15)**	**rs (5.36)**	**adin (2.55)** **inc (3.12)** rs (2.06)	**coj**
				coj (2.3)	taa,tres (2.23) tae,tres (2.08)	taa,tres (3.01)	nrs (2.12) taa,dos (2.13) taa,tres (2.48) tge (2.12)	inc (2.41) rs (4.29)	adin (2.62) rs (4.11) tga (2.66)	cosj

Bold values indicate patterns of interest according to the aim of the study.

TABLE 5 | Prospective patterns obtained in the group of participants who solved the task.

Criterion behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5	Lag +6	Lag +7	Lag +8	Lag +9	Lag +10
rs		coj (6.61) cosj (6.11)								
plp,uno	**plp,dos (3.95)** **plim,dos (3.08)**	**plim,tres (6.01)** **plim,dos (3.08)** **nace,tres (2.17)**	**acpla,uno (3.07)**	**acpla,uno (3.82)** **nace,uno (1.98)**	**acpla,dos (1.98)** **naca,tres (1.98)** **nace,dos (1.98)** **nace,tres (1.98)**	**acpla,tres (2.82)** **acple,dos (2.82)** **tae,uno (1.98)**	**nrs (2.79)**	**coj (2.42)**	**taa,tres (3.28)** **inc (2.28)**	**rs (2.14)** taa,tres (2.14)
plp,dos	**plp,tres (6.51)** **nace,tres (3.72)**	**plp,uno (6.27)** **plim,uno (3.58)**	**nace,uno (3.21)** **aday (2.17)** **adin (2.17)**	**acpla,dos (3.66)** **naca,tres (3.21)** **nace,dos (2.06)**	**acpla,tres (3.29)** **tae,uno (3.21)**	**acpla,uno (4.56)** **acple,uno (3.21)** **taa,dos (2.17)**	**rs (2.42)**			aday (2.32) adin (2.32)
plp,tres	**plp,uno (10.15)**	**plp,dos (4.82)**	**nace,tres (2.91)** **acpla,dos (2.47)**	**acpla,tres (2.28)**	**acple,uno (4.93)** **nace,uno (4.33)**	**rs (3.26)**	**adin (2.03)**	**cosj (2.5)**	aday (2.6)	
plim,uno	plim,dos (4.85)	aday (3.16) plim,tres (2.35)	plim,dos (3.21)	plim,tres (3.21) acple,uno (2.06)	acple,tres (2.17) acple,uno (2.06) taa,uno (3.21)	acpla,dos (3.21) acple,tres (2.06) aday (2.06) nrs (2.17)	acpla,uno (3.11)			tae,tres (3.03)
plim,dos	plim,tres (6.57)	adin (3.29) acpla,uno (2.45)	taa,dos (1.98)	acple,tres (3.1)	tae,tres (3.97)	tae,dos (2.21)				
plim,tres	**acpla,uno (4.63)** **acple,dos (2.05)** **plim,uno (2.05)**	**acpla,uno (3.82)** **acple,dos (2.21)**	**acple,tres (3.37)**	**tae,tres (2.4)**	**taa,dos (3.5)** **tae,dos (2.52)**		**taa,tres (3.2)**	**rs (2.47)**		

Bold values indicate patterns of interest according to the aim of the study.

TABLE 6 | Retrospective patterns obtained in the group of participants who did not solve the task.

Lag −10	Lag −9	Lag −8	Lag −7	Lag −6	Lag −5	Lag −4	Lag −3	Lag −2	Lag −1	Criterion behavior
tae,tres (1.98)	adin (2.91)		tae,dos (2.38) **plim,tres (2.33)**	**plim,dos (3.04)**	**tae,dos (2.0)**		**acpla,uno (2.68)** **tae,dos (2.28)**	**tae,tres (4.3)** **tae,dos (3.81)** **acple,dos (3.02)** **taa,dos (2.32)**	**tae,tres (4.61)** **aday (2.95)** **tae,dos (2.71)** **acple,tres (2.34)**	**nrs**
tga (4.31)	acpla,dos (4.31) acpla,uno (2.89) cosj (2.89) taa,tres (2.88)	acple,uno (4.31) acple,dos (2.89)	acple,tres (4.31) **plp,dos (4.31)** cosj (2.89) taa,uno (2.89)	**plp,tres (4.31)**	**naca,uno (4.33)** **plp,uno (2.9)** **taa,tres (2.24)**	**nace,dos (4.33)** **tae,uno (2.9)**	**nace,tres (4.33)** **acpla,tres (2.24)**	acpla,uno (4.34) **nrs (3.86)**		**coj**
taa,dos (2.21)	tae,tres (3.04) **plim,dos (2.33)**		**acpla,dos (2.33)** **taa,dos (2.21)**			**taa,uno (3.58)** **taa,dos (2.86)** **tae,tres (2.0)**	**tga (5.08)** **tae,tres (2.47)** **taa,uno (2.34)**	**nrs (3.94)** **taa,tres (2.35)**	**nrs (2.5)** **adin (2.06)**	**cosj**
plim,uno (2.57) **plp,tres (2.42)**	**plim,tres (4.89)** **inc (2.5)**	**plim,dos (3.43)** **acpla,tres (2.42)**	**plim,dos (2.5)** **coj (2.42)**	**acple,tres (2.57)** **acple,uno (2.42)** **coj (2.42)**	**acpla,uno (3.45)** **acple,dos (3.45)**	**acple,uno (3.45)** **acle,dos (2.04)**	**acple,tres (2.04)**	**inc (3.04)** **nrs (2.03)**	**nrs (4.54)**	**inc**

Bold values indicate patterns of interest according to the aim of the study.

account the different bifurcations that are generated in some of the delays, a total of 508 possible patterns of this type are obtained: 288 generated from "precise planning of piece number one" (*plp,uno*); 216 generated from "precise planning of piece two" (*plp,dos*) and 4 generated from "precise planning of piece three" (*plp,tres*). Only these four patterns generated by "precise planning of piece three" (*plp,tres*) contain aspects related to evaluation, being correct but not justified (*cosj*).

Although sometimes the child starts planning inaccurately (*plim*), he/she can solve the task (*rs*), but not evaluate it. This happens only when this imprecise planning (*plim*) affects piece three (*plim,tres*) (not piece one or two, which do not generate patterns of interest). In particular, imprecise planning of piece three (*plim,tres*) generates 12 patterns.

Regarding the patterns obtained in the group of children who did not solve the task, taking into account the retrospective perspective (**Table 6**), it can be seen that all categories considered as criteria ["Does not solve" (*nrs*) and all those referred to *Evaluation* (*coj, cosj, inc*)] generate patterns of interest (a total of 510 patterns). As a whole, these patterns show that although participants did not solve the task, previously used planning, both precise (*plp*) and imprecise (*plim*), and both types of planning affecting any of the three pieces involved (*uno, dos, tres*).

The patterns generated by the category "Correct evaluation justified" (*coj*, 12 patterns) indicate that children were able to correctly evaluate and justify their result, even though previously they could not solve the puzzle successfully. And this happened even though they previously made precise planning (*plp*) of the three pieces that make up the puzzle.

However, the patterns generated by the category "Does not solve" (*nrs*), compared to the previous ones [those generated by "Correct evaluation justified" (*coj*)], show us important differences in the metacognitive skills of children: participants who did not solve the task and did not evaluate it, previously made plans that were imprecise (*plim*). On the other hand, just as it has been explained in the previous paragraph, the children who did not solve the task but correctly evaluated and justified their result, had made previous precise plans (*plp*).

It is noteworthy that, in relation to the evaluation categories, as the quality of children's evaluation increases ("incorrect" -*inc*-, "correct without justifying" -*cosj*-, and "correct justified" -*coj*-) less number of patterns are generated (*inc*, 394 patterns; *cosj*, 72 patterns; *coj*, 12 patterns).

In regard to the prospective patterns (**Table 7**), certain similarities are detected with the group of participants that solved the task in that all precise planning (*plp*) generated interest patterns; although a smaller number of patterns is generated. In this case, a total of 44 patterns are generated, distributed as follows: 12 from "precise planning of piece one" (*plp,uno*); 8 from "precise planning of piece two" (*plp,dos*); and 24 from "precise planning of piece three" (*plp,tres*).

In addition, corroborating the information previously exposed referred to the retrospective patterns generated by "correct evaluation justified" (*coj*), the following is appreciated. Precise planning (*plp*) with any of the 3 puzzle pieces gives rise to patterns that show that although children did not solve the task correctly, they were able to issue a justified correct evaluation (*coj*).

In the patterns generated from imprecise planning (*plim*), differences appear between groups of children. In the group of participants that did not solve the task only the "imprecise planning of piece two" (*plim,dos*) generates patterns (48 patterns). Remember that imprecise planning only generates patterns with piece three (*plim,tres*) in the other group of participants (participants that solved the task).

Polar Coordinate Analysis

Table 8 and **Figure 2** show the significant results of polar coordinate analysis and its vector maps for the group of participants that solved the task.

Among the results obtained, the following aspects stand out (**Figure 2**). Task resolution (*rs*) activates correct evaluations, regardless of whether they are justified (*coj*) or not (*cosj*). Precise planning (*plp*) is activated mutually, except for precise planning with piece three (*plp,tres*) although it activates precise planning of piece one (*plp,uno*), this inhibits the previous one. Incorrect evaluation (*inc*) activates adult participation (*adin* and *aday*), although depending on what type of adult participation is concerned, this can activate the incorrect evaluation (case of *adin* -adult intervention-) or inhibit it (case of *aday* -adult help-).

Table 9 and **Figure 3** represent the significant results of polar coordinate analysis and its vector maps for the group of participants who did not solve the task. The non-resolution of the task (*nrs*) activates trials with piece two and piece three, these trials being able to imply both correct (*taa,dos* and *taa,tres*) and error (*tae,dos* and *tae,tres*) outcomes. All these actions in turn also activate the non-resolution of the task (nrs). The same happens with adult help (*aday*): the non-resolution of the task (*nrs*) and adult help (*aday*) activate each other. On the other hand, although the non-resolution of the task (*nrs*) activates evaluation that is both correct without justifying (*cosj*) and incorrect (*inc*), both evaluations inhibit that category. When referrals to evaluation are considered as focal behaviors ("correct evaluation without justifying" (*cosj*) and "incorrect evaluation" (*inc*)] these activate adult intervention (*adin*).

Among all these results that allow us to respond to our objective, we first compare the temporal patterns (T-patterns) and the sequential patterns and then, we compare both with the significant results of the polar coordinate analysis (associative structures) in order to know if they can be complementary.

Concerning the T-patterns and the sequential patterns, we can distinguish between those structures that can be considered complete (they contain information referring to the three metacognitive skills analyzed: planning, monitoring, and evaluation) and those that can be considered incomplete (only referred to the metacognitive skills of planning and monitoring).

The number of structures of each obtained typology with lag sequential analysis and with T-pattern detection is shown in **Table 10**.

Table 10 shows how the lag sequential analysis detects a greater number of patterns and also more varied typologies (prospective/retrospective, complete/incomplete) for both groups of participants. In addition, with this data analysis

TABLE 7 | Prospective patterns obtained in the group of participants who did not solve the task.

Criterion behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5	Lag +6	Lag +7	Lag +8	Lag +9	Lag +10
nrs	inc (3.93) cosj (2.36)	coj (2.1) cosj (3.05)								
plp,uno	**plp,dos (3.8)** **acpla,uno (3.09)** **acpla,tres (2.51)**	**plim,tres (3.07)** **acpla,dos (2.5)**	**acpla,uno (3.9)** **acple,uno (3.77)**	**nrs (3.62)**	acple, dos (3.96) **coj (3.77)** acple,tres (2.16)	aday (2.31)	plp,dos (4.0)		acpla,tres (3.98)	
plp,dos	**plp,tres (6.66)**	**plp,uno (4.53)** **acpla,uno (3.33)**	**acpla,tres (2.65)** **acple,dos (2.04)**	**acpla dos (3.97)** **acpla,tres (3.97)**	**acple,uno (3.97)**	**nrs (2.51)** taa,dos (2.29)	**coj (3.14)** taa,dos (2.64)		plp,dos (5.72) taa,dos (2.63)	adin (2.07) plim,dos (3.92)
plp,tres	**plp,uno (5.04)** **acpla,uno (2.0)**	**naca,uno (3.52)** **acpla,tres (2.77)**	**acpla tres (5.0)** **acpla dos (3.51)** **nace dos (3.51)**	**naca,tres (5.14)** **acple,uno (3.51)**	**nrs (2.85)**	taa,dos (4.38) **coj (3.49)**	tae,tres (2.09)	plp,dos (5.12) tae,dos (2.21)	plim,dos (3.48) adin (2.82) taa,dos (2.28)	coj (3.46) acpla,uno (2.27)
plim,uno	plim,tres (5.82) acpla,tres (2.92) plim,dos (2.07)	plim,dos (6.42) plp,tres (2.9)	acpla dos (2.89)	acpla,uno (4.27) naca,uno (2.89) acple,tres (2.4)	nace,dos (4.31) acple,tres (4.27) acpla,tres (2.23)	acple,uno (4.29) naca,tres (4.29) acple,dos (2.61)	taa,tres (4.29)	inc (2.39)	aday (2.19)	inc (2.58)
plim,dos	**plim,tres (3.07)** **plim,uno (2.87)** **plp,uno (2.55)** **acpla,uno (2.13)**	**acple,dos (3.13)** **acpla,uno (3.06)**	**acple,tres (3.49)** **acple dos (3.27)** **nace,tres (2.96)**	**acple,dos (3.21)**	**naca,tres (2.96)** **taa,dos (2.23)**	**nrs (2.2)**	**inc (2.34)**	taa,dos (2.21)		taa,tres (4.15)
plim,tres	plim,dos (5.63) acple,dos (4.62) acpla,dos (3.25)	nace,tres (3.4) acpla,uno (2.66) acple,tres (2.2)	acpla,uno (3.36) acple,tres (2.87) acple,dos (2.32)	taa, uno (3.38) acple, tres (2.87) acple, dos (2.64) acpla, tres (2.19)	acple,uno (2.19) acple,dos (2.04)			aday (2.51)	inc (3.81) tae,tres (3.25)	

Bold values indicate patterns of interest according to the aim of the study.

TABLE 8 | Polar coordinate analysis results: group of participants that solved the task.

Focal behavior	Categories	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle
rs	cosj	I	3.17	0.55	3.22 (*)	9.8
	coj	IV	2.7	−0.39	2.73 (*)	351.81
	adin	IV	1.45	−4.16	4.4 (*)	289.16
plp,uno	plp,dos	I	1.1	1.85	2.15 (*)	59.25
plp,dos	plp,tres	I	2.06	1.46	2.53 (*)	35.42
plp,tres	plp,dos	I	1.41	2.03	2.47 (*)	55.15
	plp,uno	IV	3.09	−0.42	3.12 (*)	352.26
plim,uno	plim,dos	IV	2.21	−0.29	2.23 (*)	352.59
plim,tres	plim,uno	I	0.48	2.01	2.07 (*)	76.47
	inc	I	1	4.04	4.16 (*)	76.15
	adin	I	0.05	3.75	3.75 (*)	89.23
	taa,dos	IV	0.74	−1.95	2.09 (*)	290.66
	taa,tres	IV	0.52	−1.89	1.96 (*)	285.34
cosj	rs	I	0.28	2.80	2.82 (*)	84.20
inc	adin	I	0.7	1.94	2.06 (*)	70.2
	aday	IV	3.13	−0.55	3.17 (*)	350.08

**Significant relationships ($p < 0.05$) between the focal behavior and conditional behaviors.*

technique more categories generate patterns, comparatively to T-pattern detection since the latter technique only allows to detect behavior patterns that occur in a time interval. Therefore, T-pattern detection in our study only allows to detect patterns about planning. Comparing the patterns generated from these categories, it is striking that precise planning (*plp*) generates patterns with any piece when lag sequential analysis is used, but not when using T-pattern detection, which only does it with precise planning for piece one (*plp,uno*). On the other hand, when dealing with imprecise planning (*plim*), lag sequential analysis generates patterns only with piece three (*plim,tres*) while T-pattern detection also finds patterns for piece three in addition to piece two (*plim,dos*).

Despite detecting differences in the results obtained with each data analysis technique, common aspects among them have also been found. **Table 11** includes these aspects: the common aspects between the three techniques are highlighted and common aspects between two of them are underlined (T pattern-detection and polar coordinate analysis). No similarities were detected that only affect lag sequential analysis and polar coordinate analysis.

DISCUSSION

The results obtained in this research from the mixed methods perspective represent a very important advance in the field of: (1) children metacognitive skills and (2) their assessment.

(1) Concerning children metacognitive skills, this study provides evidence on: (a) the ability to use these skills in preschool children, which corroborate results obtained by other researchers (Whitebread et al., 2009; Marulis et al., 2016; Roebers, 2017; Mari and Saka, 2018). More specifically, the study has allowed to know the sequential and associative structure of metacognitive skills that 5 year old children put into action during the resolution of a puzzle. These results highlight, once again, the importance of conducting studies in the natural context of children and using meaningful play tasks for them; (b) the existence of differences in these capacities between those participants who solved the puzzle and those who did not. We hypothesized that there would be differences both in their planning and in their monitoring and evaluation. However, the differences between the both groups of participants mainly affect their monitoring. The participants who solved the task, in the case of committing an error, that is, in the case of incorrectly solving the puzzle in a first attempt (*nrs*), were able to make their plan of action more flexible and make a new action with the corresponding piece, taking them to solve the puzzle (*rs*) (see **Table 5** for patterns generated by *plp,uno*). However, the participants who did not solve the task showed a greater number of sequential structures in which incorrect resolutions appeared on their first attempt (see *nrs* in **Table 7** for patterns generated by *plp,uno*; *plp,dos*; *plp,tres,* and *plim,dos*). After committing these errors they were not able to generate alternative actions to solve the task (see **Table 7** for the patterns we have just indicated). This could be due to failures in their executive function of cognitive flexibility. Several studies defend the existence of relationships between metacognition and executive functions, although the mechanisms that would explain these relationships are still unknown (Bryce et al., 2015; Nelson and Marulis, 2017; Roebers, 2017).

As already mentioned, we expected to find differences in planning between children who solved the puzzle and those who did not, but this was not the case. Both groups of participants made accurate plannings (*plp*). Moreover, in both groups of participants the accurate planning of each of the three pieces of the puzzle (*plp,uno; plp,dos; plp,tres*) generated patterns (see **Table 5** for participants who solved the puzzle and **Table 7** for those that did not). However, these results imply important implications for the teacher's daily practice because they show

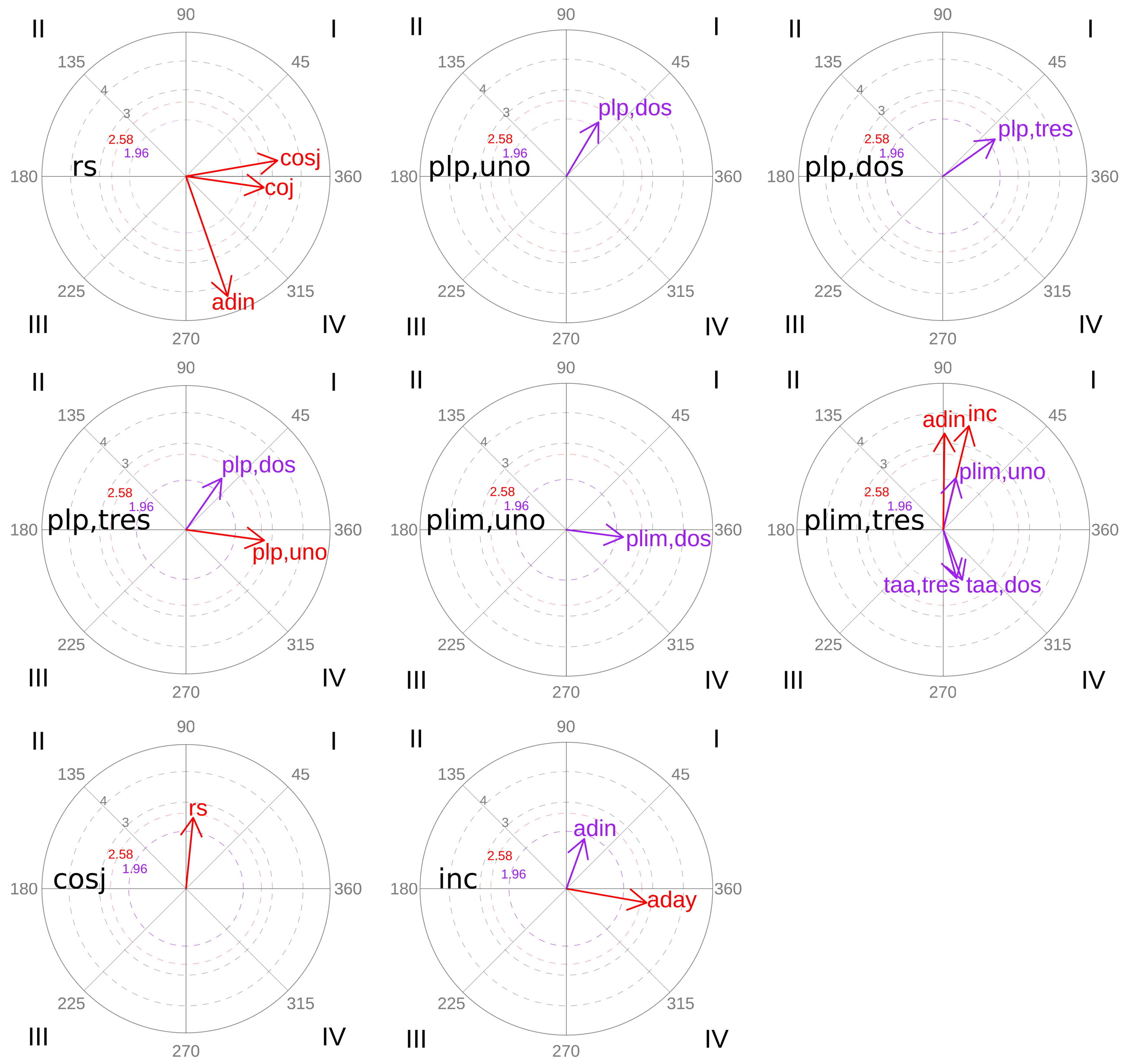


FIGURE 2 | Polar coordinate vector maps: group of participants that solved the task.

that the mere fact of initiating the task correctly does not ensure its success (see **Table 7** for patterns generated by *plp,dos* where it can be seen that despite precisely and sequentially planning the three puzzle pieces -*plp,dos; plp,tres; plp,uno*-, participants made mistakes in their execution and did not solve the task -*nrs*-). So, teachers must attend all the phases of execution of a child's task, and not merely its beginning.

The metacognitive difficulties detected already at these early ages may increase as children develop, with the repercussions that this implies since what happens in the first years of life is the basis for later learning (Scharf et al., 2016). This shows the need to address these difficulties as soon as possible and offer interventions tailored to the child's level, so that the child can benefit from the help offered. The teacher must be a guide and an aid in child learning (Robson, 2015; Perry et al., 2018). Consequently, the teacher must know the level of metacognitive skills of each of his/her students and how its sequentiality works to offer proposals that are within the area of the child's next development, in accordance with Vygotsky's concepts of scaffolding and the zone of proximal development (Vygotsky, 1978). If this is not the case, it is very difficult for the teacher's educational work to produce the desired effects (Perry et al., 2018). This is the situation that is detected in the group of children who did not solve the puzzle: despite interventions and

TABLE 9 | Polar coordinate analysis results: group of participants that did not solve the task.

Focal behavior	Categories	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle
nrs	taa,dos	I	1.44	3.3	3.6 (*)	66.43
	taa,tres	I	1.31	1.53	2.01 (*)	49.4
	tae,dos	I	3.08	2.5	3.97 (*)	39.08
	tae,tres	I	3.98	4.06	5.69 (*)	45.61
	aday	I	1.78	1.74	2.49 (*)	44.28
	cosj	IV	1.89	−1.07	2.17 (*)	330.52
	inc	IV	0.14	−2.03	2.03 (*)	273.93
plp,uno	plp,dos	I	1.9	2.04	2.78 (*)	47.03
	adin	I	0.08	2.6	2.6 (*)	88.26
	acpla,uno	IV	2.31	−1.08	2.56 (*)	334.89
	acpla,tres	IV	1.8	−0.79	1.97 (*)	336.2
plp,tres	plp,dos	I	1.13	1.9	2.21 (*)	59.25
	acpla,uno	IV	1.82	−0.95	2.05 (*)	332.33
plim,tres	acpla,dos	I	0.21	2.1	2.11 (*)	84.25
	inc	I	0.11	2.35	2.35 (*)	87.3
	acple,dos	IV	3.21	−0.18	3.21 (*)	356.79
	acple,tres	IV	2.13	−0.28	2.15 (*)	352.57
	aday	IV	0.31	−2.01	2.04 (*)	278.66
cosj	adin	IV	1.18	−2.01	2.33 (*)	300.35
inc	adin	I	2.38	0.15	2.39 (*)	3.49

**Significant relationships ($p < 0.05$) between the focal behavior and conditional behaviors.*

assistance from adults (*aday*), children do not get to benefit from these proposals or interventions and therefore continue to produce errors in the placement of the pieces, without moving toward a successful resolution of the puzzle.

Although the Preschool Education curriculum in Spain (Education and Science Ministry of Spanish Government, 2008) makes multiple references to the "learning to learn" competence and the ability of learning and autonomous activity of children (highlighting the need for children to be more capable of making decisions, solving problems or using cognitive resources in an increasingly complex and elaborated way), it is true that in educational practice, in general, teachers devote little time to it. Usually, in the classroom, more instrumental learning is done, such as the beginning of basic numerical skills and reading and writing skills. In addition, for children to acquire these instrumental learnings it often happens that the teacher offers tasks too structured with rigid instructions that must be fulfilled by all children, not allowing the child to stop and think to make their own decisions on how to solve the task. We consider that it is necessary to allocate time for the student to think and explore different ways of solving the tasks, so that the professorate promotes the importance of the process and pays less attention to the quality of the result. In short, it is necessary that the educational environment promotes moments of constant reflection, before, during and at the end of all activity, so that children acquire the habit of stopping, thinking and acting on what they do. For this, it is appropriate for the teacher to act as a model and to accompany all of his/her actions with verbalizations that express and justify the different metacognitive skills that he/she is using to solve the task. It is important that the teacher models various strategic approaches to tasks, exemplifying a flexible use of procedures. Through modeling students can observe the processes that are required to perform the task, helping them to develop their metacognitive skills and their conscious use. Subsequently, the teacher must complete the modeling with metacognitive dialogues (also called posing questions; interrogation; questioning; mayeutics or socratic method of teaching). In these dialogues, the teacher raises questions about the process followed when acting ("*How did you do it?*", "*Why did you do it that way?*", "*Why did you say this?*", "*Can you do it in a different way?*", etc.), so that the child must think and reflect on it. Through these dialogues and questions adults offer strategy models of self-questioning, self-diagnosis, and self-correction, transferring to the child the control and planning of their own activity. Thus, the objective of the technique is to ensure that students become aware of their own thought processes. Although this will not be achieved until later ages -given that even in adolescence metacognitive skills continue to improve (Roebers, 2017)—it is necessary to work in this direction from an early age; but always with enjoyable tasks, as has been done in this study.

(2) With respect to the assessment of children metacognitive skills, the realization of this study entails contributions for: (a) the practical and applied evaluation of these skills in the classroom of Preschool Education by the teacher. The Spanish educational legislation requires that in Preschool Education the teacher assesses the learning and development of students through direct and systematic observation (Education and Science Ministry of

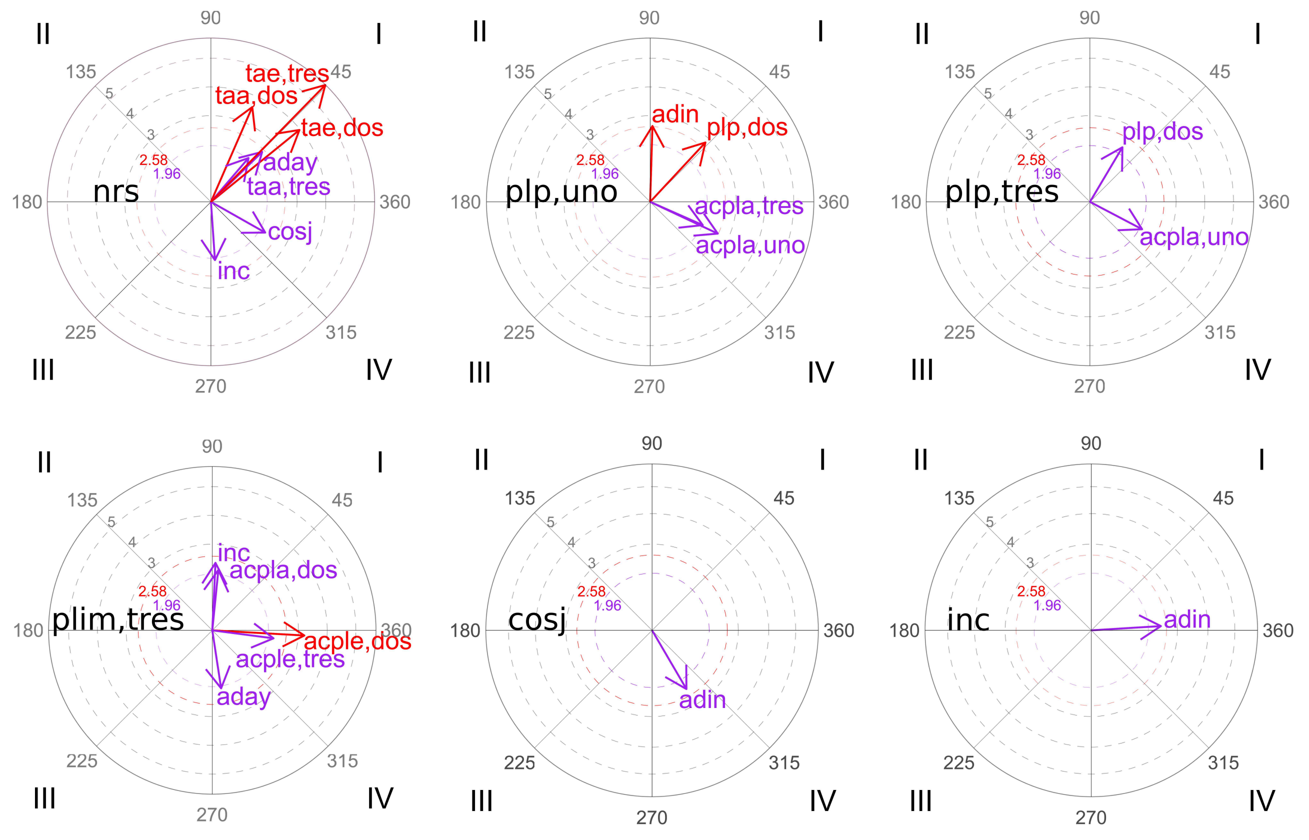


FIGURE 3 | Polar coordinate vector maps: group of participants that did not solve the task.

Spanish Government, 2008). However, it is not always done that way. Often, observation is used inaccurately in schools, without clear criteria and in a non-objective way, in addition to focusing only on the results or final product and not on the process followed by the child. This means that sometimes information may be lost about the progress the child is making in the process (although still not achieving a successful result) and therefore, obtain information that reflects a false stagnation or involution in his/her development and learning. This study helps to avoid these malpractices since an observation instrument is offered (see **Table 1**) whose use allows the teacher to evaluate the metacognitive skills of his/her students in an objective and rigorous manner, focusing on their process as a result and obtaining reliable information. This allows to offer a sensitive educational response tailored to the needs of students. In short, the built observation instrument facilitates the teacher's assessment of their students and contributes to the objectivity of the same, with the benefits that this entails for children; (b) This study also entails methodological contributions for the evaluation of children metacognitive skills in the field of research.

The complementary use of three powerful data analysis techniques allows a rigorous, objective, and exhaustive assessment. It implies a methodological advance in the research field. Therefore, in general terms, it can be said that the combined use of both techniques has provided more exhaustive information about the sequentiality of the use of metacognitive skills in participants than if only one analysis technique had been used. Now, focusing on the results offered by each of them individually, in this study the lag sequential analysis is the one that has provided the most information. This fact could initially seem contradictory to what was found by other authors (Santoyo et al., 2017; Tarragó et al., 2017), who affirm that T-pattern detection offered in their researchs a more exhaustive and profound information. However, it should be noted that in our study lag sequential analysis was performed considering 10 prospective lags and 10 retrospective ones, while in other studies (such as those cited), only five prospective and five retrospective lags are calculated. It is true that the consideration of five delays both prospectively and retrospectively is a usual practice with this type of analysis, although in the present study given the subject, its aim and participant characteristics it would have been insufficient to do so and therefore, information would have been lost. It would be interesting that in future studies this usual practice of considering five delays on lag sequential analysis is extended to 10 and that results obtained are also compared with those found with the use of T pattern-detection.

Until now, studies focusing on this type of data analysis techniques have mainly used these techniques in isolation, without seeking complementarity (Arias-Pujol and Anguera, 2017; García-Fariña et al., 2018; Maneiro and Amatria, 2018).

TABLE 10 | Classification of the sequential and associative structures obtained with lag sequential analysis and T-pattern detection.

Group of participants	Data analysis technique	Pattern start	N° complete prospective patterns	N° incomplete prospective patterns	N° complete retrospective patterns	N° incomplete retrospective patterns
Solves	T-pattern detection	plp,uno	1	4	–	–
		plim,dos	0	3	–	–
		plim,tres	2	1	–	–
	Sequential analysis	coj	–	–	64	0
		plp,uno	0	288	–	–
		plp,dos	0	216	–	–
		plp,tres	4	0	–	–
		plim,tres	0	12	–	–
Does not solve	T-pattern detection	plim,dos	0	1	–	–
	Sequential analysis	nrs	–	–	-	32
		coj	–	–	12	–
		cosj	–	–	72	
		inc	–	–	394	
		plp,uno	12	0	–	–
		plp,dos	8	0	–	–
		plp,tres	24	0	–	–
		plim, dos	48	0	–	–

TABLE 11 | Assessment of children metacognitive skills from the complementarity of the three data analysis techniques.

Participant group	Lag sequential analysis	T_Patters detection	Polar coordinate analysis
Solves	**plp,uno** plp,dos **plim,tres acpla,uno** nace,uno acpla,dos acpla,tres nrs coj taa,tres **rs**	**(plp,uno (((plim,tres acpla,uno**)(taa,dos **rs**)) adin))	
	plp,uno plim,dos **plim,tres acpla,uno** nace,uno acpla,dos tae,uno nrs coj **taa,tres rs**	((**plp,uno plim,tres**)((**acpla,uno taa,tres**) **rs**))	
	plp,uno plp,dos plim,tres **acpla,uno** nace,uno nace,dos acpla,tres nrs coj inc **rs**	((**plp,uno** (**acpla,uno rs**)) coj)	
	plp,uno plp,dos plim,tres acpla,uno nace,uno **acpla,dos** tae,uno nrs coj tae,tres **rs**	(**plp,uno** (**acpla,dos rs**))	
	plp,uno plim,dos nace, tres acpla,uno nace,uno nace,dos **acpla,tres** nrs coj tae,tres **rs**	(**plp,uno** (**acpla,tres rs**))	
	plim,tres acpla,uno acple,dos acple,tres tae,tres **taa,dos** tae,tres **rs**	(((**plim,tres** **acpla,uno**)(**taa,dos rs**))(adin cosj))	plim,tres - adin // **plim,tres - taa,dos**
	plim,tres acple,dos **acpla,uno** acple,tres tae,tres tae,dos **taa,tres rs**	(**plim**,tres (**acpla,uno** (**taa,tres rs**)))	**plim,tres - taa,tres**
	plim,tres plim,uno **acpla,uno** acple,tres tae,tres taa,dos taa,tres **rs**	((**plim,tres acpla,uno**)(**rs** coj))	
Does not solve	**plim,dos** plim,tres acple,dos acple,tres acple,dos naca,tres **nrs** inc	(((**plim,dos** nrs)(tae,tres aday))((tae,dos aday) **nrs**))	

Bold values indicate common aspects between the three data analysis techniques.

There are recent works that have begun to use them in addition, but it has been mainly two to two (Castañer et al., 2017). We only know two papers (Santoyo et al., 2017; Tarragó et al., 2017) that have addressed the complementarity of the three techniques, and although one of them has been developed in the educational context, it has been used with more senior students and analyzing activity organization in the classroom.

In conclusion, the complementary use of these three techniques of observational data analysis is an important contribution to the field of metacognitive skills for children and their assessment, and therefore also to the field of learning and early childhood education, both at the practical and research levels.

These numerous contributions and implications of the study could be even greater if the following limitations could have been overcome: observe the implementation of the metacognitive skills of children in a single moment of the course and in a single playful task.

In order to overcome these limitations and keep moving forward in the field, in the future it would be interesting to: (a) track the participants to know the development of their metacognitive skills in the following school years. This would make a great contribution to this field of study because there are hardly any longitudinal studies on the development of metacognitive skills, and even less at early ages (Paulus et al., 2013). We also consider that this would be of great interest, taking into account that in the next course these participants will begin Compulsory Education, characterized by more complex tasks and higher academic demands; (b) to estimate the predictive power of metacognitive skills for academic achievement but not only in mathematics and literacy but also in different components of them (mental calculation, solving mathematical problems, reading comprehension, etc.). If preschool metacognitive skills turned out to be good predictors of these academic competences, it would be possible to detect children who are likely to present different academic difficulties later and intervene preventively according to their limitations, contributing in this way to their academic success; (c) compare the metacognitive skills of children in cooperative learning tasks with those demonstrated in individual tasks, since several studies indicate that social interactions can facilitate the development of metacognitive skills (Chatzipanteli et al., 2014); (d) collect information on the teaching style of the teaching staff, since it is one of the variables that most affects the development of the children's metacognitive skills, but has been scarcely analyzed (Roebers, 2017).

ETHICS STATEMENT

This study was part of a wider research which was evaluated and approved by the Research Unit of Zaragoza University. Research was also approved by the school management team and teachers. In accordance with the Organic Law 15/1999 of December of Protection of Personal Data (1999, BOE n_ 298 of December 14) all the parents of the participants signed the informed consent authorizing the participation of their son/daughter in the study and being recorded while playing. In addition, and following the guidelines of the aforementioned law, the observers signed the confidentiality agreement. No ethics special approval was required for this research since the Spanish public education system and national regulations require no such approval. Each participant received a small reward (two chocolates) in gratitude for their participation.

AUTHOR CONTRIBUTIONS

EE-P contributed to conceptual structure, collecting data, systematic observation and performed data analysis and results. She was responsible for the literature review and the drafting of this manuscript. MH-N involved in collecting data, systematic observation and performed data analysis and results. MTA contributed to methodological structure, offered guidance on data analysis, performed and supervised them. All of the authors contributed to revising the manuscript and provided final approval of the version to be published.

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Contextual Factors and Decision-Making in the Behavior of Finalization in the Positional Attack in Beach Handball: Differences by Gender Through Polar Coordinates Analysis

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The aim of this study was to analyze, in the framework of the mixed methods, the relationship of different contextual factors with the decisions shown in the finalization of the positional attack in beach handball. For this reason, a polar coordinates analysis was carried out, by gender, using as focal behaviors the simple and double goal, and the loss of possession of the attacking team, which are considered decisive in assessing the success of the decisions at the end of the positional attack. These focal behaviors have been linked to criteria that characterize the attack situation such as the minute, the score, the numerical balance, the defensive system and the duration. A total of 24 sessions were observed with the HOISAN computer software, using an *ad hoc* designed tool. The model of observation used was punctual, multidimensional, and nomothetic. The observation unit used for the positional attack from when the specialist gains control of play until the possession changes. The results obtained showed that an advantage of goals scored and the numerical balance situations of the teams modulate significantly the appropriate decision made by both categories. However, they also indicated differences in the flow of pairing behaviors for both categories in some aspects. Specifically, it has been observed that a longer duration of the attack in the female category has been linked significantly to a successful performance and the results also show that an elaborated attack is related to successful behaviors. In the male category, it has been observed that the technical fouls made by the attackers increase in the last minutes of the match. Likewise, as regards the to the opposing team's defensive system, the results in the male category are related to successful behaviors before any of them; whereas, in the female category, when playing against a defensive pressure system, the results relate more to errors during the performance of the pass and reception. The use of polar coordinates for the estimation of technical-tactical relations allows, from a psychological point of view, determine the techniques and procedures of psychological intervention that optimize the action resources of the players individually and the team as a collective.

Keywords: mixed methods, systematic observation, polar coordinates, beach handball, decision making

INTRODUCTION

Published research on the planning of training in collective sports emphasizes the importance of the gradual increase of physical, technical and tactical demands in the competition in recent decades (Carling, 2011; Sarmento et al., 2017). This fact has led to the need to increase specific knowledge to carry out proper planning and make the preparation of the team as complete as possible (Nunes et al., 2015). Beach handball has also been immersed in this tendency, proof of this is the constant evolution that has developed in all aspects of the game since its beginnings in the nineties to today (Morillo-Baro and Hernández-Mendo, 2015; Navarro et al., 2018), promoting in the professionals of this sport a continuous update and innovation.

Despite being a method that comes from the handball court, it also brings with it many differences, turning it into a completely new method (Belančić, 2005). One of the most significant differences lies in the possibility of scoring goals, each with a different point value, achieved through a variation of types of game play. Goals of simple value are achieved by means of a classic throw made by any of the players except the goalkeeper-specialist, and goals of double value are made by a specialist's shot, throwing from a dive shot or throwing in 360 degrees (Ostoić and Ohnjec, 2015). The commitment of the International Handball Federation (IHF) and the European Handball Federation (EHF) by this modality is evident. This has led an increase in the number of international tournaments that are held every year, such as world championships and continental championships (Morillo-Baro et al., 2015).

Being a collective sport, beach handball has an open character. This means that it presents a high degree of uncertainty, which can lead to thinking about randomness of the game (Jiménez-Salas and Hernández-Mendo, 2016). So, to compete at the highest level it requires a high level of selective attention that allows the athlete to capture the most important stimuli of the game for further processing, enabling a correct decision making at all times (Gil-Arias et al., 2016). During the game there are constant changes of players and different situations of numerical superiority or inferiority that occur at a high speed, this recreates a continuously changing environment, where athletes have to make decisions constantly to adapt to the large number of different game situations found (Gil-Arias et al., 2012).

There are numerous factors or situational variables that can alter the decisions made during the course of a match, such as the type or level of the opponent he/she faces to, the result, the moment of the game or the evolution of the score (Aguilar et al., 2012). Another aspect is the possibility that a player from the opposing team receives a suspension, creating a situation of double numerical superiority, creating a different decision situation that can lead to a change in the decisional performance of the attacking team (Aguilar et al., 2012). There is research that has studied the influence of these determining factors in athletes' decisions. In handball, there has been studies concerning the situations of numerical inequality (Aguilar et al., 2012). Research in volleyball analyzes the relationship between decision-making and performance in three actions of the game (reception, stage, attack) (Conejero et al., 2018). Studies in soccer show the results of the influence of contextual factors on the decision making of highly qualified players through semi-structured personal interviews, where it was clear the importance of considering the dynamic and static context in which players make decisions (Levi and Jackson, 2018). The study of these factors or external variables that determine the decision making of athletes is the central axis around which this research has revolved. Araújo et al. (2016) propose to study the decision-making process based on the ecological perspective, observing the results of the athletes' performance through patterns of success against unsuccessful patterns considering various factors such as the game space, the team mates and rivals. The observation of this result of performance can be done through a Field Format and Systems mixed observation tool of E/ME categories (Exhaustive and Mutually Exclusive) (Araújo et al., 2016).

The investigations carried out in the field of sports, within the framework of the mixed methods, have to connect qualitative and quantitative elements (Plano-Clark and Sanders, 2015). In this way, the Observational Methodology (OM) is a technique and/or methodology suitable for analyzing performance behavior in sport (Anguera and Hernández-Mendo, 2013; Portell et al., 2015). Also, systematic observation is widely applicable and offers an optimal balance between rigor and flexibility. The wide scope of opportunities available for processing data derived from observation that supports the idea that purely observational studies should be considered as mixed methods research studies, even though they constitute a somewhat special case and do not follow traditional patterns (Anguera et al., 2017). Numerous tools have been created to observe and analyze the different situations of play that occur during a handball match (González, 2012; González et al., 2013; Sousa et al., 2014; Loffing et al., 2015; Helm et al., 2016; Jiménez-Salas and Hernández-Mendo, 2016) and beach handball (Morillo-Baro and Hernández-Mendo, 2015). In recent years, the analysis of decision-making has gained great interest with the publication of different investigations (Martín et al., 2013; Weigel et al., 2015). Specifically, in handball observations of the referees have showed the influence of playing time on the decision making in relation to the tactical means employed (Prudente et al., 2017) and the influence on the decisions depending on the area of the referee's placement (Morillo-Baro et al., 2017).

The OM takes place in natural or habitual contexts, and is based on a scientific procedure that, depending on the objectives that are stated, expresses the occurrence of perceptible behaviors, for its subsequent registration through an observation tool built specifically using the appropriate parameters. The motor behavior can be studied through the most characteristic analysis of OM, the sequential analysis of delays and the analysis of polar coordinates (Anguera and Hernández-Mendo, 2013, 2014, 2015).

In recent years, the use of polar coordinates analysis as one of the most used analysis techniques has been developed in Sports Sciences (Morillo-Baro et al., 2015; Araújo et al., 2016; Castañer et al., 2016; Maneiro et al., 2019). Numerous investigations have used this analysis of polar coordinates focusing on different sports methods, a great number of which concerning football (Echeazarra et al., 2015; Castañer et al., 2017; Maneiro and Amatria, 2018), but also in other sports such as karate or basketball (Nunes et al., 2015; Riveiro-Bozada et al., 2016). In handball, the study was focused on the offensive situations of two against two, obtaining the different effective behavioral vectors (Sousa et al., 2014). Moreover, specifically, in beach handball the positional attack was studied, determining differences by gender (Morillo-Baro et al., 2015; Navarro et al., 2018).

Based on all this background on beach handball as an object of study, the objective is to study the relationship of some situational factors in the decisions of beach handball players through the analysis of polar coordinate.

MATERIALS AND METHODS

For the development of the research, a nomothetic, punctual, and multidimensional design was chosen (Anguera et al., 2011). The sequence of positional attack that has been observed begins from the moment the specialist gains play until the possession is changed, being this, the unit of observation used.

Participants

Six teams have been observed for each category of the 24 that participated in total during the 2016 Senior Spanish Cup ($M \pm$ SD: age male = 26.67 $\pm$ 5.85; age female = 23.27 $\pm$ 5.74). The six teams have been chosen randomly with the intention of examining two observations from each team. There were 24 observation sessions, 12 in the male category and 12 in the female category, these being the number of sessions that were estimated necessary to be able to generalize with precision (Morillo-Baro and Hernández-Mendo, 2015). The analyzed matches are shown in **Table 1**.

Instruments

The Royal Spanish Handball Federation (RFEBM) was in charge of recording the matches. The HOISAN computer software was used to perform the data recording and coding, the sequential analysis, the polar coordinate analysis and its vectorial representation (Hernández-Mendo et al., 2012). The tool used was already created and was *ad hoc* designed and had passed the quality tests of the data that are required in OM (Morillo-Baro and Hernández-Mendo, 2015). It consists of 11 criteria and 90 categories that correspond chronologically with the development of an attack on beach handball (Morillo-Baro and Hernández-Mendo, 2015). The criteria of the observation tool and the categories that make up each one of them are shown in **Table 2**. Next, **Figure 1** shows the division of games spaces.

TABLE 1 | Analyzed matches.

Category	Matches
Male	C. BMP. Alcala – Zonabalonmano Cadiz
	C. BMP. Ciudad de Malaga – C. BMP. Bahia de Algeciras (team no observed)
	C. BMP. Ciudad de Malaga – C. BMP. Barbate “B” (team no observed)
	BHC Plan B Barcelona – C. BMP. Barbate
	BHC Plan B Barcelona – Zonabalonmano Cadiz
	Pinturas Andalucia BMP Sevilla – C. BMP. Barbate
	Pinturas Andalucia BMP Sevilla – C. BMP. Alcala
Female	C. BMP. Algeciras – C. BMP. Ciudad de Malaga
	C. BMP. Algeciras – Deporte y Empresa Clinicas Rincon Malaga
	C. BMP. Ciudad de Malaga – C. BMP. Getasur juvenil Madrid
	C. BMP. Getasur junior Madrid – Deporte y Empresa Malaga
	C. BMP. Getasur junior Madrid – C. BMP. Getasur juvenil Madrid
	Jugui SOS Valencia (team no observed) – Deporte y Empresa Málaga
	Grupo Llopis BMP Sevilla (team no observed) – C. BMP. Algeciras

Procedure

Data Quality

The correlations have been obtained, once the data has been collected, with the coefficients of Pearson, Spearman, Tau b of Kendall and the coefficient Phi besides the concordance index of Cohen Kappa for the complete session. This is a necessary process in OM since the observer must have the necessary guarantee on the quality of the data obtained (Anguera, 2003). The results are shown in **Table 3**.

As it can be observed, the Cohen Kappa index for this research exceeds 0.90 for both intra-observer (0.94) and inter-observer (0.91) reliability. Due to this, it is considered that there is high reliability, according to the values proposed by Gelfand and Hartmann (1975) or Landis and Koch (1977).

Generalizability Analysis

The Theory of Generalizability has been applied through the use of SAGT computer software (Hernández-Mendo et al., 2016). A design of two facets, categories and observers = C/O has been determined, which has served to determine the intra-observer and inter-observer concordance. The homogeneity of the categories has also been assessed, also using a two-faceted design, but with an O/C design. In the Theory of Generalizability, the definitions of reliability, validity and precision are unified. The Generalizability study consists basically of four phases: (1) Definition of the facets of study; (2) Analysis of variance of the scores obtained on the study facets; (3) Calculation of the error components; (4) Optimization of the Generalizability coefficients (Blanco-Villaseñor et al., 2014).

To determine inter-observer reliability, a two-faceted design (C = O) was established, as we previously mentioned. The results show that practically all the variability is associated with the facet categories (97.12%), being 0 for the facet observers and of 2.28% for the interaction of the facets categories/observers. The generalizability coefficients for this structure show a result of 0.98, which corresponds to excellent results.

The same design was taken to determine intra-observer reliability. The obtained results showed that almost all the variability was associated to the facet categories (97.99%) being 0 for the facet observers and resulting for the interaction of the facets categories/observers 2.01%. The generalizability coefficients for this design structure showed excellent results when it was obtained a value of 0.99.

TABLE 2 | Observation instrument: criteria and corresponding categories and codes.

Criterion	Categories	Criterion	Categories
1. Minute	**M1**: minute one of first half. **M2**: minute two of first half. **M3**: minute three of first half. **M4**: minute four of first half. **M5**: minute five of first half. **M6**: minute six of first half. **M7**: minute seven of first half. **M8**: minute eight of first half. **M9**: minute nine of first half. **M10**: minute ten of first half. **M11**: minute one of second half. **M12**: minute two of second half. **M13**: minute three of second half. **M14**: minute four of second half. **M15**: minute five of second half. **M16:** minute six of second half. **M17:** minute seven of second half. **M18:** minute eight of second half. **M19**: minute nine of second half. **M20**: minute ten of second half. **MGOAL1**: golden goal of first half. **MGOAL2**: golden goal of second half.	**2. Score**	**TIE:** tie. **1WIN**: observed team is winning by one point. **2WIN:** observed team is winning by two points. **M2WIN**: observed team is winning by more than two points. **1LOS**: observed team is losing by one point. **2LOS**: observed team is losing by two points. **M2LOS**: observed team is losing by more than two points.
3. Numerical balance	**EQUAL:** equality. **1SUP**: advantage of one. **M1SUP**: advantage of more than one. **1INF**: disadvantage of one. **M1INF**: disadvantage of more than one.	**4. Defensive system**	**S30**: 3:0 defensive system. **S21**: 2:1 defensive system. **S2M1**: 2+1 defensive system. **SPRES:** individual defensive system. **SRETR:** retreat defensive system. **S20**: 2:0 defensive system.
5. Zone of end of attack	**Z1:** attack ends in zone 1. **Z2:** attack ends in zone 2. **Z3:** attack ends in zone 3. **Z4:** attack ends in zone 4. **Z5:** attack ends in zone 5. **Z6:** attack ends in zone 6. **Z7:** attack ends in zone 7. **Z8:** attack ends in zone 8. **Z9:** attack ends in zone 9.	**6. Substitution area**	**SAYES:** attack ends in one of the zones adjacent to the observed team's substitution area. **SANO:** attack ends in one of the zones adjacent to the opposing team's substitution area. **SAMID:** attack ends in one of the central zones.
7. Assisting player	**ASPE:** assist by specialist. **ALWING:** assist by left wing. **ARWING:** assist by right wing. **ACENT:** assist by center. **APIV:** assist by pivot. **NASIS:** no assist.	**8. Player who ends attack**	**FSPE:** specialist ends attack **FLWING:** left wing ends attack. **FRWING:** right wing ends attack. **FCENT:** center ends attack. **FPIV:** pivot ends attack.
9. How attack ends	**FLY:** attack ends with in-flight shot. **SPIN:** attack ends with spin shot. **SHOT:** attack ends with shot. **6M:** attack ends with 6-m throw. **TURN:** attack ends with passing or catching error. **TECNF:** attack ends with technical foul.	**10. Result of end of attack**	**GOAL1**: one-point goal. **GOAL2**: two-point goal. **MSHOT:** missed shot. **CPOSE:** change of possession. **G1SUSP**: one-point goal and suspension. **G2SUSP**: two-point goal and suspension. **6MGOAL**: goal scored by 6-m throw. **6MM**: missed 6-m throw. **GOAL1R**: one-point rebound goal. **GOAL2R**: two-points rebound goal. **6MGSUSP**: goal scored by 6-m throw and suspension. **6MMSUSP**: missed 6-m throw and suspension. **GOAL1RSUSP**: one-point rebound goal and suspension. **GOAL2RSUSP**: two-point rebound goal and suspension.

(Continued)

TABLE 2 | Continued

Criterion	Categories	Criterion	Categories
11. Duration	**D05**: between 0 and 5 s.		
	D610: between 6 and 10 s.		
	D1115: between 11 and 15 s.		
	D1620: between 16 and 20 s.		
	D2125: between 21 and 25 s.		
	D2630: between 26 and 30 s.		
	DM30: more than 30 s.		

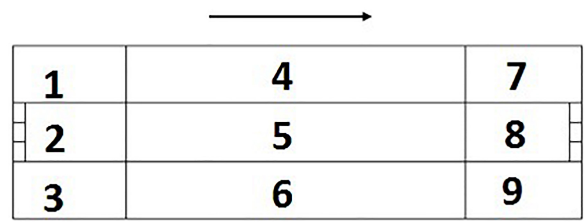

FIGURE 1 | Division of game spaces. The numbering is related to the sense of attack.

TABLE 3 | Intra- and inter-observer agreement.

Coefficient for entire session	Intra-observer agreement (Obs. 1 vs. Obs. 1bis)	Inter-observer agreement (Obs. 1 vs. Obs. 2)
Pearson's	0.98	0.97
Spearman's (ρ)	0.95	0.89
Kendall's tau-b	0.95	0.91
Kappa	0.94	0.91
Phi	0.89	0.85

Finally, the homogeneity of the categories was assessed, to do it, a two-faceted design (observers and categories = O/C) was chosen, thanks to this design, the degree of differentiation of the proposed categories was obtained. The generalization coefficients obtained for this design are zero (0.00), which means that the homogeneity of the categories is optimal in the sense of differentiators.

Polar Coordinate Analysis

Sackett (1980) was the precursor of this technique, which over the years was optimized by Anguera's (1997) genuine technique, which allows a drastic reduction of data and a graphic representation of the vectors that determine the interrelations between the different categories that make up the proposed taxonomic system (Hernández-Mendo and Anguera, 1999; Gorospe and Anguera, 2000). This technique is supported by a sequential analysis of prospective delays (Sackett, 1980) and retrospective, with the genuine technique (Anguera, 1997) of the successive behaviors that occurred. The values obtained in the calculation of the conditioned probability will allow to obtain the Zsum parameter (Zsum = $\Sigma z/\sqrt{n}$, where n is the number of delays) (Cochran, 1954). The distribution of this Zsum parameter has one $\bar{x}$ = 0 and one *SD* = 1. The interrelation map of behavior or map of polar coordinates (Gorospe and Anguera, 2000) is obtained from obtaining these values. It is necessary to determine the value of the vectors (they must be equal or greater than 1.96 to be considered significant) for the preparation of behavioral maps. The module or length of the radius is obtained by taking the square root of the sum of the square of the Zsum of the X (prospective) and the square of the Zsum of the Y (retrospective). The angle of the vector (φ) (which will depend on the quadrant where it is located) marking the nature of the relationship (Castellano and Hernández-Mendo, 2003). This angle (φ) is calculated as φ = Arc sine of Y/Radius.

The HOISAN computer program (Hernández-Mendo et al., 2012) allowed the coding and analysis of polar coordinates. Firstly, once the criterion behavior was selected, a sequential analysis was performed for each category of all the observations, obtaining the Z results for a range of delays −5 and 5. Once these values were obtained, the necessary calculations were made to obtain the parameters Zsum (prospective and retrospective), the assignment of the quadrant, the module, the angle and the transformed angle (AT) for the rest of the categories (Castellano and Hernández-Mendo, 2003):

Quadrant I [+, +]: The criterion behavior is excited with respect to the pairing behavior in retrospective and prospective perspective.

Quadrant II [−, +]: The criterion behavior has a relation with respect to the pairing of excitation in retrospective perspective and of inhibition in prospective perspective.

Quadrant III [−, −]: The criterion behavior has a relation with respect to the pairing of inhibition in retrospective and prospective perspective.

Quadrant IV [+,−]: The criterion behavior has a relationship with the behavior of arousal pairing in prospective perspective and inhibition in retrospective perspective.

The behaviors selected as criteria (focal) have been:

- GOAL2: this behavior is what refers to the final objective of the attack and, therefore, its appearance can be associated with a pattern of success in the decision made by the attacking team. In addition, it includes all the possibilities of scoring a goal of double value (flight, turn, throw of the goalkeeper and throw of 6 m).
- TURN and TECNF: both behaviors refer to the loss of possession of the ball by the team that attacks either by

an own error or a forced error by the defensive action of the opposing team. Therefore, both are associated with an unsuccessful pattern in the decision made by the attacking team.

It has been decided to link these behaviors only with the criteria of the observation tool that are related to external factors or variables and that can modulate the decision making of the athletes: Minute, Score, Numerical Balance, Defensive System, and Duration.

RESULTS

Then, it can observe the results obtained by analyzing polar coordinates for the selected behaviors as a criterion. **Table 4** shows the pairing behaviors that are significantly linked when the criterion behavior is GOAL2 (per quadrant and category).

In quadrant I, where it is excited with respect to pairing behavior in retrospective and prospective perspective. In masculine category, it is associated with four pairing behaviors: the score of more than two goals in favor (M2WIN), the score of a goal in favor (1WIN), the defensive system of the opposing team (SRETR) and the minute fifteen of the second half (M15). While in the female category, it is associated with three pairing behaviors: the score of more than two goals in favor (M2WIN), the score of two goals in favor (2WIN) and the defensive system of the opposing team 3: 0 (S30). It emphasizes that in both categories the two behaviors that more intensity present in their relation refers to the score in favor of the attacking team.

In quadrant II, where the criterion behavior has a relationship with respect to the mate of excitation in retrospective perspective and inhibition in prospective perspective, in the male category, three pairing behaviors that belong to the same criterion, minute number, are excited, the minute one, six, and seven of the first half (M1, M6, and M7). Meanwhile, in the female category, there is only a pairing behavior that is the score of two goals against (2LOS).

In quadrant III, the criterion behavior has a relationship with respect to the pairing of inhibition in retrospective and prospective perspective. In both categories, two pairing behaviors are excited, and for both of them, the greater radius presents the score of more than two goals against (M2LOS).

Finally, in quadrant IV, the criterion behavior has a relationship with the behavior of excitation matching in prospective perspective and inhibition in retrospective perspective. In male category, it is associated with two behaviors of pairing: the score of two goals in favor (2WIN) and the minute eight of the second half (M18); whereas for feminine category only one appears, the duration of the attack between eleven and fifteen seconds (D1115).

Next, in **Figures 2**, **3**, it can observe the graphical representation resulting from the analysis of polar coordinates for this criterion behavior.

Table 5 shows the results obtained when the criterion behavior is TURN.

In quadrant I, in the two categories there are four pairing behaviors, in the male category the one with the highest radius is a player in inferiority (1INF), while in the female category, it is the defensive system of the opposing team two plus one (S2M1).

In quadrant II, four paring behaviors also appear in both categories, for the male category all pairing behaviors refer to the criterion minute number, being the one with the greatest intensity of relation the minute two of the second half (M12); On the other hand, in the female category, the score of more than two goals in favor (M2WIN) stands out.

In quadrant III, again the number of pairing behaviors that are excited in both categories coincides, two in this case. Being those that greater radius presents the score of more than two goals in favor (M2WIN), in male category, and the defensive system of the opposite team 3: 0 (S30).

TABLE 4 | Relationships between focal behavior GOAL2 and conditional behaviors.

Criterion behavior	Q	Male			Female		
		Pairing behavior	Vector module	T.A.	Pairing behavior	Vector module	T.A.
GOAL2	I	M2WIN	7.63	10.76	M2WIN	4.14	2.43
		1LOS	3.42	59.02	2WIN	3.90	8.50
		SRETR	3.05	35.18	S30	2.86	64.26
		M15	3.00	81.84			
	II	M6	3.00	137.12	2LOS	2.32	168.94
		M1	2.84	139.71			
		M7	2.72	159.41			
	III	M2LOS	7.38	201.54	M2LOS	5.70	194.79
		S21	2.34	219.78	S20	2.09	216.02
	IV	2WIN	2.63	305.16	D1115	1.98	346.23
		M18	2.50	346.10			

Q, quadrant; T.A., transformed angle; GOAL2, two-points goal; M2WIN, observed team is winning by more than two points; 1WIN, observed team is winning by one point; SRETR, individual defensive system; M15, minute five of second half; M6, minute six of first half; M1, minute one of first half; M7, minute seven of first half; M2LOS, observed team is losing by more than two points; S21, 2:1 defensive system; 2WIN, observed team is winning by two points; M18, minute eight of second half; S30, 3:0 defensive system; 2LOS, observed team is losing by two points; S20, 2:0 defensive system; D1115, between 11 and 15 s.

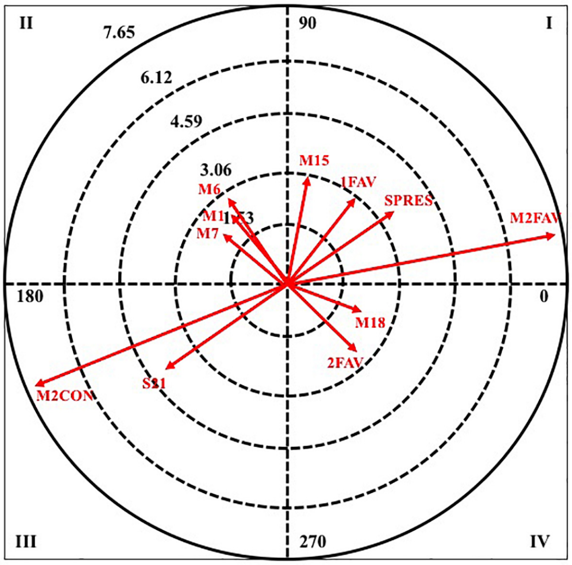

FIGURE 2 | Vector maps for focal behavior GOAL2 in male category.

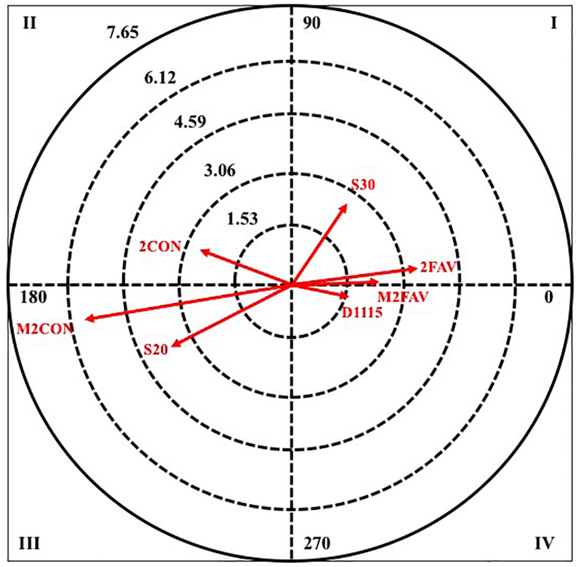

FIGURE 3 | Vector maps for focal behavior GOAL2 in female category.

To finish this criterion behavior, in quadrant IV, in the male category there are five pairing behaviors, where four belong to the criterion minute number, being the one with the highest radius the minute seven of the second half (M17), and one to the result of the score in a tie (TIE). While, in the female category, three pairing behaviors are excited, being the score of more than two goals against (M2LOS), the most intense in their relationship.

Next, in **Figures 4**, **5**, it can observe the graphical representation resulting from the analysis of polar coordinates for this criterion behavior.

Table 6 shows the results obtained when the criterion behavior is TECNF.

For quadrant I, the results show that in male category there are three pairing behaviors, the minute corresponding to the

TABLE 5 | Relationships between focal behavior TURN and conditional behaviors.

Criterion behavior	Q	Male			Female		
		Pairing behavior	Vector module	T.A.	Pairing behavior	Vector module	T.A.
TURN	I	1INF	3.22	61.80	S2M1	2.30	5.44
		M2LOS	2.51	56.22	SRETR	2.22	79.03
		M16	2.44	19.20	M7	2.10	58.36
		M18	2.31	2.45	D05	1.98	11.82
	II	M12	4.04	138.09	M2WIN	3.45	179.87
		M13	2.58	115.48	M1	2.33	169.95
		M14	2.43	117.99	M9	2.32	107.00
		M11	1.98	131.74	M20	2.16	158.66
	III	M2WIN	2.12	220.15	S30	2.38	239.58
		M20	2.08	205.62	M18	2.31	246.84
	IV	M17	3.87	329.85	M2LOS	2.47	348.82
		M9	3.30	309.83	M12	2.18	355.09
		TIE	2.53	298.28	M17	2.09	286.37
		M1	2.43	302.59			
		M10	1.97	285.94			

Q, quadrant; T.A., transformed angle; TURN, attack ends with passing or catching error; 1INF, disadvantage of one; M2LOS, observed team is losing by more than two points; M16, minute six of second half; M18, minute eight of second half; M12, minute two of second half; M13, minute three of second half; M14, minute four of second half; M11, minute one of second half; M2WIN, observed team is winning by more than two points; M20, minute ten of second half; M17, minute seven of second half; M9, minute nine of second half; TIE, tie; S2M1, 2+1 defensive system; SRETR, individual defensive system; M7, minute seven of first half; D05, between 0 and 5 s; M1, minute one of first half; S30, 3:0 defensive system.

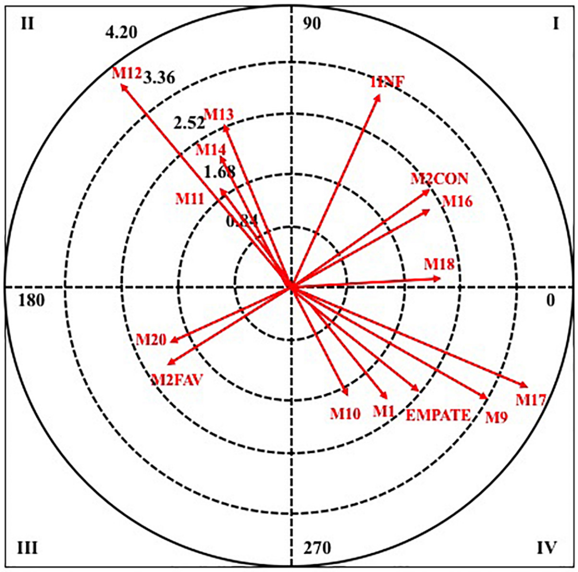

FIGURE 4 | Vector maps for focal behavior TURN in male category.

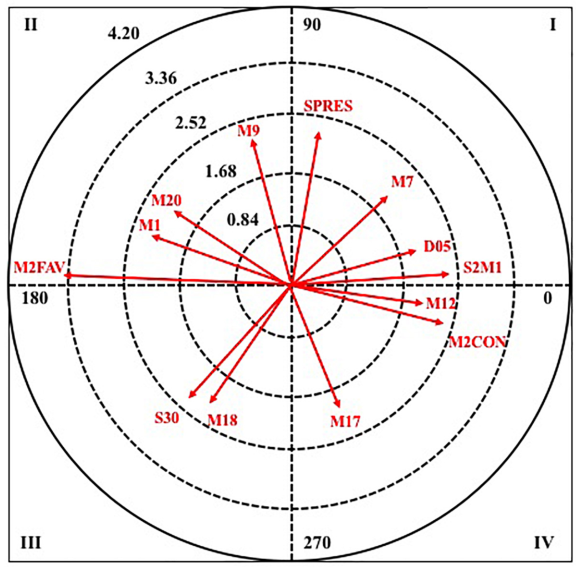

FIGURE 5 | Vector maps for focal behavior TURN in female category.

golden goal in the first set (MGOAL1), the score more than two goals against (M2LOS) and the minute one of the first half (M1). In female category, four behaviors appear, highlighting that it coincides with the male category, the score of more than two goals against (M2LOS).

In quadrant II, three pairing behaviors are excited in the two categories, being the minute eight of the second half (M18) in the male category, and the score of one goal against (1LOS), in the female, those with the highest radius.

In quadrant III, in male category, only a pairing behavior appears, the score of more than two goals in favor (M2WIN) and in the female category there are two, the defensive system of the opposing team two plus one (S2M1) and the minute one of the second half (M11).

Finally, in quadrant IV, two pairing behaviors are excited in both categories, in the male, the minute three of the second half (M13) and the score of two goals against (2LOS), and in the female, the minute six and five of the first half (M6 and M5).

Next, in **Figures 6**, **7**, it can observe the graphical representation resulting from the analysis of polar coordinates for this criterion behavior.

DISCUSSION

The objective of this research was to study the relationship of some external factors with the decisions made by beach handball players through the analysis of polar coordinates. The results obtained showed that there are differences between the flow of behaviors that are significantly related in the male category compared to the female category, this agrees with the results obtained in the investigations of Morillo-Baro et al. (2015) and Navarro et al. (2018).

In the male category, the achievement of the double value goal excites the appearance of pairing behaviors related to the result of the favorable score, as shown in quadrants one, two and four. Therefore, it can be interpreted that the success in the decision making of the players is closely related to winning. A fact that agrees with the results obtained by Conejero et al. (2017). It is important to bear this in mind, since Morillo-Baro (2011) determined that 70% of the time of the match, the score takes place with differences between plus two and minus two points; however, it must be pointed out that this is a study carried out both with a population and in a different competition. Another noteworthy result is the pressing defensive system presented by the opposing team. This can be related to the fact that, faced with open defensive systems, players are able to make appropriate decisions and show that not only the specialist is capable of making decisions, a fact that provides a great tactical wealth to the collective game in this category.

Analyzing together the other two selected criterion behaviors, it stands out that both are associated with the unfavorable score. Players commit more pass or reception errors and more technical fouls when their team is losing, which could indicate an increase in pressure to reverse that situation resulting in more precipitation. They also agree in both that they occur more in the last minutes of the matches, when the match moment is critical (overtime and last 5 min of the game when the difference of points is less than six, Navarro et al., 2012). What is in line with other works that indicated a decrease in performance and accuracy in the decision-making in the last minutes of the match (Oñoro et al., 2015). It should also be noted that errors of pass or reception also occur more when the attacking team is in numerical inferiority, a fact that agrees with that stated by Aguilar et al. (2012).

TABLE 6 | Relationships between focal behavior TECNF and conditional behaviors.

Criterion behavior	Q	Male			Female		
		Pairing behavior	**Vector module**	**T.A.**	**Pairing behavior**	**Vector module**	**T.A.**
TECNF	I	MGOAL1	4.90	44.66	1WIN	3.68	52.66
		M2LOS	3.82	61.44	M2LOS	2.89	29.48
		M1	2.11	8.72	MGOAL2	2.52	45.22
					1SUP	2.25	6.51
	II	M18	3.07	150.00	1LOS	2.82	152.23
		M17	2.18	177.09	M2	2.30	108.96
		D610	2.01	107.88	D1620	1.97	113.80
	III	M2WIN	4.96	206.20	S2M1	2.69	240.70
					M11	2.04	183.74
	IV	M13	2.50	271.04	M6 2.15 344.52		
		2LOS	2.49	330.41	M5 2.10 339.43		

Q, quadrant; T.A., transformed angle; TECNF, attack ends with foul; MGOAL1, golden goal of first half; M2LOS, observed team is losing by more than two points; M1, minute one of first half; M18, minute eight of second half; M17, minute seven of second half; D610, between 6 and 10 s; M2WIN, observed team is winning by more than two points; M13, minute three of second half; 2LOS, observed team is losing by two points; 1WIN, observed team is winning by one point; MGOAL2, golden goal of second half; 1SUP, advantage of one; 1LOS, observed team is losing by one point; M2, minute two of first half; D1620, between 16 and 20 s; S2M1, 2+1 defensive system; M11, minute one of second half; M6, minute six of first half; M5, minute five of first half.

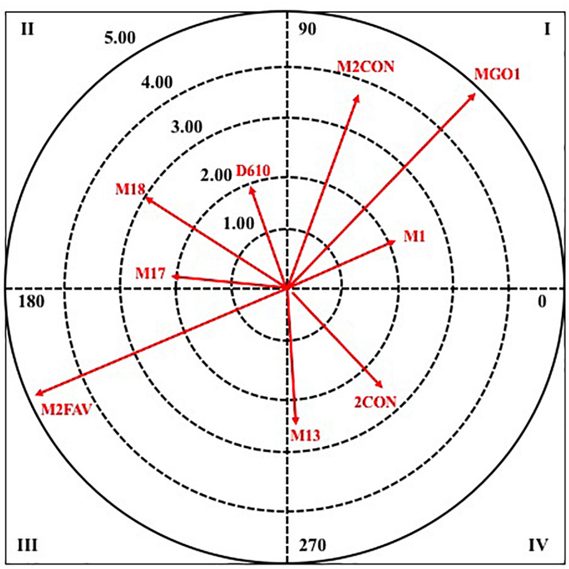

FIGURE 6 | Vector maps for focal behavior TECNF in male category.

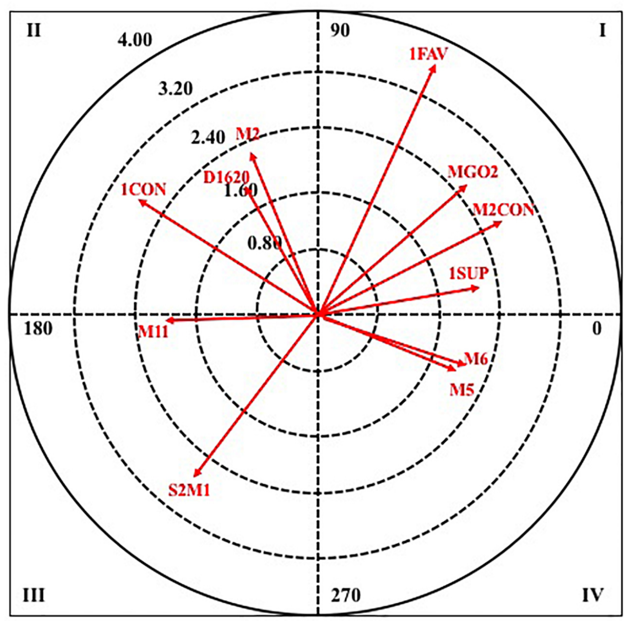

FIGURE 7 | Vector maps for focal behavior TECNF in female category.

With regard to the female category, the double value goal, as it happens in the male category, is directly related to the score in favor, therefore, it can be considered that this fact favors the decisions made by the players. On the other hand, this occurs before closed defensive systems, so, there is less pressure on the player that acts as a specialist and is able to make better decisions when constructing the static attack. It should be noted that in the female category, there is a great dependence on the actions of the specialist player (Morillo-Baro et al., 2015), therefore, she bears great responsibility when she comes to making decisions. Finally, it is noteworthy that the duration of the attack is between 11 and 15 s. A fact that does not offer information about whether the decisions made by the players are modulated by this criterion, but that it agrees with the fact that it lasts half a positional attack in beach handball (Morillo-Baro, 2011) and that it is interpreted as a reasonable construction of the static attack.

With regard to the error of pass or reception, the excitement of behaviors that are related to defensive pressing systems is observed, that is, the defense acts in a more active way reducing the spaces and times of action of the attacking team, besides limiting the action of the specialist. Another interesting result is the excitement of the duration of the attack less than 5 s;

this is translated into a quick attack and probably it has been little elaborated. Therefore, it can be considered that this type of defense encourages players to make quick decisions under pressure through an immediate reading of the situations that arise, carrying out a negative influence on decision-making (Ruiz et al., 2014). For that reason, it could be interpreted that in front of pressing defensive systems the female teams make fast attacks that produce a greater number of errors in the pass or reception, diminishing the effectiveness of their actions.

Finally, it is directly related to the performance of technical faults in what has been previously determined critical moment of the game, therefore, it can see again how this fact modulates in a negative way the decisions made by the players. In addition, it is curiously the excitement of behavior one in superiority, this fact can be interpreted as the teams do not handle well the different decision scenarios that are created in the game and even being in superiority are not always able to make appropriate decisions. It cannot be interpreted clearly in this conduct criterion that the result influences in some way in the decision making.

By virtue of all explained until now, one might think that in both categories a correct decision-making is linked to having a favorable result on the score. In the male category, players are able to make correct decisions against any defensive system, while in the female category when they are pressured, the decisions made are reduced properly. The numerical balance has also shown its negative influence on the decision making of the athletes, in the male category when the attacking team is in inferiority and in the female category when it is in superiority. The duration of the attack is only significantly linked to the female category, showing that when they perform elaborate attacks they make a greater number of appropriate decisions than when they perform quick attacks with little elaboration, while in the male category a decrease in the success of decision-making has been observed in the last minutes of the matches.

There is hardly any published research on this modality, which leads to be cautious when conclusions are established about the results obtained. Since the research published up to now (Morillo-Baro et al., 2015; Navarro et al., 2018) had discussed the analysis of polar coordinates but they had not dealt with the analysis of decision making, which makes it difficult to compare these results with them. Another caution to consider is the limitation that is found when interpreting the decision-making process through the observation of the behaviors, ignoring other cognitive variables that surely influence. Finally, only Spanish players formed the sample, so this research has focused on the development of the game in this country.

All these results have highlighted the significant relationship between different external factors in the decisions made by beach handball players during the game. Thus, the use of observation and the technique of polar coordinates have been useful to discriminate between specific actions and behaviors, which provides data on the decisions of athletes during the competition. For all this, it would be of great interest to continue exploring this line of research on beach handball, creating new investigations with different focal behaviors to be able to establish the different patterns of the game in both categories.

AUTHOR CONTRIBUTIONS

AH-M, VM-S, and RR: design of the work, acquisition, analysis, and interpretation of data for the work. JPM-B: acquisition, analysis, and interpretation of the data for the work. JAV-D: acquisition and analysis of the data for the work. All authors were involved in drafting, revising, and approving the final version of the manuscript, and also agreed to be accountable for all aspects of the work.

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Offensive Transitions in High-Performance Football: Differences Between UEFA Euro 2008 and UEFA Euro 2016

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Coaches, footballers and researchers agree that offensive transitions are one of the most important moments in football today. In a sport where defense over attack dominates, with low scores on the scoreboard, the importance of these actions from the offensive point of view becomes very important. Despite this, scientific literature is still very limited on this topic. Therefore, the objectives set out in the present investigation have been two: first, by means of a proportion analysis and the application of a chi-square test, it was intended to describe the possible differences between the offensive transitions made in the UEFA Euro 2008 and UEFA Euro 2016; then, through different multivariate analyzes based on logistic regression models, it was intended to know the possible differences among the proposed models. Using observational methodology as a methodological filter, 1,533 offensive transitions corresponding to the observation of the quarter final, semifinal, and final quarter of UEFA Euro 2008 and UEFA Euro 2016 have been analyzed. The results obtained have shown that offensive transitions between both championships have changed throughout both UEFA Euro, as well as some of the variables or behaviors associated with them ($p < 0.05$). The predictive models considered, although they have been developed from the same predictor variables, have also yielded different results for both championships, evidencing predictive differences among themselves. These results allow to corroborate that the offensive phase in high level football, specifically in what refers to moments of transition defense-attack, have evolved over these 8 years. At the applied level, the results of this research allow coaches to have current and contemporary information on these actions, potentially allowing them to improve their offensive performance during competition.

Keywords: offensive transitions, football, high performance, mixed methods, observational methodology

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INTRODUCTION

In football, the reality of competition forces teams to operate dynamically with alternatives when they have possession of the ball or the opponent has it. Attack and defend are a cyclical and dichotomous continuum. Contrary to what happens in other sports, teams can opt for a tactical provision based on the almost total renunciation of the ball. The use or not of the ball through possession of the same is not marked by any temporary limit regulation, teams have full freedom to start or finish possession when they deem appropriate (Castelano, 2008).

Team general tactics imply a constant interaction between attack and defense patterns (Barreira et al., 2014b; Araújo and Davids, 2016; Maneiro and Amatria, 2018). The complex nature of these interactions (Duarte et al., 2012), conditions the passage from one phase to another, so it requires a time of adaptation, which includes differentiated behaviors in the case of defending after attacking (defensive transition), or attacking after defending (offensive transition).

An offensive transition (or defense-attack transition) is considered all technical-tactical actions that a team makes since regaining possession of the ball in play and seek to take advantage of the rival's collective reorganization (which is at that moment in defensive transition), to achieve an optimal progression situation of the ball and/or end, until it is organized offensively (organized attack) or the opponent is reorganized defensively (organized defense) (Casal et al., 2015).

In today's football, the importance of the attack that starts with an offensive transition has experienced an increasing importance, according to several works (Mombaerts, 2000; Gréhaigne, 2001; Carling et al., 2005; Yiannakos and Armatas, 2006; Acar et al., 2009; Armatas and Yiannakos, 2010; Tenga et al., 2010b; Barreira et al., 2013; Leite, 2013; Plummer, 2013; Sarmento et al., 2014; Casal et al., 2015; Winter and Pfeiffer, 2015; Sgrò et al., 2016; Fernández-Navarro et al., 2018).

The purpose of offensive transitions varies according to the needs and will of the team that executes them. A direct and rapid offensive transition, with immediate goal search, is associated with two types of offensive end-of-play behaviors: counterattack and direct attack. On the other hand, an elaboration offensive transition, without immediate search of goal, and attack or defense not presenting organized patterns, is associated with progression behaviors toward the attack or as a means to reach various offensive subprinciples (Tenga et al., 2009, 2010c; Fernández-Navarro et al., 2018).

Offensive transition moments become unique actions due to the fluidity of the game's dynamics. These are situations of role change, of an open nature, and to which we should add special spatial conditions (the game action takes place in wide spaces) and temporary ones (these are actions that are usually carried out at high speeds) (Lago et al., 2012). In addition, they are actions that emerge from a certain disorder, from role change because of the change in ball possession.

It is important to remember that the game is a continuous, cyclical and non-linear process, where attack, defense and transitions do not exist separately. Some phases condition and are conditioned by others. The defensive moment of the game begins before the loss of the ball, just as the offensive moment begins before the recovery. Therefore, a rational occupation of the strategic space is important, as well as knowing the rival's tactical behavior. Whenever there is an offensive transition, there is an antagonistic response from the opposing team, in the form of a defensive transition (Vogelbein et al., 2014; Winter and Pfeiffer, 2015; Casal et al., 2016).

Works that have studied attack mechanisms in football confirm that attacks in transition (rapid attacks or counterattacks) have greater chances of success (goals scored, throws to goal or arrivals to the area) than other attack styles (Tenga et al., 2010a,b; Barreira et al., 2013; Sgrò et al., 2017; Fernández-Navarro et al., 2018).

Analyzing in detail behaviors that modulate or condition the effectiveness of these actions, preceding works have highlighted a series of variables that teams must take into account.

The beginning zone of the offensive transition has been analyzed in different studies. The vast majority of literature has agreed that offensive success effectiveness increases the closer to the rival goal the transition is achieved (Tenga et al., 2010a,b; Lago et al., 2012) although with moderate differences depending of the starting sector (James et al., 2002; Barreira et al., 2014b; Casal et al., 2016). Probably this lack of consensus is provoked by different proposals of field division.

With regard to the progression strategy to rival goal or conservation immediately after ball recovery, most of the available data confirm that rapid and direct progression is the most effective behavior, both when producing area arrivals as goals attainment (Tenga et al., 2010a,b; Zurloni et al., 2014; Casal et al., 2015). Although works that disagree with these results should also be taken into account (Tenga et al., 2010c; Sgrò et al., 2016).

Regarding the sequence of passes used in the offensive transition, different results are also found among the scientific community. In this sense, a large majority of publications emphasize that the use of a small number of passes constitutes the most effective offensive procedure ($\leq$4 passes) (Mombaerts, 2000; Acar et al., 2009; Lago et al., 2012), although there are works that reject these results (Tenga et al., 2010c; Barreira et al., 2014b).

Finally, with regard to the transition duration, the available data allows us to speak of a general consensus among different authors. Thus, practically all studies conclude that they must be actions developed at high speed to be successful (Wallace and Norton, 2014), with a temporal margin that varies between 1″ and 5″ (Gréhaigne, 2001; Hughes and Churchill, 2005; Acar et al., 2009) and $\leq$15″ (Garganta et al., 1997; Carling et al., 2005).

All the data and evidence presented have highlighted the importance of offensive transitions during matches. At the methodological level, many of the works consulted are of a quantitative nature (motion analysis), based on competition description through element or behavior frequency. In this work, in addition to a quantitative analysis, a complementary qualitative analysis will be carried out, thus providing greater uniqueness and a more objective and holistic view to the study of the football reality and transitions in particular. For this, the ideal option is systematic observation, thus ensuring a balance between the robustness of quantitative data, and the flexibility provided by qualitative data, in order to make a more objective approach of the observed reality. For this, the present study starts from a *mixed methods* perspective (Johnson et al., 2007; Creswell, 2011; Creswell and Plano-Clark, 2011; Freshwater, 2012; Anguera et al., 2018b).

The integration of quantitative and qualitative data from the mixed methods perspective will allow proposing a holistic and integral model, allowing a more objective approach of the observed reality. Systematic observation, both direct and indirect, provides qualitative information on the registry, focused, respectively, on transition quality and previous documents (Gorard and Makopoulou, 2012; Anguera et al., 2017, 2018a), which will be followed by a second quantitative stage (data quality control and data analysis), to recover the initial objective by discussing results. In this way, a new methodological alternative to the study of football and its different manifestations is opened, proposing solutions to the aforementioned complex reality (Duarte et al., 2012).

The observational methodology application will achieve the objectives set out in the present work, which are: on the one hand, to know the differences in terms of regularity and usual execution practices in offensive transitions executed during the European Championship of Nations Euro 2008 and UEFA Euro 2016; and, on the other hand, by performing different multivariate analysis, design an execution model of the offensive transitions with greater probabilities of success, for both championships, and identify the differences between both models.

MATERIALS AND METHODS

Design

Among the possible designs that can be presented by the observational methodology, a nomothetic, intersessional monitoring and multidimensional design was applied (Anguera, 1979). Nomothetic because a plurality of units are studied, intersessional over time and multidimensional because we analyzed the multiple dimensions that constituted the *ad hoc* observation instrument used.

The systematic observation carried out has been non-participant and active, using an observational sampling "all occurrence".

Participants

In this study, the analysis unit is the defense-attack transitions in top-level football. The observation sample was a convenience sample (Anguera et al., 2011). We analyzed 1,533 events corresponding to the observation of 14 matches, during the Quarter-finals, semi-finals and finals of UEFA Euro 2008 and UEFA Euro 2016. These matches are played in the direct elimination mode, which causes both teams to need offensive attack procedures to achieve a positive result.

Observation Instrument

The observation instrument proposed by Casal (2011) was used. In it, the inclusion and exclusion criteria can be consulted. This observation instrument is made up of a combination of field formats and category systems, where the dimensions of the instrument's categories and the inclusion and exclusion criteria can be consulted.

Data was collected and coded using the LINCE software (v 1.2.1, Gabin et al., 2012). The IBM SPSS Statistics 25 program for descriptive and bivariate analysis and the R program for multivariate analysis were used as analysis tools. Finally, the STATGRAPHICS Centurion program, v16, was used to analyze proportions.

Procedure

The meetings were recorded from images broadcast on television.

According to the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical, and Behavioral Research, 1978) the use of public images for research purpose does not require informed consent or approval of an ethical committee.

There were four observers selected for data collection, four of them being doctors in Sports Science. Three are national soccer coaches, and also with more than 5 years of experience in the use and application of observational methodology. Prior to the coding process, observers were trained during eight training sessions (Losada and Manolov, 2015; Manolov and Losada, 2017), applying the consensual agreement criterion among observers and were provided with a specifically designed observation protocol.

Data Quality Control

The quality control of the data was carried out using the IBM SPSS Statistics 25. To try to ensure data reliability, all matches were registered and analyzed by four observers, three of them national soccer coaches with years of experience in the field of training, teaching, and research in football through observational methodology. In addition, the following training process was carried out. First, eight observing sessions were conducted on teaching the observers following the Losada and Manolov (2015) criteria and applying the criterion of consensual agreement (Anguera, 1990) among observers, so that recording was only done when agreement was produced. To ensure inter-reliability consistency of the data (Berk, 1979), the Kappa coefficient was calculated for each criterion (**Table 1**), it revealed a strong agreement between observers, which means high reliability, taking Fleiss et al. (2003) as a reference.

Data Analysis

As regards data analysis, and in accordance with the objectives set, three types of analysis were defined: by means of a proportion analysis and the application of a chi-square test, the aim was to describe differences on the championship level, and the modulating variables level, in the execution and habitual practices of the offensive transitions between both championships. Then, three types of analysis were carried out: a logistic regression to know the variables that may be modulating the effectiveness achieved; the Mcfadden test was applied to check the model's goodness of fit. Finally, an ANOVA analysis was implemented to analyze the variance and deviation table. The aim is to know the differences between successful models for UEFA Euro 2008 and UEFA Euro 2016.

RESULTS

First, a proportion comparison (**Figure 1**) has been carried out using the binomial test. Data presented in **Figure 1**

TABLE 1 | The interobserver agreement analysis for each criterion.

Criteria	Ob_1–Ob_2	Ob_1–Ob_3	Ob_1–Ob_4	Ob_2–Ob_3	Ob_2–Ob_4	Ob_3–Ob_4
Start of possession	0,82	0,83	0,86	0,82	0,87	0,91
Interaction context	0,74	0,74	0,81	1	0,76	0,75
Defensive organization	0,81	0.85	0,83	0,78	0,8	0,8
Time	1	0,96	1	0,84	1	0,81
Intention	0,8	0,82	0,72	0,91	0,87	0,82
Number of Intervening	0,82	0,72	1	0,86	0,72	1
Number of passes	1	0,80	0,80	0,92	1	0,86
Final interaction context	0,76	0,81	0.92	0,81	0,83	0,81
Match status	0,9	1	1	1	1	0,88
Success	1	1	0,88	1	0,9	1
K_{total}	0,86	0,85	0,88	0,87	0,81	0,86

shows statistically significant differences between the UEFA Euro 2008 and UEFA Euro 2016 championships (sample proportions = 0.347 and 0.413, sample size = 743 and 790).

Statistics z calculated = −2.65932; p = 0.007.

On the other hand, data presented in **Table 2** shows statistically significant differences between variables considered for each championship. Specifically, there are eight variables that present significant differences between both championships: "Start of possession" ($p < 0.001$), "Interaction Context" ($p < 0.001$), "Defensive Organization" ($p < 0.001$), "Intention" ($p < 0.001$), "Number of passes" ($p < 0.001$), "Final Interaction Context" ($p < 0.001$), "Match status" ($p < 0.001$) and "Success" ($p = 0.008$). The quantitative variable "No. of Intervening" does not follow a normal distribution (**Figures 2**, **3**).

Finally, an analysis was applied based on a logistic regression model (**Tables 3**, **4**) configured by the same predictor and explained variables, for both UEFA Euro 2008 and UEFA Euro 2016 championships, in order to be able to compare which variables are significant in achieving success, and knowing whether or not they are the same, in both competitions, based on their *Deviances*.

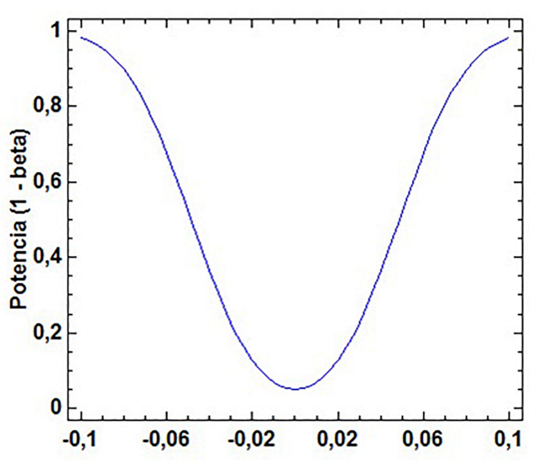

FIGURE 1 | Proportion analysis for the UEFA Euro 2008 and UEFA Euto 2016 samples. Power curve (alpha = 0.05, average ratio = 0.381012).

Specifically, for the UEFA Euro 2008, the proposed model is:

$$\text{Success} = \mu + \beta_1\ \text{DefensiveOrganization} + \beta_2\ \text{FinalInteractionContext} + \beta_3\ \text{Intention} + \beta_4\ \text{InteractionContext} + \beta_5\ \text{MatchStatus} + \beta_6\ \text{NumberOfPasses} + \beta_7\ \text{StartOfPossession}$$

The adjustment of the model is checked with the McFadden test with a value of 0.0589. The accuracy in the predictive capacity of the model is 0.918 (Accuracy).

Next, an Anova analysis was executed in the model to analyze the deviation table. By specifying a single model, a sequential analysis of the deviation table is made to fit. That is, the reductions in the residual deviation that is added to each model term, in addition to the residual deviations themselves.

The wider the difference between the zero deviation and the residual deviation, the better. Analysis of the table shows the descent of the deviation when adding each variable. The addition of "Final Interaction Context" significantly reduces the residual deviation. A large p-value indicates that the model without the variable explains more or less the same amount of variation. Ultimately, the optimum is a significant drop in deviation. Finally, the Rao efficient scoring test was applied, which has an asymptotic chi-square distribution to detect the most influential factors in success.

On the other hand, the proposed model for the UEFA Euro 2016 is:

$$\text{Success} = \mu + \beta_1\ \text{DefensiveOrganization} + \beta_2\ \text{FinalInteractionContext} + \beta_3\ \text{Intention} + \beta_4\ \text{InteractionContext} + \beta_5\ \text{MatchStatus} + \beta_6\ \text{NumberOfPasses} + \beta_7\ \text{StartOfPossession}$$

The adjustment of the model is checked with the McFadden test with a value of 0.2819095. The accuracy in the predictive capacity of the model is 0.5128 (Accuracy).

An Anova analysis is performed in the model to analyze the deviation table. By specifying a single model, a sequential analysis of the deviation table is made to fit. That is, the reductions in the residual deviation that is added to each term of the formula, in addition to the residual deviations themselves.

The wider the difference between the zero deviation and the residual deviation, the better. Analysis of the table shows

TABLE 2 | Summary descriptives table by groups of "competition".

	Euro 2008 N = 743	Euro 2016 N = 790	p. overall
Start of possession:			< 0.001
Defensive	230 (31.0%)	215 (27.2%)	
MD	332 (44.7%)	195 (24.7%)	
Central	120 (16.2%)	235 (29.7%)	
MO	56 (7.54%)	133 (16.8%)	
Ofensiv	5 (0.67%)	12 (1.52%)	
Interaction Context			< 0.001
PA	132 (17.8%)	113 (14.3%)	
RA	262 (35.3%)	291 (36.8%)	
RM	53 (7.13%)	14 (1.77%)	
MR	7 (0.94%)	36 (4.56%)	
MM	250 (33.6%)	249 (31.5%)	
MA	12 (1.62%)	33 (4.18%)	
AR	21 (2.83%)	41 (5.19%)	
AM	5 (0.67%)	13 (1.65%)	
A0	1 (0.13%)	0 (0.00%)	
Defensive organization			< 0.001
Organized	604 (81.3%)	451 (57.1%)	
Circums	139 (18.7%)	339 (42.9%)	
Time			0.491
0–30	248 (33.4%)	271 (34.3%)	
31–60	219 (29.5%)	223 (28.2%)	
61–90	202 (27.2%)	232 (29.4%)	
91–120	74 (9.96%)	64 (8.10%)	
Intention:			< 0.001
Progress	370 (49.8%)	613 (77.6%)	
Conserve	373 (50.2%)	177 (22.4%)	
Number of Intervening	4.00 [2.00; 5.00]	4.00 [2.00; 5.00]	0.907
Number of passes	3.00 [1.00; 5.00]	3.00 [2.00; 7.00]	< 0.001
Final Interaction context			< 0.001
PAF	21 (2.83%)	17 (2.15%)	
RAF	56 (7.54%)	13 (1.65%)	
RMF	10 (1.35%)	23 (2.91%)	
MRF	24 (3.23%)	26 (3.29%)	
MMF	280 (37.7%)	198 (25.1%)	
MAF	4 (0.54%)	7 (0.89%)	
ARF	312 (42.0%)	451 (57.1%)	
AMF	12 (1.62%)	22 (2.78%)	
A0F	24 (3.23%)	33 (4.18%)	
Match status			< 0.001
Winning	101 (13.6%)	195 (24.7%)	
Drawing	538 (72.4%)	404 (51.1%)	
Losing	104 (14.0%)	191 (24.2%)	
Success			0.008
No success	485 (65.3%)	463 (58.6%)	
Success	258 (34.7%)	327 (41.4%)	

the descent of the deviation when adding each variable. The addition of "Defensive Organization," "Final Interaction Context," "Interaction Context," "Number Of Passes," and "Start Of Possession" significantly reduces the residual deviation. Finally, the Rao efficient scoring test was applied, which has an asymptotic chi-square distribution to detect the most influential factors in success.

In summary, variables that provide information to the explained variable "success," in the case of Eurocopa 2008, is the predictive variable "Final Interaction Context". The inclusion of other variables does not provide any variation in the model. In the case of Euro 2016, the variables "Defensive Organization," "Final Interaction Context," "Interaction Context," "Number Of Passes," and "Start Of Possession," decrease the residual *deviance* and therefore are important in the model. Depending on the competition, all of them participate significantly in success achievement in the game.

DISCUSSION

The present work was proposed with the objective of identifying and describing possible differences in the execution of defense-attack transitions in one of the most important championship of nations: the UEFA Euro. For this, the editions of 2008 and 2016 have been analyzed. By performing different statistical analysis (accompanied by a proportion analysis, a chi-square contrast and various logistic regression analysis), and in view of the available data, it can be verified that these actions do present different behavior patterns between both championships.

In the first place, as regards the first of the stated objectives, it can be said that significant differences in a championship level between UEFA Euro 2008 and UEFA Euro 2016 are found. In particular, during the last championship there has been an increase in 6.32% of the number of offensive transitions ($p = 0.007$) compared to the 2008 championship. These results allow us to think that attack game dynamics have evolved toward open nature patterns, with the development of the game in wider spaces and with shorter offensive actions. This occurs to the detriment of more elaborate attack mechanisms, where high defensive density and reduced time in decision-making hinders the creation of favorable superiority contexts (Wallace and Norton, 2014; Barreira et al., 2015; Casal et al., 2017). As a consequence, it is plausible to affirm that new teams take advantage of the possible moments of uncertainty and stress caused by the role change during the game. Furthermore, this change in attack mechanisms has probably also emerged answering to new scenarios in the environmental conditions of the game, such as the partial result of the game, competition type or the opposing team quality (Lago, 2009).

Finally, available results allow to qualify works where it is concluded that soccer has barely changed in the last decades (Castellano et al., 2008). This work corroborates previous works in which the evidence of football evolution has been contrasted (Wallace and Norton, 2014; Barreira et al., 2014a, 2015).

About the second objective, to know differences between the efficiency degree achieved and the different variables considered in both championships, it has been detected that teams have experienced a marked evolution regarding the beginning zone of the transition, passing from the mid-defensive zone to the central area of the field. In addition, there has also been a noticeable increase in the recoveries that occur in the medium-offensive

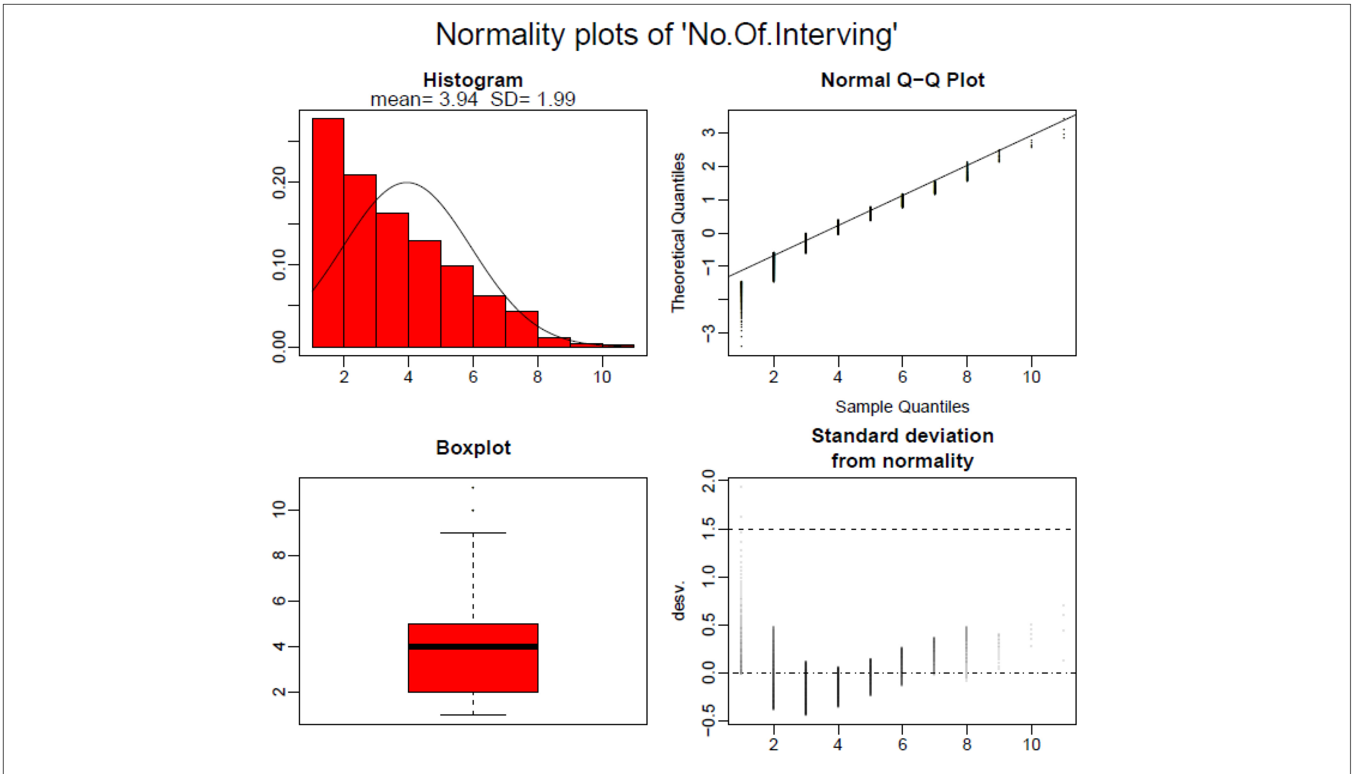

FIGURE 2 | Distribution for the quantitative variable Number of Intervening. Shapiro–Wilks *p*-value: <001.

zone compared to the 2008 Euro edition. This circumstance may be due to a better management of the technical, tactical and physical player resources, since according to different works (Tenga et al., 2010a,b; Lago et al., 2012), the optimal zone of ball recovery is in the offensive midfield, especially in regions near the rival goal (Barreira et al., 2014a).

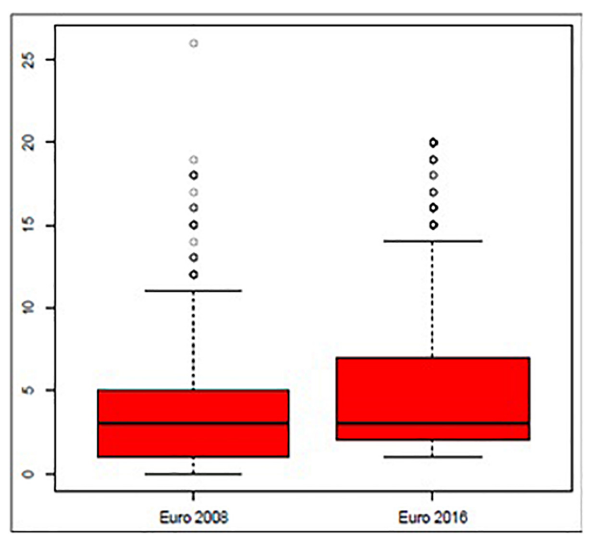

FIGURE 3 | Boxplot of Number of Intervening by competition.

This fact causes less physical wear and less demand for complex tactical benefits (attack construction begins in areas close to the target). Ball recovery in this zone would allow a greater use of the game phase weaknesses in which the opponent is situated (attack construction and ball possession), that when being in attack deployment, this propitiates the appearance of larger spaces between the different lines (inter-lines), as well as between players of the same line (intra-line), a circumstance that the defending team can take advantage of at the moment of role change (move to attack after defending) to advance or finalize the action. In addition, the ball recovery in areas close to the rival goal means, in most cases, that the attacking team will only have

TABLE 3 | Analysis of deviance table.

	Df	Deviance Resid.	Df Resid	Dev	Rao	Pr (>Chi)
NULL			742	959.54		
Defensive organization	1	1.267	741	958.28	1.2835	0.2572498
Final interaction context	8	36.979	733	921.30	30.7907	0.0001531***
Intention	1	1.413	732	919.8	1.4155	0.2341398
Interaction context	8	13.117	724	906.77	12.6617	0.1240335
Match status	2	0.378	722	906.39	0.3759	0.8286680
Number of passes	1	0.772	721	905.62	0.7830	0.3762162
Start of possession	4	2.626	717	902.99	2.6298	0.6215546

*Model, binomial, link logit, and response success Significance codes: 0 '***' 0.001 '' 1.*

TABLE 4 | Analysis of deviance table.

	Df	Deviance Resid.	Df Resid.	Dev	Rao	Pr (>Chi)
NULL			742	1019.33		
Defensive organization	1	35.105	741	984.22	34.970	3.349e-09***
Final interaction context	8	218.276	733	765.95	177.748	<2.2e-16***
Intention	1	0.242	732	765.71	0.242	0.62296
Interaction context	7	16.688	725	749.02	15.478	0.03033*
Match status	2	0.818	723	748.20	0.817	0.66472
Number of passes	1	3.813	722	744.39	3.795	0.05139.
Start of possession	4	12.416	718	731.97	11.955	0.01769*

*Model, binomial, link logit, and response success Significance codes: 0 '***' 0.001 '*' 0.05 '.' 0.1 '' 1.*

to overcome the rival defensive line or, at most, this one plus the middle line.

With regard to the "Interaction Context" in which the defense-attack transition begins, several authors have highlighted the importance of motor interaction analysis in football (Castellano and Hernández-Mendo, 2003; Garganta, 2009; Sarmento et al., 2018). In view of the available data, it is possible to verify that teams have significantly modified their spatial configuration of interaction, resulting in greater recoveries in the most offensive contexts considered (AM, AR, MA, and MR). These data corroborate the work of Casal et al. (2015), which finds worse data in success terms in the PA category; Almeida et al. (2014), who observe that successful teams recover the ball in areas close to the rival goal: and Castellano and Hernández-Mendo (2003), who associate the MR variable as of great offensive value. Finally, the MM and RA categories continue to appear as the most regular, that is, losses usually occur in the middle and advanced line of the observed team. The frequency of the MM category during transitions allows us to think that it is a transition category, where the team attacks flow with a certain offensive character.

The third variable that has shown significant differences has been the type of "Defensive Organization". Available data of both championships allow to verify a robust evolution in defensive mechanisms. Specifically, the increase of 24.2% of circumstantial defense after role change in ball possession with respect to the 2008 edition allows to speak of two antagonistic aspects: on the one hand, a possible defensive flexibilization is verified by part of the teams, which accept the inherent risks of circumstantial defense (greater defensive disorder and incorrect management of strategic spaces) in favor of potentially greater offensive features (larger spaces and more players in a position to carry out an attack); on the other hand, it identifies possible defensive weaknesses in the teams when they pass from attack to defense. These weaknesses are far from the studies of Casal et al. (2016), where the importance of the defensive transition in the moments following the loss of the ball is highlighted; and from Winter and Pfeiffer (2015), where they affirm that part of the winning teams' success is due to high performance in these transitions. Transition effectiveness is related to team organization before them.

On the other hand, significant results were found regarding the "Tactical Intention" of the team immediately after ball recovery. Although in the 2008 edition teams opted for a balanced disposition between progressing toward a rival goal or keeping the ball at the beginning of the offensive transition, 8 years later teams have a clear desire to progress toward offensive areas. These data could be directly related to the variable "Defensive Organization," it is possible that a defensive behavior causes the appearance of an offensive and antagonistic behavior in the rival team, and vice versa. On the other hand, the works of Tenga et al. (2010b) and Lago et al. (2012), state that counterattacks are the ideal attack against disorganized defenses. On the other hand, it should be noted that the importance of this variable is still under debate in scientific literature (Tenga et al., 2010c; Sgrò et al., 2016; Sgrò et al., 2017).

Regarding the "Number of Passes" variable, results show significant differences. In particular, it is possible to highlight an increase in the variance of these actions in the Euro 2016 edition. This corroborates previous works such as those of Barreira et al. (2014b), which currently confirm a new tactical alternative in teams, based on greater collective behavior in offensive transitions; and Tenga et al. (2010c), who report higher efficiency rates with long possessions (>5 passes).

The "Final Interaction Context," the spatial configuration of both teams at the moment in which the observed team finishes its offensive sequence, presents significant differences (<0.001). Lower finalization rates have been found in the MMF context, and instead higher rates (15% more) of offensive transitions ending in the ARF context are collected, as well as better results for the AMF and A0F contexts. Again, this behavior reinforces the evidence presented: in these 8 years, teams have greater offensive will.

In regard to the "Partial Result of the Match," variable regularly collected in scientific literature, it is possible to refer significant changes (<0.001). Despite the fact that a large part of the offensive transitions are executed with a draw (51.1%), a strong evolution is observed in comparison to the 2008 championship. In particular, one of every two offensive transitions occurs with an imbalance in the scoreboard. A possible explanation could be found in that this imbalance occurs in very early phases of the game, which rival teams fail to neutralize in successive instants, thus promoting the existence of more effective time with an unbalanced score. Another possible explanation could lie in the fact that teams in the UEFA Euro 2016 have higher rates of circumstantial defense (<0.001), a situation that could cause attack levels to be above defense levels. Finally, the possible team heterogeneity in terms of quality, which promotes unstable markers on a regular basis as a last possible explanation.

Finally, "Success" rates at UEFA Euro 2016 are significantly higher than at UEFA Euro 2008. 41.4% of offensive transitions have been successful, in comparison to 34.7% at UEFA Euro 2008. It is worth remembering that this paper collects performance indicators collected in Casal et al. (2015) as success.

In short, empirical data reveals the tactical alternative success of the teams that have opted for defense-attack transitions with a marked finalizing character, with an immediate search for auction opportunities, and away from speculative or containment behavior. Teams have opted for the alternative of initiating transitions in more advanced areas of the field, a moderate variance in the number of passes and finalizing actions in more offensive contexts.

Finally, the multivariate analysis carried out has allowed to verify the alternative of the explanatory variables that intervene in the presented models (**Tables 3**, **4**). The test allowed us to measure the extent to which the accuracy of the complete model improves compared to the reduced model. In this case, for the UEFA Euro 2008, the predictive capacity of the model is very good (0.918), although the only variable that provides information is the "Final Interaction Context," having a low adjustment level. These results highlight the importance of deciding on which line of the observed team the offensive transition ends and in which defensive line of the rival team it is important to establish this interaction. Some possible explanations for the importance of finishing offensive transitions against the middle or delayed line of the rival team is that the opponent has fewer players in position to defend; on the other hand, if an offensive transition finalizes in this context, it is probably because the ball has been stolen from the midline or delayed line and the defending team is probably disorganized. Finally, it is also congruent to think, in view of the data and the strength of the variable explained, that this finalization should occur in offensive areas, close to the rival goal, as the best means to achieve success. Although it must be taken into account that the model is more efficient taking all variables in their entirety (**Table 3**).

In contrast, for UEFA Euro 2016, although worse values are found in predictive terms, the model has a more robust overall adjustment. In applied terms, it is possible to explain the success of these actions taking into account five variables ("Defensive Organization," "Final Interaction Context," "Interaction Context," "Number Of Passes," and "Start Of Possession"). This way, the model explains 51% of the offensive transitions in the 2016 championship, with a higher adjustment than the 2008 championship model. In practical terms, it is plausible to think that the results emphasize the importance of the team's tactical construction, based on a refined space management on where to recover the ball and interact with the opponent, the number of precise passes and the need to know the defensive behavior of the opponent. Also, the inclusion of the variable "Final Interaction Context" in the second model reinforces the suitability of where to end the offensive transition, and against which line of the rival team. It is likely that this finalization, as in the 2008 championship, should occur in offensive areas (AR, front line of the observed team against the opponent's delayed line).

CONCLUSION

The main conclusions that can be drawn from this work can be summarized in: (1) Football is not a sport that experiences regular and stable behavior, but behaves like a living organism, which changes and evolves over time. (2) The success of the offensive transitions in the 2016 edition is greater than in the 2008 edition. (3) Offensive transitions executed in the UEFA Euro 2016 present significantly more offensive behavior than in the 2008 edition. (4) The multivariate model presented for the 2008 edition better predicts offensive transitions in their entirety, but their adjustment is moderate; on the other hand, the model presented for the 2016 competition has worse predictive capacity, but greater adjustment in its entirety.

LIMITATIONS

First, it is important to note that the goodness of fit of the explanatory models presented is moderate. Another of the present limitations has to do with the generalization degree of the results or external validity of the same, given that actions corresponding to only one specific competition were selected as the unit of analysis: the UEFA Euro.

FUTURE LINES OF RESEARCH

The future lines of research that can be derived from this study include the incorporation of new variables such as possession duration, individual technical behavior of different players and the proposal of a playing field zoning to prioritize optimal spaces to execute offensive transitions. Finally, it would be interesting to perform comparative analysis with domestic league competitions. Undoubtedly, the incorporation of these variables should help reduce the error component in the different models.

AUTHOR CONTRIBUTIONS

RM and IÁ collected the data, reviewed the literature, and wrote the manuscript. CC, SL, and JM reviewed the literature and supervised the work critically. JL analyzed the data and performed statistical analyzes. AA performed the method.

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Agreeing/Disagreeing in a Dialogue: Multimodal Patterns of Its Expression

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Multimodality is a key property of communication. Even though the main channel of exchanging information is textual, the written text also relies on paralinguistic means to convey additional information using various kinds of punctuation. Speech, too, is always present in contributing to the understanding of the wider scope of the context, represented by some restricted means, including typography, typesetting, and style. Gestures are also part of the text in its broader sense: public stage performances necessarily accompany the text, too. The complex of text, speech and gestures can be understood as a set of unified multimodal patterns that progress in time. This paper offers a comprehensive insight in the temporal structure of dialogue interaction through the study of the multimodal expression of agreement/disagreement in the HuComTech Corpus, presenting patterns of behavior discovered using the research environment *Theme*.

Keywords: multimodality, communication, agreement, *Theme*, HuComTech

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1. INTRODUCTION

Agreeing is not an autonomous state of mind of an individual: it is a behavioral event that necessarily involves an interaction requiring at least two actors and a subject. It comes about as a reflection on the truthfulness of some statement, view or opinion and can evolve under at least two conditions: (a) in the course of the interaction the actors realize that they share the same view independently from one another, or (b) one or more of the actors get convinced by the argument of the other actor(s). The process of agreeing takes different forms depending on these two different conditions: when the actors *A* and *B* share the same view independently, agreement by actor *B* usually follows a statement or elaboration by actor *A* as a backchannel of some sort (such as *Yes, indeed!*). When actor *B* gets convinced by actor *A* about the truthfulness of a given view, the act of agreeing by actor *B* may follow a question or some inquiry by actor *A* (such as *What do you think?* or *Do you agree?*), but other scenarios (such as those involving nonverbal events or pauses, virtually anything that prompts for a turn change) are also possible. Similarly to agreement, disagreement also evolves as a reaction act to a preceding prompt (Kakavá, 1993; Locher, 2004). Disagreement is often described as a behavior that reflects some kind of confrontation which, being understood as a function of face and politeness, should be avoided (cf. Sacks, 1973/1987; Brown and Levinson, 1978/1987; Leech, 1983; Pomerantz, 1984). Schiffrin (1984) shows, however, that it can also signal sociability, i.e., disagreement can even strengthen social relations. The role of context in the interpretation of these behaviors is widely recognized in pragmatics, even though the term itself is not sufficiently defined. Sifianou (2012) notes that, for proper interpretation, one even needs to consider longer periods of time allowing for the recognition of the development of personal traits and relational histories.

Agreeing and disagreeing are not in a simple binary relation: there can be several shades, degrees of this behavior (full or partial), indecision about what opinion to adhere to or advocate (uncertainty), or even a total lack of it (indifference). The recognition of these variants of agreeing/disagreeing is a key factor in conveying a successful conversation: not recognizing, or misinterpreting events of agreement can even lead to the total failure of the given interaction. Even though languages usually possess a number of lexical and syntactic means for the expression of this behavior, relying solely on the linguistic form may still be misleading. When, for example, actor *B* agrees with actor *A*, he/she would say "yes"; however, the same "yes" can also be used to suggest just the opposite, i.e., to mean disagreement—depending on the way "yes" is pronounced. Alternatively, one can agree or disagree by not even saying a word, just by keeping silent: again, it is the nonverbal behavior that contributes to the understanding of the context, effectively to the pragmatic interpretation of the event. Accordingly, in order

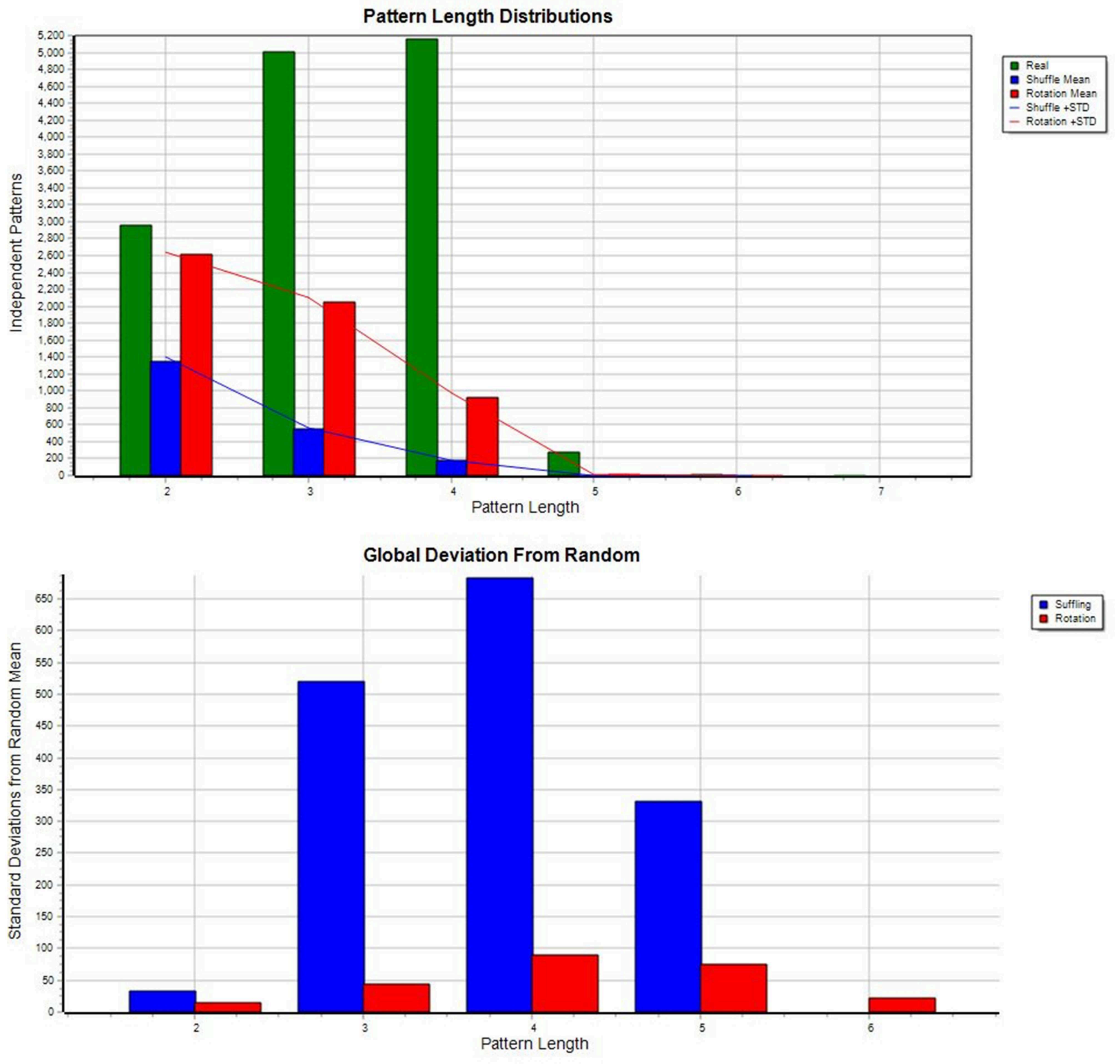

FIGURE 1 | Real vs. random (Upper) and devition from random (Below) using file: i082.

to properly identify the instances of the pragmatic functions of agreement/disagreement, one has to consider all available modalities, both verbal and nonverbal, either audio or visual. However, there is one more challenge here. When someone expresses agreement by saying "yes" and nodding at the same time, this agreement is identified as the co-occurrence, the virtual temporal alignment of the two (verbal and gestural) events. But how can the wisdom of the proverb "silence gives consent" be justified, i.e., how can agreement be interpreted on the basis of the lack of the co-occurrence of any behavioral events? In fact, it is not the case that we face zero input here. We assume that we actually arrive at the interpretation of (some degree of) agreement after a certain period of observation, during which we collect pieces of data from all the available (verbal and nonverbal) modalities. In this process we go beyond just searching for simple temporal alignments of certain events, we rather try to identify behavioral patterns composed of events over a longer observation period. This is, in fact, a cognitive process in which the patterns identified in this way are matched against stereotypical patterns of behavior we are already aware of (either as innate or acquired ones), and the pragmatic function of the best match is assigned to the given pattern found in the observation period, in our case to the one associated with agreement/disagreement.

When designing the HuComTech Corpus, we wished to identify a variety of multimodal patterns of behavior across a given observation period. Using data from the resulted database, this paper has a focus on the discovery of temporal patterns related to agreement/disagreement. It describes the methodological basis of both building the corpus and analyzing and interpreting the data. Special emphasis is given to the research tool *Theme*: we both describe its theoretical foundations that facilitate the analysis of multimodal behavioral data and specify certain methodological questions of its application to the HuComTech Corpus. Finally, we present a selection of the most frequent temporal patterns associated with the pragmatic function of agreement discovered in the corpus and demonstrate their actual context in the recorded interactions.

2. THE HuComTech CORPUS: ITS STRUCTURE AND ANNOTATION SCHEME

The corpus is the result of joint efforts by researchers representing computational linguistics, pragmatics, engineering and information science and psychology. The project that started in 2009 aimed at a detailed study of human-human communication so as to offer important contribution to building various systems of human-machine interaction. From the outset it became clear that such a system should be multimodal, i.e., it should go beyond verbal communication and should include gestures as well that would enhance the user friendliness of such systems. It was also clear that the system should be capable of modeling a two-way communication. Namely, it should be able to be engaged in a recursive sequence of events of interaction by going beyond simply answering a query or fulfilling a request - it should "listen" to further reactions by the human user, evaluate them and act accordingly. Such a system requires two simultaneously active channels of communication, those of analysis and synthesis, through which the actors can continuously switch their roles as speaker and listener. The model we proposed as underlying our corpus building was designed to follow exactly this requirement (cf. Hunyadi, 2011). Naturalness of a two-way communication necessarily assumes that the actors are freely involved in the given topic and that the flow of interactions allows for unconstrained expression of gestures and emotions. Accordingly, we designed two kinds of dialogues: a predominantly formal one – in the form of a job interview with a set of predefined turns and a second, representing an informal conversation (for better data management the latter also followed some guidance, but allowed for individual variation). In order to better understand

TABLE 2 | Emblem—frequency of items from the head class.

Nod	Turn	Raise	Lower	Right	Left	All
3683	1672	1869	1966	3946	2128	15264

TABLE 1 | Emblem class: frequency of items in annotation and in patterns.

Item	Annotation entries # with item	# Files with item	Patterns # with item	Files with item # in patterns	Type-token ratio files with items in annotations vs. files with items in patterns
Attention	5154	66	6707	13	76.85
Default disagree	5136	186	7349	111	69.89
Agree	4798	141	7091	71	67.66
Doubt	1452	91	645	23	225.12
Block disagree	1196	109	1363	47	87.75
Refusal	594	65	196	6	303.06
More-or-less	516	70	0		n/a
Doubt-shrug	342	51	405	5	84.44
Surprise-hands	290	45	68	3	426.47

the possible structure of sequences of interactions and offer useful generalizations, the experimental scheme put emphasis on the following: turn management, the variation of intentions and the generation of emotions. The video recordings were made with 111 participants as speakers (60 male and 51 female, aged between 21 and 30) and two participants as agents (one male and one female, aged 25 and 28, respectively) with an average duration of the formal interviews being about 10 minutes and the informal conversations about 20 minutes. The resulted corpus has a total duration of about 50 hours (for further descriptive details of the corpus cf. Pápay et al., 2011; Hunyadi et al., 2012).

Even though our corpus building followed the main characteristics of multimedia corpus annotation in general, especially the DiAMSL framework (cf. Bach and Robert, 1979; Sperber and Wilson, 1986; Wilson and Sperber, 2002; Bunt et al., 2010), it differed from them in that in addition to assigning certain annotation labels as a result of multimodal observation, we also relied on unimodal observation. Whereas in multimodal observation all available modalities (in general, both video and audio) were involved, the unimodal observation followed either the video or the audio of the given recoding only. The rationale for this additional unimodal observation was that we wished to better identify which of the modalities in question has or have a specific contribution to the perception of certain communicative/pragmatic functions, including intentions, and emotions. By doing so we hoped to get a better understanding and a more detailed description of the individual differences among speakers in the expression of such functions as perceived and interpreted by the observers. Labeling of both verbal and especially nonverbal events for behavioral categories followed an elaborate protocol during which the annotators were continuously involved in discussions. The specificity of between-subject differences was captured by a significant period of familiarizing with the overall behavior of each of the subjects on the recording before the actual annotation could start.

There were 40 levels of annotation, including video and audio; either multimodal or unimodal, representing either physically measurable events or non-physical, abstract ones, the latter as resulting from pragmatic interpretation (for the development of the pragmatic features of the corpus cf. Németh, 2011). Each level of annotation was done independently from any other annotation. Each file was annotated by one annotator but checked by another one. Inter-annotator agreement was assured by frequent consultations and debates. The annotation of physical events was naturally all unimodal, since they came from direct visual or audio observation or measurement, including, based on video, the direction of gaze, blinking, hand- and head movements, posture and, based on audio, pitch movements, changes of intensity, silence, overlapping speech, start, and end of speaking. Emotions were annotated in three ways: multimodally (observing both video and audio) and unimodally, following audio, and again unimodally, following video (facial expressions). As a matter of fact, these three different modalities of observation effectively showed differences in the scope and intensity of emotions observed across the modalities for one and the same recording. In addition, this approach, as probably expected, also gives the chance to capture the speaker-specificity of the expression of emotions.

With these ideas in mind, an extensive annotation was performed on all the 222 recordings. The texts of the speakers and their agents made up about half a million running words, and each of the words was time-alined within the given speech flow, an especially helpful feature of the

TABLE 4 | Emblem—frequency of items from the gaze class.

	Blink	Up	Down	Right	Left	Forwards	All
v_gaze	3801	3981	7658	3496	2156	13365	34457

TABLE 5 | Emblem/agree—frequency of items from the gaze class.

	blink	b, up	e, up	b, down	e, down	All
b, agree	1186	110	7	897	1385	3585
e, agree	1225	140	19	841	654	2879

TABLE 6 | Emblem/disagree—frequency of items from the gaze class.

	Blink	b, up	e, up	b, down	e, down	All
b, disagree	42	7	7	10	16	82
e, disagree	13	0	0	13	27	53

TABLE 7 | Emblem/doubt—frequency of items from the gaze class.

	Blink	b, up	e, up	b, down	e, down	All
b, doubt	240	36	57	108	139	580
e, doubt	218	62	88	112	133	613

TABLE 8 | Emblem/refusal—frequency of items from the gaze class.

	Blink	b, up	e, up	b, down	e, down	All
b, refusal	57	0	7	29	10	103
e, refusal	13	0	7	34	13	67

TABLE 3 | Emblem—frequency of items from the hand class.

	Flat	Spread	Crossing fingers	Right	Left	Fist	Index-out	Broke	All
v_hand	3283	461	166	4041	496	290	225	21	8983

corpus to associate non-verbal events with the corresponding spoken text. The text was also annotated for morphology and syntax, another important feature which, due to its information about linguistic flaws and incompleteness during a conversation can contribute to both learning more about the cognitive flow of linguistic behavior and to building more natural interactive systems. Video annotation included the classes of facial expression, gaze, eyebrows, headshift, handshape, touchmotion, posture, deixis, emotions and emblem. Audio was annotated for the classes of intonation phrase, emotions and discourse, in addition to phonetic events within speech, such as silence, hesitation, restart, non-phonemic sounds, and noise. Automatic methods were applied to the annotation of the phonetic features of the sound track: in addition to marking the absolute values for F0 and intensity, a special algorithm (Szekrényes, 2014, 2015) was used to annotate stylized intonation and intensity contours of speech in order to capture the contribution of speech prosody to the multimodal expression of the pragmatic content of the interaction. The pragmatic levels of annotation included the classes of turn management, attention, agreement, deixis and information structure. Since each and every event of any class was annotated as time-alined, the scheme made it possible to associate virtually any event of any kind with another event. Due to computational restrictions (of which we'll be more specific in the next section) this work is concerned with only the following classes: the physical classes of gaze, handshape, headshift and posture, and the interpretive pragmatic classes of agreement and emblem. The present study uses data from this restricted set of classes from the HuComTech Corpus to identify multimodal patterns associated with the behavioral events of agreement/disagreement.

TABLE 9 | Emblem/block—frequency of items from the gaze class.

	Blink	b, up	e, up	b, down	e, down	All
b, block	13	0	0	8	5	26
e, block	11	0	0	22	21	54

TABLE 10 | The most frequent patterns of agreement consisting of 2 events.

Patstring	Number of files	Total number
(up_agr,b,default_disagree up_agr,e,default_disagree)	90	490
(v_head,b,shake up_agr,b,default_disagree)	37	221
(v_head,e,shake up_agr,e,default_disagree)	32	182
(up_agr,e,default_disagree v_head,e,shake)	33	174
(up_agr,b,uninterested up_agr,e,uninterested)	25	158
(up_agr,e,default_disagree v_gaze,b,forwards)	33	157
(mp_spcommact,b,constat up_agr,b,default_disagree)	36	155
(up_agr,b,default_disagree v_head,b,shake)	32	143
(up_agr,b,default_disagree v_head,e,shake)	28	142
(up_agr,b,default_disagree v_gaze,b,forwards)	26	125

3. *THEME*: WHY THIS COMPUTING ENVIRONMENT CAN BE SUITABLE FOR IDENTIFYING PATTERNS OF BEHAVIOR FROM THE HuComTech CORPUS

One faces at least four challenges when attempting to discover multimodal patterns of behavior: (a) even though there are stereotypical assumptions about what modalities or events can be associated with a given pragmatic function in behavior, the set of such candidates may not eventually be a closed one; (b) even if just considering a stereotypical set of events making the pattern for the given behavior, it is often the case that one or another event can be missing from the pattern without violating the given functional interpretation, that is, some (or sometimes all?) of the events in a stereotypical description of a pattern can be optional; (3) whereas the constituting events can either co-occur with or follow one another, their temporal sequence does not necessarily follow adjacency, i.e., one or more events can occur between two "stereotypical" events as "noise"; (d) even though behavioral patterns occur in time, the temporal sequence of the constituting events cannot be determined as having a constant, stable discrete duration, rather, the interval between two events within a pattern can only be determined by statistical probability. *Theme* (Casarrubea et al., 2015, 2018; Magnusson et al., 2016; patternvision.com) appears to capture the optionality of possible pattern-making events, overcome the strict adjacency requirement of certain analyses and surpass the constraint of predetermined intervals between events as presupposed by time series analysis. As such, it captures the inherent property of behavioral patterns of (between-subject and within-subject) variability both in composition and timing and define occurrences of patterns by statistical probabilities. *Theme* is a statistical environment that computes all these conditions and determines which of the theoretically possible co-occurrences or sequences of any two events make a minimal (i.e., first level) pattern. Computation by *Theme* is based on the concept of critical interval: it determines which of the temporal occurrences of any two events, such as A and B are within an interval that satisfies the condition of a certain probability, say $p = 0.005$. *Theme* recursively associates any two events into a minimal pattern, or minimal patterns into more complex patterns, thus building a theoretically non-finite hierarchy of events and patterns. *Theme* has one more important concept: whereas, intuitively, one associates an event with its duration, *Theme* considers both the starting point and the ending point of such an event as a separate event, and it associates them with any other event individually to form a pattern. This is how *Theme* can capture the difference between the following two situations: in the first, *B* starts answering *A*'s question while *A* is still speaking, in the second, *B* only starts answering after *A* has finished the question. The fact that *Theme* is fundamentally based on discrete points of time associated with any kinds of events, allows us to attempt to discover even behavioral patterns which are hidden from the naked eye, i.e., without relying on stereotypes. The only restriction for *Theme* is, however, understandable: it can only identify patterns based on events that were previously annotated.

Theoretically, the responsibility of the selection of categories (classes in *Theme*'s terms) to be annotated solely lies on the design of the annotation scheme. Our work, however, is also restricted by the computational power available at present: in order to successfully manage a reasonable amount of computation, our search for patterns was restricted to the classes of annotation enumerated in the previous section. We hope, however, that the resulting patterns will prove to be representative of agreement and they will correspond to our everyday intuitions. This is what the next section is intended to offer.

4. PATTERNS OF AGREEMENT AS DISCOVERED BY *THEME*

All analyses were done using *Theme 6* (full version) on a virtual machine equipped with 64 GB memory and 20 virtual CPUs. Due to the large amount of data to process the corpus was divided into 10 smaller chunks, and the same procedure was followed for each of them. The data files contained all the annotations available in the corpus, including those which were not targeted in the current research. For pattern discovery, classes and event types relevant to this study were only selected using the Reorganize Data option. The basic search settings were as follows: significance level: 0.005, minimal occurrence of candidates for a pattern: 3, univariate patterns: no, minimum d1: 1, maximum d1: 1500 (i.e., the critical interval between any two events to be considered as candidates for a pattern fell between 1 and 1500 ms), maximum number of search levels: 3, exclude frequent event types: 0.25, top percent kept per level: 75. The values of the three latter parameters reflect the existing computational restrictions imposed on the amount of the data: even though there was a chance to discover even more complex patterns searching at levels higher than the preset 3, even the available 64 GB memory would not have been sufficient for that. The reduced values of the other two parameters reflect the same computational constraint, too. The data were randomized using shuffling and rotation (an outstanding testing feature of *Theme* to ensure that the patterns identified are indeed generated within some specific temporal structure of events). **Figure 1** allows us to compare the number of patterns derived from either real or randomized data: from level 2 and upwards (with 3 or more pattern constituents) patterns tend to be specific to real data, and as such, to the communicative situations the real data are based on:

Before turning to the actual analysis of patterns of agreement, let us have a look at some basic data about the corpus as a whole.

The total set of 111 formal and 111 informal dialogues (each by the same 60 male and 51 female speakers) was included in the discovery of patterns. Annotations of an action, such as "head turn to the right based on video observation" were separated into two events: one for the beginning, one for the end of the given head turn, such as "v_head,b,right" and "v_head,e,right." Out of the total 3,929,630 events annotated (1,964,815 for the beginning and the same amount, 1,964,815 for the end of an action) a large number of them were actually found in one or another pattern: 1,699,825 denoted the beginning (86.5% of all annotated "begin" events), and 1,469,751 denoted the end of a given event (74.8% of all annotation "end" events). The events contributed to the complexity of the resulting patterns in such a way that more than one instance of one and the same event type could be part of a given (more complex) pattern, as shown in file f003:

```
((( v_head,b,right  v_head,e,right )
      v_head,b,right )  v_head,e,right )
```

This pattern tells us that the speaker turned his head to the right twice ("v_head" = head movement annotated using video observation, "b" = begin, "e" = end, "right" = head movement to the right). The dependency denoted by the bracketing also showed that the first head movement was shorter than the second one. In all, the occurrence of the "begin" events in patterns was about 16% higher than that of the "end" events showing that the beginning of an action was somewhat more specific to a pattern than its end.

The total number of pattern occurrences (i.e., pattern tokens) throughout the corpus was 967,446. As for their distribution by gender, male speakers showed more patterns than females: males: 599,533, females: 367,913. As for their distribution by formal/informal dialogue type, the informal dialogues had 37.9% more patterns than would be expected by the difference by duration between formal and informal dialogues (257,478 vs. 709,968 patterns in about 10 vs. 20 min dialogues, respectively).

TABLE 11 | The most frequent patterns of agreement consisting of 3 events.

Patstring	Number of files	Total number
(v_head,b,shake (up_agr,b,default_disagree v_head,e,shake))	7	44
(v_head,b,shake (up_agr,b,default_disagree up_agr,e,default_disagree))	10	41
(up_agr,b,default_disagree (v_head,e,shake up_agr,e,default_disagree))	8	41
((v_head,b,shake up_agr,b,default_disagree) v_head,e,shake)	6	35
(mp_spcommact,b,constat (up_agr,b,default_disagree up_agr,e,default_disagree))	10	34
((mp_spsuppact,b,backch up_agr,b,default_disagree) mp_spsuppact,e,backch)	8	29
(up_agr,b,default_disagree (mp_spcommact,e,constat up_agr,e,default_disagree))	9	28
((up_agr,b,default_disagree up_agr,e,default_disagree) v_gaze,b,forwards)	7	27
((v_head,b,shake up_agr,b,default_disagree) v_gaze,b,forwards)	3	26
(up_agr,b,default_disagree (v_head,b,shake v_head,e,shake))	7	25

Search for patterns by *Theme* is done recursively. It means that once a pattern is discovered at search level 1, this pattern is carried on to the next level where *Theme* attempts to associate it with another event or another pattern to make it part of a more complex pattern. In this process *Theme* may find that pattern 1 found at level 1 will be associated with pattern 2 found at level 2 in a resulting pattern 3 so that pattern 1 is higher on the hierarchy that pattern 2 – this is the case of forward embedding; or, alternatively, pattern 2 can be higher in the hierarchy than pattern 1 in the resulting pattern 3– the case of backward embedding. As for the whole corpus we find that out of the 967 446 pattern occurrences 82.9% (802 236) have some sort of embedding (i.e., they are generated at level 2 or level 3), evenly distributed as forward or backward embeddings: single forward embedding: 291,771, single backward embedding: 289 663, double forward embedding: 108,893, double backward embedding: 111 909. These data demonstrate how important it is in the modeling of the generation and perception of behavioral patterns to consider a pattern as a temporal complex which is not necessarily built as just a forward looking temporal sequence of events, but where some events can have a backward structural reference to one or more temporally preceding events as well.

Let us now turn to the events and patterns associated with the expression of the pragmatic function of agreement.

The following video classes were included in the discovery of associated patterns: the physical descriptive classes of v_gaze, v_hand, v_head and v_posture (the prefix "v_" in each case representing video observation), and the interpretive class of v_embl (=emblem; including various shades of agreement). **Table 1** shows the occurrences of items representing the emblem class:

We can see that the frequency of items in annotations does not necessarily coincide with their frequency in actual patterns: *attention*, the most frequent annotation item is only ranked as the 3rd most frequent item occurring in a pattern, it is preceded in frequency by both *default disagree* and *agree*. These frequency data give us a glimpse of the nature of the conversations recorded: there were many moments of attention, as a natural component of a dialogue, but the fact that there were more moments of (default) disagreement than agreement also suggests that the interaction was fairly free. The small number of items *refusal*, *doubt-shrug* and *surprise-hands* suggests that the interaction did not include much of direct confrontation. An additional series of annotation to determine the degree of agreement revealed that there were 2331 instances of the item *uninterested* – yet another reflection of the speaker to some moment of the interaction. Its relatively small frequency shows again that the actors were duly engaged in the dialogues.

The following tables show a subset of patterns observed with the above items in the emblem class – the association of these items with events of the head, hand, and gaze classes:

Tables 2–4 above show that gaze movement was more frequently annotated than either head or hand, indicating again that there was much eye contact between the actors—as expected from an active interaction in general. This suggestion is also supported by the large number of nods as well as blinks, both of them usually accompanying conversational events. The speakers held their hand flat most of the time, suggesting again the non-confrontational nature of the dialogues;

TABLE 12 | The most frequent patterns of agreement consisting of 4 events.

Patstring	Number of files	Total number
(((v_head,b,shake up_agr,b,default_disagree) v_head,e,shake) up_agr,e,default_disagree)	4	16
((v_head,b,shake up_agr,b,default_disagree) (v_head,e,shake up_agr,e,default_disagree))	4	15
(v_head,b,shake (up_agr,b,default_disagree (v_head,e,shake up_agr,e,default_disagree)))	3	12
(((v_head,b,shake up_agr,b,default_disagree) v_gaze,b,forwards) mp_spcommact,e,constat)	2	11
(v_gaze,b,forwards ((v_gaze,e,forwards v_gaze,b,down) up_agr,e,default_disagree))	1	10
(v_head,b,shake (up_agr,e,default_disagree (v_head,e,shake v_gaze,e,forwards)))	1	10
(up_agr,b,default_disagree (v_head,b,shake (v_gaze,b,forwards mp_agcommact,e,constat)))	1	9
((up_agr,b,default_disagree (v_gaze,b,down up_agr,e,default_disagree)) v_gaze,e,down)	1	9
(((v_gaze,e,forwards v_gaze,b,down) up_agr,e,default_disagree) v_gaze,e,down)	1	9
(mp_spcommact,b,constat (up_agr,b,default_disagree (up_agr,e,default_disagree mp_spcommact,e,constat)))	3	9

TABLE 13 | The most frequent patterns of agreement consisting of 5 events.

Patstring	Number of files	Total number
(((v_head,b,shake up_agr,b,default_disagree) v_gaze,b,forwards) (up_turn,b,endsp up_att,b,paying))	1	5
(((up_turn,b,endsp up_turn,b,intendsp) (mp_spcommact,b,constat up_agr,e,uninterested)) v_gaze,b,forwards)	1	4
((v_head,b,shake up_agr,b,default_disagree) ((v_head,e,shake up_agr,e,default_disagree) v_gaze,e,forwards))	1	4
(((v_head,b,shake up_agr,b,default_disagree) v_gaze,b,forwards) (v_head,e,shake up_agr,e,default_disagree))	1	4
(v_gaze,b,blink ((v_gaze,e,blink v_gaze,e,up) (up_agr,b,block_disagree up_agr,e,block_disagree)))	1	4
(((v_head,b,shake up_agr,b,default_disagree) v_head,e,shake)(up_agr,e,default_disagree mp_agsuppact,b,backch))	1	3
(((up_agr,b,default_disagree v_gaze,b,forwards) (up_agr,e,default_disagree mp_agsuppact,b,backch)) mp_spcommact,e,constat)	1	3
(((up_agr,b,default_disagree mp_spsuppact,b,backch) (v_head,e,shake up_agr,e,default_disagree)) v_gaze,b,forwards)	1	3
((mp_spsuppact,b,backch up_agr,e,uninterested) ((v_gaze,b,forwards mp_agcommact,b,constat) mp_agsuppact,e,backch))	1	3
(mp_spsuppact,b,backch ((up_agr,e,uninterested v_gaze,b,forwards) (mp_agcommact,b,constat mp_agcommact,e,constat)))	1	3

TABLE 14 | The most frequent patterns of agreement consisting of 6 events.

Patstring	Number of files	Total number
(((v_head,b,shake up_agr,b,default_disagree) v_head,e,shake)(up_agr,e,default_disagree (mp_agsuppact,b,backch mp_spcommact,e,constat)))	1	3
(((mp_spcommact,e,constat mp_spcommact,b,constat) v_gaze,b,down)((up_agr,b,default_disagree mp_spinf,e,new) mp_sptopic,b,t_elab))	1	3
(((v_gaze,e,left v_gaze,e,forwards) up_agr,e,default_disagree)(mp_agtopic,b,t_elab (v_head,b,right v_head,e,lower)))	1	3
(((v_head,b,shake up_agr,b,default_disagree) (up_agr,e,default_disagree up_agr,b,default_disagree)) (v_head,e,shake up_agr,e,default_disagree))	1	3
((up_agr,b,block_disagree (mp_sptopic,b,t_init mp_sptopic,e,t_init)) ((mp_sptopic,e,t_elab mp_agcommact,b,constat) v_hand,e,right,flat))	1	3

whereas the predominant use of the right hand against the left hand speaks about the predominant right-handedness of the actors.

Tables 5–9 show the role of gaze in the expression of various items (subcategories) associated with agreement ("b" and "e" denote the beginning and the end of an action, respectively):

Among the many possible observations let us just notice the role of *blink*: it is mostly present as accompanying agreement, either its beginning or its end (even if with fewer occurrences, the same it true of *disagreement*). The beginning of the action of agreement is also strongly associated with "e,down," i.e., the speaker stops gazing downwards—effectively looks up, most probably meets the eyes of the agent. When, also frequently, the speaker begins looking down ("b,down") while starting agreeing, it may suggest a moment of deliberation and may eventually take his/her turn to continue the conversation.

Finally, let us have a closer look at the most frequent patters associated with agreement. In **Tables 10–14**, following *Theme*'s convention, each pattern is shown to consist of at least two event types. Event types making up a pattern are separated by a space. Each event type starts with the name of a given class, followed by "b" or "e" for "begin" or "end," followed by the name of the item within the given class. As an example of this general syntax of notation cf. the first pattern in **Table 10**:

```
( up_agr,b,default_disagree up_agr,e,
      default_disagree )
```

event type 1: up_agr,b,default_disagree
where
"up_agr" = unimodal pragmatic class of agreement,
"b" = the beginning of the event,
"default_disagree" = an item of the class of agreement, i.e., an event of default disagreement.
event type 2: up_agr,e,default_disagree
where
"up_agr" = unimodal pragmatic class of agreement,
"e" = the end of the event,
"default_disagree" = an item of the class of agreement, i.e., an event of default disagreement.

One more note: the prefixes "v_" and "up_" equally stand for video observation. The difference is that "v_" stands for events definable by their physical form, such as direction, whereas "up_" stands for an event definable by its content, as the result of the interpretation of a pragmatic event that is based on video observation.

Table 10 confirms our stereotypes regarding disagreement: it is strongly associated with head shake in a number of files (recordings). Its temporal alignment with disagreement is also obvious: the start of disagreement aligns with the start of head shake, its end aligns with the end of headshake. It is also interesting to notice that starting looking forward can be associated with both the beginning and end of disagreement, the gaze direction suggesting some cognitive processes corresponding to the current status of disagreement. When the pattern has opposite values of begin/end of the two constituents as in (up_agr,b,default_disagree v_head,e,shake), it may suggest that the head shaking started earlier than disagreement could be observed—showing that it is also a possible variant for the pragmatic situation.

Table 11 confirms what we also saw in the simplest, two-event patterns: head shaking is found both as preceding and following the expression of disagreement. In addition, constatives and backchannel are also among the most frequent events taking part in more complex patterns, including embedding.

As shown above, head shaking is a main constituent both in the forward and backward embedding patterns. The intensive use of gaze movement by one speaker in the pattern (((v_gaze,e,forwards v_gaze,b,down) up_agr,e,default_disagree) v_gaze,e,down) suggests an active cognitive process during the course of disagreement (the sequence "ending looking forward + starting looking down" takes place while the speaker is disagreeing), and the speaker ends looking down right after finishing the act of disagreeing.

The set of the above, already longer patterns sheds light on the wider context of disagreeing, from just the intension of speaking to the start or end of speaking, backchannel and constative acts. Importantly, these data show that even these more complex patterns can have statistical probability.

Table 14 with its even larger context indicates the recursive role of hand shaking, backchannel and constative acts in building even loger behavioral patterns:

Finally, let us see the single longest, 7-item pattern of agreement:

```
((( mp_spcommact,e,constat mp_spcommact,b,
  constat )
v_gaze,b,down )(( up_agr,b,default_disagree
  mp_spinf,e,new )
( mp_sptopic,b,t_elab mp_spcommact,
  b,constat )))
```

This is the longest pattern discovered in the current settings. It shows that the act of disagreeing is embedded in a series of constative acts and topic elaboration, indicating the continuous reaction of the speaker to the further development of the given interaction.

5. SUMMARY

The present paper focused on the discovery of multimodal patterns of agreement/disagreement based on data from the HuComTech Corpus. It argues for a multimodal approach to human interaction by showing the interdependence of text, speech and gestures in communication, and shows the importance of implementing human behavioral patterns in more user friendly human-machine interaction systems. It describes the main features of the annotation of the corpus with emphasis on those classes that are mainly responsible for the expression of agreement/disagreement. After a short introduction to the basics of the research environment *Theme*, relevant behavioral patterns of various complexities discovered by *Theme* were presented.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Develop Your Case! How Controversial Cases, Subcases, and Moderated Cases Can Guide You Through Mixed Methods Data Analysis

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In this article, we present mixed methods data analysis in educational research as a process of *case development*. We define a case as a theoretical construct that is developed through iterative and spiraling cycles of interaction between ideas and evidence. On a larger scale, cases develop over a period of several years or even decades, involving many studies. But cases also develop within a much smaller timescale, within studies. Development of cases within mixed methods studies is the theme of this article. We define the purpose for any mixed methods study as to *acquire detailed insight into the case, subcases, and the way the subcases are moderated.* Developing a case starts with identifying a phenomenon that will be the object of research. A phenomenon can be investigated empirically once researchers are able to identify specific contexts, localized in time and space, in which the phenomenon occurs. At that point, an *underdeveloped case* has come into being, and the specific contexts in which the case occurs are called *instantiations* of the case. Connected to each case are *claims*, statements about the case that are used to describe the case more precisely and to distinguish cases from non-cases. Developing these claims is the aim of the analysis processes. Case development includes three different research processes—namely, resolving a controversial case, developing subcases, and developing a moderated case. Case development typically occurs in this order; however, each of these processes *can* but do not *need* to be present. When cases develop, they typically become *controversial* for some time. Some research studies support a specific claim, while other research studies refute this claim. Next to claims that apply to all instantiations of a case, claims may be developed that apply to only some of the case's instantiations. In that case, claims are used to distinguish *subcases*. A *moderated case* is developed when researchers come to understand under which circumstances their claim does and does not apply, which leads to their subcases. This is called "moderation" of their claim.

Keywords: mixed methods, data analysis, educational research, case development, controversial case, subcase, moderated case

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INTRODUCTION

This article examines data analysis in mixed methods educational research, henceforth referred to as *mixed analysis*. Mixed analysis presents a challenge for mixed methods researchers from the very beginning of an inquiry until the very end. The challenge begins with research design. At the beginning of a study, the researcher must develop a plan that describes various aspects of mixed analysis. These aspects include how the results of separate quantitative and qualitative analyses will be amassed, how qualitative and quantitative data are brought together during analysis, and how qualitative and quantitative data collection and data analysis proceed together. Typically, not all aspects of a mixed analysis can be planned before the study starts. Thus, in addition to prior planning, the researcher will often have to engage in unforeseen forms of mixed analysis during the research process. Another challenge that especially affects evaluation research and case study research is the sheer amount of qualitative and quantitative data that become available in the course of the study and the challenge of what to analyze and how to analyze these various data types together.

Thus, a question arises in relation to what principles can guide researchers through the challenging process of mixed data analysis. One fruitful approach to mixed analysis assumes that the qualitative and quantitative data engage in a *dialogue*. The idea of research as a form of dialogue is not unique to mixed methods research. Within case development, for example, "[i]nteraction between ideas and evidence results in a progressive refinement of the case conceived as a theoretical construct" (Ragin, 1992, p. 9). Mixed methods scholars have added that this dialogue between ideas and evidence may include qualitative and quantitative research components and strands. Mixed analysis has been termed both iterative and interactive, and as an "ongoing iterative exchange between the qualitative and quantitative strands that invites an engagement with the unexpected and often paradoxical" (Creamer, 2017, p. 200). It has also been referred to as a "meaningful two-way exchange of information and inferences between varied types of sources gathered and/or analytic strategies employed" (Bazeley, 2018, p. 8).

Various metaphors can be used to describe this dialogue and thereby guide mixed analysis (Bazeley and Kemp, 2012). One group of metaphors describe the mixed analysis process as a spiral (see also Bazeley, 2018), for example as a DNA double helix (Mendlinger and Cwikel, 2008; Bazeley and Kemp, 2012). Mixed methods has the potential to "spiral iteratively around the different data sets, adding depth of understanding with each cycle" (Caracelli and Greene, 1993, p. 202).

The challenge of how to engage in a spiraling analysis process can be addressed as four related questions—namely, how can a researcher create conditions that are optimal for the analysis process? How can the outcomes of the analysis process be judged? What principles can guide the analysis process itself? And finally, how can a researcher know that they are making progress during the analysis process?

The main condition for a fruitful dialogue has been described by Jennifer Greene as "engag[ing] with difference" (Greene, 2005, p. 208; Greene 2007, p. 80; see also Johnson and Schoonenboom, 2016; Johnson, 2017). Greene (2005) goes on to say that:

> [A] mixed method way of thinking seeks not so much convergence as insight; the point is not a well-fitting model or curve but rather the generation of important understandings and discernments through the juxtaposition of different lenses, perspectives, and stances; in a good mixed methods study, difference is constitutive and fundamentally generative. […] In practice, mixed method educational inquiry includes multiple and diverse methods for gathering, analyzing, and representing educational phenomena within a framework that intentionally engages with the different ways of knowing and valuing that the different methods embody. (p. 208).

While creating conditions for a fruitful dialogue begins at the outset of a study, at the end of a study, the researcher faces the problem of how to judge the outcomes of the dialogue. Within the DNA metaphor, the validity criterion that is used for judging the dialogue's outcomes is the functionality of the resultant organism:

> The rigor of this type of integration derives from an inability to force any part into the organic helix; each component in the DNA sequence has a key and it has to fit in place. As in the construction of DNA, only certain sequences are possible, and only particular proteins (data) can bind together, yet variation and improvisation are important, and, as in nature, infinite variety can result. Ultimately, at the conclusion of the process, everything must "fit" and "work" so that the rigor and the validity of the integrated analysis can then be judged by the functionality of the resultant organism. (Bazeley and Kemp, 2012, p. 68).

This validity criterion can be used for judging the outcomes of mixed analysis, not for guiding the analysis itself, or for making decisions during analysis. This is because the "resultant organism" is not yet known.

Some authors have proposed that decision-making during mixed analysis should be driven by the study's purpose. For Bazeley (2018), mixed methods integration is performed in order to meet the overall purpose of the study. Similarly, Creamer (2017) identified the purpose as what drives the decision to use mixed methods. However, although a study's purpose may provide some direction for the researcher, it is not sufficient to guide the researcher during the analysis. This is because research purposes may change during a study. As a result, the process of research analysis may change. In addition, a study's purpose is of little use in answering the fourth question—namely, how can a researcher know that he\ she is making progress during the process of analysis? The study's purpose does not provide feedback *on* or indicators *of* the current status of the study. The purpose does not tell a researcher how close he\she is to reaching said purpose.

This article introduces an approach to mixed analysis that intends to support researchers in making analysis decisions. It provides support by presenting information about how to assess the current status of a study and giving suggestions for the next step in the analysis. We refer to this approach as the "develop your case" approach, and we take as our starting point Bazeley's (2018) description of data analysis within a mixed methods case study, which is based on the case study as "an empirical method that investigates a contemporary phenomenon (the 'case') in depth and within its real-world context" (Yin, 2018, p. 15). Bazeley claims that:

> Analysis of the diverse data gathered in a case study begins with the development of a systematically organized database of information including both words and numbers. […] Writing might begin with a comprehensive case description that draws on the kinds of complementary analyses and integrative processes described already. Information is pieced together, sources compared, and documentation garnered to build a sound database of evidence that can be called on to test and support claims made regarding the case. (p. 238).

Although meant to describe the mixed methods case study, it is clear that Bazeley's description also applies to much of mixed methods research that is outside the case study itself: many mixed methods researchers develop "systematically organized databases" of both quantitative and qualitative data. As well as this, many mixed methods researchers piece together information, compare sources, and test claims.

In this article, we present mixed analysis within the field of educational research as a process of *case development*. The development processes and their sequences help researchers determine the status of their research and provide directions for how to continue. As Ragin (1992) has pointed out, a problem associated with discussing cases is that the word *case* is used in many different ways. In this article, we refer to the *case* as a theoretical construct. Thus, when we say that a significant amount of research outside the case study aims to develop cases, we mean that the research aims to gradually refine theoretical constructs through empirical research.

This meaning of the case as a theoretical construct is illustrated by Ragin (1992):

> A[n] […] investigator interested in tyranny, for example, would study many possible instances of tyranny. This investigation might lead to an identification of an important subset of instances with many common characteristics, which might be conceived, in turn, as cases of the same thing (e.g., as cases of "patrimonial praetorianism" or as cases of "modern tyranny"). Interaction between ideas and evidence results in a progressive refinement of the case conceived as a theoretical construct. (p. 9)[1].

Throughout this article, the word *case* refers to the case as a theoretical construct. We will use *instantiation* to refer to an empirical instantiation of the theoretical construct. We will use the word *example* to refer to an empirical context that we use to illustrate or investigate the development of a case as a theoretical construct.

We define the purpose for a mixed methods study as to *acquire detailed insight into the case, subcases, and the way the subcases are moderated.* Our definition is based on Greene's (2007) goal of "generating better understanding of social phenomenon" (p. 20). But we go beyond this by stating that, in addition, three related goals of mixed methods research are (1) to develop claims, (2) to develop what we call "subcases," and (3) to understand how claims are moderated. These last three goals, we will show, will provide information about the status of the study and will help researchers determine their next analysis step.

Developing cases occurs at different timescales. On a larger scale, cases develop over a period of several years or even decades, involving many studies. Think, for example, about the case of the noxiousness of smoking, including the claim that smoking causes lung cancer, a claim that took several decades to fully develop. But cases also develop within a much smaller timescale, within studies. Development of cases within mixed methods studies will be the main theme of this article. We will start, however, by explaining our concepts of case development using examples of developing cases on a larger timescale.

HOW CASES DEVELOP ACROSS RESEARCH STUDIES

In this section, we explain how cases can develop across several studies. We use three examples, with each one emphasizing a different process within case development.

The Violence Example

Figure 1 shows the development of the case in the first example, the "violence example."

Through a comparison of many instances of violence, Randall Collins developed the notion of violence as "a set of pathways around confrontational tension and fear" (Collins, 2009). As Collins explains:

[1]While this fragment clearly illustrates the meaning of *case* as a theoretical construct, it also unwittingly demonstrates how difficult it is to separate the various meanings of *case*. Thus, Ragin begins by distinguishing "[empirical] instances of a case [as a theoretical construct]," identical to our "instantiation of a case." In the second sentence, however, Ragin speaks of "cases of the same thing." In this sentence, *cases* does not refer to the case as a theoretical construct, but to the case as an empirical instance. Thus, to avoid confusion, it would have been better if Ragin had said "as instances of the same subcase (e.g., as instances of the subcase 'patrimonial praetorianism' or as instances of the subcase 'modern tyranny')."

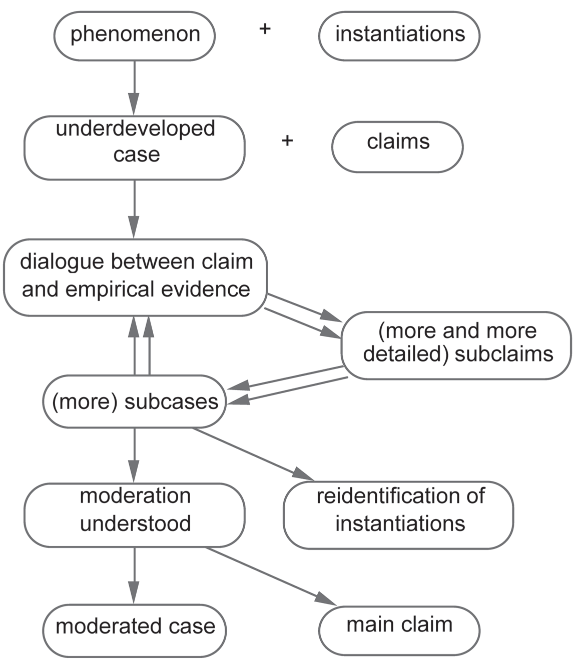

FIGURE 1 | Case development across studies in the violence example: the interactive development of subcases.

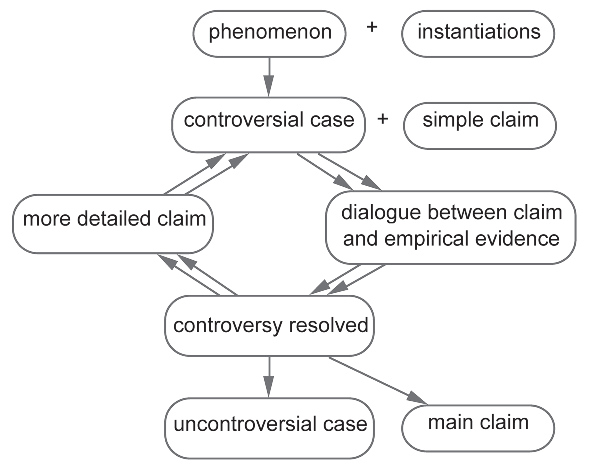

FIGURE 2 | Case development across studies in the TRF example: the interactive resolution of a controversial case.

> Violent interactions are difficult because they go against the grain of normal interaction rituals. The tendency to become entrained in each other's rhythms and emotions means that when the interaction is at cross purposes—an antagonistic interaction—people experience a pervasive feeling of tension. This is what I call confrontational tension; at higher levels of intensity, it shades over into fear. For this reason, violence is difficult to carry out, not easy. Those individuals who are good at violence are those who have found a way to circumvent confrontational tension/fear, by turning the emotional situation to their own advantage and to the disadvantage of their opponent. (p. 20).

The use of comparison helped Collins to not only develop the concept of violence, but also to distinguish and classify different types of violence, for example, the type *find a weak victim to attack* (e.g., military violence, police violence, domestic violence), and the type *fighting before an audience* (e.g., personal fights, martial arts, violence in sports). Based on his definition, Collins criticizes Bourdieu's use of "symbolic violence" for being unrelated to other forms of violence and for not being helpful to explain the micro-sociology of violence.

Developing a case starts with identifying a *phenomenon* (**Figure 1**) that will be the object of research. At the beginning, this phenomenon is given a label; in the violence example, the label is "violence." A phenomenon can be investigated empirically once researchers are able to identify specific contexts, localized in time and space, in which the phenomenon occurs. At that point, an *underdeveloped case* has come into being, and the specific contexts in which the case occurs are called *instantiations* of the case. For example, one instantiation of the case "violence" is the Battle of Waterloo, which took place in 1815.

By definition, a case has more than one instantiation. Thus, the Battle of Waterloo shares its status as an instantiation of the case "violence" with many other specific contexts, for example, with the boxing match between Muhammad Ali and Joe Frazier in New York in 1971.

Connected to each case are claims, statements about the case that are used to describe the case more precisely and to distinguish cases from non-cases. These claims are developed in an interactive cycle. Claims may refer to the case as a whole: in the violence example, to violence in general. Examples include *violence is a set of pathways around confrontational tension and fear*, *violence is difficult*, and *confrontational tension is a requirement for the coming into being of violence*.

Next to claims that apply to all instantiations of a case, claims may be developed that apply to only some of the case's instantiations. In that case, claims are used to distinguish *subcases* (**Figure 1**). According to Collins' description, the Battle of Waterloo can be considered an instantiation of the subcase "Find a weak victim to attack," while the boxing match between Ali and Frazier is considered an instantiation of the subcase "Fighting before an audience." The Battle of Waterloo and the boxing match between Ali and Frazier belong to different subcases of the case "violence."

The TRF Example

When cases develop, they typically become *controversial* for some time: some research studies support a specific claim, while other research studies refute this claim. This is apparent in the TRF example, about the discovery of thyrotropin-releasing factor (TRF). **Figure 3** shows that between 1962 and 1969, claims were developed about the existence and the chemical composition of TRF, a hormone produced by the hypothalamus (Latour and Woolgar, 1986). **Figure 2** displays the structure of the TRF example.

Before 1962	Is there a TRF?		
After 1962	There is a TRF. What is it?	It is a peptide.	
Around 1966		It might not be a peptide. It is not a peptide.	
January 1969		It is a peptide.	It contains His, Pro, and Glu.
April 1969			It is either R-Glu-His-Pro or R-Glu-His-Pro-R It is not Pyro-Glu-His-Pro-OH nor Pyro-Glu-His-Pro-OMe nor Pyro-Glu-His-Pro-NH2
November 1969			TRF is Pyro-Glu-His-Pro-NH2

FIGURE 3 | Development of TRF claims. From Latour and Woolgar, 1986. (p. 147). Copyright 1986 by Princeton University Press. Reprinted with permission, conveyed through Copyright Clearance Center, Inc.

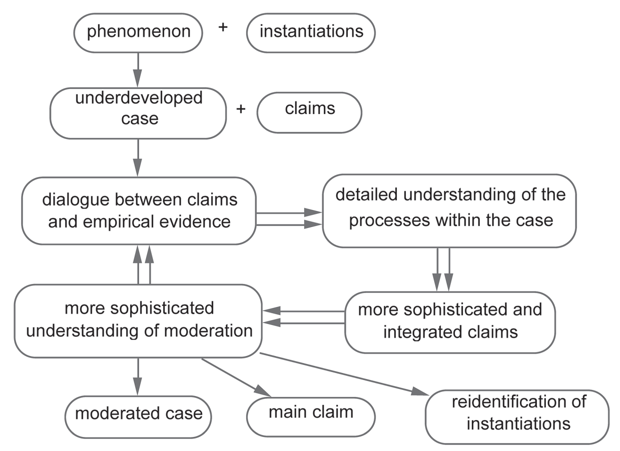

FIGURE 4 | Case development across studies in the terrorism example: the interactive development of a moderated case.

This example starts with a phenomenon labeled "TRF." The underdeveloped case starts with a simple claim "There is a TRF." Before 1962, this case was controversial because it was not clear whether TRF really exists. This controversy is resolved in 1962. Researchers then proceed with a more detailed claim, "TRF is a peptide," which is controversial for 6 years. From 1963 to January 1969, some studies support the claim "TRF is a peptide," while other studies support the opposite claim, "TRF is not a peptide." In January 1969, this controversy is resolved, and TRF is definitively considered a peptide. Research continues with an even more detailed claim, "TRF is Pyro-Glu-His-Pro-NH2," which is controversial from January 1969 until November 1969. In this period, some studies support the claim "TRF is not Pyro-Glu-His-Pro-NH2," while others support the opposite claim "TRF is Pyro-Glu-His-Pro-NH2" or still other claims. This controversy is solved in November 1969. From that moment on, TRF is a "developed case": TRF is Pyro-Glu-His-Pro-NH2.

The Terrorism Example

The next example, the "terrorism example," demonstrates how interacting with empirical evidence leads to a detailed understanding of the processes within the case and to the development of a *moderated case* (**Figure 4**).

Between 1981 and 1988, Michel Wieviorka (Wieviorka, 1992) interviewed people who were considered by themselves and the outside world as former terrorists. He interpreted and compared these instantiations to each other and to other cases of terrorism, and he developed the notion of "inversion" as a characteristic of all instantiations of terrorism. Inversion means that terrorists speak "artificially" in the name of a reference group but at the same time distort the ideas of the reference group in such a way that members of the reference group do not see themselves as being represented by the terrorists. As terrorists thus become decoupled from the group they claim to represent, their violence becomes more violent and unstoppable, as outside legitimation fails. Going back to his terrorist interviewees, Wieviorka realized that not all of them fit his developed definition of terrorism.

In the terrorism example, the researcher opens the black box of the case to understand the processes that occur in this specific context, processes that show how one event leads to the other, and that describe the processes that are essential for considering this specific context an instantiation of the case. As a detailed understanding develops, the researcher not only understands *that* a specific context is an instantiation of a particular case, but also understands in detail *how* the processes within the case take place.

The terrorism example transcends the simple claims and detailed claims of the violence example and the TRF example. It describes the processes within the case. It shows how terrorist groups become detached from the reference groups in whose name they claim to operate, and how this leads to inversion, a distortion of the ideas of the reference group. As a result, the reference group no longer considers itself represented by the terrorist group. Consequently, the bond with the reference group disappears and, through this, any control the reference group might have over the terrorist group also disappears. Due to this lack of control, the violence of the terrorist group becomes more severe and unstoppable.

Through this detailed description, the terrorism example creates *integrated claims*: two or more claims that are connected to each other. For example, the claim "terrorist groups become detached from the reference groups" and the claim "terrorist groups start to distort the ideas of the reference group" are connected: terrorist groups become detached from the reference groups, *and as a result*, they start to distort the reference group's ideas.

Researchers use these detailed insights for four purposes: to develop additional and more detailed claims, to understand what their main claim is, to understand how their main claim is moderated, and to understand how this affects what counts as instantiations of the case. First, researchers develop various other and more detailed claims that either apply to all instantiations, and thus to the case as a whole, or to some of the instantiations, and thus to subcases. Examples of such additional claims in the terrorism example are "inversion is the result of the detachment of terrorist groups from the reference group they claim to represent" and "inversion leads to heavier and unstoppable violence."

Second, researchers usually develop a "main" claim of the case. The main claims of the three examples, like other main claims that are the result of several years or decades of research, are claims that are not visible on first consideration of the phenomenon. They are unexpected and insightful: "violence involves pathways around resolving tension," "TRF is Pyro-Glu-His-Pro-NH2," "terrorism is characterized by inversion."

Third, researchers come to understand under which circumstances their main claim does and does not apply. This is called *moderation* of their claim. In the terrorism example, inversion is such a moderator: if inversion does not occur, a terrorist group does not come into being. Similarly, in the violence example, tension moderates violence in the sense that it determines how difficult it is to be violent. As long as the tension is unresolved, violence is difficult; as soon as the tension is resolved, violence can continue for a prolonged period.

Fourth, researchers may reconsider the instantiations of a case. The development of the concept of inversion in the terrorism example showed that not all of the instantiations that had been selected beforehand were actual cases of terrorism: some did not demonstrate inversion. Similarly, in the violence example, Collins argued that Bourdieu's cases of "symbolic violence" were not real instantiations of violence because they lack a resolution between tension and anxiety.

In summary, the three examples highlight a specific process of case development: the TRF example highlights the resolution of a controversial case; the terrorism example highlights the development of a moderated case; and the violence example highlights the development of subcases. Thus, it is clear that case development can involve various processes, and not all of these will always be present.

However, the processes of controversy resolution, the development of subcases, and the development of a moderated case may and often do occur together in the development of a case. When they do, they typically occur in a specific order, as shown in **Figure 5**. Thus, cases often begin with a controversial case (Ragin, 1992; see the TRF example), but not always (see the violence and terrorism examples). The development of subcases comprises a typical way to resolve a controversial case (but not always; see the TRF example). The controversy is resolved by demonstrating that one claim is valid for one set of instantiations, while the opposite claim is valid for another set of instantiations. However, subcases can also develop without a preceding controversial case (see the violence example). Subcases *can* but *needn't be* further developed by showing how they result from a moderating factor, which is present in one subcase but absent in another. Yet, a moderated case can also be developed without preceding subcases (see the terrorism example).

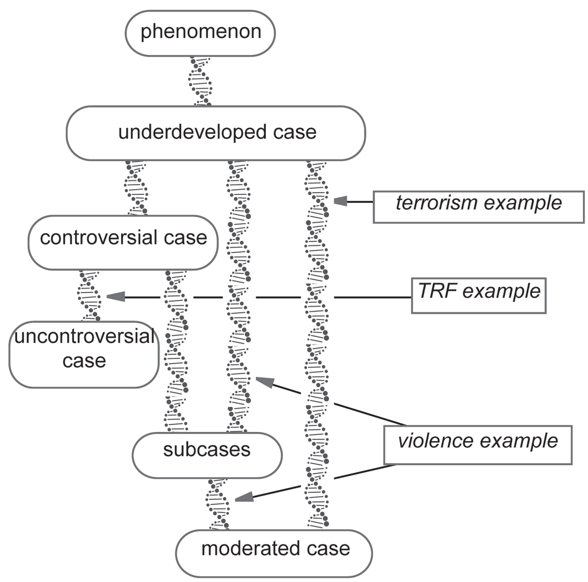

FIGURE 5 | The processes of case development. The DNA double helices indicate the spiraling nature of the analysis processes.

DEVELOPING CASES IN MIXED METHODS RESEARCH

This case development process across studies can also be applied to case development within a study, in particular in a mixed methods study. The main tenet of our article is that we can understand mixed analysis as a process involving the resolution of a controversial case, and the development of subcases, and finally a moderated case. We will demonstrate these processes using two real-life examples of mixed methods research. The phenomena they study are, respectively, the introduction of textbooks at primary schools where textbooks had not been used before ("the textbooks example"), and language-related problems of international students who use English as a Second Language ("the ESL example"). **Figure 6** shows the development of the two examples in one graphic. We can recognize the resolution of a controversial case and the development of subcases and a moderated case, described in the previous paragraph (see **Figure 5**).

The two examples started at a different stage of the case development process (**Figures 5, 6**): the textbooks example started as an underdeveloped case, while the ESL example started as a controversial case. They both next developed into a controversial case, and then into subcases, and then into a moderated case. The studies differed in their design: the textbooks example started by collecting quantitative data only, while the ESL study started by collecting both quantitative and qualitative data.

Figure 6 presents the various processes in relation to two real-life examples. It shows the data analyses performed, with the qualitative analyses in oval boxes and the quantitative

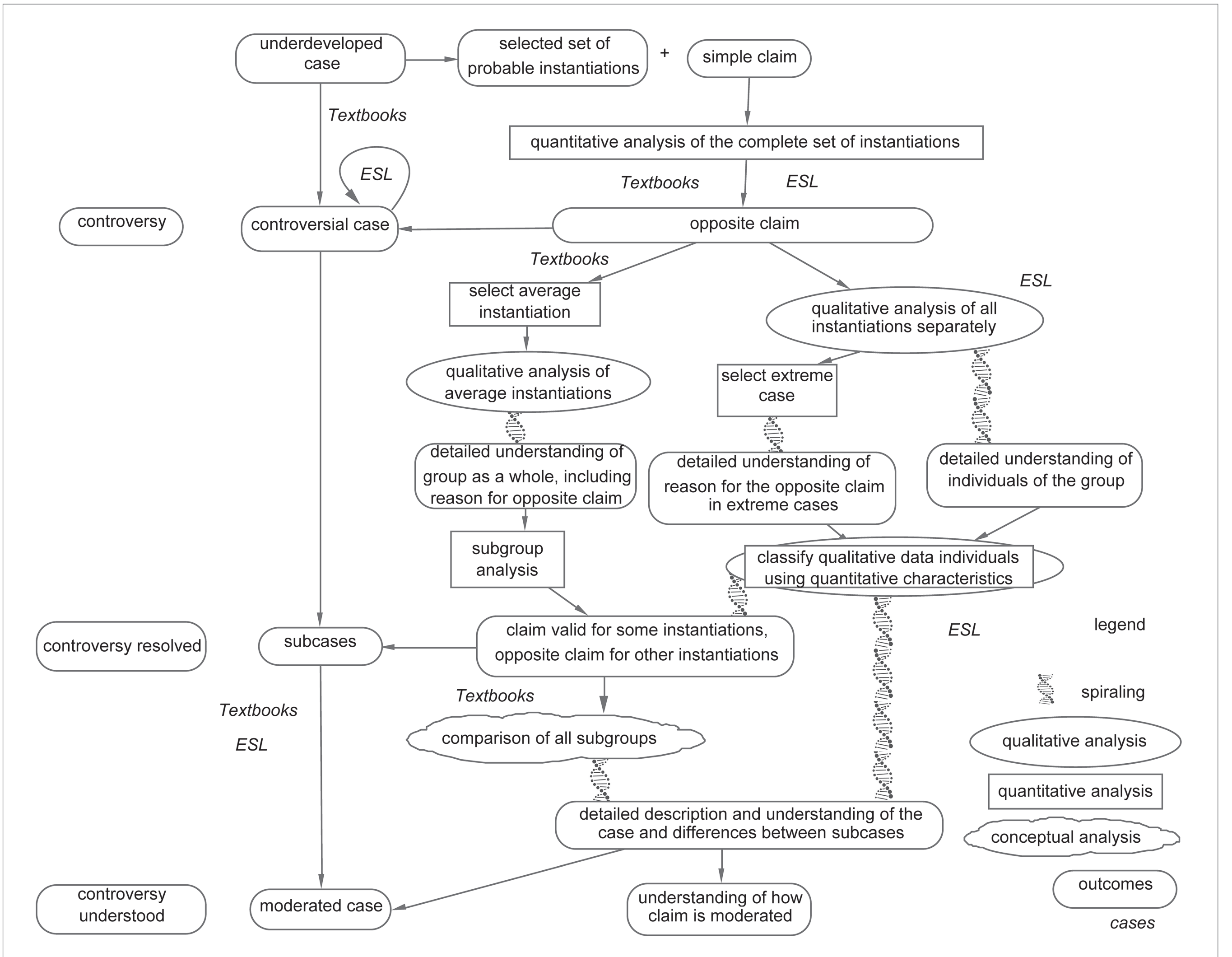

FIGURE 6 | Case development in the textbooks example and the ESL example.

analyses in rectangular boxes. Outcomes are shown in rectangular boxes with rounded edges. Qualitative and mixed analyses that involve a spiraling analysis process are indicated by the DNA double helix that connects the description of the analysis with its outcomes. We will now describe the two examples separately, beginning with the textbooks example.

THE TEXTBOOKS EXAMPLE

From Underdeveloped Case to Controversial Case

As said before, cases typically become controversial for some time: some research studies support a specific claim, while other research studies refute this claim. Individual studies can make a case controversial when they show that a claim previously assumed to be valid does not apply to the instantiations of the study. Showing that a claim does not apply is typically accomplished through quantitative research. Such claim testing was done at the start of both examples. This test was performed using quantitative data analysis, indicated in **Figure 6** as a rectangular box. The quantitative test at the beginning of the textbooks example turned an underdeveloped case into a controversial case:

> In an intervention study by Glewwe et al. (2009), 100 primary schools were randomized to treatment conditions. Unlike previous studies, Glewwe et al. (2009) found that the provision of textbooks to primary school children in rural Kenya had no effect on students' quantitative test scores. (Schoonenboom et al., 2018, p. 274).

As a result of the quantitative test, the case of the textbooks example became controversial: contrary to other sites, where textbooks had an effect on students' quantitative test scores (claim), in rural Kenya, textbooks did not have an effect on students' quantitative test scores (opposite claim). This was achieved through a test that fit the textbooks example as a quasi-experiment. The test measured the influence of one dichotomous independent variable, the intervention, on a continuous dependent variable, the quantitative test scores.

From Controversial Cases to Subcases

After the quantitative test, the case of the textbooks example had become controversial. This controversial case was subsequently developed into subcases (**Figures 1, 6**). This means that the researcher tries to solve the controversy by showing that the claim applies to a subset of the instantiations and does not apply to another subset. The textbooks example proceeded as follows:

> From the quantitative test score list, the researchers selected for each of 50 schools one child with a median score. They went to each school and asked the selected child who scored at the median to read a fragment from his or her textbook and answer a few questions about what was read. This revealed that in the lower grades, most median children, up to 85% in Grade 3, were unable to read their textbook. One of the problems with reading turned out to be that these difficult textbooks were written in English, which was not the children's native language. Not surprisingly, most median children were unable to answer questions about the textbook's contents, thereby supporting the "no effect" derived from the lack of a significant correlation in the quantitative test score analysis. Further subgroup analysis of the quantitative test scores showed that providing textbooks did have an effect on the test scores of high achievers, who were able to read their textbooks (Schoonenboom et al., 2018, p. 274).

The process from controversial case into subcases did not proceed directly. Qualitative analysis was performed to reveal the reason behind the lack of an effect. This knowledge was subsequently used to develop the subcases. First, the researchers obtained a detailed understanding of the reading processes of the children for whom the textbooks failed to have an effect. As they wanted to study in depth the process on average, they decided to observe in depth the "average" child. Thus, they started by using their quantitative data to select a child with a median test score in each class ("select average instantiation" in **Figure 6**). Next, the researchers observed the average children ("qualitative analysis of average instantiations" in **Figure 6**). It became clear that these children were unable to read their textbooks, which were in English, not their native language. Thus, the researchers obtained a detailed understanding of the processes involved and were able to explain why textbooks did not have an effect.

This did not turn the controversial case into subcases yet. For this next stage, the researchers went back to their quantitative data and conducted a subgroup analysis, in which they focused on high achievers, and compared the effect of textbooks on high achievers. This led to the development of two different claims for two different groups: textbooks had an effect for high achievers but not for the other students. Thus, out of the controversial case, the researchers were able to construct two subcases, one case for high achievers, for whom providing textbooks had an effect on their quantitative scores, and one case for the other students, for whom providing textbooks did not have an effect. In this way, they resolved the controversial case. The case was no longer controversial because there was no longer a controversy about whether providing textbooks did or did not have an effect. Instead, they now had an effect for only one specific group: high achievers.

From Subcases to a Moderated Case

After establishing the subcases, the researchers tried to find an explanation for why the textbooks had an effect for high achievers. They tried to identify a factor that was present in the high achievers and lacking in the other students. Such a factor is called a moderator (Hayes, 2017). The factor moderates the effect of providing textbooks on quantitative test scores. They identified this factor through reasoning: if the inability to read the textbooks prevents the average child from learning from them, the high achievers are most probably able to read their textbooks. Thus, while the ability to read the textbook earlier is part of the explanation of the controversial case (the average child lacks this ability), it later becomes the moderating factor, as it explains the existence of the subcases: textbooks have an effect only for those children who can read them.

THE ESL EXAMPLE

Contributing to the Controversial Cases

Different from the textbooks example, the ESL example started as a controversial case, and the ESL example contributed to the controversy:

> Lee and Greene's (2007) purpose was to understand the predictive value of scores on an English as a second language (ESL) test—the Computerized Enhanced ESL Placement Test (CEEPT)—for international graduate students at a large public university in the United States in relation to their academic performance —measured as Grade Point Average (GPA)—and their language difficulties in courses during their first semester. The results of previous studies had been inconclusive. Some studies showed a less than perfect command of the English language had a negative effect on grades, while this effect was lacking in other studies. Lee and Greene correlated the scores of the 100 students who had taken the CEEPT test with their GPAs, which resulted in a non-significant correlation.

The ESL example started as a controversial case. Some studies had shown that language problems had an effect on international students' first semester GPA (claim), while other studies had not demonstrated an effect (opposite claim). As in the textbooks example, the ESL example started with a quantitative test of the claim, which showed a lack of a significant correlation between language abilities and first semester GPA. Thereby, the ESL example contributed to the controversy by providing yet another example in which the opposite claim (no effect) held. Different from the textbooks example, the ESL example was a correlational study, and its variables were continuous variables that were not experimentally manipulated. Data analysis involved establishing a correlation between the continuous independent variable score on the CEEPT test and the continuous dependent variable, GPA.

From Controversial Case to Subcases

Like the textbooks example, development of the ESL controversial case into subcases started by performing a qualitative data analysis to try to find an explanation for the lack of an effect of CEEPT scores on first semester GPAs:

> 100 students had performed the ESL-test, 55 students had done a self-assessment, and 34 faculty members had evaluated their students. Interviews had been held with 20 students and 10 faculty members. "Extreme case analysis showed that students' views of academic success and their perceived levels of background knowledge can help explain low GPAs relative to the CEEPT scores." (Lee and Greene, 2007).

In the ESL example, extreme instantiations, rather than the average instantiation, were selected to explain the nonoccurrence of an effect of language problems on GPA. The extreme instantiations were individuals to whom the effect did not apply, that is, students with a high CEEPT score and nevertheless a low GPA. Next, Lee and Greene (2007) connected their qualitative data to their quantitative data:

> And a display that connected quantitative CEEPT scores to qualitative interview quotations in a table revealed that the CEEPT scores differentially predicted perceptions of academic performance for both students and faculty members. (p. 380).

Combining the quantitative and qualitative data showed that the connection between CEEPT score and GPA was different for different instantiations (individuals).

At this point, Lee and Greene (2007) had not developed subcases yet, but had shown why effects were lacking at the individual level. In a reanalysis, we took Lee and Greene's published data one step further by developing real subcases. In our analysis, we used the quotes that had been published in Lee and Greene (2007) concerning what both successful and unsuccessful students had said about their language problems and how this influenced their GPA.

> We constructed a sortable table, in which the statements of students were put next to their language test score and first semester GPA. By sorting and resorting the three columns of this table, we discovered an interesting pattern. We identified four successful students with the highest GPA of 4 in spite of a CEEPT score of less than 4. Three of the four successful students mentioned some method of compensating for their language problems. One student compensated for his or her misunderstanding of the professor by reading the textbook, another other compensated for problems speaking English by calling on a strong mathematical background, and yet another compensated by careful reading. A comparison with their less successful counterparts showed that the compensation strategies mentioned by three of the four successful students were not mentioned by any of the unsuccessful students. This finding could explain the lack of an effect of CEEPT on GPA: good students have strategies to compensate for their language problems.

We developed this subcase by creating a table in which the qualitative and quantitative data of each individual were shown next to each other. This is displayed in **Figure 6** as an analysis that involves both qualitative and quantitative data (a rectangular box within an oval box). By coding the qualitative utterances and sorting the table on the quantitative scores, we saw that one group with specific quantitative characteristics (a less than perfect CEEPT in combination with a perfect GPA) was characterized by successful strategies for overcoming their language problems. Thus, we were able to distinguish three subcases: students with a less than perfect CEEPT and a perfect GPA, students with a less than perfect CEEPT and a less than perfect GPA, and students with a perfect CEEPT.

From Subcases to a Moderated Case

The three subcases quite naturally led to the identification of the moderator: successful strategies for overcoming language problems. These were mentioned by the students with a less than perfect CEEPT and a perfect GPA, but not by students with a less than perfect CEEPT and a less than perfect GPA. The successful strategies for overcoming language problems prevent the effect of a less than perfect CEEPT on GPA from occurring.

SIMILARITIES AND DIFFERENCES BETWEEN THE REAL-LIFE EXAMPLES

We have provided two real-life examples of mixed methods educational research in which a case is developed within one study. Both examples showed development from a controversial case into subcases into a moderated case. And in both examples, both qualitative and quantitative research played more than one role, and these roles were the same for both examples. In both examples, quantitative data analysis was used at the beginning to test a simple claim, which turned the cases into controversial cases. Also in both examples, the same quantitative data were used to select the cases for the qualitative data analysis that was to provide an explanation for the lack of an effect. Finally, in both examples, the same quantitative data were used in identifying the subcases. In both examples,

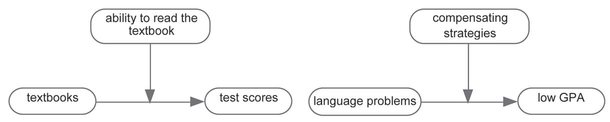

FIGURE 7 | The moderated claims at the end of the study in the textbooks example and the ESL example.

qualitative data analysis was used to obtain detailed insight into the processes of the case. This qualitative data analysis fulfilled two important functions. First, it explained the lack of an effect derived from the quantitative research. Second, it was used to understand moderation, that is, to understand which factor was responsible for the differences between the subcases (**Figure 7**).

The examples differed in the data analysis methods that were used. Data analysis methods were adapted to the specific characteristics of each study. First, the type of quantitative data analysis was different depending on the research design. In the textbooks example, a quasi-experiment, a regression analysis of a nominal variable, the intervention, was used to establish the lack of an effect. In the ESL example, a correlational study, a correlation between CEEPT and GPA was calculated to test the existence of an effect.

The examples also differed in their strategy for sampling instantiations that were used for finding an explanation for the nonoccurrence of the effect. This difference originated in differences between a quasi-experiment (textbooks example) and a correlational study (ESL example). In the textbooks intervention, the researchers tried to find an explanation for the nonoccurrence of an overall effect by investigating the average child as a representative of the experimental group as a whole. In the ESL example, where the independent variable was continuous, the researchers focused on individuals at both ends of the spectrum for whom the effect was not there: individuals with a low CEEPT score and a high GPA, and individuals with a high CEEPT score and a low GPA.

DISCUSSION

Characteristics of the Case Development Approach

The mixed analysis processes described in this article have five characteristics. First, and most importantly, they depend on the status of a case as either a controversial case, a collection of subcases, or a moderated case. In addition to this, mixed analysis processes depend on the fact that, by definition, a case has more than one instantiation; they also enable and make use of rich databases; their claims are always tentative; and their final conclusions may differ in strength. We discuss these last four characteristics first.

The idea that the phenomenon in a case is not unique but that there are always various instantiations of a case distinguishes case development from some forms of qualitative research. If one assumes that a phenomenon is unique, one can acquire deep insights into the processes involved through qualitative research, meaning that there is no need for quantitative research. If, conversely, one assumes that a case is not unique but that there are various instantiations of it, then quantitative research can fulfill some useful roles. For example, it then makes sense, at the beginning of the study, to make a preliminary distinction between instantiations and non-instantiations and to select a set of instantiations for investigation. For this purpose, quantitative data are very useful. Similarly, quantitative data can be used to make a preliminary distinction between various subcases.

Second, data collected for case development are typically used more than once and for different purposes. In both examples, quantitative data led to the identification of controversial cases and/or subcases, while qualitative data led to a detailed understanding, and combining the two led to the identification of moderation. The database was not only used once, for testing a claim, but was also used for sampling and in developing subcases and determining moderated factors.

A third characteristic of our approach is the tentativeness of the claims, the case, and its instantiations. This became most clear with the controversial cases. The two controversial cases were only temporarily controversial. Both were developed into subcases during the study. In the end, the textbooks example consisted of two subcases: one group of instantiations to which the effect did not apply and another group of instantiations to which the effect did apply. The ESL example did not end with one group of instantiations for which language problems did not affect GPA. Instead, for one specific group—students with compensation strategies—the effect did not apply, while for another group of students with language problems, the effect did apply.

As a result, the relevance of the claim of the controversial case to the whole set of instantiations is temporary as well. At the end of the study, it is no longer important to know whether textbooks have an overall effect for the whole set of instantiations, or to know whether language problems overall have an effect on GPA. Once the researcher has described and understood the moderating factors, the overall effect loses its meaning.

Fourth, there is one remarkable difference between the two examples at the end of the analysis process: the status of the moderated claim or, more precisely, the strength of the evidence for the moderated claim. The evidence in the textbooks example was strong. The qualitative research in the textbooks example was targeted at one possible moderator: the ability to read the textbooks. Detailed information was acquired regarding the question of whether the average child could read and understand a textbook. Yet, the evidence concerning why there was an effect for high achievers remains implicit: it was assumed, rather than tested, that high achievers are able to read their textbooks. The evidence in the ESL example is very weak. It is only a first conjecture. Nevertheless, it is an interesting conjecture that is worth further investigation.

The extent to which the claims are generalizable is different as well. None of them can be generalized statistically, as none of them involves a randomly drawn sample. The claim in the textbooks example is a very strong candidate for theoretical generalization: it is very likely that being able to read a textbook is a requirement for being able to understand the contents of the textbooks, and that this is a requirement for textbooks to have an influence on students' grades. Finally, as said above, the claim in the ESL example is a conjecture. It is neither generalizable nor can it be said to be valid for the sample as a whole.

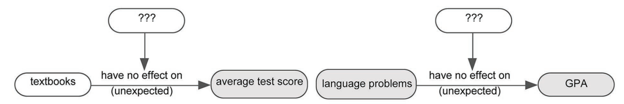

FIGURE 8 | Sampling in the textbooks example and the ESL example. Variables involved in sampling are represented by light grey boxes.

How Knowledge of a Case's Status Can Guide Mixed Analysis

In this article, we presented mixed methods analysis as a process of case development, which typically proceeds by resolving a controversial case and developing subcases and a moderated case. We are now able to distinguish two different ways in which these processes of case development can guide mixed methods researchers through the process of mixed analysis.

First, knowing whether the case is currently an underdeveloped case, a controversial case, or whether it contains subcases or is a moderated case can help the researcher decide which analysis to perform next. When a case is underdeveloped or controversial, the researcher can decide to use quantitative data to test whether the claim applies to the groups of instantiations that they investigate. This group analysis may prove that the claim does not apply, and this either confirms that the case is controversial (ESL example) or creates a controversial case (textbooks example). When the case has already been developed into subcases, the researcher can decide to use qualitative data to discover and develop the moderating factors that distinguish said subcases.

Second, knowing whether one is working toward resolving a controversial case, toward developing subcases, or toward developing a moderated case can also help a researcher to decide which analysis to perform next. If a researcher is working toward the development of subcases, it makes sense to return to the quantitative data to see whether there is a differential effect for different groups.

If a researcher is working toward moderated claims, it makes sense to use qualitative data analysis to uncover the processes in the case and possible moderating factors of the effect. This applies in at least two stages of the analysis process: first, after the quantitative analysis at the beginning, when researchers may use qualitative data to obtain an explanation for the group as a whole. The factors that constitute these explanations are typically those factors that may prove to be moderators later on. Second, after establishing subcases, a researcher may use qualitative data analysis to see whether the processes for the subcases are different, in which case they have discovered moderating factors.

Knowing that one is working toward the development of a moderated case can also be used by the researcher to determine the sampling strategy. **Figure 8** shows the moderated effect in the two studies, with the as yet unidentified moderated factors as question marks.

In the textbooks example, the researchers knew after the first quantitative test that textbooks did not have an effect on the quantitative test scores on average. Therefore, it made sense to select individuals representing the "average child" to investigate what moderating factor caused the nonoccurrence of the effect in this group. In the ESL example, the researchers knew after the first quantitative test that language problems unexpectedly proved not to affect GPA. Therefore, it made sense to investigate various combinations of CEEPT scores and GPA, to see under which circumstances language problems lead to a lower than expected GPA.

In summary, we have demonstrated that knowledge of a case's status can guide mixed methods research in various ways. But the general purpose that we have formulated for mixed methods research acts as a steering guide as well. In the introduction, we formulated the general purpose of mixed methods research as *to acquire detailed insight into the case, the subcases, and the way the subcases are moderated.* In both examples, researchers did achieve insight into their case, their subcases, and the moderated case. Thus, the outcomes of both examples are remarkably similar, in spite of considerable differences between the examples at the beginning. Our general purpose in mixed methods research puts the case, the subcases, and the moderated case in a specific order and can thus be used as a basis for what to do next. The researchers of both examples used this order. When their case was controversial, the researchers next resolved the controversy by developing subcases; and when they had developed subcases, the researchers went on to understand the moderators that led to the subcases.

Relation to Other Approaches

Several approaches to mixed methods research state that qualitative and quantitative research provides different perspectives on a phenomenon. These different perspectives were called, for example, "variance theory" versus "process theory" by Maxwell (2013) and Mohr (1995). Variance theory, according to Maxwell et al. (2015), is connected to quantitative research, in which causality is studied on the basis of connections between variables. Process theory, aimed at describing events and processes that connect these events, is "fundamentally different from variance theory as a way of thinking about scientific explanation" (Maxwell et al., 2015, p. 227). Different perspectives are also a characteristic of Greene (2015), who described an example of a mixed methods evaluation as a combination of a postpositivist strand, using a quasi-experiment, and a constructivist strand, using mini-case studies.

Our approach is different. We do not consider qualitative and quantitative research as providing different perspectives but rather as playing two different roles within one overall perspective. While Maxwell (2013) and Greene (2015) related qualitative research to studying cases, *we view both qualitative and quantitative research as playing different roles within a case development approach*. For Maxwell and Greene, the question remains how to combine the different perspectives, how these different perspectives actually work together in a study (Mol, 2002). This question is answered in our approach, by stating that qualitative and quantitative research work together in developing cases and their claims. In this development process, we view qualitative data as necessary for obtaining detailed insight into the processes within the case and for understanding moderation, and quantitative data as necessary for identifying possible instantiations of the case, for testing claims, and for distinguishing subcases.

The case development approach includes an approach to sampling, which is similar to Emmel (2013). Handbooks on qualitative and mixed methods research provide many different methods for sampling individuals (among others Patton, 2014). In our approach, the choice of the sample depends on the status of the claims and the moderation that the researcher is investigating (see **Figure 8**): researchers should sample their individuals on the basis of their values on the dependent variable related to the claim (quantitative test scores in the textbooks example and GPA in the ESL example), and, if relevant, on the basis of their values on the independent variable related to the claim (CEEPT score in the ESL example).

Our approach to research as case development has consequences for our view on triangulation. Traditionally, triangulation is considered an attempt to support or reject a specific claim. This form of triangulation is found at the beginning of our cases, where testing a claim led to a controversial case: the claim was not confirmed. In our approach, however, *the outcome of testing a claim only has temporary relevance*. Testing claims has to be followed by attempts to resolve controversial cases by developing subcases and by understanding the moderating factors. Triangulation is not the aim or the end result of a mixed methods study, it is only the beginning. The aim of mixed methods research is detailed insight into the case, including the start claim and/or more differentiated claims, and how they are moderated.

Our approach is different from a grounded theory approach. Both within a study and over time, the process of case development has two characteristics: first, it develops through a stage of being a controversial case, in which some studies support one claim, while other studies support the opposite claim. This stage of a controversial case was visible within our two cases. A second characteristic of our approach is that claims become more detailed over time and that they change (think of the TRF example). Thus, the theory does not gradually emerge from the data but instead goes in many and sometimes conflicting directions. Any new study may lead to new insights and further developments. That means that we do not work according to the principle of theoretical saturation (Emmel, 2013; Becker, 2014).

We agree with many mixed methods scholars that design is very important. In our approach, it is important that researchers think very carefully about the quantitative and qualitative data they collect. One reason is because researchers go back to their collected data several times. At the beginning, researchers will use their quantitative data for testing an effect. Later on, they will use the same data to select a sample for qualitative research. Still later, they will return to their quantitative data to perform a subgroup analysis. Similarly, they will first use their qualitative data to explain the effect or lack of an effect derived from their quantitative research, but later they will use the qualitative data to describe the processes of the case and to investigate moderation.

The stages and type of analyses used for our case development process do not depend on the order in which the quantitative and qualitative data are collected. Our examples differed in their design: the ESL example started as a concurrent design (Creswell and Plano Clark, 2018), in which quantitative and qualitative data were collected at the same time. The textbooks example started as an explanatory sequential design with the collection of quantitative data only, later followed by qualitative data collection. Yet the case development process and the type of data and analysis used were the same: first developing a controversial case by testing a claim using quantitative data, then proceeding toward subcases by first trying to explain the lack of an effect through analysis of qualitative data and using the quantitative data to select a sample for this qualitative data collection or selection. Then, the qualitative data in combination with the qualitative data are used to establish subcases. Finally, in both example cases, the researchers tried to understand the moderating factors.

We have presented our approach as if it were a general approach to mixed methods research. Of course, we cannot prove the usability of our approach as a general approach on the basis of just two examples, but we have reasons to assume that the approach might provide a good basis for mixed methods in general. First, the approach proved able to describe two mixed methods studies that at first sight appeared to be quite different, one being an experiment, the other a correlational study, and one being a sequential design, the other a concurrent design. We have applied the approach successfully to two additional different examples, which we cannot include here due to lack of space.

Second, we saw that we can use our approach both for describing mixed methods studies and for the development of research more generally, across research studies. This adds to the credibility of our approach. Actually, the ESL example is partly a case across studies because we developed the subcases ourselves on the basis of an existing study by Lee and Greene (2007). At a minimum, we can say that our approach is applicable to a range of studies and particularly to mixed methods studies.

AUTHOR CONTRIBUTIONS

JS performed the research and wrote the article.

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Episode of Situated Learning to Enhance Student Engagement and Promote Deep Learning: Preliminary Results in a High School Classroom

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Teaching is now experiencing a new centrality due to the fast socio-cultural transformations, the vertical growth of digital media and, therefore, the new ways children and young people learn. New paradigms and teaching methodologies are emerging to meet the new educational needs; among them, the "Episodes of Situated Learning" approach (EAS in Italian) was chosen for this study. This approach broadly refers to the "Flipped Class" model, in which the lesson structure reverses the traditional teaching/learning cycle with a positive outcome on engagement and learning. The present study aims to explore whether the EAS teaching methodology, according to literature about the Flipped Class model, has a positive outcome on student engagement, focusing on its emotional, cognitive and behavioral components. In particular, we hypothesize that the EAS teaching methodology changes teachers' behavior in classroom, increasing their movements and body expression during the lesson. Moreover, we expect higher levels of self-efficacy and positive emotions and lower levels of perceived anxiety in teachers, thus improving students' level of engagement. The research was conducted in a secondary school, in Milan, and includes a classroom of sixteen students and three teachers. We chose a quasi-experimental nested design, a mixed-method approach that combines the qualitative and quantitative collection and analysis of data, in order to reach, as far as possible, a holistic, effective and exhaustive representation of the studied phenomenon. Pre-post measures, including video-recording, systematic observation and questionnaires, of both students and teachers were collected during the 8 months of experimentation. This research project could foster positive outcomes for participants as well as the broader society, in which school dropout is increasing. Many authors positively associate low levels of students' engagement to high rates of school dropout; for this reason, working on improving teaching methodologies and students' engagement measurement, could be an effective way to enhance learning and opposing school dropout.

Keywords: flipped class, EAS, observation, mixed methods, qual-quan integration, engagement

INTRODUCTION

School, today, has to be restored and transformed into a "school of independence" (Mariani, 2017), where didactics have to become more experiential (Freinet, 1978), reflective, in a way that provides disciples with meaningful learning, deep and stable in time. In this perspective (Rivoltella and Rossi, 2012), schools should grant teachers the necessary conditions to implement an effective and authentic learning context, where learning individuals have the opportunity to train their skills in an active and participative environment, developing significant learning (Ausubel, 1968), with a clear transformative effect (Dewey et al., 1974).

The variables involved in developing a relevant impact on the efficacy of teaching and learning processes are many: teachers' motivation, emotions and self-efficacy (Bandura, 1982) positively impact their perceived working satisfaction and decrease *burnout* symptoms, while also being beneficial to their disciples (Moè et al., 2010). Motivation, for example, can also be fueled by being close to motivated people. Teacher-student relationship does not only transmit certain contents, but also the desire and motivation to improve their learning experience. This consideration becomes particularly relevant when considering the fact that motivated teachers perceive themselves as capable to face specific situations, increasing, as consequence, the self-efficacy perceived by their students (Anderson et al., 1988): therefore, it is important to invest in making the "belief to be able to make it" become an ever more present belief in classrooms.

The communicative effectiveness in teaching and learning processes is not exclusively influenced by the teacher's psychological perceptions, but it appears to be strictly and significantly correlated to the *immediacy* construct (Mehrabian, 1967; Martin and Mottet, 2011). Immediacy can be defined as the kind of communication that increases closeness between two people, and its associated behaviors express "easier approachability," availability for communication, transmitting "warmth" and nearness (Andersen, 1985; Mazer, 2013). Several research studies have shown that, during any kind of communication, visual contact, proximity, posture facing toward the interlocutor and smiling, all constitute indicators that develop communicative intimacy, attraction and trust (Burgoon et al., 1984).

Given the above premises, the Flipped Classroom model (Baker, 2000; Lage et al., 2000), defined within *process-oriented* models (Perla, 2012), becomes significantly more relevant, especially considering the objectives of this work, since it includes all the necessary features to favor conditions useful to the development of a significant learning environment. The term "flipped" refers to the methodology, because it inverts the traditional order of the teaching/learning cycle in didactic actions. According to this method, a student approaches new information through autonomous work that usually happens at home and, once at school, the learning process sees the students involved in reworking, sharing and discussing their assignments (Bergmann and Sams, 2012).

The Flipped Classroom methodology was shown to be effective from a "student engagement" perspective (Fredricks et al., 2004), a construct that literature has shown to be significantly related to the development of learning (e.g., Connell et al., 1994; Boekarts et al., 2000). Engagement is to be intended as a multi-dimensional construct that comprehends, in its nature, diverse components that are intrinsically related. For this reason, in accordance with Fredricks et al. (2004), engagement is to be thought as a "meta-construct," involving behavioral vectors (e.g., positive conduct, active contribution during class), emotional ones (e.g., positive emotions, sense of belonging to the institution, low anxiety levels), and cognitive ones (e.g., learning strategies and self-regulation). When considered as a synergic whole, it can describe the student experience in a comprehensive and holistic manner (Buskirk, 1961; Connell and Wellborn, 1991; Finn, 1993; Guthrie and Anderson, 1999; Wigfield and Guthrie, 2000; Stipek, 2002; Trowler, 2010).

Therefore, we can affirm that behavioral, emotional and cognitive matrixes incorporate a wide variety of constructs, highlighting the clear multi-dimensionality of engagement, as discussed by Fredricks et al. (2004), p. 65 in terms of "construct inclusiveness."

Summing up the relationship between the quoted constructs, we can affirm that, through a Flipped Classroom planning, it is possible to foster engagement in students (e.g., Mok, 2014; Clark, 2015), making the learning process more effective and significant.

This research project takes in consideration the Episodes of Situated Learning, ESL[1] ("Episodi di Apprendimento Situato," EAS in italian; Rivoltella, 2013) as a relevant case study in the Italian context. The ESL model is a Teaching and Learning Activity (TLA), part of many didactic models and capable to foster meaningful learning opportunities (Rivoltella, 2017). Like the Flipped didactics, ESL can provide students the opportunity to link contents before coming into the classroom, through activities aimed at increasing interest and curiosity. Nonetheless, ESL didactics present a three-way structure, with three main work phases, each one comprising specific actions by teacher and students (Rivoltella, 2017). The first, anticipatory, phase, is focused on the student's problem-solving ability, and gives space for discovery. In this phase, the teacher organizes the work the students will do at home, giving it an "anticipatory" function concerning the class's contents. During the class, the teacher will provide a conceptual framework to organize the acquired contents and finally give the students a stimulus accompanying an assignment. The second phase is an operational one, where the teacher asks the group of students (or an individual) to follow an activity that will result in sharing a product made by the person/group. The third phase is dedicated to restructuring, when teachings are revised, corrected, re-formed. ESL ends each class with the teacher recalling the main concepts discussed, underlining the most important aspects to remember and correcting any misconceptions.

The objective of the ESL didactics, furthermore, is to facilitate a kind of deep learning (Ausubel et al., 1953; Gardner, 1999; Novak, 2001; Ausubel, 2004): the term denotes a learning that results by the assimilation of an experience (or new knowledge) with previous knowledge.

[1]The ESL acronym has not to be confused with the same mentioned in Packler's work (1959): in this case "ELS" indicates a didactic model theorized by Rivoltella (2013) in the Italian context.

The Present Study

The current study's objective is to present preliminary results collected by observing one of the classes involved in a broader research, randomly extracted from the total sample.

The research project aims to explore and describe how ESL didactics differentiate from the traditional didactic employed by teachers. The objective is also to highlight the ESL model's features, as well as the possible differences with traditional didactic styles, where the usual class structure involves the frontal transmission of its contents. Specifically, the study will focus on the teacher's classroom management, on his/her didactic actions and the proxemics shown in class.

Considering what we proposed, a further objective is to create a *systematic observational grid* (Aureli and Perucchini, 2014) that would integrate dimensions and indicators corresponding to each investigated construct.

On a second level, the research aims to show how ESL didactic is an effective methodology by the perspective of student Engagement, in its behavioral, emotional and cognitive components, in line with the main theoretical evidences regarding the Flipped Classroom model. We also expect that an increase in engagement will favor a decrease in perceived anxiety, in both students and teachers.

Two hypotheses will be investigated by this study:

> **Hp1**: The ESL model favors higher levels of scholastic Engagement in students, in all three components, and reduces their level of perceived anxiety.
>
> **Hp2**: The ESL model favors higher levels of scholastic Engagement in teachers, in all three components, and reduces their level of perceived anxiety.

MATERIALS AND METHODS

The methodology implemented to reach the objectives stated and test the presented hypotheses will be mixed, combining collection and analysis of quantitative and qualitative data (Greene and Caracelli, 1997).

Specifically, we will use a nested quasi-experimental design (Creswell et al., 2003), with pre-test and post-test measurements, and the collection of different data:

- Quantitative data: observed frequencies gathered from the systematic coding of video-recordings, validated self-reports;
- Qualitative data: pen-and-paper observations, qualitative *ad hoc* questionnaires, focus groups.

The choice to adopt a mixed method is encouraged by the idea that this kind of approach can offer an effective and holistic interpretation of multi-componential constructs, such as the Engagement one, in complex environments such as the scholastic one (Anguera et al., 2012; Castañer et al., 2013; Camerino et al., 2014).

The comparison of quali-quantitative data also allows to reach better inferences, to increase data validity and the possibility to reach a superior level of comprehension of the phenomena, which could be lacking in a single-method study (Johnson and Onwuegbuzie, 2004).

Sampling

The study was conducted at an Upper Secondary School in the province of Milan, Italy. The Institute, not far from the city center, offers two different study curricula, a "classical" one and a "linguistic" one.

Before the actual beginning of the research project, approval by the Ethical Committee of the University of Milano-Bicocca was requested and the committee expressed their consent, through sharing of *Protocol n. 324*.

The study saw the participation of 15 teachers (35.7% male and 64.3% female, average age: 41) and 5 classes (2 from the "classical" curriculum, 3 from the "linguistic" one) including a total of 101 students (26.7% male and 73.3% females; 20 students per class on average). Sample size was calculated using an expected Effect size of 0.40 (Cohen's f: 0.40 "large") and 0.80 Power (1–β). All teachers included in the study were observed at work with a specific class; therefore, each class was observed (both before and after teachers' training) with three different teachers and subjects. This choice was made to guarantee that each class would be involved for an equal and balanced number of hours, according to the ESL model, and to partially control the effects deriving from teaching different subjects.

Considering inclusion and exclusion criteria, we remind that this study included role teachers, who spoke Italian as mother tongue, with a minimum of 2 h of class per group, without any experience with the ESL didactic model, nor any knowledge of its theoretical principles and modalities. Concerning the students, all recipients of the scholastic educational offer (*Piano Offerta Formativa*, POF), attending 11th and 12th grade, who expressed their consent to participating in the study and received consent by their parents, were eligible for this study.

The choice to select students from the 11th and 12th grades, excluding the 13th [last year of Secondary School (2nd grade) in Italy], was made to have a homogeneous sample and, consequentially, homogeneous data.

In accordance with the University Ethical Committee guidelines, informed consent was given via written form by all participants (students and teachers) and parents of the students.

Instruments and Measurement

What follows is a panoramic view of the instruments and measures used in the study (for a summary see **Table 1**).

Self-Report Questionnaires

Ad hoc questionnaire on initial expectations

Before the project's beginning, teachers' initial expectations were investigated: for this purpose, we made an *ad hoc* qualitative questionnaire, including open questions and attitude scales. This questionnaire was designed to collect qualitative information in order to better understand and interpret data from the systematic observation and the other psychometric instruments.

MESI

Teachers' perceived self-efficacy was investigated through the MESI questionnaire (*Motivations*, *Emotions*, *Strategies*, and *Teaching*), built and validated in Italian by Moè et al. (2010).

TABLE 1 | Observed dependent variables and adopted instruments.

Teachers	Students
Initial expectations: *Ad hoc qualitative questionnaire*	**Behavioral engagement** *SEM (item 1–4)* *Systematic observation of video-recordings* *Pen-and-paper observations*
Satisfaction and self-efficacy *MESI (Motivations, Emotions, Strategies and Teaching)*	**Emotional engagement** *SEM (item 5–10)* *Pen-and-paper observations*
State emotions *PANAS (Positive and Negative Affect Schedule)* *Pen-and-paper observations*	**Cognitive engagement** *SEM (item 11–17)* *Pen-and-paper observations*
State anxiety *STAI T/S (State-Trait Anxiety Inventory)* *Pen-and-paper observations*	**State emotions** *PANAS (Positive and Negative Affect Schedule)* *Pen-and-paper observations*
Class management, didactic actions, proxemics *Systematic observation of video-recordings* *Pen-and-paper observations*	**State anxiety** *STAI T/S (State-Trait Anxiety Inventory)* *Pen-and-paper observations*
Final impressions/opinions *Ad hoc qualitative questionnaire*	**Final impressions/opinions** *Focus group*

PANAS

State emotions perceived by teachers and students during the observed class were measured by administering the PANAS (*Positive and Negative Affect* Schedule). The questionnaire, validated in Italian (Terraciano et al., 2003) asks the participant to express, on a 5-point scale, the level of intensity of each emotional state felt at the time of answering the questionnaire.

STAI T/S

Trait and state anxiety were measured through the STAI questionnaire (*State-Trait Anxiety Inventory*) in two versions: the first, concerning the usual levels of anxiety perceived by the participant, the second concerning anxiety perceived at the time of answering the questionnaire. This questionnaire, also validated in Italian (Pedrabissi and Santinello, 1989) as a 20-item scale, asking to indicate the degree of agreement with statements on a 4-point scale.

SEM

Behavioral, emotional and cognitive components of Student Engagement were investigated through a self-report questionnaire. The Student Engagement Measure (SEM) was chosen because of its three sub-scales, each one referring to one of the dimensions constituting the Engagement construct as we are considering it. The questionnaire was translated and adapted from the English version (Fredricks et al., 2011) through *back translation* and it includes 17 items (4-Behavioral engagement, 6-Emotional engagement, 7-Cognitive engagement) on a 5-point scale.

Ad hoc questionnaire on satisfaction and final impressions

As conclusion for the proposed project and once third phase measurements are finalized, we investigated opinions and final impressions by all participants. The teachers received an online questionnaire created for the purpose, comprising open and multiple-answer questions.

As for the questionnaire about initial expectations, this questionnaire was also designed to collect qualitative information for a better understanding and interpretation of data.

Focus Group

Opinions and impressions perceived by the students were also investigated through a final focus group, proposed to all classes involved once measurements were finalized.

Proposed activities included moments of discussion and workshop where, through active confrontation with other members of their class, participants could express their opinions based on experiential reflections.

Results from the thematic analysis of the focus group are still ongoing and will not be presented in this article.

Pen-and-Paper Observations

During the observation period, the researcher was present in the classroom and took note of personal impressions and events that would otherwise be excluded by the systematic observation conducted subsequently. In this case, the focus was on teachers and students alike, with no pre-established target variables.

Systematic Observation Grid and Coding Software

Systematic coding of target behaviors was possible thanks to the creation of a systematic observation grid (see **Supplementary Material File**) based on literature review during the first pilot study (cfr. par. Pilot study) through a series of context-specific trials that allowed to adapt the instrument in a way that would be effective before its actual implementation. The grid was subsequently implemented in a coding software, which made the procedure quicker and drastically reduced the margin for errors, resulting in clean datasets, immediately available for further elaboration and analysis. The details for both instruments follow:

The grid was planned so that all dimensions would be distinct, homogeneous, exhaustive and mutually exclusive: a first dimension requires for the researcher to define if the activity is "on," or if the lesson has been interrupted; in the latter case, the researcher will select the "off" category and move to the next one. All the temporal segments judged valid, were then coded by 7 main dimensions. The first refers to lesson management and has 4 distinct categories referring to the individual or the group that are mainly managing that didactic segment and include: *teacher*, *student*, *independent group*, and *independent individual*. The second dimension refers to the main didactic actions the teacher uses in the classroom; there are 10 categories (some examples: *introduction*, *presentation*, *clarification*, *knowledge teaching*).

The coding grid also includes some dimensions referring to the teacher's proxemics in the classroom. Three different criteria define this dimension: the first is *proxemic orientation* and requires the researcher to identify who the teacher is speaking to, for example the whole class, a group of students, a single one; the second criteria concerns the position the teacher is occupying in the room (*proxemic position*), while the third refers to transitions (*proxemic transition*).

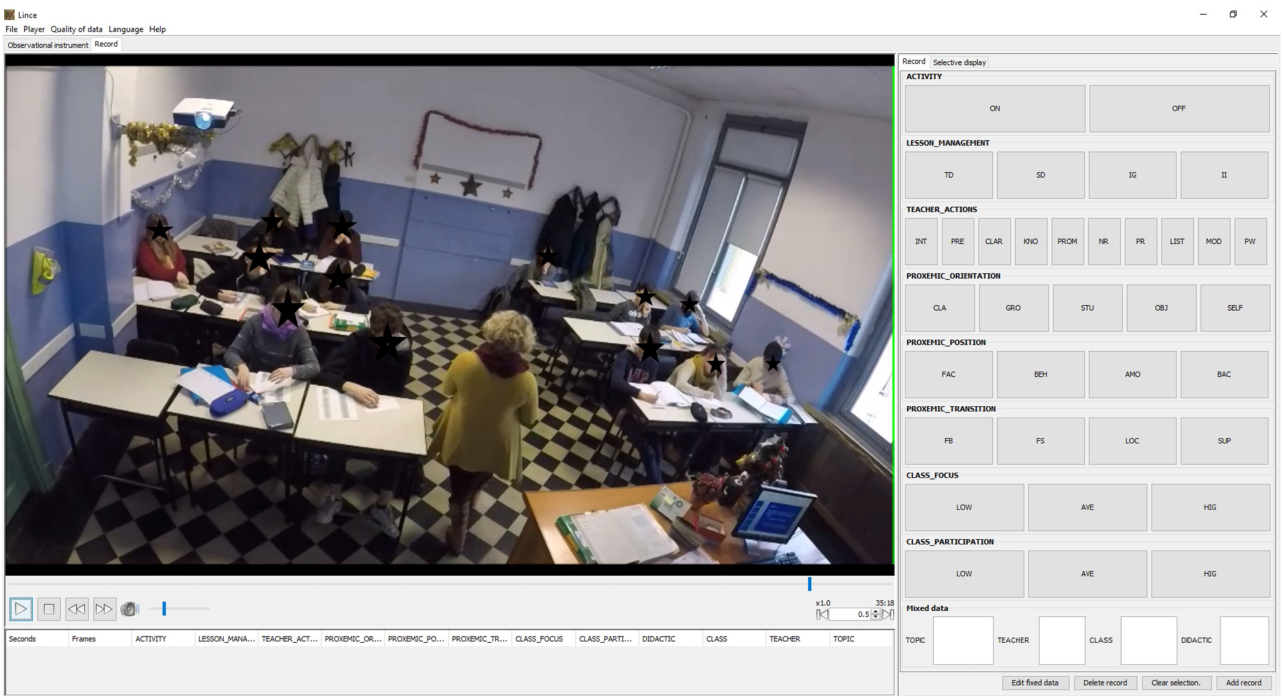

FIGURE 1 | The LINCE software interface. Informed consent and authorization for the publication of this image was given via written form by all participants (students and teachers) and the students' parents.

The grid, as mentioned above, also includes two dimensions investigating the behavioral component of engagement, specifically *attention* and *active work* by students, as well as the students' *level of participation* during the lesson. In this instance, agreement between observers is crucial, since these categories require the researcher to judge the level of attention and participation in the classroom on a low, medium and high scale.

The choice to exclude the systematic observation of behaviors belonging to the emotional and cognitive components of Engagement is mainly due to the difficulty, also found in literature review, to isolate clear and objective evidences concerning behaviors that refer to partly subjective and hardly observable dimensions.

Coding software

The grid was used with the support of LINCE software (Gabin et al., 2012; Hernández-Mendo et al., 2014), which made the adopted procedure much easier, i.e., systematic observation on a temporal basis (Aureli, 1997), where time divided in 30-s segments was considered as a useful sampling unit.

The software, first developed for the observation of sport performance (e.g., Cavalera et al., 2015; Diana et al., 2017), has been proven particularly suitable for the observation and coding of behaviors in general (e.g., Casarrubea et al., 2018; Diana et al., 2018), due to its clear and easy interface (see **Figure 1**[2]).

[2]Informed consent and authorization for the publication of this image was given via written form by all participants (students and teachers) and the students' parents.

Procedure and Data Collection

Measurement within subjects (before and after formation) of the dependent variables discussed above. Time was considered the independent variable in two points (T0 pre-training measurement; T1 post-training measurement).

The study was organized in four distinct and inter-dependent stages (see **Table 2**), from September 2017 to February 2018, for a total of 6 months. The instruments presented were used in different modalities and times, related to the study's objectives and investigated construct. What follows is a sum up of each stage of the study, defining administration methods for each instrument.

Pilot Study

A pilot study was conducted in the participating classes. Main objective of this stage was to allow participants to have a period of familiarization, in order to decrease the observer's influence on behaviors during class. To maintain a proper ethical profile on this study, in fact, it was not possible to implement a disguised observation; during video-recordings with the researcher, while trying to render it as less intrusive as possible, the camera was

TABLE 2 | The research scheduling.

September 2017	October 2017	November 2017	December 2017	January 2018	February 2018
1. Pilot Study	2. Pre-training measurements		3. EAS training	4. Post-training measurements	

not completely hidden. The familiarization period was organized in two distinct phases: the first one saw the researcher go to class with no recording devices, 1 h per class. Subsequently, the recording instruments were introduced in the classroom and the researcher explained they were turned off. Another hour per class was spent with the devices off.

The second objective for the pilot study was to prepare the experimental setting, identifying the position for the cameras and the researcher so that they would not interfere with the process. Two GoPro Hero5 cameras were used to video-record the lesson periods with external microphones for the elimination of background noise, allowing for a clear audio recording. To allow for a good visibility of the environment and classroom dynamics, cameras were placed on opposite ends of the room: the first was behind the teacher, while the second was in the back of the classroom, to have a shot of the teacher from the front. The wide-range shooting angle offered by the cameras allowed for a good total vision, without having to exclude anything from the shot. Having fixed cameras allowed to decrease the interference usually associated with a researcher moving around the room, capturing each behavior or participant involved. The experimenter, depending on the width of the room and disposition of school desks, mainly stationed in the back of the room, so as not to enter the students' field of vision.

The third objective functional to the first stage was to define measurement instruments, specifically the coding grid used to conduct the systematic observation of target variables. The grid was built basing on related literature and was subsequently tested and revised before the actual implementation: it includes exhaustive and mutually exclusive categories for each dimension, thus allowing for a systematic coding on a temporal basis (Harrigan et al., 2008; Castañer et al., 2010, 2016).

Pre-post Training Measurements

Generally, measurements collected before the training class aimed to define a pre-training baseline, through the repeated measure of different dependent variables; these included, for the teachers, *initial expectations*, *teaching strategies*, *proxemics*, *classroom management, perceived self-efficacy* and, for students, *behavioral*, *emotional*, and *cognitive engagement*.

The fourth stage of the project, implemented at the end of the training course, included post-measurements, which investigated, other than the same dependent variables measured in the first stage, the final impressions of teachers and students concerning the proposed research project. In this case, objectives were to investigate the effectiveness of the training course in terms of skills learned, as well as the effectiveness of the ESL didactic model in terms of perceived school Engagement.

Training Course on ESL Didactic Model

The second stage of this research involved a training course, free and certified, offered to all teachers involved in the project and conducted by a CREMIT (Center for Research on Education for Media, Information and Technology) expert. The objectives of this stage were mainly to introduce the ESL didactics, explaining its theoretical bases and methodological structure and provide teachers with useful skills to plan and implement ESL didactics in class. The training course was provided on a weekly basis in a Blended mode and saw the teachers involved in four training meetings (3 h each), mainly featuring workshop activities.

During the training course, each teacher was able to build a realizable ESL program, in line with their own subjects and didactics planning, to implement later (during the post-training observations) with the assigned class. Teachers were asked to conduct their lessons according to their usual didactics style before the training course (during the pre-training observations), while they were asked to propose the ESL planned during the training for the post-training observations.

The presence of a CREMIT expert was crucial in allowing and guaranteeing every teacher to plan an ESL lesson following the correct theoretical model and its related methodological structure.

A final meeting with the teachers and students involved will be held at the end of the project. The objective will be to share the main evidences emerged and discuss impressions and feelings about the experience. This stage is currently under scheduling.

DATA ANALYSIS AND RESULTS

All teachers who took part in the experiment were observed with their assigned class (before and after the training). Each teacher-class combination remained the same for the duration of the study, in order to allow for a stable observation and a within subjects design. Following, the preliminary results from one of the five classes involved (3 teachers and 24 students, before and after the teachers' training), randomly extracted from the sample will be discussed.

Systematic Observation

Encodings were carried out by two trained observers, who viewed and coded all the recorded material using a 30 s temporal unit. Inter-rater agreement was calculated through Cohen's k (Cohen, 1960): categories included in the coding grid showed a high level of agreement, never below 0.824 (see **Table 3**).

In order to maximize comparability between the two didactics modalities observed (usual teacher's didactics vs. ESL didactics), the length of the observation period (in terms of coded time units) has to be as equivalent as possible. Therefore, we decided to randomly delete excess encodings (ESL classes, on average, lasted less than the teacher's usual ones), obtaining 172 temporal units for each observed didactic modality (344 temporal units in total).

Kurtosis and asymmetry for all variables observed ranged between −2 and +3.56, describing a "normal" data distribution (Barbaranelli, 2007).

TABLE 3 | Inter-rater agreement values.

Category	Agreement rate (Kappa)
Class management	0.978
Teacher actions	0.953
Proxemic: orientation	0.974
Proxemic: position	0.968
Proxemic: transition	0.968
Class focus	0.824
Class participation	0.900

TABLE 4 | Differences in class management between usual lessons and EAS lessons.

Usual lesson		Frequency	Percentage	% valid
Valid	Teacher	154	89.5	***89.5***
	Student/s	6	3.5	3.5
	Group Work	11	6.4	***6.4***
	Individual Work	1	0.6	0.6
	Total	172	100.0	100.0
Missing	System	/	/	
Total		172	100.0	
EAS lesson		**Frequency**	**Percentage**	**% valid**
Valid	Teacher	15	8.7	***8.8***
	Student/s	59	34.3	34.5
	Group Work	97	56.4	***56.7***
	Individual Work	/	/	/
	Total	171	99.4	100.0
Missing	System	1	0.6	
Total		172	100.0	

Bold values represent the most relevant results.

Teacher in Classroom

Class management appears to be drastically different depending on the didactic model used. As **Table 4** shows, time spent handling the class by the teacher's self significantly changes between conditions: while during a traditional lesson the teacher manages the class for almost 90% of the time (89.5%), ESL lessons see the value decrease to 8.8%, consequentially increasing space for autonomous work and moments where the students are the ones managing class.

Considering the didactic actions, data shows how, while usual didactics see the teacher presenting new content to the class for more than half the time (58.7%), ESL lessons show no sign of this kind of intervention, with a related increase in the number of times the teacher is listening to the students (their requests, reflections, sharing of their work with the class group, etc.) and clarifying their doubts. These two didactic actions were coded, respectively in 34.9 and 19.2% of cases (see **Table 5**).

Taking the teacher's proxemics in consideration, in its three variants, it is interesting to note how the teacher, during a usual lesson, mostly addresses the class (79.1%), occupying frontal space from the students' perspective, between the teacher's desk and the blackboard.

During ESL lessons, the teacher addresses more frequently specific groups of students and increases didactic moments of nearness to the students, in the middle of the room where school desks are usually placed (see **Tables 6**, **7**).

Table 8 shows proxemic transitions by the teacher, which do not suggest a significant change between the two styles.

Students in Classroom

Students' attention during ESL lessons improves significantly: moments when most of the class is actively focused on the lesson's contents increase by 54.7%, while moments when attention is judged as low decrease by almost 40% (see **Table 9**).

TABLE 5 | Difference in teacher actions between usual lessons and EAS lessons.

Usual lesson		Frequency	Percentage	% valid
Valid	Introduction	7	4.1	4.1
	Presentation	**101**	**58.7**	**58.7**
	Clarification	*5*	*2.9*	*2.9*
	Knowledge testing	41	23.8	23.8
	Providing materials	/	/	/
	Negative reinforcement	6	2.3	2.3
	Positive reinforcement	/	/	/
	Listening	*5*	*2.9*	*2.9*
	Moderating debate	/	/	/
	Personal work	9	5.2	5.2
	Total	172	100.0	100.0
Missing	System	/	/	/
Total		172	100.0	100.0
EAS lesson		**Frequency**	**Percentage**	**% valid**
Valid	Introduction	12	7.0	7.0
	Presentation	/	/	/
	Clarification	33	19.2	***19.3***
	Knowledge testing	/	/	/
	Providing materials	4	2.3	2.3
	Negative reinforcement	/	/	/
	Positive reinforcement	/	/	/
	Listening	60	34.9	***35.1***
	Moderating debate	/	/	/
	Personal work	62	36.0	36.3
	Total	171	99.4	100.0
Missing	System	1	0.6	
Total		172	100.0	

Bold values represent the most relevant results.

TABLE 6 | Proxemics differences between usual lessons and EAS lessons _orientation.

Usual lesson		Frequency	Percentage	% valid
Valid	Class	154	79.1	***79.8***
	Group	/	/	/
	Student	10	5.8	5.8
	Object	1	0.6	0.6
	Self	7	4.1	4.1
	Total	172	100.0	100.0
Missing	System	/	/	
Total		172	100.0	
EAS lesson		**Frequency**	**Percentage**	**% valid**
Valid	Class	22	12.8	12.9
	Group	86	50.0	50.3
	Student	1	0.6	0.6
	Object	/	/	/
	Self	62	36.0	36.3
	Total	171	99.4	100.0
Missing	System	1	0.6	
Total		172	172	

Bold values represent the most relevant results.

TABLE 7 | Proxemics differences between usual lessons and EAS lessons_position.

Usual lesson		**Frequency**	**Percentage**	**% valid**
Valid	Facing	159	92.4	92.4
	Behind	1	0.6	0.6
	In the middle	9	5.2	5.2
	Giving the back	3	1.7	1.7
	Total	172	100.0	100.0
Missing	System	/	/	
Total		172	100.0	
EAS lesson		**Frequency**	**Percentage**	**% valid**
Valid	Frontal	135	78.5	***78.90***
	Behind	/	/	/
	In the middle	31	18.0	***18.0***
	Giving the back	5	2.9	2.9
	Total	171	99.4	100.0
Missing	System	1	0.6	
Total		172	100.0	

Bold values represent the most relevant results.

TABLE 8 | Proxemic differences between usual lessons and EAS lessons_transition.

Usual lesson		**Frequency**	**Percentage**	**% valid**
Valid	Standing	43	25.0	25.0
	Sitting	123	71.5	71.5
	Walking	5	2.9	2.9
	Support	1	0.6	0.6
	Total	172	100.0	100.0
Missing	System	/	/	
Total		172	100.0	
EAS lesson		**Frequency**	**Percentage**	**% valid**
Valid	Standing	37	21.5	***21.6***
	Sitting	126	73.3	73.7
	Walking	1	0.6	***0.6***
	Support	7	4.1	4.1
	Total	171	99.4	100.0
Missing	System	1	0.6	
Total		172	100.0	

Bold values represent the most relevant results.

TABLE 9 | Differences in attention and active work between usual lessons and EAS lessons.

Usual lesson		**Frequency**	**Percentage**	**% valid**
Valid	Low focus	67	39.0	39.0
	Average focus	96	55.8	55.8
	High focus	9	5.2	5.2
	Total	172	100.0	100.0
Missing	System	/	/	
Total		172	100.0	
EAS lesson		**Frequency**	**Percentage**	**% valid**
Valid	Low focus	/	/	/
	Average focus	68	39.5	21.7
	High focus	103	59.9	***76.7***
	Total	171	99.4	100.0
Missing	System	1	0.6	
Total		172	100.0	

Bold values represent the most relevant results.

TABLE 10 | Differences in active participation between usual lessons and EAS lessons.

Usual lesson		**Frequency**	**Percentage**	**% valid**
Valid	Low partic.	163	94.8	94.8
	Average partic.	1	0.6	0.6
	High partic.	8	4.7	4.7
	Total	172	100.0	100.0
Missing	System	/	/	
Total		172	100.0	
EAS lesson		**Frequency**	**Percentage**	**% valid**
Valid	Low partic.	68	39.5	***39.8***
	Average partic.	/	/	/
	High partic.	103	59.5	***60.2***
	Total	171	99.4	100.0
Missing	System	1	0.6	
Total		172	100.0	

Bold values represent the most relevant results.

Active participation by the students also seems to be increased during ESL lessons, judging by the indicators values: during usual lessons, the class is completely involved in 4.7% of cases, while ESL lessons see that percentage increase by over 50%, and moments when the students' participation was judged as low decreased by 55.3% (see **Table 10**).

Psychometric Questionnaires: Teachers

To accurately describe and evaluate each considered variable, we conducted paired samples t-tests. Perceived self-efficacy by the teachers (MESI) did not show any significant change ($p = 0.427$); no significant change for perceived emotions (PANAS) during teaching activities was found as well ($p = 0.303$).

Perceived anxiety (STAI S) during usual lessons and ESL lessons appears to be slightly higher during ESL (+1.6 points). These changes were not found to be significant ($p = 0.701$).

Psychometric Questionnaires: Students

All questionnaires were analyzed through paired samples t-tests. The SEM (Student Engagement Measure) highlights positive results for each of the three components constituting the Engagement construct: scores on each sub-scale significantly increase for both Behavioral, Emotional, and Cognitive Engagement.

Table 11 summarizes scores obtained and significance for each result. The level of total perceived Engagement increases to 11 points.

Finally, considering emotions felt by the students (PANAS) during the lesson, it is possible to notice a significant change regarding positive emotions in the classroom. Considering all questionnaires administered, we see how students perceive higher

TABLE 11 | Student Engagement (SEM), pre- and post.

CLASS 3		*Mean*	*Means difference*	*p*
Pair 1	**Eng. Tot. Pre**	50.7917	−11.75	0.000
	Eng Tot. Post	62.5417		
Pair 2	Behavioral Pre	15.3333	−2.54	0.000
	Behavioral Post	17.8750		
Pair 3	Emotional Pre	18.1667	−4.54	0.000
	Emotional Post	22.7083		
Pair 4	Cognitive Pre	17.2917	−6.67	0.000
	Cognitive Post	21.9583		
	Cognitive Post	21.3125		

TABLE 13 | Perceived anxiety (STAI S) by students, pre- and post.

ANXIETY	Mean	Standard deviation	Std. Error difference	Means difference	t	gl	*p*
Anxiety Pre	39.2667	9.72689	3.07591	3.40000	1.402	9	0.194
Anxiety Post	35.8667	5.23332	1.65492				

levels of positive emotions and lower levels of negative ones during ESL lessons; the former see an increase of about 11 points, while the latter decrease by 4 points. T-tests show a significant change only on the first (positive emotions, see **Table 12**).

Through paired samples t-tests analysis, it was possible to notice how perceived anxiety in students (STAI S) during usual lessons was higher than the one perceived during ESL lessons. Results are not statistically significant (see **Table 13**).

Expectations and Final Reflections by Teachers: *Ad hoc* Questionnaires

Expectations

The initial expectations questionnaire administered to the teachers highlighted their curiosity and interest toward the project addressing them; adjectives used by the three teachers were "curiosity" and "interest." The reflection concerning strengths and weaknesses in the proposed approach highlighted, on one side, a desire for the training to be interesting and stimulating, and the preoccupation it would be too tiresome or even useless on the other. In this case, teachers used adjectives such as "stimulating" and "interesting," as well as "tiresome," "time-consuming," and "useless."

Examining the scores given by teachers to the sentences offered by the questionnaire, wide expectations are detected regarding the acquisition of new teaching strategies and new digital instruments in support of teaching. Low expectations were expressed concerning acquisition of new manuals for professional education.

Final Reflections

As stated above, after the video-recording stage, all teachers were administered with another questionnaire, mainly aiming at collecting opinions and subjective impressions that could contribute to the interpretation of quantitative data. What follows is a quick summary of each of the seven questions comprised in the questionnaire, highlighting thematic cores extracted by reading the analyzed answers.

The first two questions asked, in general, about the main strengths and weaknesses in ESL didactics found by teachers.

On a fully shared perception emerging, is that of a stimulating teaching way, both for teachers and students ("*it forced me to think of a relationship between a subject and contemporary suggestion*"), as well as an engaging experience ("*students are free to participate in a more direct manner*," "*involving them in first person*").

Among the critical elements that were found, the most important seems to be its time-consuming nature ("*time-consuming, because it requires more hour than a usual lesson on the subject to prepare*").

The third question asked teachers if, according to their own personal experience, the ESL approach facilitated participation and involvement in students. The teachers responded positively in all cases.

The fourth question asked teachers to reflect on the class atmosphere perceived during the ESL lesson, detailing a change when compared to the usual climate. In this case, teachers reported an improvement of their relationship with and cooperation between students ("*the climate in the classroom is different: in the beginning, everyone is fairly skeptical, because of the "new approach" they have to confront with, but during the practical stage a good work and cooperative climate establishes between students*").

The two final questions addressed emotions and feelings by the teachers when they were managing their teaching actions. The first question asked to state the main emotional states perceived ("*calm*" and "*comfortable*" were the main answers), while the second question addressed personal satisfaction with the work done ("*yes, I am very satisfied*").

In conclusion, a multiple-choice question addressing future intentions on the use of ESL didactics asked if the teachers would use the ESL method again. The three teachers included in this article have expressed their intention to use ESLS didactics again in 100% of cases, choosing the answer "*yes, surely*."

TABLE 12 | Emotions (PANAS) perceived by students, pre- and post.

Perceived Emotions	Mean	Standard deviation	Std. Error difference	Means difference	t	gl	*p*
Emozioni Positive Pre	76.300	14.46874	4.57542	−11.18496	−3.477	9	0.007
Emozioni Positive Post	87.500	15.36410	4.85855				
Emozioni Negative Pre	41.400	13.99365	4.42518	4.10000	−1.204	9	0.259
Emozioni Negative Post	37.300	9.32202	2.94788				

DISCUSSION

The observational grid used to encode video-recordings represented the main result for this work. The objective was to build the observation instrument and, secondarily, to verify whether its implementation would produce coherent results. From this perspective, the instrument presents a good internal reliability, allowing replication and decreasing the number of errors due to misinterpretation or subjective beliefs in observers (Hintze et al., 2002). The choice of a closed set of categories (exhaustive and mutually exclusive) and behaviors that occur within them, forces the researcher to a previous and clear conceptual analysis, other than a better pre-definition of categories, therefore producing a better result in terms of validity and an advantage in terms of reliability (Aureli, 1997; Castañer et al., 2010, 2016). The implementation of the coding grid in LINCE software has also allowed to collect wide-ranging datasets with a variety of immediately available data for different kinds of analysis, optimizing research times.

The more explorative objective of this work was to describe how ESL didactics differentiate from the traditional didactic acted by teachers and highlight the peculiarities of the ESL model; preliminary evidence shows how the ESL approach involves the teacher and the student in an active construction of didactic action, in a different way from the habitual practice (Rivoltella, 2014). Going further than the mere exposition of didactic contents, the teacher becomes more involved in the relationship with the students: not only explaining things but also listening to them, their questions, clarifying doubts, expressing appreciation toward the students, asking questions and encouraging active participation, getting closer by decreasing the usual proxemic distance separating the teacher from the class. The evidence underline how an ESL teacher can transmit availability for communication and psychological immediacy, indicators of communicative effectiveness and positive linked with students' interest and involvement on the learning process (Andersen, 1985).

Furthermore, class management is defined as a shared dynamic, where the students themselves co-construct the teaching action: students are less likely to perceive themselves as passive recipients of an educational offer and more likely to actively live the learning process (Dewey, 2004). In this perspective, the student is the first actor of the teaching play and the teacher does not limit to apply pre-ordered didactic models; educational practice become a continuous search for the most effective ways to shape teaching and learning processes through the construction of a shared meaning. Results shows how ESL didactics seems to encourage teachers to occupy the central space of the classroom, and move between desks, more than what usually happens with a positive impact on students' attention.

The first hypothesis stated that the ESL model favors higher levels of scholastic Engagement in students, in all three components, and reduces their level of perceived anxiety). Preliminary results from this study show a clear and significant positive correlation between ESL modality and Student Engagement in all its components; the decrease in anxiety was not found to be significant.

Active and participative involvement of the students emerges univocally from different kinds of data and analyses. Students have expressed a positive judgment of the experience, describing ESL as a stimulating didactic modality, requiring them to work in first person and, for this, allowing to foster engagement on a behavioral perspective.

From the emotional point of view, students experienced more, and more intense, positive emotions, and a higher level of satisfaction perceived during the ESL; this evidence is confirmed focusing on the STAI item "I feel satisfied," which responses were widely more positive after the ESL lessons. In fact, a satisfied student is the one who perceives to have a personal role in what he/she does, having to choose the best strategy to reach established objectives (Moè et al., 2010) as it happens in every-day life, where the individual is called to be a protagonist and has to take adaptive decisions (Goldberg, 2005).

The ESL didactics seems effective on a Cognitive Engagement perspective as well; results from the SEM questionnaire show that students employ a higher level of effort, and adopt cognitive strategies, to foster effective learning (for example by trying to watch TV shows dealing with the topics brought in class, or by reading "extra" books to deepen what has been learned). These dynamics create the necessary conditions for the student to be strategically involved, fostering significant learning (Ausubel, 1968) and the establishment of relationships between the old and the new meanings. In fact, students report themselves trying to regulate their attention, creating connections between different information, actively monitoring their comprehension level through self-evaluation and all of these are effective strategies.

The first hypothesis is therefore partially accepted, since the decrease in anxiety was not found to be significant.

The second hypothesis stated that the ESL model favors higher levels of scholastic Engagement in teachers, in all three components, and reduces their level of perceived anxiety. Preliminary results from this study show that Engagement levels seem to not change significantly; analyses highlighted a slight increase in perceived anxiety and a decrease in the self-efficacy judgment.

The teachers probably perceived the project proposal as new and challenging, provoking a higher psychological activation. As underlined by in-depth qualitative information, teachers define the planning of an ESL lesson as highly time-consuming and hardly repeatable during the course of the school year (mostly because of curricula structure). Perceived self-efficacy, referred to the belief a person has in him/herself and their capabilities, represents a relatively stable component and it is possible that a better assessment could be obtained through a longitudinal study (e.g., Caprara et al., 2011) and/or a different measurement tool.

The second hypothesis is therefore rejected.

CONCLUSION, LIMITS, FUTURE PERSPECTIVES

Strength points of this work are mainly related to its multi-disciplinary nature, emerged from the heterogeneity of the investigated constructs and the mixed research design, which called for the collection of different kinds of data and the application of different instruments and methods of analysis. This project has included participants from a Secondary School (II grade), increasing the relatively scarce evidence to be found in literature regarding this specific school period. A positive fallout interested the teachers and students involved: the formers were active recipients of a free and certified training, the latter experienced a diverse educational offer, more stimulating and meaningful.

This research could have a positive impact on a broad level: school Engagement is focal for students but also something for a teacher to be considered when planning or evaluating their actions. The correct measurement of this variable could bring an improvement in awareness about teaching practices and could foster deep learning in students. Moreover, ESL didactics seem to represent an effective methodology in terms of school Engagement; defining engagement as an impactful co-variable on dropout levels (Fall and Roberts, 2012), the systematic introduction in the school *curricula* of Teaching and Learning Actions like the ESL model could help in preventing school dispersion.

The main limits of this work are to be found in the sample size and extraction. Furthermore, repeated measurements and follow-ups would have been useful to evaluate the results stability on the long term, considering the continuously changing nature of the environment, where students and teachers represent interested participants of a cycle of growth and evolution. This research concerned state variables as well as stable constructs (such as perceived self-efficacy in teachers), thus it could be useful to replicate measurements over time and to test other instruments for a better measurement. New instruments could be proposed, for example, to monitor change in teachers' emotions and perceived anxiety, important to be considered and measured for future studies.

Academic research could help in improving and suggesting new transformative pathways. On this note, it would be interesting to further improve and test the multi-method measurement protocol used in this work, with the objective of a multi-language validation (both in Italian and English first); this would improve the validity of the results and could allow international collaborations and studies.

Future actions will include further analyses on the entire corpus of data that will provide more evidences; furthermore, the feedback meetings (currently ongoing) will be crucial for the design and development of new research lines and studies on this matter and context.

DATA AVAILABILITY

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations and guidelines of the "University of Milano-Bicocca Ethical Committee," with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the "University of Milano-Bicocca Ethical Committee." with the Protocol Number 324.

AUTHOR CONTRIBUTIONS

IT, BD, and VZ contributed to the method development, study designing, data analysis, and manuscript writing. PR contributed to study designing and data acquisition and coding. ME contributed to data analysis. MC and OC contributed to method development and data analysis. MA contributed to method development and manuscript writing. All authors made suggestions and critical reviews to the initial draft and contributed to its improvement until reaching the final manuscript, which was read and approved by all authors.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01415/full#supplementary-material

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To Mix or Not To Mix? A Meta-Method Approach to Rethinking Evaluation Practices for Improved Effectiveness and Efficiency of Psychological Therapies Illustrated With the Application of Perceptual Control Theory

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Progress in the development of more effective and efficient psychological therapies could be accelerated with innovative and nuanced approaches to research methodology. Therapy development has been dominated by a mono-methodology attitude with randomized controlled trials (RCTs) regarded as a "gold standard" despite the concept of a single methodology being ascribed gold standard status having been called into question. Rather than one particular methodology being considered superior to all others, the gold standard approach should be matching appropriate methodologies to important research questions. The way in which that matching should occur, however, is far from clear. Moving from a mono-methodological approach to mixed-method designs has not been straightforward. The ways in which methods should be mixed, to arrive at robust and persuasive answers to genuine research questions, is not entirely clear. In this paper, we argue that attention to the meta-methods underpinning all research designs will improve research precision and provide greater clarity about the contribution of any particular program of research to scientific progress in that field. From a meta-method perspective, the matter of *what* changed can be delineated from *why* or *how* these changes occurred. Different methods and different types of mixing can be justified for each meta question. A meta-method approach should make explicit the assumptions that guide the development of research designs and also promote the articulation of putative mechanisms that might be relevant. By paying greater attention to assumptions such as how causality occurs, and important mechanisms of change, the mixing of methodologies that are still not mainstream in this area such as routine outcome monitoring and evaluation and functional model building, can occur. By adopting methodologies that focus on learning about a program's strengths and weaknesses rather than presiding over judgments of whether or not the program is deemed to be effective, we will move much closer to a position of being able to understand what programs under which conditions people find most helpful for their purposes.

Keywords: randomized controlled trial, perceptual control theory, effectiveness, efficiency, internal validity, test for the controlled variable

There is little doubt that the provision of psychological treatment is extremely beneficial for many people a lot of the time (Cuijpers et al., 2008). There is equally as little doubt, however, that both the effectiveness and efficiency of treatments could be improved. To a very large extent, the development and evaluation of psychological treatments has relied almost exclusively on a mono-methodological approach, with the Randomized Controlled Trial (RCT) being afforded a privileged position in comparison to alternative methodologies. Despite RCTs being regarded as a "gold standard" methodology and an exponential increase in the number of RCTs of psychological treatments being conducted in the decades since 1980, evidence indicates that both the effectiveness and efficiency of psychological treatments is decreasing rather than increasing (Carey et al., 2017; Weisz et al., 2018), though the interpretation of this finding has been taken to reflect improving methods (Ljótsson et al., 2017).

When scientific activity is deployed to solve a problem, it is generally not considered acceptable to apply rigorous and improved research methods and move *further* from a solution, rather than closer to it. It is difficult to understand the argument, therefore, that, even though our research methods are *improving*, the effectiveness of our treatments, and, by implication, the helpfulness to patients, is *decreasing*. Clearly, a different approach is required in terms of researching what the best solution might be, and how to rigorously and impartially test whether it is effective.

We argue, in this paper, that the different approach that is required is a difference in *kind* as well as in content. We are not arguing simply for switching from RCTs to some other methodology. Nor are we advocating that we should necessarily change from a mono-methodological approach to a mixed-method approach. While mixed-method designs have become increasingly popular and are capable of providing rich data, they suffer from the same problems as mono-methodological approaches when they are used indiscriminately. The quality of mixed-method research is not always easy to determine. Furthermore, there are currently few guidelines or protocols to assist researchers in how to most appropriately mix different methodologies. The United Kingdom Medical Research Council produced pragmatic guidance for those developing complex interventions (Medical Research Council, 2000). While this guidance offers questions that researchers can use to guide their research decision making, along with illustrative case studies, it takes an a-theoretical perspective on the practical steps required to evaluate interventions.

Our position in this paper is that, greater attention must be paid to the "meta-methods" underpinning all research designs. We use the term "meta-methods" to refer to a researcher's implicit or explicit assumptions about the nature of reality (ontological assumptions) and how that reality can be known (epistemological assumptions), as well as how these assumptions subsequently inform decisions about the most appropriate methodology or methodologies (research strategy) to use and the specific strategies to be employed. It is conventional for researchers conducting qualitative methods to reflect the ways in which their values, experiences, and theoretical and ideological stances have shaped the research process (Berger, 2015). Because of the theoretical assumptions of quantitative research, which have their origins in positivism (Sale et al., 2002), the same level of attention has not been paid to these meta-method issues. For the reasons outlined below, we argue that meta-method considerations should explicitly inform the decision-making process about when and how to mix quantitative and qualitative methods.

We begin by illustrating problems with a mono-methodological approach by highlighting how a commonly held assumption, that RCTs allow causality to be attributed specifically to *interventions* (Sprott and Farewell, 1993), has impeded the development of increasingly effective and efficient psychological treatments. Throughout this discussion, we will highlight relevant meta-method considerations and then, in the second half of the paper, we will outline the meta-method approach in greater detail. In the first part of the paper, we focus on RCTs specifically only because they are an extremely common and an especially highly regarded methodology. It is the general principles we regard as important, however, rather than the way they are applied specifically to RCTs.

We will also propose in this paper that a theory of human behavior, Perceptual Control Theory (PCT), provides a useful basis for meta-method decision-making. When researchers pay more direct attention to the meta-method assumptions *that are already* guiding their decision-making processes with regard to important research decisions, research might become more creative but also more robust and compelling. Research will also become part of a more complete scientific process in which the results of the research are used to inform theories and assumptions (Piantadosi, 2005) about the ways in which a particular aspect of the world "works." The ultimate consequence of creating a cyclical relationship between theory and the research process will be psychological treatments that enable people to create the outcomes they desire with greater effectiveness and efficiency.

It should be stated explicitly at this point that we are making an assumption in this paper that the researchers go about their business in the ways that they do in order to achieve certain purposes. These purposes are related to the beliefs, attitudes, and values that researchers hold with regard to the acquisition of knowledge and the nature of human functioning. These beliefs and attitudes might be implicit rather than explicit. They might also not be fully formed or reasoned. Nevertheless, it is our contention that they exist in some form and have an important role in determining the way in which research is conducted.

PROBLEMS WITH ASSIGNING CAUSATION TO INTERVENTIONS OR TREATMENTS

Methodological problems with RCTs of psychological treatments are well recognized and longstanding (Jadad and Enkin, 2007; Carey and Stiles, 2016). A problem that is perhaps more important, but also less well recognized, concerns the statement about causation which underpins the RCT methodology.

Causality is a meta-method factor that researchers should be required to *explicitly* address when designing programs of research. The causality mechanism underpinning RCTs, however, is rarely explicitly discussed, even though RCTs have been described as "Galilean experiments" (Cartwright, 2010, p. 65). The Galilean term is used to illustrate how the operation of the cause in the absence of interfering factors is analogous to how two objects in a gravity field attract each other with a single force that can be derived from Newtonian principles. As we later make clear, however, this meta-method assumption is questionable when considering that people in research studies are purposeful entities and not inanimate objects moving in space. Meta-method assumptions become more problematic when these assumptions are held implicitly and can lead to methodological decisions that are erroneous.

The fundamental purpose of an RCT is to establish that a particular product or agent *causes* certain results reliably and unambiguously (Sprott and Farewell, 1993). It is causation that the "R" and the "C" are primarily used to address. Random allocation (the "R") and controlled conditions (the "C") are two examples of the meta-method assumptions we are highlighting in this paper. Both of these methodological strategies are instructive in the context of meta-method assumptions because they each have nuances that influence the credibility of research results. Random allocation, for example, does not always occur according to the variables that are important in the delivery of psychological treatments (Carey and Stiles, 2016). This is not a comment on the way in which the allocation process is conducted. Rather, it is a statement about the *relevance* of the variables that guide this allocation. If the purpose of implementing an allocation process is to remove bias and ensure comparability between groups (Suresh, 2011), then it is important to ensure that the groups are comparable according to the variables that are likely to be important in the study. Even when allocation does occur according to relevant variables, however, it needs to be remembered that random allocation is only effective, in terms of establishing equivalence between groups, *on average* across many studies. Despite comparability being a stated purpose of random allocation, this process does not guarantee equivalence of groups *for any particular study*.

The strategy of controlled conditions to improve internal validity has introduced additional problems in terms of creating an implementation gap between experimental studies and routine clinical practice (Carey et al., 2017). Moreover, neither random allocation nor establishing controlled conditions addresses the problems that occur when samples are not randomly drawn from an identified population. Random sampling, however, is a meta-method assumption that appears to be routinely ignored or dismissed in research such as this.

Is the kind of causal statement that an RCT invites actually the statement that researchers who conduct RCTs of psychological treatments want to be able to make in all situations? Given the current design of psychological treatments, with different activities occurring in each session, it is difficult to believe that statements of causality are at the front of researchers' minds during the conduct of this research. In a 12-session program of Cognitive Behavior Therapy (CBT), for example, what is it that can be identified as causal? Is it the sequence of activities, the number of sessions, the types of activities, or something else? It seems unlikely that such a non-specific approach would be as widespread as it currently is if more attention was paid to the causal statements that guide this research. What are the specific features and activity sequences in a manualized treatment protocol that are crucial to *cause* effective changes to occur? Does the client's perspective on these aspects of the treatment protocol affect the assumptions of causality and the purported causal process?

A psychological treatment does not "work" independently of the clinician who is delivering the treatment and the client who is accessing it. That is, effectiveness is not an inherent property of the intervention (Carey, 2011; Carey et al., 2019). Effective outcomes are created by the client in interaction with the resources of the intervention. In the context of assigning causation to the treatment itself, "packages" of treatments have been developed that consist of pre-determined, but arbitrary, numbers of treatment sessions. Treatment manuals do not usually provide justification for the duration of treatments or why all the components of the package are necessary for effectiveness to be observed (Carey, 2011).

A specified number of sessions within a treatment protocol are very consistent with the "dose" model commonly applied in medicine (Carey, 2011). Understanding treatment as having a particular "dose" is another example of a meta-method assumption which has not been explicitly expressed and examined. Conceptualizing psychological treatments in terms of "doses," however, and evaluating the potency of this dose with RCTs, has created two serious problems which will be discussed below. One arises from an error of interpretation and the other is a pragmatic problem.

Improvement and recovery for those people in non-treatment or control arms of RCTs is an example of how interventions cannot be claimed to cause effectiveness in the way that RCT methodologies assume. Invariably, in any RCT of psychological treatment, some participants in the control group will improve more than some participants in the treatment group. One review of wait list and cohort studies estimated that 53% of patients achieve remission from major depression within 12 months (Whiteford et al., 2013). Indeed, it has been estimated that only a third of individuals with mental health problems ever seek treatment (Alonso et al., 2004), so it might be assumed they recover without help. Taken together, these findings highlight how change is ongoing and dynamic, regardless of treatments that are offered. Many people seek informal help – from family or friends – for difficulties, and are likely to do so regardless of treatment (e.g., Brown et al., 2014).

Statements about mechanisms of change, in terms of the way in which they are stated – mostly statistically or conceptually – and the extent to which the stated mechanisms are linked to know biological structures and functions – are further meta-method assumptions that underpin many research designs but are seldom expressed explicitly. The regular scheduling of appointments of fixed duration, for example, is consistent with an assumption that change occurs in a linear, step-wise fashion. Despite evidence that change is frequently non-linear and unpredictable and can be "characterized by sudden disturbance and increased variability in system behavior before reorganization" (Hayes et al., 2007, p. 716), the regular scheduling of appointments remains a standard practice in routine clinical care.

Other work examining treatment as usual conditions of RCTs found that a third of patients achieved remission in this context (Kolovos et al., 2017). Treatment as usual was reported as rarely clearly defined and as a "dynamic treatment condition that is context dependent" (Kolovos et al., 2017, p. 78). This description highlights the difficulty of assigning causality to differences between conditions when the differences themselves have not been articulated. From a meta-method perspective a "dynamic treatment condition" does not provide sufficient detail to adequately inform a decision about appropriate methods to employ. Once again, attention to assumptions of causality at the design stage of the research process might help to address some of these problems.

An Error of Interpretation

The first problem created through the assumption of psychological treatments providing different "doses" of assistance is an error of interpretation arising through flawed logic. By creating a treatment protocol of 16 sessions, and demonstrating, *via* RCTs, that 16 sessions of this particular treatment is associated with better outcomes than 16 sessions of something else (including nothing at all), people such as clinicians, health service managers, and policy makers, seem to have interpreted these results as indicating that 16 sessions are *necessary* for desirable results. Perhaps, if researchers were required, as part of making meta-methods explicit, to justify their decision to formulate a treatment protocol according to a particular number of sessions, these attitudes about how long treatment *should be* would not have arisen. Why are 16 (or some other number) "doses" required to *cause* reductions in psychological distress?

The necessity of 16 sessions, or any other pre-determined number of sessions, has never been established. Evidence that 16 sessions *can* be used to achieve good outcomes is, in no way, a demonstration that 16 sessions are *necessary* for good outcomes (Carey, 2011). This error, however, about what the results of an RCT actually mean, is currently reflected in policy documents such as the National Institute of Clinical Excellence (NICE) guidelines which state that "For all people with depression having individual CBT, the duration of treatment should typically be in the range of 16 to 20 sessions over three to four months" (National Institute for Health and Clinical Excellence, 2009, p. 28). In relation to the treatment of psychosis, NICE recommend that "CBT should be delivered on a one-to-one basis over at least 16 planned sessions" (National Institute for Health and Care Excellence, 2014, p. 22).

The recommendation of a specific number of sessions is especially surprising given that little agreement exists between treatment protocols as to what constitutes an "adequate dose" of CBT for psychosis (Addington and Lecomte, 2012). Guidelines such as these set unrealistic expectations that are not only costly, but lead to undue pressure in service delivery, as well as unacceptably long waiting times. There is also a risk that these guidelines have an unintended consequence of encouraging clinicians to focus more on retaining clients in treatment and less on helping clients achieve the outcomes that are important to them, irrespective of the number of sessions this takes.

A Pragmatic Problem

The second problem created by the "dose" assumption is related to the first but is more of a pragmatic difficulty than an error of interpretation. The establishment of expectations about fixed durations of regularly scheduled treatment protocols creates an inflexibility in treatment delivery leading to inefficient services. There is a substantial and long-standing divide between the number of sessions that treatments are designed to be, and the number of sessions clients typically attend in routine clinical practice (Carey and Spratt, 2009). Furthermore, while treatment protocols are generally delivered in regularly scheduled sessions with weekly or twice-weekly intervals, clients in routine clinical practice rarely maintain a fixed attendance pattern (Carey and Spratt, 2009; Carey, 2011; Carey et al., 2013). This mismatch between the way in which treatments are offered and the way in which they are actually accessed lead to missed and cancelled appointments which, again, imposes an unnecessary financial burden on services and can compromise treatment. Therefore, there appears to be another important meta-method assumption which guides the design and research of psychological treatments but is actually discordant with routine clinical practice.

Further Problems Created by the Preponderance of RCTs

While the problems mentioned above are serious enough, further problems created by the implicit assigning of causation to treatments inherent in an RCT methodology have resulted from the very narrow agenda established by RCTs.

RCTs are extremely valuable for establishing, under very specific conditions, if something achieves a result that something else does not. With regard to psychological treatments, however, many important questions remain unanswered and cannot be answered using RCTs. For example, we still do not understand how psychological treatments help in the ways that they do (Kazdin, 2009). That is, when someone accesses a psychological treatment and, during the course of that treatment, they experience an amelioration or alleviation of their psychological distress, we are still quite some way off from being able to coherently articulate the process by which the distress diminished. Perhaps, it is our unstated and erroneous meta-method assumptions that are guiding decisions about research designs which are impeding progress in this area.

Furthermore, evidence is lacking that identifies what elements of treatments are important for change (Cuijpers et al., 2019). Knowing why or how treatments work would enable us to both correct treatments efficiently when people have problems using them to create desired outcomes, as well as tailor treatments to meet the needs of individuals. It would also allow us to systematically design more helpful treatments. The mechanism of change is an example of a meta-method consideration because it applies whether someone is taking part in a pilot study interview, a clinical trial, or providing feedback in routine care. Whatever method is chosen, researchers should consider the relevance of mechanisms of change and should identify the mechanisms of change that they are implicitly subscribing to in the designs and methodologies they use.

In addition to not knowing how distress resolves, we still do not have a clear understanding of the reasons why it is that people access psychological treatment, though the barriers to accessing psychological help have been more clearly articulated (Salaheddin and Mason, 2016). Indeed, the latter line of research has developed a scale that only explores reasons for *not* seeking help, which is unlikely to shed light on reasons *for* seeking help. The assumption that people seek help for characteristic symptoms of diagnostic conditions may be another implicit, and erroneous, meta-method assumption. It is vital, however, to consider help seeking from the perspective of patients, as patients can be distressed by symptoms in idiosyncratic ways (Carey, 2017). Fried and Nesse (2015), for example, analyzed the symptom patterns of 3,703 people who had all been diagnosed with Major Depressive Disorder (MDD). They found 1,030 unique symptom profiles with 501 profiles being unique to 501 different individuals. Fried and Nesse (2015) concluded that the substantial individual variation in symptom patterns calls into question categorizing MDD as a discrete disorder and may explain some of the difficulty in demonstrating treatment efficacy when only sum-scores are considered.

What informs decision making about the timing of accessing psychological treatment is similarly unclear. Indeed, it is likely to be the case that there are a range of different reasons that people seek out psychological treatment but if we had dependable procedures for establishing what those reasons are, we could target our resources more precisely. Such procedures could form part of a program of research, or be used in the context of routine clinical practice. Again, this would lead to a more efficient use of resources.

Operationalization Problems

Another problem created by the inappropriate assignment of causation to treatment occurs when specifying the Independent Variable (IV) and Dependent Variable (DV). As mentioned above, the underpinning, but rarely articulated, model of causation for RCTs is linear, and it is essential in the conduct of RCTs that IVs and DVs are clearly demarcated (Carey and Stiles, 2016). Unambiguously defining IVs and DVs would be another matter addressed by a meta-methods approach. With an RCT of psychological interventions, the IV is considered to be the treatment being tested, and the response of the client is taken to be the DV. When defined in this way, it can be readily appreciated that the IV and DV change during the course of treatment. Each session of treatment, for example, is different. A protocol of psychological treatment is unlike a protocol of pharmacological treatment in important ways. Moreover, the same session of a treatment protocol will be delivered differently by different clinicians or by the same clinician to different clients. Stiles and his colleagues use the term "responsive regulation" to refer to the phenomenon of the clinician and the patient adapting their conduct with each other in an ongoing way so that they each achieve their goals (Stiles et al., 2008). This entails a trial and error exploration so the client and therapist can identify what topics are pertinent to the client (Stiles et al., 1998). If "responsive regulation" was a meta-method assumption underpinning psychological treatment research, it is difficult to envisage how standardized treatment manuals would be used or fixed schedules of treatment delivery.

Apart from the practical difficulties mentioned above, it is not clear that IVs and DVs are the most appropriate way of conceptualizing variables gathered in studies of treatment effects with humans who have agency and purpose. Consequently, from this perspective, it is difficult to know the most appropriate outcomes to be measured when conducting an RCT. In RCTs of psychological interventions for psychosis, for example, reduction of psychotic symptoms is the most commonly measured primary outcome (Greenwood et al., 2010), despite the fact that there is evidence that symptoms of psychosis are only one of many possible sources of distress for this population and not necessarily the most important ones from the individual's perspective (Griffiths et al., 2018). If an individual does not consider their symptoms to be distressing it would seem inappropriate to use symptom scores as the DV in research investigating treatment effectiveness. Issues such as these would be addressed by a meta-methods approach.

AN ALTERNATIVE TO THE CURRENT TREND – INTRODUCING THE CONCEPT OF META-METHOD

In order to make research more systematic, coherent, and scientific, it is essential that researchers begin to attend to important contextual considerations. Currently, our position is that these considerations guide research design and other research decisions invisibly but forcefully. By not recognizing and articulating coherent meta-method assumptions concerning causality, mechanisms, and so on, their influence on how research decisions are made cannot be evaluated. Researchers might develop more nuanced approaches to these matters if they were required to articulate and examine them explicitly.

Meta-method factors can be grouped into two broad categories with regard to the results of programs of research. The first category incorporates all matters relating to *what* outcomes a researcher is interested in obtaining. The second category includes those matters relating to *why* particular outcomes were obtained in the conduct of a particular study.

Specifically and clearly discerning the *what* and *why* factors in any proposed research will enable researchers to make important decisions about such matters as: which designs to use; how and when to mix methods; and the most appropriate measures to include. Perhaps the most important consideration will be the articulation of a coherent theoretical position that provides a strongly defensible rationale for the decisions that are made. The theory guiding the understanding of how therapy works can also be deployed to guide how it is tested. The section below describes one particular theory to illustrate the way in which a theoretical position can be employed in the manner just described.

Perceptual Control Theory

Perceptual Control Theory (PCT; Powers, 2005) contends that humans, and indeed all living things, function according to the principle of negative feedback. When the results of different actions are fed back to the behaving agent, the agent can control environmental variables according to specified standards. While this control process has been recognized in areas such as homeostasis and cybernetics for many years (Wiener, 1948; Ashby, 1952), Powers' unique insight was to realize that the same principle applied to *all* behavior, at all levels of complexity. Whether it is body temperature, the satisfaction of a relationship, or the progress of a career, that is being maintained, the same control process involving negative feedback loops applies (Carey et al., 2014). The feedback loops are negative feedback loops such that the task is always to *reduce* the difference between the standard that has been established and the current experience. Crucially, Powers argued that the standard is set by a process *internal* to the organism rather than inputted by a human controller as in the servo mechanisms described in cybernetics.

Circular Causality

PCT provides a robust and integrative framework for research in both concept and method. The importance of feedback loops has already been highlighted but PCT also provides an alternative to linear conceptualizations of behavior. From a PCT perspective, circular causation, rather than linear causation, is a more appropriate model for understanding the activity of entities that live. Circular causation should not be confused with circularity. Its importance in understanding behavior has been recognized for over 100 years (Dewey, 1896) but, as a concept, it has been excruciatingly slow to gain traction in the life sciences. From the perspective of circular causality, CVs (controlled variables), rather than IVs and DVs, are more appropriate to investigate. CVs are those aspects of an individual's perceived environment that do not vary according to environmental circumstances. Rather, the individual maintains these variables in a controlled state through acting on their environment.

The difference between DVs and CVs highlights a crucial departure by PCT from standard current approaches to researchers. Whereas it is standard practice to manipulate IVs to look for changes in the DVs, in PCT research, the focus is on identifying that variables (CVs) that *do not change* when IVs are manipulated. While standard research, therefore, focuses on the study of variability, PCT is the study of *invariance* which is more akin to research in the physical sciences. One reason for the power and precision of the physical sciences has been suggested to be the focus on invariance or the common, fundamental, underlying properties of seemingly distinct objects (Carey and Mansell, 2009, p. 128). Adopting this approach, therefore, might assist in improving the rigor and precision of research in the life sciences.

Underlying Explanations Rather Than Superficial Causes

An assumption underpinning the RCT methodology is that causality can be isolated by the manipulation of the treatment conditions compared to the control conditions. Thus, the same causality is extrapolated to future instances without gaining an understanding of what underlying process or processes brought about the effectiveness that was observed. The observations of beneficial effects of a treatment reflect what have been termed "consequences of underlying causes" (Powers, 2005). RCT researchers of psychological treatments, however, have been remarkably lax in the attention paid to underlying causes. Piantadosi (2005) asserts that "a clinical trial alone does not represent a scientific test of a therapy in the absence of a plausible mechanism of action for that therapy" (p. 19). Here Piantadosi (2005) is directly referring to meta-method considerations. Plausible mechanisms of relevance to psychological treatments, however, have been notoriously elusive, providing further evidence of the inadequacy of our current mono-methodological approach.

IMPLICATIONS OF MAKING META-METHOD ASSUMPTIONS BASED ON PCT

The principles of PCT have important implications for the way in which research might be designed including the methods that will be used. In many ways, the activity of researchers who base their work on the principles of PCT will look similar to the activity of researchers who base their work on other theoretical principles. There will, however, be some important differences as well.

Viewing Treatments as Resources Rather Than Interventions

The notion that effectiveness is a consequence of patients interacting with treatments, positions the locus of change in a more appropriate position. As already noted, effectiveness is not something that is imposed on patients but something they create as they use the resources the treatment provides. This is a meta-method assumption that follows from PCT as outlined above, and the theory specifies that standards are internal - only the patient can define what resources are appropriate to enable them to move closer to the life they would like to live. If a resource is not being used by a patient, then that resource, for whatever reason, could be considered inappropriate and, therefore, not a resource at all, from that patient's perspective. Considering treatments as resources, highlights how treatments do not *intervene* to force change in the way that a golf club projects a ball closer to its destination. This metaphor illustrates that the patients are unlike inanimate objects which can be directed from the outside. Instead, they are purposeful agents with their own sense of direction. If a clinician seeks to direct patients in a manner that is discrepant with the direction the patient has in mind, the likely reaction is *resistance to* the efforts of the clinician, resulting in what clinicians may interpret as drop out or treatment resistance. Psychological treatments, as resources, should enable patients to project themselves closer to whatever ultimate destination they intend.

Ongoing Monitoring

The value of ongoing monitoring and evaluation is being increasingly recognized across different health fields (Carey et al., 2019). In the provision of psychological treatment, Routine Outcome Monitoring (ROM) has been demonstrated to be a useful innovation in assisting clients to maintain progress throughout treatment (Carey et al., 2019). In other fields, Continuous Quality Improvement (CQI) approaches have been adopted to improve service delivery (Carey et al., 2019).

While different names and methods are used in different contexts, the consistent theme with these approaches is the ongoing collection of data which is fed back to service providers so that treatments can be modified flexibly and responsively as required to maximize the likelihood of favorable outcomes (Carey et al., 2019). Clients are an important part of this process and data can be collected from a variety of sources in order to improve the accuracy of the information being accumulated. Research from this perspective is considered to be a means of learning rather than a way of making a judgment (Carey et al., 2019). The meta-method assumption following from PCT is that living things are constantly evaluating their experience against what standards they seek to achieve. PCT conceptualizes the process of living as an analogue, rather than as a digital (stop-start), process. For this reason, methods should construct research processes in an ongoing way rather than as occurring at arbitrary points chosen by the researcher.

Perceptual Control Theory and Mixed Method Research

The underlying assumptions of PCT also offer a pertinent theoretical basis for conducting mixed method research. Proponents of mixed method approaches have extolled the advantages of mixing methods over using either quantitative or qualitative approaches alone (Johnson and Onwuegbuzie, 2004). Mixed methods are particularly appropriate when trying to develop complex interventions, such as psychological therapies (Craig et al., 2008; O'Cathain et al., 2013). Reconciling the apparently incompatible epistemologies that underpin qualitative and quantitative methodologies, however, the so-called "incommensurability thesis" (Symonds and Gorard, 2010), has presented challenges for researchers who wish to draw on the relative strengths of both approaches. From a PCT perspective, the meta-method assumption is that there is no inherent contradiction in adopting a position whereby an independent reality is assumed to exist, while simultaneously recognizing that this reality can only be known through our subjective perceptions. Using PCT to reconcile the theoretical positions of quantitative and qualitative approaches provides researchers with the opportunity to draw on a wider repertoire of research methodologies. Indeed, PCT can be considered a meta-theory which makes it especially suitable for assisting with meta-method assumptions. Designing programs of research that incorporate mixed methods might enable us to answer some of the previously intractable questions posed earlier in this article, such as *how* or *why* change occurs for people engaging with particular treatments.

The Method of Levels (MOL; Carey et al., 2009, 2013, 2017) is a cognitive therapy based on the principles of PCT that has used qualitative and quantitative approaches as well as relying on model building to test important theoretical propositions. Over a sustained period of time, MOL has been demonstrated to be an effective and efficient treatment which is flexible and responsive to clients' varying needs. The development of this therapy, and a description of the different methods used, has been described elsewhere (Carey et al., 2017).

METHODOLOGICAL APPROACHES THAT EMERGE DIRECTLY FROM PCT

While PCT has a number of important implications for the meta-method assumptions that either implicitly or explicitly underpin all research, it also has some practical implications for methodological approaches.

The Test for the Controlled Variable

A methodology called the Test for the Controlled Variable (TCV) has been proposed as a means of determining those aspects of the environment an individual is controlling, and has been fully described in a number of articles (Runkel, 1990; Marken, 2014). The process for the TCV involves establishing a hypothesis about a proposed variable an individual is controlling and then systematically applying disturbances or perturbations to the variable while observing the responses of the individual. If the individual responds by removing the effects of the disturbance and maintaining the variable in a particular state, this provides evidence of confirmation of the hypothesis. If, however, the individual does not remove the effects of the disturbance, then the hypothesis is disconfirmed and a new hypothesis is generated. The TCV is a systematic approach to the study of invariance alluded to above.

When considered from a PCT perspective, it can be appreciated that the controlled variable is both the cause, and a consequence, of a respondent's actions, and their behavior is viewed as a manifestation of a closed loop system. This is a useful illustration of the concept of circular causality mentioned earlier. The TCV method emerges explicitly from PCT, rather than being based on looser assumptions about causality described earlier in relation to RCTs. As such, it helps to close the gap between a researcher's meta-method assumptions and the experimental design being used. To date, the TCV has mostly been used in computer tracking tasks with extremely robust results (Marken, 2014). However, an interview technique is currently being developed to explore more abstract variables. This technique is described below.

Model Building

The main approach to theory testing with PCT has been model building whereby functional models are constructed to simulate the phenomenon being investigated at the level of individual participants (Powers, 1989; Bourbon and Powers, 1993). The meta-method assumption being invoked here is that building functional models that simulate the behavior being investigated, is the most exacting form of model building. The term "model" is being used here in the same way that it would be used in engineering: "a precise quantitative proposal about the way some system operates in relation to its environment" (Bourbon and Powers, 1993, p. 51). By relying on simulations from models to test basic assumptions, PCT could be considered to be a theory that behaves. "A theory that behaves, that produces a stream of behavior, would seem in an intriguing way to fit better with Skinner's chief criterion for a good theory than do many more common sorts of behavioral theory. Skinner has argued that a good behavioral theory is a theory on the same level as the behavior itself. What is closer to the level of a behavior stream of an organism than a behavior stream of a theory?" (Shimp, 1989, p. 170).

From a model building perspective, it is the degree of fit between the behavior being investigated and the behavior of the model that has been constructed to understand the investigated behavior, that is the outcome of interest rather, than a level of statistical confidence in the probability of making a Type I error. Simulations are already used extensively in the behavioral sciences (Fum et al., 2007) but this effort has not yet yielded the progress that has been expected or hoped for. This may be because the main tradition of modeling has been to simulate how *behavior is generated* rather than how *perceptions are controlled* to achieve and maintain inner standards (Mansell and Huddy, 2018). Here is another powerful illustration of the importance of meta-method assumptions. When the latter meta-method assumption is made, the level of fit between models and behavior is almost perfect.

One advantage of simulations is they can be used to predict population characteristics based on an underlying theory. This could include modeling whether individuals access therapy, and for how long, based on parameters in the model such as goals, or initial levels of distress. Model building, therefore, could be an additional methodology used to complement quantitative and qualitative approaches to further enhance the rigor of a program of research.

USING A NEW FRAMEWORK TO EXPAND OUR RESEARCH EFFORTS

A different conceptualization of treatment effectiveness, supported both by PCT and ongoing monitoring and evaluation, provides a valuable opportunity to more carefully consider the provision of psychological treatments for enhanced effectiveness and efficiency. In fact, it is our position, that enhancing the effectiveness and efficiency of psychological treatments will *only* be substantially improved by combining a range of different methodologies. By collecting both quantitative and qualitative data from different sources in an ongoing way, important questions about *what* changes occur during psychological treatment can be answered. Also, by incorporating model building methodologies with other methods, important questions about *why* and *how* these changes occur can be answered. Developing the TCV as a systematic approach to interviewing informed by PCT will provide an additional methodological resource for answering *what*, *why*, and *how* questions robustly.

A TCV INTERVIEW

The use of the TCV as an approach to conduct interviews in qualitative research has the potential to improve our ability to understand the aspects of psychological treatments that people find most helpful. When combined with model building methodology, the TCV could also provide useful insights into the mechanisms of psychotherapeutic change, which are still poorly understood (Kazdin, 2009). Based on the same principles as in the example above, once an interviewer has formed a hypothesis about the variables that a participant might be controlling, it should be possible to ask questions that act as potential disturbances to that variable. Assuming that the interviewers' hypothesis is correct, and the questions do act as a disturbance to a CV, the participant's response is likely to serve the function of counteracting the effects of the question. If the participant is found to "push back" against the disturbance created by the question, the interviewer can have some confidence in their hypothesis. If no attempts to resist the disturbance are observed, the hypothesis is unlikely to be correct and another hypothesis should be formed.

Clearly, as with any approach to conducting interviews, it is envisaged that the TCV would be used sensitively. The aim is to generate a disturbance sufficient to test hypotheses regarding the variables that a participant might be controlling, not to cause the participant any discomfort or to withdraw from the conversation. As well as being ethically questionable, disturbances of excessive magnitude are likely to impede the overall interview process.

CONCLUDING COMMENTS

Reorganizing our understanding of the locus of treatment effectiveness from inert treatment protocols to agentic individuals provides an opportunity to ask important questions about treatment effectiveness and efficiency. Combining different methodologies in the conduct of a program of ongoing monitoring and evaluation allows robust answers to these questions to be provided. An improvement in both the effectiveness and efficiency of psychological treatment, through explicit articulation and examination of important meta-method assumptions, will help to reduce the burden of psychological problems and will lead to more contented and productive individuals and communities.

AUTHOR CONTRIBUTIONS

TC developed the concept for the manuscript and drafted the initial version of the paper. VH and RG contributed information and technical expertise and edited, expanded, and modified the manuscript. TC provided additional information and final editing of the manuscript. All authors agree on the final version of the manuscript.

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Optimizing Education: A Mixed Methods Approach Oriented to Teaching Personal and Social Responsibility (TPSR)

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This methodological article provides a Mixed Method approach to analyze how the Teaching Personal and Social Responsibility (TPSR) Model is feasible to enhance student's autonomy. The objective is to detect how teachers' behavior-oriented patterns shift in response to continuing professional development to reinforce TPSR strategies. We compared the application of TPSR by three teachers who had previously attended a training course for this model, with that of an expert in the model. A total of 44 sessions of primary and secondary school semesters in various subjects, taught by all four teachers and comprising 120 students. A mixed-method approach followed in the study involved: (a) the Observational System of Teaching Oriented Responsibility (OSTOR), which revealed how the teachers' behavior patterns shifted over their interventions, and (b) the Tool for Assessing Responsibility-Based Education (TARE 2.0.), which focused on perceived behaviors by teachers and student behaviors. Data analysis was conducted for (a) the T-pattern detection technique, (b) polar coordinate analysis to obtain detailed sequences of instruction, and (c) descriptive and correlational analysis from the TARE. The mixed-method analysis of data confirms how the TPSR improved the teaching behaviors of the three teachers in training compared with the expert teacher.

Keywords: teaching strategies, observational analysis, integration methods, T-pattern detection, polar coordinate analysis

INTRODUCTION

Innovation in pedagogy has been shaped by great paradigms and educational perspectives moving through diverse theories such as the maturational and sociocultural theories that promote the educational involvement of social and cultural agents (Bandura, 1977; Vygotsky, 1978). In order to develop them, however, educational methods range widely from the direct instruction method, where the teacher is the main axis, to constructivist principles or scaffolding, where children build their own learning. Alongside educational methods, various teaching procedures and strategies relating to learning and teaching styles, such as problem-solving, have been deployed (i.e., Kluge, 2008). In sum, paradigms, theories, methods, procedures, and strategies are always linked in order to convey the teacher's style (Castañer et al., 2010, 2013a; Waring and Evans, 2015). In this study we focus on the Teaching Personal and Social Responsibility model (TPSR, Hellison, 1978, 1985) as a pedagogical model that enhance personal and social responsibility.

Enhance Personal and Social Responsibility

The Teaching Personal and Social Responsibility model (TPSR, Hellison, 1978) is a curriculum and pedagogical model based on the assumption that students need to learn to be responsible for themselves and others in order to socially interact in a suitable way (Hellison, 1985), and this is a goal that is implicitly included in current Spanish legislation. "One of the principles on which the Spanish Educational System is based on the transmission and implementation of values that favor personal freedom, responsibility, democratic citizenship, solidarity, tolerance, equality, respect, and justice" (LOMCE, 2013). The TPSR model-based program suggests five levels of responsibility: (1) respect for the rights and feelings of others; (2) self-motivation; (3) self-direction; (4) caring; and (5) transfer "outside of the gym" (Hellison, 2011). Moreover, the TPSR model-based program provides a specific lesson plan format, as well as teaching strategies to support the implementation program, which teachers adapt to their context.

This model is regarded as one of the most effective approaches in terms of developing values in adolescence, given the positive results it has achieved (Escartí et al., 2010a). It has been applied in numerous studies which relate it to improvements in responsibility levels (Hellison and Wright, 2003), self-efficacy levels (Escartí et al., 2010a), cognitive, participation, and relatedness improvements (Likfa, 1990), self-control and sportiness (Cecchini et al., 2007), cognitive improvement (DeBusk and Hellison, 1989), and interpersonal skills (Cutforth and Puckett, 1999), as well as to better grades and lower levels of absenteeism (Wright et al., 2010). Furthermore, life satisfaction and lower academic stress are strongly related to personal responsibility levels and to academic performance (Smithikrai, 2013).

Some of these variables (sportsmanship, violence, and personal and social responsibility) have been linked in studies in PE classes and in school sports, showing how encouraging sportsmanship or personal and social responsibility can prevent violent behaviors (Sáenz et al., 2012). Several studies have demonstrated that although teachers' adherence to the TPSR model was deemed moderate, the strategies they used to foster responsibility were significantly correlated with students' increasingly responsible behaviors (Escartí et al., 2018; Sánchez-Alcaraz et al., 2019). This evidence points to the need for more in-depth educational research in this line of action. In this study we apply a mixed-method approach involving two specific techniques: T-pattern detection, to detect repeated behavioral patterns, and polar coordinate analysis, to detect significant associations between teaching behaviors in various curricular subjects.

Professional Development for Teachers

Continuing professional development (CPD) for teachers is considered crucial for moving away from traditionally dominant pedagogical practices, such as PE practices, to meet the needs of contemporary students (Armour et al., 2017). Unfortunately, there is no clear evidence of an effective form of CPD. Moreover, pedagogical changes among teachers are considered to be evidence-based and dependent upon teachers' understanding of student responses to their instructional approach (Goodyear et al., 2014). Sadly, this is no easy task and demands complex research projects to connect teacher practice and student learning. However, there has been a call to assess the impact of sustained school-based CPD on teacher practices and student learning to gain new insights into the characteristics of effective programs.

Due to the importance of the TPSR as one of the best models for promoting values, responsibility, and life skills, several studies (Pozo et al., 2016) place particular importance on future research going forward in two directions: (a) the TPSR application requires surveillance and professional assessment; and (b) longitudinal studies with follow-up data and *ad hoc* methodological designs. This study takes into account the first direction because the TPSR model emphasizes a strong teacher-student relationship, and throughout the teaching process of the study teachers followed a CPD (Hemphill et al., 2015). Moreover, this study takes into account the second direction because it has implemented a mixed-method design (Anguera et al., 2012, 2014, 2017; Camerino et al., 2012; Castañer et al., 2012, 2013b) that merges quantitative and qualitative data using various methodological tools and techniques.

As the purpose of this research project is to fulfill the need of more in-depth educational research on TPSR and to broaden the knowledge of its effects, the objective of this study was to detect how teachers' behavior-oriented patterns shifted in response to CPD to reinforce TPSR strategies.

MATERIALS AND METHODS

Research Design

Although current pedagogic discourse points out the importance of integrating qualitative and quantitative data using mixed methods research (Creswell, 2003, 2015; O'Cathain et al., 2010), numerous researchers still struggle to merge the two approaches and restrict their research to instruments (i.e., only questionnaires) and data (only quantitative or qualitative) of the same etiology. Fortunately, in the last decade some researchers of pedagogical models—and more specifically the TPSR model—have implemented mixed methods approaches, for example, within the PE context (Escartí et al., 2010b; Gordon, 2010; Hemphill et al., 2015). Thus, by incorporating observational methodology, we also used a mixed methods approach because we had already demonstrated its effectiveness in previous research (Camerino et al., 2012; Castañer et al., 2012, 2016a; Anguera et al., 2014, 2017; Casarrubea et al., 2018).

There is a lack of observational methodology in research relating to TPSR. Therefore, we used systematic observational methodology (Anguera, 2003), which has proven to be effective in teacher strategies and communication analysis (Castañer et al., 2010, 2012, 2013a, 2016b; Alves Franco et al., 2013; Torrents et al., 2013), combined with perceived behaviors by teachers themselves. T-pattern detection and polar coordinate analysis exemplify the most powerful specific techniques of observational methodology which has proven to be effective in previous research (Castañer et al., 2011; Lozano et al., 2016; Fernández-Hermógenes et al., 2017) and could provide essential input on pedagogical research.

Participants

Overall context: the study involved two different schools (one primary and one secondary schools) from a Spanish region with a similar low and middle-level socio-demographic profiles.

Teachers. Four teachers with a similar level of experience in the national educational system (between 5 and 10 year teaching in their subjects) were analyzed, who were labeled as follows:

Teacher 1, PE teacher in the first stage of secondary education (2 lessons per week for 55 min).

Teacher 2, History teacher in the first stage of secondary education (4 lessons per week for 55 min).

Teacher 3, Spanish language teacher in the final stage of primary education (4 lessons per week for 55 min).

Teacher 4, PE teacher in the final stage of primary education (2 lessons per week for 55 min).

The contents developed for each teacher (**Table 1**) in the different subjects where those included in the current Spanish Educational System (LOMCE, 2013). All teachers reached at least the first level of responsibility in lesson 5 and the second level in lesson 10. Teachers 1 and 4 implemented all their lessons in an indoor gym and outdoor courts. Teachers 2 and 3, implemented all their lessons in a usual classroom and a computer room. Teachers 1, 2, and 3 had been trained in TPSR and were unaware of the TPSR methodology (inexperienced teachers in TPSR). Teacher 4 was familiar with the TPSR methodology thanks to an initial training course and 3 year experience (experienced teacher in TPSR).

Students. The study also involved 120 students (57 females and 63 males) aged between 11 and 16 (M = 13.8 years, SD = 2.3), who were taught by the four participant teachers, no one of them had previous experience with TPSR and were selected based on accessibility and convenience. For student age selection, as a point of interest we included the first stage of secondary education, defined according to current legislation in Spain (LOMCE, 2013), along with the final year of primary education, which would mark the boundary between the penultimate and final stages of Piaget's cognitive development (Piaget and Cook, 1952).

The study was carried out in accordance with the Declaration of Helsinki and was accepted and verified by the Ethics Committee of the University of Murcia, Spain (ID 1685/2017). As the observational methodology we use is always conducted over natural context, we observed the natural development of the scholar sessions, therefore written informed parental consent was not obtained for the purposes of research participation and was not required as per applicable institutional and national guidelines. Regarding video recording, the institution has a consent form about image privacy that parents of students enrolling at the school are required to sign. All four teachers signed a consent form in order to participate in the research study, the consent obtained was both written and informed.

Materials

A mixed methods approach was followed in this study: (a) the Observational System of Teaching Oriented Responsibility (OSTOR) adapted from the Spanish version SORPS (Prat et al., 2019a,b) was used to obtain teacher behavior patterns and (b) the Tool for Assessing Responsibility-Based Education 2.0. (TARE 2.0, Escartí et al., 2015) focused on perceived behaviors of teachers and students by two external observers based on the Tool for Assessing Responsibility-Based Education (TARE, Wright and Craig, 2011).

Observational System of Teaching Oriented Responsibility

The OSTOR (**Table 2**) comprised six criteria. Four criteria related to teacher actions: (1) (Expectations); (2) (Explanations); (3) (Organization); (4) (Task adjustments). One criterion related to the student: (5) (Student's responses). And a final criterion related to the last session: (6) (Session summary). Each criterion was expanded to build an exhaustive and mutually exclusive observation system that included a total of 18 categories.

Recording Instrument *(LINCE)*

For recording teaching behavior sequences, sessions were coded using the free instrument software LINCE (v.1.2.1) (Gabin et al., 2012) and LINCE PLUS (Soto et al., 2019). This software program was also used for the data quality check. LINCE has been designed to facilitate the systematic observation of spontaneous behaviors in any situation or habitual context. LINCE is highly practical and easy to use, and integrates a wide range of functions: coding, recording, obtaining data quality, and enabling data export to several data analysis applications. The exported LINCE information was analyzed using two programs for data analysis: (a) THEME software package (Magnusson et al., 2016) for T-pattern detection; (b) HOISAN v.1.6.3.2 (Hernández-Mendo et al., 2014) for polar coordinate analysis.

Assessing Responsibility-Based Education *(TARE)*

Assessing Responsibility-Based Education 2.0. (TARE) by Escartí et al. (2015) was used to obtain teacher and student behaviors coding 3-min intervals. This instrument has already been applied in previous studies (Escartí et al., 2015; Ivy et al., 2018) and has a Likert scale: 0 (Absent), 1 (Weak), 2 (Moderate), 3 (Strong), and 4 (Very strong), and consists of a two-part observation scale:

Student responsibility: (1) Participation: the student is "on task," i.e., following directions and participating in activities or tasks organized by the teacher. (2) Engagement: the student seems to have a high level of interest and motivation for the task

TABLE 1 | Lessons, responsibility levels, strategies, contents, and task examples among the implementation.

Number lesson	Responsibility level and Strategies	PE secondary Teacher 1	History secondary Teacher 2	Spanish language primary Teacher 3	PE primary Teacher 4
1–5	L1 and L5 Introduction to TPSR, responsibility contracts, cooperative activities, conflict resolution	Fitness: tests, strength, endurance, speed and mobility	Prehistory: paleolithic, neolithic and metal age	Vocabulary: types of dictionary Spelling: accentuation rules Grammar: text, paragraph, sentence and word	Cooperative-Opposition games
6–10	L2 and L5 (reinforce L1) Cooperative challenge tasks	Latin dancing: salsa and merengue	Old Age: Egypt, Greece and Rome	Vocabulary: synonyms and antonyms Spelling: accentuation Grammar: Syntax	Volleyball: technique and tactic Physical condition: test and comparison of outcomes
Task example Level 1		Circuit training: in groups of 4–5 people. They have to do a number of repetitions in every station, student may do them or not but at least they have to go together.	Historic timeline: in groups 4–5 people. They have to draw a timeline with the events that occurred during the studied periods, giving to the students the choice not to participate but respecting the rest of the mates.	Literature: in small groups of 5 people, read the book "The Little Prince". Every student has to write the character with he/she feels more represented, making a story among all of them and telling the rest of the groups. Those who do not want to participate can only write their character.	Dodge ball game, with two fields and three cemeteries. Students who do not want to play, can be settled in the central cemetery to retrieve balls that go out and leave them in the center to be taken by the fastest player.
Task example Level 2		Creating a choreography: students have to create a merengue choreography where everyone has to contribute with an individual step and participate in the group choreography.	Punic Wars: from an event list, students have to answer as many question as they can individually.	Syntax: each Student receives a list with 10 syntax problems, in progression of complexity. Each Student tries to solve all that he/she can, receiving a point or a reward for each sentence he/she gets to do rightly.	A volleyball reduced game: they have to play a 4vs4 match and they have in a Borg scale (1–10) to up 8 points.
Task example Level 3		*Fitness: in small groups of 4 students, have to expose to the rest of the classmates a progression routine to improve the speed, strength or endurance.	The Great Battles. Students have to do an individual task where they look for information about an history battle, origin, main characters, current consequences and personal conclusions to expose at the end of the learning unit to the classmates.	*Spelling: accentuation rules. Individually, each student has to look for on internet typical words from Murcia Region, indicating if they have the stress in the final, second-to-last or third-to-last syllable. Verbal explanation to classmates of the meaning of these words.	Individual work plan. Students after doing Alpha Fitness Children Battery and comparing their outcomes with the average values, they will elaborate an individual work plan with 5 sessions to improve the physical ability they most like and with that with the lowest outcome.
Task example Level 4		*Fitness: groups of 5 students have to create their own circuit training with 4 stations to improve their strength. One student of the group will be responsible for choosing the next station to go and finally, he/she explains to the rest of the groups what they have done in every one of the four stations.	*History of Rome: groups of 4 students, each group does its own work on the History of rome for 5 lessons. Each lesson will have a leader who will be responsible for writing the report to be delivered to the teacher at the end of each class.	*Spelling: groups of 5 students play the contest "Up the pencil". The teacher says a letter and a family or words (for example A and fruits). Each group collects as many words as possible and the leader of every group	*Cooperative/ opposition games: groups of 4 students have to play an alternative games (for example "colpbol". The skillest players will help the rest of the team to get a goal.

(Continued)

TABLE 1 | Continued

Number lesson	Responsibility level and Strategies	PE secondary Teacher 1	History secondary Teacher 2	Spanish language primary Teacher 3	PE primary Teacher 4
				chooses only those ones which are right. When the teacher gives the final sign every leader will say all the words of his/her group had collected.	
Task example Level 5		*Latin dancing: workshop for families. Students teach a latin dance choreography to their parents, including some steps they have learnt previously during the physical education lessons.	*Ancient world: An ancient theater. Students are invited to participate in a theater play about Punic Wars where, they can choose between being audience or actors and actresses.	*Accentuation: after working accentuation and grammar rules, the game "goose of the letters" is carried out, inviting the 4th grade students, playing a human goos in teams, with 4th level Language qüestions. Each 4th grade Student is accompanied by a 6th grade Student who help him but never say the answer.	*Cooperative games: the 6th grade students after finishing the cooperative games unit, in the party at the end of the term, they invite the 4th grade students to participate in a game session lead for them.

Note: L1, L2, and L5: Responsibility levels.

TABLE 2 | Observational System of Teaching Oriented Responsibility *(OSTOR)*.

Criterion	Category	Code	Description
Expectations	Objective of Session	OBS	Prospects and aims of the session
	Objective of Task	OBT	Prospects and aims of the task
Explanations	Imposition Instructions	IMP	Without the possibility to include changes
	Shared	SHA	Proposals are allowed to be decided in common
Organization	Established	EST	Spaces and materials are mandated
	Distribution of Function	DIS	Functions and roles are allocated
	Suggested	SUG	Teachers pose opportunities to pupil's interventions
Task adjustments	Negative Evaluation	NEG	Rebuke to the students
	Redirect	RED	Correct student's responses
	Positive Evaluation	POS	Encourage and motivate the students
	Proposals	PRO	Formulate new options to be successful
Student's responses	Reproduction	REP	Replicate tasks or situations
	Unbalances	UNB	Disarranged or disordered responses
	Autonomy and Leadership	AUT	Drive initiatives
	Self-Assessment	SAS	The student evaluates its own performance
Session summary	Guided Summary	GUS	The teacher summarizes the session
	Shared Summary	SHU	The students take part to the sessions summary
	Nonexistent Summary	NSU	The sessions end without be summarized

or for the educational activity that is evident in their level of active contribution. (3) Showing Respect: the student is actively showing respect for others, i.e., making eye contact, paying attention to others, or actively listening. (4) Cooperation: the student demonstrates the social skills needed to work effectively with others in accomplishing a common task. (5) Encouraging Others: the student offers social support to others in proactive ways. (6) Helping Others: the student takes on helping roles. (7) Leading: the student takes on a leadership role with regard to an educational task. (8) Expressing Voice: the student makes suggestions, shares opinions, and/or reflections in ways that express their personality and individuality. (9) Asking for Help: the student seeks out assistance and asks for help from the teacher or peers.

Teacher responsibility: (1) Modeling respect means the teacher models respectful communication. (2) Setting Expectations means the teacher explains or refers to explicit behavioral expectations. (3) Opportunities for Success means the teacher structures the lesson so that all the students have the opportunity to successfully participate and be included, regardless of individual differences. (4) Fostering Social Interaction means the teacher structures activities that foster positive social interaction. (5) Assigning Management Tasks means the teacher assigns specific responsibilities or management-related tasks that facilitate the organization of the program or a specific activity. (6) Leadership means the teacher allows students to lead or be in charge of a group. (7) Giving Choices and Voices means the teacher gives students a voice in the program. (8) Role in Assessment means the teacher allows students to have a role in learner assessment. (9) Transfer means the teacher directly addresses the transfer of life skills or responsibilities from the lesson to contexts beyond the program.

Procedure

Recording Procedure

A camera was installed in the classroom six sessions prior to commencement to familiarize students and avoid non-spontaneous behaviors. An initial session of all four teachers, pre-intervention session (the experienced teacher in TPSR and the inexperienced ones) was registered and coded. The three inexperienced teachers then undertook a TPSR course based on an intensive teacher training process. After training, one weekly session of all four teachers was registered and coded (44 sessions, 11 for each teacher) over a 2-month period. In addition, the research team assessed the teachers on a weekly basis, giving feedback through a written online document and in a one-to-one meeting, and providing suggestions for improved model implementation from the results obtained. Teaching behavior sequences were analyzed from the moment the teacher effectively started the session, that is, disregarding the time spent checking the attendance list.

For appropriate training in using OSTOR, before the full data set was coded, two expert observers recorded one session per teacher, which was not included in the final sample. Intra- and inter-observer reliability was calculated from that session in LINCE, resulting in a kappa statistic of 0.95 for inter-observer and 0.98 for intra-observer analysis.

Specific Teacher Training

The correct implementation of any program requires specific teacher training (Lee and Choi, 2015). Inexperienced teachers were trained in TPSR in a two-phase approach:

1. A 10-h course on TPSR theory and practice: a group of 29 teachers in Primary and Secondary school were instructed how to design classroom climates according to the model-based program, and were provided with global and specific strategies for the development of responsibility in PE. Firstly, they received the theoretical foundations of TPSR Model, the lesson structure, the five different levels of responsibility, the general strategies and specific strategies for teaching responsibility, the strategies for solving problems. Secondly, the teachers acted like students in a practical lesson based on the TPSR Model. Teachers were splitted up in two groups, one of them was made up of physical education teachers (12 teachers) and implemented a practical lesson in a sports court. The other group (17 teachers) was made up of those teachers who taught other subjects such as Mathematics, Literature, Spanish Language, Historic, etc., and implemented a lesson in a classroom. The main changes done in the group of teachers in the classroom were: (i) part 3 and 4 of the lesson structure were jointed, and (ii) some new strategies were incorporated to improve teaching responsibility levels in the classroom. For example, to promote level 2, the "petals blackboard" strategy was created, where a flower without petals is drawn on the blackboard and students must complete the class activities to achieve the petals, making a count at the end of the lesson to show the values of participation and effort reached. Eventually, their knowledge was assessed both with a multiple choice questionnaire and by completing a lesson implementing in their subject.
2. Continuous training: three teachers who were interested in following the TPSR study, had signed a consent form and their respective schools had a consent form signed about image privacy of students and were enrolled throughout the 2-month program, the main researcher met with them before and during implementation. Beforehand, the teachers outlined the sessions they planned to carry out with the responsibility strategies; the main researcher then assessed the session and provided appropriate (or correcting or guiding) feedback.

The goal was to develop a class climate to promote responsibility through the application of TPSR. Students learned responsibility progressively, moving through the different levels (Escartí et al., 2013). Each session format followed Hellison's (2011) five-part proposal: (1) Relational time; (2) Awareness talk; (3) Physical activity plan; (4) Group meeting; and (5) Reflection time (for students to self-assess their own responsibility). Teachers used both general strategies (e.g., being an example of respect, setting expectations, providing opportunities for success) and specific strategies (e.g., redefining success, personal work plans, responsibility for students of other groups) to implement TPSR. They also used strategies to solve individual conflicts (e.g., progressive separation from the group) and collective conflicts (e.g., accordion principle) thereby fully integrating TPSR in their PE classes (Escartí et al., 2013). In addition, at the end of each session, teachers also had to self-assess their performance using the TARE (Wright and Craig, 2011) to encourage reflection on the implementation of the model-based program, answering in a dichotomous (yes/no) scale.

Fidelity of Implementation

Hastie and Casey (2014: p. 423) believe that researchers need to provide: (a) a rich description of the curricular elements of the unit, (b) a detailed validation of model-based program implementation, and (c) a detailed description of the "program context" for readers to acquire an exact and comprehensive understanding of the research design and the outcomes obtained.

Parts (a) and (b) have already been detailed in the "Specific teacher training" section. For a detailed validation of model implementation, the research team videotaped one session every week (40 lessons), apart from an initial session before the implementation program.

These video recorded lessons were analyzed independently by two external observers using the TARE 2.0 instrument (described in the "Assessing Responsibility-Based Education TARE" section). They were two university researchers who had more than 5 years of experience in this kind of analysis and were trained following the sequence established by Wright and Craig (2011). First, explanation and clarification of the meaning of each of the categories of the tool (they were put in different situation examples to distinguish them clearly). Second, the observers together watched two complete classes implementing the TPSR (corresponding to a two lessons applied in a different school not related to the present study) using TARE 2.0. Third, the results of the observers were shared to unify criteria. Fourth, when observers obtained an inter-reliability of 80%, we took such inter-reliability to be satisfactory, thus that the observers were ready to start the analysis of the study sessions.

Data Analysis

From the 44 sessions that were systematically observed, the pre-intervention (k = 4) and final sessions (k = 4) of each teacher were analyzed to obtain teacher behavior patterns using OSTOR and TARE 2.0 instruments (124 × 3-min intervals). On the other hand, to get to know the strategies used by teachers to promote responsibility and the differences between subject areas, all the TPSR intervention sessions (40 lessons/632 × 3-min intervals) using TARE 2.0 were analyzed.

Data analysis was conducted using two particularly fitting techniques for analyzing such complex teaching behaviors in order to obtain detailed sequences of instruction: (a) T-pattern detection and (b) polar coordinate analysis. Both techniques pinpointed synergies in terms of the behaviors obtained. The differences over the implementation program and between teacher behavior and student responses subject areas were analyzed by means of TARE 2.0.

T-Pattern Detection

T-pattern detection (temporal pattern detection) (Casarrubea et al., 2015; Magnusson et al., 2016) is a relevant data analysis technique in systematic observation. The function of T-pattern analysis is to detect repeated behavioral patterns that are invisible to unaided observers because the temporal structure of complex behavioral sequences is composed of observable event-types (Magnusson et al., 2016). THEME software is a powerful research tool for obtaining T-patterns using an evolution algorithm which compares all patterns and retains only the most complete. Because any basic time unit can be used, behavioral structures can be explored in detail and stronger connections between successive recorded behaviors are revealed. T-pattern detection has been successfully used in several research fields (Burgoon et al., 2016; Pérez-Tejera et al., 2018) to reveal hidden behaviors and underlying pedagogical actions (Castañer et al., 2010, 2013a; 2016b; Rodríguez-Dorta and Borges, 2017; Prat et al., 2019a). In sum, T-pattern detection is an analysis technique that scrutinizes all coded behaviors and their combinations, revealing which ones establish a behavior pattern that appears several times throughout the observed sessions. THEME software (Magnusson et al., 2016) detects T-patterns from the most to the least complex in relation to the number of branches (dendrogram diagram) that comprise the pattern.

Polar Coordinate Analysis

Polar coordinate analysis was developed by Sackett (1980) and later improved by Anguera (1997). It involves the detection of significant associations between a focal behavior (the behavior of interest) and conditional behaviors (the other behaviors analyzed). Polar coordinate analysis provides a vectorial representation of the complex network of interrelations between carefully chosen, exhaustive, and mutually exclusive defined criteria of behaviors. It is a powerful data reduction technique that is increasingly being used in studies (Castañer et al., 2016a, 2017; López Jiménez et al., 2016; Arias-Pujol and Anguera, 2017).

As stated in previous research (Castañer et al., 2016a), **Figure 1** gives a graphical explanation of how to interpret the associations between the focal behavior (F), placed in the center of the figure, and the conditional behaviors in each quadrant. The association is shown both quantitatively (length of vector) and qualitatively in quadrant I, II, III, or IV, as follows:

Quadrant I (++). The given and conditional behaviors are mutually excitatory.

Quadrant II (− +). The given behavior is inhibitory and the conditional behavior is excitatory.

Quadrant III (− −). The given and conditional behaviors are mutually inhibitory.

Quadrant IV (+ −). The given behavior is excitatory and the conditional behavior is inhibitory.

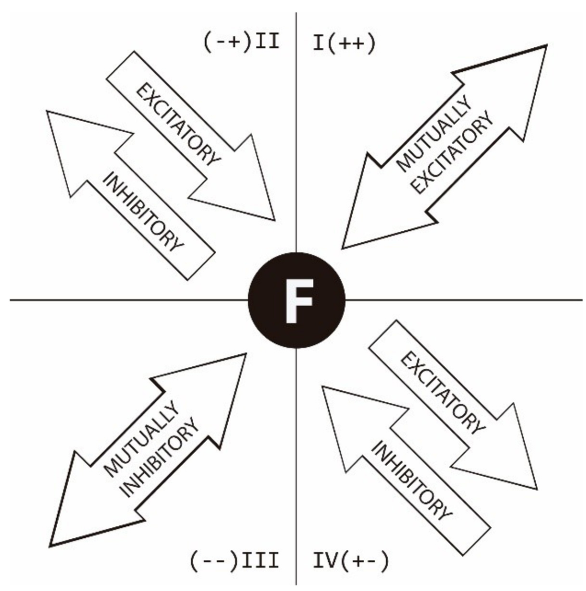

FIGURE 1 | Graphical explanation of how to interpret polar coordinate quadrants (Castañer et al., 2016a, p. 5).

Data Analysis From TARE

TARE 2.0 offers descriptive statistics analysis conducted to obtain the values of teacher intervention and student responses. In turn, these values provided an assessment of the extent to which teachers promoted responsibility throughout their lessons. Inter-reliability was obtained using the agreements/(agreements + disagreements) × 100 (García-López et al., 2012). The total agreement for teacher behaviors was 84.7% and for student behaviors 82.8% before starting the analysis of the lesson in the present study.

A descriptive analysis of the TPSR strategies used by teachers to promote responsibility was carried out with the 40 implemented lessons (632 × 3-min intervals). Normal distribution was verified using the Shapiro Wilk test ($p > 0.05$), before applying T test for related samples to obtain differences between pre-intervention and last lessons of the TPSR implementation for each teacher (between 14 and 16 × 3-min intervals per teacher in the pre-intervention lessons and 15 and 17 × 3-min intervals in the last lessons). Finally, after verifying the normal distribution with the Kolmogorov-Smirnov ($p > 0.05$), a T test for independent samples was then conducted for each strategy to contrast the results between the different subject areas (316 × 3-min intervals of physical education lessons versus 316 × 3-min intervals of other subjects). The software used for the analysis was IBM SSPS 22.0.

RESULTS

Strategies Used by Teachers to Promote Responsibility

To evaluate the instruction and treatment validity, the use of strategies to promote responsibility, the Likert scale value (0–4) of the nine teacher categories measured by the TARE 2.0 was assessed (**Table 3**). The descriptive analysis reflected values above zero in all the variables studied. The mean every 3-min intervals for each strategy was always above zero and greater than one except for the strategies ‘transfer’ and ‘leadership’ of participant 3.

Initial and Final T-Patterns Detected

From the total of T-patterns detected, we selected a common T-pattern obtained from the four initial and four final sessions of each teacher (**Figure 2**). This common T-pattern is relevant because all sets of behaviors that comprise the 21 branches of the T-pattern tree include student behavior of Autonomy (AUT). Some of these sets also contain Shared (SHA) and Suggestions (SUG) associated with Autonomy (AUT). The left side of **Figure 2** shows the practical nonexistence of those behaviors in the four initial sessions of all teachers, including the experienced teacher (teacher 4) (pre-intervention). Those initial sessions were compared with the four final sessions which show many of those behaviors, as seen on the right side of the **Figure 2**.

Mixing T-Patterns and Polar Coordinates

Because our methodological aim is a mixed-method approach, we decided to offer a new graphical depiction that clearly connects and contrasts T-pattern and polar coordinate data of both the initial and final sessions of the teachers (**Figure 3**). We selected a total of eight images for this new understanding of data contrast from the T-pattern and polar coordinate connection. The left side of the images includes a T-pattern related to the polar coordinate obtained, which in turn appears on the right side of the image.

All polar coordinate analysis was conducted taking the behavior of Autonomy (AUT) as the focal behavior, because it is an essential part of the TPSR model. Furthermore, the autonomy of the students gained relevance in the common T-pattern shown in **Figure 2**.

TARE Results

Contrasting Pre-intervention and Final Sessions

The results of TARE 2.0, obtained from the two observers (**Table 4**), show the differences between the variables of the pre-intervention session (first rows), before commencement of TPSR, and the final session (second rows), using TPSR. The categories differentiate both types of participants: teacher and student.

Table 4 based on the data recorded with the teacher observation section of TARE 2.0, there were statistically

TABLE 3 | Teachers' Strategies used to Promote Responsibility.

	Teacher 1 ***M (SD)***	**Teacher 2** ***M (SD)***	**Teacher 3** ***M (SD)***	**Teacher 4** ***M (SD)***
The teacher. . ..				
Respect model	4.00 (0.00)	3.91 (0.28)	3.16 (0.49)	3.98 (0.07)
Expectations	2.39 (0.72)	2.27 (0.74)	3.09 (0.75)	2.60 (0.80)
Opportunities	2.14 (0.79)	2.16 (0.75)	2.39 (0.80)	2.60 (0.55)
Interaction	1.88 (0.63)	3.03 (0.82)	2.26 (1.18)	2.38 (0.94)
Assigning tasks	2.29 (0.77)	2.56 (0.96)	2.31 (1.09)	2.28 (0.57)
Leadership	2.45 (0.98)	1.21 (1.16)	0.52 (0.97)	2.77 (0.75)
Giving choices	1.79 (0.69)	2.92 (0.49)	2.35 (1.38)	2.30 (0.54)
Assessment	1.06 (1.06)	1.08 (0.93)	1.70 (0.95)	1.37 (1.25)
Transfer	0.17 (0.17)	0.49 (0.70)	0.53 (0.55)	0.45 (0.55)

M = Mean. SD = Standard Deviation.

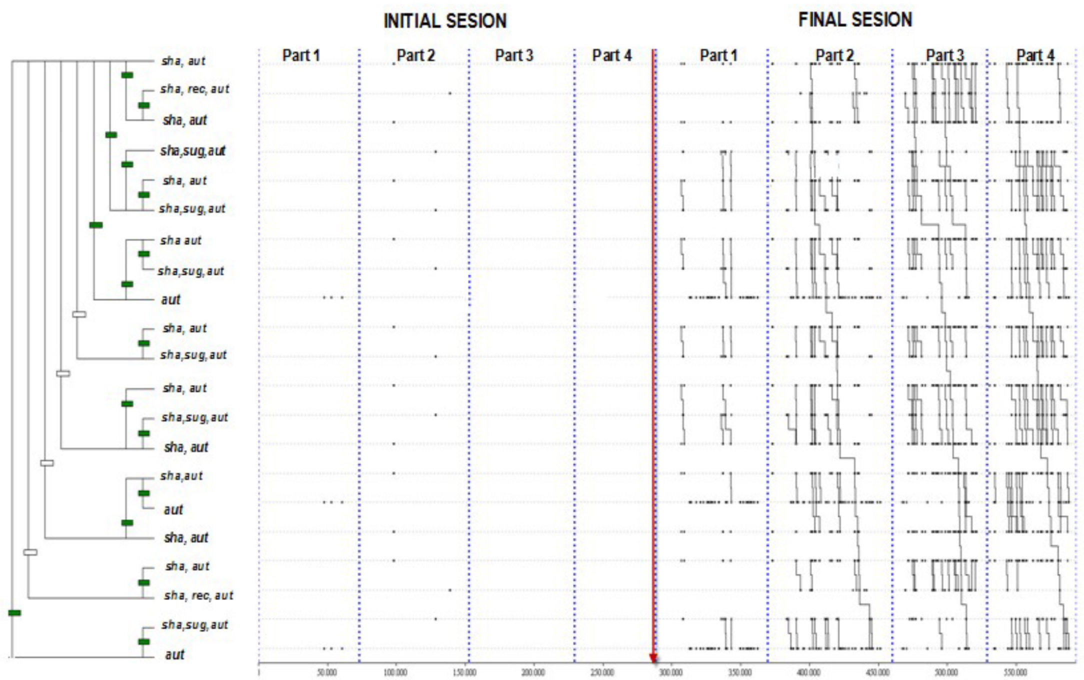

FIGURE 2 | T-pattern from the four initial and final sessions of each teacher.

significant differences in most behaviors of teacher 1, 2, and 3, except in the respect model (teacher 1 and 2), transfer (teacher 1) and assigning tasks and leadership (teacher 3). For teacher 4, no differences were found, other than in fostering interaction and role in assessment. The student observation section of TARE 2.0 revealed statistically significant differences in most behaviors of teacher 1, 2, and 3, except in showing respect (teacher 2 and 3) and helping (teacher 2). For teacher 4, no differences were found other than in engagement and leading.

Differences Between Subject Areas

As for the subject areas taught by the four teachers (**Table 5**), analysis of the 40 sessions (the first four pre-intervention sessions were excluded) in which the TPSR model was applied show statistically significant data ($p < 0.01$) in favor of PE in relation to the following behaviors: respect model, leadership, encouraging and leading. However, History and Spanish Language subject sessions obtained statistically significant data in favor of them in relation to the behavior of interaction, giving choices, transfer, respect ($p < 0.001$), asking for help ($p < 0.01$), and for cooperating ($p < 0.025$).

DISCUSSION

The aim of our study was to detect how teachers' behavior-oriented patterns shifted in response to CPD, thereby reinforcing the implementation of the TPSR (Hellison, 1978) included in the SPM depicted at the beginning of the paper. We obtained significant results in relation to the process of TPSR acquisition in two interesting aspects:

1. After specific teacher training in TPSR (Lee and Choi, 2015) and subsequent assessment, how did each teacher adapt their teaching strategies in their teaching sessions? Analysis results indicate that, for the three teachers who received training in the methodology and for the students, most behaviors reflected improved observation (OSTOR) and statistical significance (TARE) with the application of the TPSR model. Results for the experienced teacher highlighted the application of more diversified TPSR model strategies in the final session and only got better scores in a few strategies because he was already near the maximum possible developmental stage. Overall, the evolution of each teacher tended toward an increase in strategies to encourage responsibility by the students, in line with Escartí et al. (2018), where the TARE behaviors are correlated between the teachers who apply TPSR and student behaviors.
2. Are there differences according to subject area? Regarding the aspect of subject area taught, we would point out that the best results from TARE relating to respect model, leadership, encouraging and leading behaviors appear in PE sessions. We believe this is because PE intrinsically addresses student autonomy (Moreno-Murcia et al., 2008; Aibar et al., 2015). The subject areas of History and Spanish language obtain better results in interaction, giving choices, transfer, respect, asking for help, and cooperation behaviors. This could be, because in these areas teachers promote problem-solving activities oriented to achieving transference to real life (Puigarnau et al., 2016).

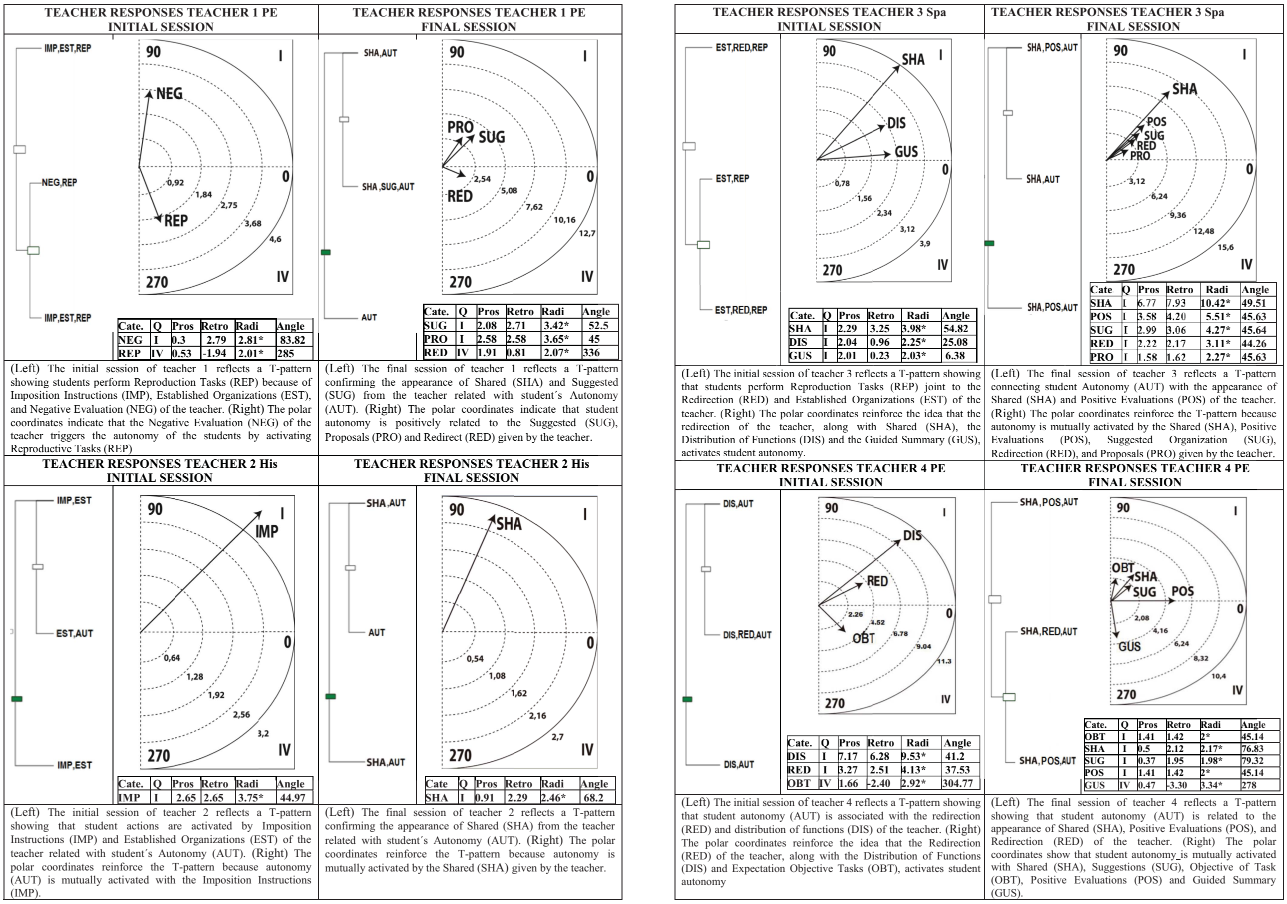

FIGURE 3 | T-pattern and polar coordinate data of both the initial and final sessions of the teachers.

Despite these interesting aspects, we have continued to delve into connections with the data obtained by means of the mixed-method approach. Essential data emerge from the T-patterns obtained and from polar coordinate analysis of the observed behaviors of each teacher and their students through comparisons of initial and final sessions. The TARE tool was integrated into this mixed-method approach to detect the responsibility levels established (Hellison and Wright, 2003) and to conduct continued assessment (Hemphill et al., 2015).

The Evidence of How Teaching Behavior Patterns Shift

We obtained a common and complex T-pattern (**Figure 2**) that we consider highly relevant because all 21 sets of behaviors included student autonomy. This result reinforces the statement that promoting autonomy attitudes from students is a pillar of the TPSR model (Hellison, 2011). In this common T-pattern, along with the student's autonomy, another two essential pillars of the TPSR model, and also considered in the TARE tool, appeared: the teaching behaviors of sharing explanations and suggestions (Wright and Craig, 2011; Escartí et al., 2015).

This common T-pattern is nonexistent in the initial sessions of the teachers. Though not linked sequentially, only the behaviors of autonomy, sharing explanations, and suggestions appear in order to create a T-pattern. A proactive change toward TPSR strategies is fully visible in the final sessions of all the teachers when this T-pattern is significant and is even more diversified in the experienced teacher.

The Evidence of Linkage Between Teacher Strategies and Student Responses

A significant T-pattern and polar coordinate analysis was selected for the initial and final session of each teacher. The contrast of T-patterns and polar coordinate analysis between the initial and final sessions clearly reveals a proactive shift in TPSR implementation. However, in order to show the potential of the mixed-method approach (Anguera et al., 2012, 2014; Castañer et al., 2013b), we decided to explore a new way for an easier understanding of both techniques. We created a new graphical depiction integrating the polar coordinate and T-pattern figures, because the technique of polar

TABLE 4 | Results of TARE 2.0 in teacher and student behaviors.

		Teacher 1		Teacher 2		Teacher 3		Teacher 4	
Category	**Variable**	***M (SD)***	***p***	***M (SD)***	***p***	***M (SD)***	***p***	***M (SD)***	***p***
Teacher	Respect model	4.00 (0.00) 4.00 (0.00)		4.00 (0.00)		2.89 (0.68)		4.00 (0.00)	
			1.000	4.00 (0.00)	1.000	3.63 (0.50)	0.001***	4.00 (0.00)	1.000
	Expectations	0.00 (0.00)		0.00 (0.00)		0.50 (0.92)		2.50 (1.03)	
		3.08 (1.08)	0.001***	2.60 (1.06)	0.001***	3.63 (0.89)	0.001***	1.76 (1.09)	0.056
	Opportunities	0.00 (0.00)		0.00 (0.00)		1.33 (1.28)		2.81 (0.75)	
		2.75 (1.36)	0.001***	2.53 (1.06)	0.001***	3.69 (0.87)	0.001***	2.65 (0.93)	0.580
	Interaction	0.00 (0.00)		0.57 (0.51)		1.39 (1.33)		3.00 (0.97)	
		2.33 (0.89)	0.001***	3.33 (1.40)	0.001***	3.25 (1.18)	0.001***	2.12 (0.33)	0.001***
	Assigning tasks	2.75 (1.91)		0.00 (0.00)		2.61 (1.82)		2.19 (1.28)	
		1.33 (0.98)	0.028*	2.27 (1.16)	0.001***	2.75 (1.57)	0.814	2.65 (.93)	0.244
	Leadership	0.00 (0.00)		0.00 (0.00)		0.00 (0.00)		2.94 (1.39)	
		2.50 (1.88)	0.001***	1.13 (0.74)	0.001***	0.19 (0.40)	0.057	3.06 (1.75)	0.828
	Giving choices	0.75 (0.45)		0.79 (0.43)		0.50 (1.15)		2.44 (1.46)	
		2.08 (0.90)	0.001***	2.47 (1.06)	0.001***	3.19 (0.98)	0.001***	2.00 (0.50)	0.252
	Assessment	0.00 (0.00)		0.00 (0.00)		0.00 (0.00)		1.31 (1.25)	
		2.17 (1.53)	0.001***	2.47 (1.60)	0.001***	3.50 (0.73)	0.001***	0.12 (0.49)	0.001***
	Transfer	0.00 (0.00)		0.00 (0.00)		0.00 (0.00)		0.19 (0.75)	
		0.50 (0.90)	0.082	1.27 (0.70)	0.001***	1.31 (1.08)	0.002**	0.29 (0.47)	0.626
Student	Participation	1.75 (0.93)		0.79 (0.43)		2.00 (0.00)		3.25 (0.86)	
		3.67 (0.49)	0.001***	3.67 (0.72)	0.001***	3.50 (0.63)	0.001***	3.71 (0.47)	0.065
	Engagement	1.44 (0.81)		2.00 (0.00)		1.78 (0.65)		2.25 (0.68)	
		2.67 (0.49)	0.001***	2.87 (0.35)	0.001***	2.81 (0.54)	0.001***	3.00 (0.00)	0.001***
	Respect	1.44 (0.51)		4.00 (0.00)		3.00 (0.00)		3.19 (0.54)	
		2.92 (1.00)	0.001***	4.00 (0.00)	1.000	3.00 (0.00)	1.000	3.00 (0.00)	0.165
	Cooperating	0.81 (0.83)		0.00 (0.00)		0.44 (0.86)		2.13 (1.26)	
		1.75 (1.29)	0.027*	3.67 (0.72)	0.001***	2.44 (1.09)	0.001***	1.41 (0.94)	0.073
	Encouraging	0.50 (0.52)		0.00 (0.00)		0.00 (0.00)		1.75 (1.00)	
		1.83 (1.34)	0.001***	1.73 (0.70)	0.001***	1.81 (1.17)	0.001***	1.41 (0.94)	0.324
	Helping	0.75 (0.86)		0.00 (0.00)		0.00 (0.00)		1.13 (1.02)	
		2.00 (1.48)	0.009**	1.73 (0.70)	0.002**	0.81 (0.40)	0.001***	1.41 (0.94)	0.408
	Leading	0.00 (0.00)		0.00 (0.00)		0.00 (0.00)		3.13 (1.63)	
		2.83 (1.75)	0.001***	1.73 (0.70)	0.002**	0.81 (0.40)	0.001***	1.41 (0.94)	0.001***
	Expressing	0.00 (0.00)		0.57 (1.09)		0.00 (0.00)		2.50 (2.00)	
		3.17 (1.03)	0.001***	2.87 (0.52)	0.001***	3.06 (0.68)	0.001***	2.59 (0.94)	0.871
	Help	0.00 (0.00)		0.00 (0.00)		0.00 (0.00)		0.13 (0.34)	
		1.50 (1.68)	0.001***	0.00 (0.00)	1.000	0.63 (0.62)	0.001***	0.00 (0.00)	0.141

*Note: $p < 0.05$ = *; $p < 0.01$ = **; $p < 0.001$ = ***; Teacher 1 and Teacher 4 = PE teachers; Teacher 2 and Teacher 3 = History and Spanish language teachers.*

coordinate analysis reinforces the results obtained from T-pattern analysis. While T-pattern analysis reveals how behaviors change over time, polar coordinates detect which behaviors are mutually activated or inhibited (Arias-Pujol and Anguera, 2017). The integrated figures show that all teachers experienced a considerable shift in their teaching strategies from directive and controlling intervention, with negative assessments that generate reproduction responses from the students, toward participatory intervention that promotes autonomy responses from the students. The three methodological tools used in this study highlight the same process of pedagogical optimization that promotes student involvement and responsibility (Lorente and Kirk, 2016; Prat et al., 2019a,b).

CONCLUSION

The mixed-method approach followed in the current study reveals the benefits that can be achieved with TPSR in an educational context for the improvement of values, as identified by several studies such as that by Pozo et al. (2016). Moreover, TPSR has been shown to be appropriate for facilitating CPD for teachers (Hemphill et al., 2015). Finally, this type of methodology indicates that TPSR implementation is possible for PE as well as other school subjects (Escartí et al., 2018), thereby enabling the teacher to achieve improved behavior interaction and assessment in class and providing students with better opportunities to acquire educational values such as engagement and leading. This

TABLE 5 | Results of TARE 2.0 in teacher and student behaviors.

		PE	History and Spanish	
		Teacher 1 and 4	**Teacher 2 and 3**	
Category	**Variable**	***M (SD)***	***M (SD)***	***p***
Teacher	Respect model	3.99 (0.21) 2.36 (1.30)	3.52 (0.62)	0.001***
	Expectations		2.47 (1.43)	0.082
	Opportunities	2.22 (1.25)	2.13 (1.37)	0.589
	Interaction	2.09 (1.28)	2.49 (1.58)	0.001***
	Assigning tasks	2.25 (1.37)	2.34 (1.65)	0.190
	Leadership	2.43 (1.77)	0.78 (1.27)	0.001***
	Giving choices	2.01 (1.23)	2.45 (1.61)	0.001***
	Assessment	1.18 (1.50)	1.28 (1.50)	0.343
	Transfer	0.28 (0.71)	0.47 (0.87)	0.001***
	Participation	2.67 (1.18)	2.82 (1.16)	0.066
Student	Engagement	2.25 (0.87)	2.31 (0.91)	0.386
	Respect	2.50 (0.85)	3.26 (0.77)	0.001***
	Cooperating	1.70 (1.29)	1.94 (1.58)	0.025*
	Encouraging	1.56 (1.51)	0.96 (1.12)	0.001***
	Helping	1.17 (1.19)	1.12 (1.25)	0.486
	Leading	2.10 (1.82)	0.99 (1.22)	0.001***
	Expressing	1.83 (1.38)	1.97 (1.54)	0.079
	Help	0.30 (0.70)	0.53 (1.01)	0.010**

*Note: $p < 0.05$ = *; $p < 0.01$ = **; $p < 0.001$ = ***; Teacher 1 and Teacher 4 = PE teachers; Teacher 2 and Teacher 3 = History and Spanish language teachers.*

study leads us to conclude that social responsibility behavior changes in students (Lorente and Kirk, 2016), based on the TPSR model, provide a favorable framework for activating encouraging and leading behaviors in PE and respect, cooperating and asking for help behaviors in other subject areas. Therefore, the ongoing and continuous application of these educational and pedagogical intervention strategies to educational programs promotes responsibility and autonomy that are a primary objective of education (Belando et al., 2012).

Prospective Future Lines

This study a systematic method for objectively analyzing the process of teacher optimization in TPSR. We therefore believe that it can serve as a reference framework for studies focusing on the essentials of education:

1. for teachers:

   a. *Enacting action research* that focuses on understanding educational environments in order to innovate and optimize the quality of education linked to pre-service teachers (PSTs). It provides a cyclical and systematic approach to problem-solving that encourages teachers to solve their educational problems through reflection-action (Gibbs et al., 2016);

   b. *Optimizing communicative competencies of teachers*. High communicative competency in the teacher will result in a higher quality of interaction for the student because the processes of teaching and learning are essentially communicative processes (Barbat, 2008; Castañer et al., 2013a). We believe that OSTOR, the observational instrument of this study, could be extended by means of existing specialized observational systems, such as SOCIN and SOPROX, to detect kinesic and proxemic behaviors, respectively (Castañer et al., 2013a, 2016b).

2 for students:

   a. Strengthening self-esteem because it is an integrated set of cognitive, affective, and attitudinal factors that also highlight effectiveness. Therefore, the criteria contained in the TARE could be expanded to include studies that point to reinforcing student self-esteem (Legault et al., 2006).

   b. The acquisition of autonomy and responsibility in education could be framed within the Self-Determination Theory (STD, Deci and Ryan, 2000, 2012), as stated in previous studies (Puigarnau et al., 2016). This theory claims that there are three basic psychological needs (competence, autonomy, and relatedness), the satisfaction of which increases intrinsic motivation and personal well-being.

In sum, as Tissington and Senior (2017) point out, carrying out pedagogical research is essential for effective learning. We believe our study offers a systematized observational tool and two specific techniques that can enhance pedagogical research.

ETHICS STATEMENT

The study was carried out in accordance with the Declaration of Helsinki and was accepted and verified by the Ethics Committee of the University of Murcia, Spain (ID 1685/2017). As the observational methodology we use is always conducted over natural context, we observed the natural development of the scholar sessions, therefore written informed parental consent was not obtained for the purposes of research participation and was not required as per applicable institutional and national guidelines. Regarding video recording, the institution has a consent form about image privacy that parents of students enrolling at the school are required to sign. All four teachers signed a consent form in order to participate in the research study, the consent obtained was both written and informed.

AUTHOR CONTRIBUTIONS

MC, OC, and AV-V developed the project, supervised the design of the study, the method section, and the drafting of the manuscript. DMS was responsible for the review of the literature. OC, AV-V, DMS, QP, and MC were responsible for the critical revision of the content. MC, AV-V, and OC were responsible for the drafting of the manuscript. OC, QP, and DMS collected and codified the data. All the authors approved the final, submitted version of the manuscript.

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"REOFUT" as an Observation Tool for Tactical Analysis on Offensive Performance in Soccer: Mixed Method Perspective

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Performance analysis in complex sports like soccer requires the study of the influence of the interaction between both teams during the game on final performance. The mixed methods approach involves the collection, analysis, and interpretation of qualitative and quantitative data for the same purpose and within the framework of the same study. To build certain observation tools, mixed methods are necessary in order to take advantage of integration between qualitative and quantitative elements. The aim of this study was to develop a new no standard observation tool to analyze soccer offensive performance considering not only the observed team but also some aspects of the opponent behavior, as well as to test its reliability. The process consisted in expert meetings and exploratory observations. Experts carried out several design and re-design steps of the observation tool to its final form which includes two macro-criteria and 31 dimensions. The basic unit of analysis was the "team possession" and the main aims of study were: (a) technical, tactical and spatial characteristics of the start, the development and the end of the team possession and its offensive performance, (b) the behavior of the observed team just after losing the ball possession and its defensive performance. Inter-observer and intra-observer analysis were carried out and kappa coefficient was calculated to test the observation tool reliability and improve the quality of data. Results indicate that optimal inter and intra-reliability levels obtained in this work are high enough as for suggesting that the observation tool for offensive performance in soccer (REOFUT) could be an adequate tool for analyzing offensive play actions and their performance in soccer.

Keywords: offensive process, goal scoring opportunities, mixed methods, systematic observation, tactics, performance analysis, soccer

INTRODUCTION

Researchers have been mixing qualitative and quantitative approaches since the last 20 years (Tashakkori and Teddlie, 1998; Teddlie and Johnson, 2009), but mixed methods research represents "a new movement, or discourse, or research paradigm (with a growing number of members) that has arisen in response to the currents of qualitative research and quantitative research"

(Johnson et al., 2007, p. 113). Many researchers do not mix qualitative and quantitative approaches in optimal ways, according to Powell et al. (2008), even when qualitative techniques can be used to enhance the development of quantitative instruments and vice versa (Collins et al., 2006). The mixed methods potential is very broad, and includes instrument fidelity, "maximizing the appropriateness and/or utility of the instruments used, whether quantitative or qualitative" (Onwuegbuzie et al., 2010, p. 57).

The goal of soccer performance analysis is to provide accurate, clear and objective information to players, coaches and clubs to improve future team performance (McGarry, 2009). In this sense, the development of new technological systems [e.g., Global Positional System (GPS), Prozone-STATS, and OPTA] has contributed to increase the quantitative based knowledge in this sport. Notational analysis, which consists of the technique by which the events that take place during the game are recorded (James, 2006) has provided and continues to provide important information for coaches and players, thus helping to improve the training process (Borrie et al., 2002).

However, there is a need to use a new methodological approach based not only on quantitative methods but also on qualitative ones. Indeed, some authors report a growth and proliferation of new methodological approaches to collect and analyze data (Sarmento et al., 2018a). In soccer, there is a need for methods that add qualitative value to performance analysis in order to increase the validity and possible applications of research. This makes necessary the implementation of a mixed methods approach that involves the collection, analysis, and interpretation of qualitative and quantitative data for the same purpose, and within the framework of the same study, on mixed methods (Anguera et al., 2018).

Soccer is a complex and multifactorial sport where the two opponent teams generate an unexpected and changing context at each moment of the game, having a constant adaptation to the characteristics caused by the confrontation between them (Gréhaigne et al., 1997). A large part of recent literature in soccer notational analysis has focused on studying offensive performance indicators such as starting zone, number of passes, duration or type of attack, and their influence on offensive performance (Hughes and Franks, 2005; Tenga et al., 2010; Wright et al., 2011; Lago-Ballesteros et al., 2012; Sarmento et al., 2018b). However, despite the complex and interdependent nature of the game action in soccer, there are still few studies focused on analyzing the effect of the interaction between offensive factors on performance while considering defensive factors of the opponent team and contextual factors (Mackenzie and Cushion, 2013). These same authors and others underline the need to implement research methodologies that show detailed definitions with the aim of facilitating the understanding of results and comparison with other studies (Mackenzie and Cushion, 2013; Sarmento et al., 2018a).

Therefore, according to reviews of the literature in performance analysis (Mackenzie and Cushion, 2013; Sarmento et al., 2014) the future of game analysis in soccer requires the building of observation instruments that integrate the study of criteria related to the interaction with the opponent. In this type of instruments, the use of qualitative attributes where the interpretation of the events by the observers is necessary for the collection of the data, can increase the ability to describe the actions developed in the game (Hughes and Bartlett, 2002).

Some instruments have been proposed to evaluate individual tactical behaviors. González-Villora et al. (2015) review different instruments for the evaluation of the tactical knowledge of football players. All instruments reported there are used to evaluate the tactical knowledge of the soccer player. We would like to highlight the FUT-SAT (Teoldo et al., 2011), which is conceived to assess the tactical knowledge of the player in game situations, both of training and competition.

However, the difficulty of interpreting the team actions in a complex, dynamic and situational context such as a soccer match makes it necessary to correctly define the criteria to limit the errors of interpretation and codification (James et al., 2007), as well as to assess the validity and reliability of the data collected to be analyzed (Hughes et al., 2004).

Therefore, in order to maximize the appropriateness and/or utility of the instruments used, whether quantitative or qualitative, the aim of this work is to describe the process of building and optimizing the development of a qualitative instrument, which will enable to integrate qualitative records with a quantitative analysis. Thus, this work developed a new observation instrument from a mixed method perspective to analyze the offensive collective performance and the tactical characteristics of the action of collective offensive game in soccer, considering the behavior of the opponent team and also contextual dimensions, it also verified the reliability of such instrument, bearing in mind that this methodology is ideal for research on behaviors that occur in soccer (Anguera and Hernández-Mendo, 2013, 2014).

MATERIALS AND METHODS

Participants

No experimental analysis involving human studies is performed in the study. Six experts were included in this process, who met the following criteria: (1) graduate in physical activity and sport sciences, (2) soccer coach license UEFA A, (3) more than 1 year as a soccer coach in a soccer team of an official competition, (4) postgraduate master in sports sciences or PhD in sports sciences, and (5) experience in performance analysis research (final master's thesis, doctoral thesis or scientific publication).

The six experts provided written informed consent after details of the study were communicated verbally and in written form prior to participate in the study and it was approved by the Ethics Committee of the University of Barcelona (IRB00003099). In order to carry out the second, third, and fifth stage of the study, in which observation was necessary, a direct, non-participatory, systematic, and natural observational methodology was used (Anguera et al., 2011) (see the "Procedures" section). Matches were recorded from TV broadcasters and were registered and analyzed post-event. Because the video recordings were public, confidentiality was not an issue, and authorization was not required from the players observed or their representatives.

Furthermore, the information cannot be considered either personal or intimate, as the research consisted solely of naturalistic observations in public places, and it was not anticipated that the recordings would be used in a manner that could cause personal harm (The American Psychological Association's [APA's], 2010).

Procedures

The design of the research instrument was carried out in five stages:

In the first stage, a literature review on tactical analysis in soccer was carried out in order to know the performance analysis methods used in previous studies. Afterward, the group of experts held an initial meeting where the basic objectives of the instrument were defined, as well as the innovative aspects that were intended to be included. In this sense, it was decided that the main objective of the observation instrument was to analyze the tactical dimensions that could influence the attainment of offensive performance in soccer. Another objective was to study the behavior carried out by a team after losing possession of the ball in play in order to know the tactical behavior in the transition between offensive and the subsequent defensive action. It was decided that the basic unit of study was the "possession" of the team's ball according to the definition of Pollard and Reep (1997) but also to observe some dimensions of the immediately subsequent possession carried out by the opponent team if the "possession" ends but the game continues. Pollard and Reep (1997) define "possession" as:

> "*A team possession starts when a player gains possession of the ball by any means other than from a player of the same team. The player must have enough control over the ball to be able to have a deliberate influence on its subsequent direction. The team possession may continue with a series of passes between players of the same team but ends immediately when one of the following events occurs: a) the ball goes out of play; b) the ball touches a player of the opposing team (e.g., by means of a tackle, an intercepted pass or a shot being saved). A momentary touch that does not significantly change the direction of the ball is excluded, or c) the regulation is violated (out of play or foul).*"

In the second stage, the design and development of the dimensions and their respective categories were carried out. This stage was characterized by several meetings based on the definition, discussion and re-definition of the dimensions and categories of the instrument separated by individual exploratory observation practices where the experts collected, suggestions or contributions resulting from the application of the preliminary research instrument. All those considerations were discussed in the following meetings in order to re-design the proposed dimensions and categories, or to add new ones that will complete a better analysis. In these observation practices soccer matches of the Spanish national team corresponding to the final phase of the South Africa 2010 FIFA World Cup (Spain-Portugal, Spain-Paraguay and Spain-Holland) were used. The first version of REndimiento Ofensivo en FÙtbol (REOFUT; in English: offensive performance in soccer) ended when each category system met the requirements of completeness and mutual exclusivity (Anguera et al., 2007) and the experts did not consider necessary new dimensions. In this sense, the completeness was considered when any behavior under analysis could be assigned to one of the categories proposed in each dimension while the mutual exclusivity was fulfilled when there was no overlap of the categories and each analyzed behavior was assigned to a single category.

In the third stage, a study was carried out by one of the researchers for the analysis of the offensive game of the Spanish soccer national team in the FIFA World Cup in South Africa 2010, the champion team (852 possessions were analyzed from 7 played matches), using the newly designed first version of REOFUT (González-Ródenas, 2013). The reliability was verified through the analysis of 20 randomly selected possessions of the Spain-Germany match.

In the fourth stage, a series of meetings of the 6 participating experts took place to analyze and discuss the results obtained in the first study in order to verify the usefulness of the criteria and categories of the first REOFUT design. These meetings allowed to eliminate, redesign, redefine criteria, as well as to add other criteria that might be necessary for a better understanding of tactical performance analysis in soccer. As a result of these meetings, the REOFUT was modified from its initial design of 3 macro criteria and 45 dimensions to two macro criteria and 31 dimensions that make up the second version of the instrument. Additionally, several dimensions were redefined as well as categories were grouped or eliminated in order to make the process of data collection and analysis of results more operative and effective.

Finally, once the final design of the instrument was built, the fifth stage was reached where a macro study was carried out in order to analyze the tactical dimensions related to offensive performance, using a sample of Major League Soccer matches. In this macro study, the verification of the reliability of REOFUT took place through the assessment of the agreement between observers (inter-observers) and the analysis of interpretative stability (intra-observer). For the study of the inter-observer agreement, apart from the analysis carried out by the main researcher, a person was trained (Bachelor of Science in Physical Activity and Sport, Master in Research in Sports Science and UEFA A coaching license) during 4 weeks (40 h) in the analysis of the offensive collective game with REOFUT. After the training period, the two observers separately analyzed a game composed of 128 "possession units" of a Major League Soccer professional team in the United States. Regarding the intra-observer agreement, the principal investigator performed the same analysis, 4 weeks after the first analysis, to minimize task familiarity (Robinson and O'Donoghue, 2007), without performing any type of analysis during this time, to check the temporal stability of the analysis performed. To assess the levels of agreement, Kappa correlation coefficients (k) were calculated and analyzed according to the classification by Altman (1991), where the values between 0.8 and 1.0 were considered very good agreement, 0.61–0.80 good, 0.41–0.60 moderate, 0.21–0.40 low and <0.21 very low.

Observational Instrument

The REOFUT observational instrument is a combination of field format and category systems (Anguera et al., 2007). As it is shown in the conceptual approach, the field format allows the appropriate location of the qualitative dimensions. Based on each of these dimensions, when the criteria of having a theoretical framework and timelessness are fulfilled, a system of qualitative categories has been developed. That obeys the double requirement of completeness and mutual exclusivity. In addition, as suggested by Mackenzie and Cushion (2013) and Sarmento et al. (2014) this instrument includes contextual dimensions such as location of the match (home, away, neutral), momentary result (winning, losing, drawing), team and opponent level (high, medium or low depending on their position in the classification) and time of game (first part, second part, extra time).

As it is shown in **Figure 1**, the REOFUT analyzes two large macro-criteria, the offensive where the observed team has possession of the ball and the defensive only in case the rival team manages to recover the ball in play and initiate a subsequent attack. In this way the REOFUT allows us to study four out of the five important moments of the game according to the classification of Hewitt et al. (2016), such as the offensive transition, the positional attack, the offensive set pieces and the defensive transition. Within the macro offensive criterion, 5 temporary successive moments from each possession are analyzed: start of the possession (**Table 1**), development of the possession (**Table 2**), penultimate action of the possession (**Table 3**), end of the possession and performance outcome (**Table 4**) and the following possession (**Table 5**), with the singularity that the moment relative to "penultimate action" will only be studied in the case of the existence of a goal or goal opportunity, with the aim of deepening the analysis of the tactical factors related to the attainment of offensive success. For the defensive macro-criterion, four temporary successive moments of the game action subsequent to the loss of the ball are analyzed, with dimensions relative to the start (**Table 1**), development (**Table 2**), final (**Table 4**), and performance outcome of the opponent subsequent team's possession (**Table 5**).

The REOFUT contains qualitative spatial localization criteria in the different moments of the game. On the one hand, the formal static space is considered where the game rectangle is subdivided into four transversal sectors (defensive, pre-defensive, pre-offensive, and offensive) and four longitudinal lanes (Mombaerts, 2000). In this formal space, an area called "score pentagon" is delimited (Corberán, 2009), which is the selected space from where there is a distance of less than 20 m from the goal and a high shooting angle, factors that are key for the achievement of the goals (Pollard and Reep, 1997; Ensum et al., 2005). From the completion pentagon, different areas are subdivided into zones 13 (13a and b), 14 (14a, b, c, and d), 15 (15a, b, c, and d) and 16 (16a and b) in order to be able to perform a more specific analysis of the categories of goal and goal scoring opportunities (**Figure 2**).

On the other hand, the functional and dynamic concept of space of defensive occupation (SDO) of the rival team is used, which we also call "invasive space" (**Figure 3**). The SDO is defined by Gréhaigne (2001) as the "space that is constituted by the positions of the players located, at a given moment, in the periphery of a team in play, except the goalkeeper" (positions are showed in **Figure 4**). The interrelated positions draw a polygonal surface defined as the SDO. The location of the player holding the ball in relation to the SDO of the opposing team during the possession observed has been taken into account based on subdivisions made by previous works (Castellano and Hernández Mendo, 2001; Seabra and Dantas, 2006; Aranda et al., 2009) and 10 categories

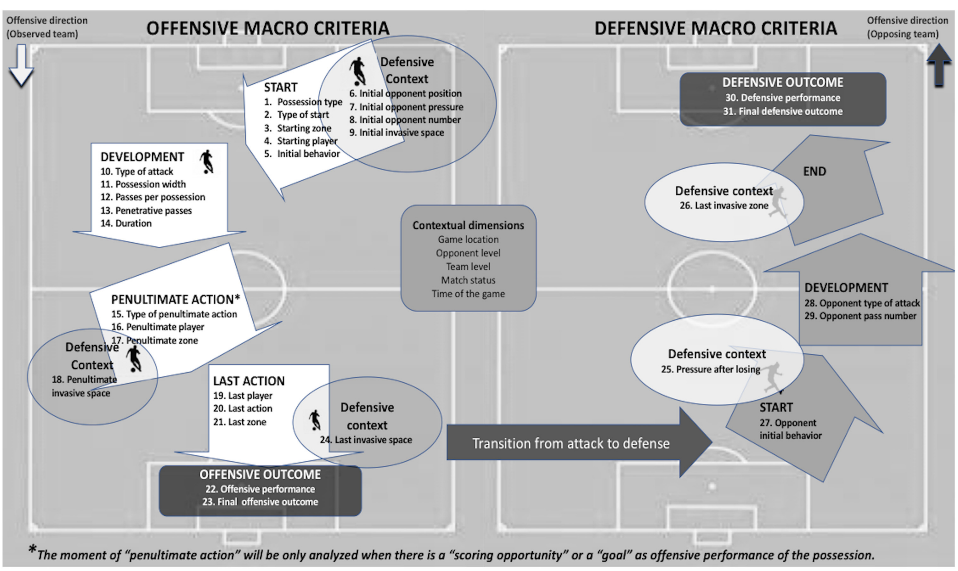

FIGURE 1 | Scheme of the macro-criteria and dimensions that REOFUT record.

TABLE 1 | Description and categories for the dimensions related to the start of the possession.

POSSESSION START

Observed team (offensive)

1-Possession type: way to start a team possession according to if the ball is in play or out of play. Three categories were considered:

A) Recovery: when a player gains the possession of the ball by any means other than from a player of the same team with the ball in play.
B) Set-plays: (1) the restart takes place in the opponents' half, (2) the tactical situation of the attacking team is prepared to try to shot at goal (both teams group players into or just in front of the box and player positions change because some of the defenders move forward to try to shot at goal) and (3) the attacking team try to cross the ball into the box or shot at goal in one or two passes. (All corner kicks, all penalty kicks and those free kicks with the above characteristics are considered in this category).
C) Re-starts: the re-start takes place in any part of the field, (2) the tactical situation of the attacking team is not prepared to try to shot at goal in one or two passes (player positions do not change) and (3) the attacking team try to pass the ball and build up a ball possession. (Goal kicks, free kicks, kick off, throw in).

2-Type of start: individual action by which the possession starts, based in previous studies (Gómez et al., 2012; Barreira et al., 2014). Two categories and eleven sub-categories were considered:

A) When the ball is not in play: the ball is out of play and it is restarted by an individual action: A.1 goal kick; A.2 throw in; A.3 free kick; A.4 corner kick; A.5 kick off; A.6 penalty kick; A.7 dropped ball.
B) When de ball is in play: the ball is in play and a team possession begins with an individual action:

b.1 Turnover won: when the defender collects, somewhere in the pitch, a ball lost (after clearances or missed passes) by the opposing team (Gómez et al., 2012).
b.2 Interception: when a player of the team that has not the ball prevents a ball passed by an opponent with the ball from reaching its intended receiver by contacting the ball and keeping his own team in possession of the ball (Barreira et al., 2014).
b.3 Steal: when the defender dispossesses the opponent of the ball through a physical challenge or defensive pressure (Barreira et al., 2014).
b.4 Possession gained by the goal-keeper: when the goal-keeper of the team collects a turnover, intercepts or steal the ball.

3-Field starting zone: zone on the field of play where the possession starts (**Figure 3**). Four categories and sixteen sub-categories were considered:

A) Defensive sector: *zones 1, 2, 3 and 4*.
B) Pre-defensive sector: *zones 5, 6, 7 and 8*.
C) Pre-offensive sector: *zones 9, 10, 11 and 12*.
D) Offensive sector: *zones 13a, b; 14a, b, c, d; 15a, b, c, d and 16a, b*.

4-Starting player: specific position of the player who performs the initial action of the possession. Seven categories were considered depending on the system of play used by the team (**Figure 4**): (A) Goal-keeper, (B) Central defender, (C) Full back, (D) Central defensive-midfielder, (E) Central offensive-midfielder, (F) Winger and (G) Forward.

5-Initial behavior: degree of offensive directness in the first three seconds of the team possession (**Figure 5**). Four categories were considered:

A) Non-penetrative action: any technical action towards any direction that does not past opponent player (s) performed during the first three seconds of the ball possession.
B) Penetrative action: passes or dribbles towards the opponent's goal past opponent player (s) performed during the first three seconds of the ball possession.
C) Long ball: aerial pass towards the opponent's goal with no clear advantage for the offensive team, forcing a duel between a teammate and an opposing player.
D) Other initial behavior: any other behavior different from the above.

Opponent defensive situation

6-Initial opponent position: opponent's height position on the field when the team possession starts (excluding goalkeeper) (**Figure 3**). Three categories were considered:

A) Low position: the opponent has the most backward player closer to their own goal line than the midline.
B) Medium position: the opponent has the most backward player closer to the midline than to their own goal.
C) Advanced position: the opponent has the most backward player in the opposing half.

7-Initial opponent pressure: distance between the player with the ball (first attackers) and an immediate pressing opponent player(s) (first defender(s)) during the first three seconds of the ball possession (Tenga et al., 2009; Lago-Ballesteros et al., 2012). Two categories were considered.

A) Pressure: one or several opponent players press the attackers within the first 3 seconds of the possession (the pressing defender(s) are always located within 1.5 meters from the first attackers).
B) No pressure: There is not any player that pressures the attackers during the first 3 seconds of the possession.

8- Initial opponent number: number of defending players located between the ball and their goal when the possession starts (excluding goalkeeper). Three categories were considered:

A) Micro-group: 3 or less defending players.
B) Meso-group: 4-6 defending players.
C) Macro-group: 7 or more defending players.

(Continued)

TABLE 1 | Continued

POSSESSION START
Opponent defensive situation
9-Initial opponent invasive space: area within the space of defensive occupation (SDO) of the opponent where team possession starts (**Figure 3**). Four categories and ten sub-categories were considered: A) Non-invasive zone: a.1: CF. B) Medium-invasive zone: b.1: CM, b.2 MR and b.3 ML. C) Very-invasive zone: c.1 CD, c.2 DR and d.3 DL. D) High-invasive zone: d.1: CB, d.2 BR and d.3 BL.

TABLE 2 | Description and categories for the dimensions related to the possession development.

POSSESSION DEVELOPMENT
Observed team (offensive)
10-Type of attack: degree of offensive directness and elaboration during the offensive process (Bangsbo and Peitersen, 2000; Tenga et al., 2009; Sarmento et al., 2010; Lago-Ballesteros et al., 2012). Three categories and five sub-categories were considered: A) Organized attack: (a) the possession starts by winning the ball in play or restarting the game; (b) in this type of team possession the opposing team is organized defensively or is able to re-organize its collective defensive system during the possession. a.1 Combinative attack: the progression towards the opponent's goal has high number of non-penetrative and short passes. The circulation of the ball takes place more in width than in depth (Sarmento et al., 2018b) and the intention of the team is to disorder the opponent using a high number of passes and slow tempo (evaluated qualitatively). a.2 Direct attack: the progression towards the opponent's goal includes a long pass from the back players or goalkeeper to the forward players (evaluated qualitatively); the circulation of the ball takes place more in depth than in width and the intention of the team is to take the ball directly near the penalty area to have opportunities of finishing by using a reduced number of passes and high tempo. a.3 Fast attack: the progression towards the opponent's goal is fast, using few passes and high percentage of penetrative and short passes; the circulation of the ball takes place in width and in depth (Sarmento et al., 2018b) and the intention of the team is to disorder the opponent using few passes and high tempo (evaluated qualitatively). B) Counterattack: the possession starts by winning the ball in play; the opponent is not organized defensively and is not allowed to re-organize their collective defensive system during the team possession; the progression towards the goal attempts to utilize a degree of imbalance right from start to the end with high tempo (Tenga et al., 2010); the circulation of the ball takes place more in depth than in width, using a high percentage of penetrative passes. The intention of the team is to exploit the space left by the opponent when they were attacking. C) Very short attack: The possession starts by winning the ball in play or restarting the game; and the duration of the team possession is too short to allow the observer to categorize the type of attack.
11-Possession width: use of the four longitudinal lanes of the field space during the team possession. Four categories were considered: A) One lane: During the possession, the ball moves through one of the four longitudinal lanes. B) Two lanes: During the possession, the ball moves through two of the four longitudinal lanes. C) Three lanes: During the possession, the ball moves through three of the four longitudinal lanes. D) Four lanes: During the possession, the ball moves through four of the four longitudinal lanes.
12-Passes per possession: number of passes performed by the offensive team during the possession.
13-Number of penetrative passes: number of passes performed by the offensive team during the possession towards the opponent's goal past opponent player(s).
14-Duration: time (in seconds) from the beginning until the end of the possession.

have been defined in the form of subspaces that show the degree of tactical penetration or invasion of the player in possession of the ball into the SDO drawn by the opposing team at a given time, as well as the situation of that player in the inside or outside of the adversary SDO (**Figure 5**). The location of the player in possession of the ball in relation to the position of the opponents constitutes a fundamental concept in the definition of many criteria included in the REOFUT (**Figure 3**).

Recording Instrument

The fifth stage, which was carried out to analyze the tactical dimensions related to offensive performance of Major League matches, was carried out using the recording instrument LINCE (v.1.2.1) (Gabín et al., 2012). Dimensions and categories of REOFUT were coded and the observation of behaviors by the two observers was done using this software.

Statistical Analysis

To assess the inter- and intra-observer concordance of the REOFUT, kappa index Cohen's (1960) was calculated using SPSS 21.0 for Windows (SPSS, Chicago, IL, United States).

RESULTS

Given the objective of this article, oriented to the construction of an observation instrument, the results refer to the quality control of the data, focused on the intra-observer and inter-observer concordance.

TABLE 3 | Description and categories for the dimensions related to the penultimate action of the possession.

PENULTIMATE ACTION (only registered if it is followed by a scoring opportunity)

Observed team (offensive) in the penultimate action

15-Penultimate action: technical-tactical action performed immediately before the final action that allows the final player to have the opportunity of shooting at goal. This action may be performed by the same player that shoots at goal (individual action) or by a teammate that pass the ball to the final player (collective play). Two categories and seven sub-categories were considered:

A) Individual action: the final player receives the ball without having a scoring opportunity but he achieves to create one by means of an individual action. This category has four sub-categories:
a.1 Dribbling: the final player dribbles the ball goal past defenders to create a scoring opportunity.
a.2 Running with the ball: the final player carries the ball towards a goal scoring situation.
a.3 Collecting a free ball: the final player collects a free ball that allows him to have an immediate scoring opportunity.
a.4 Shot from distance: the final player shoots from outside the score pentagon.

B) Collective play: The penultimate player in the team possession performs a pass that allows the last player to have an immediate scoring opportunity. This category has three sub-categories.
b.1 Pass in behind the defence: pass from central channels of the field that breaks the opposing defensive line and allows the receiver to have an immediate scoring opportunity in front of the goalkeeper.
b.2 Cross: pass performed from the wide channels of the field in the opposing half (**Figure 1**) towards the penalty box (Sarmento et al., 2010) that allows the receiver to have an immediate scoring opportunity.
b.3 Goal pass: the final player receives an assist in form of a pass (different from a pass in behind and cross) from a different player that allows him to have an immediate scoring opportunity.

16-Penultimate player: specific position of the player that performs the penultimate action. Seven categories were considered depending on the system of play used by the team (**Figure 4**): A) Goal-keeper, B) Central defender, C) Full back, D) Central midfielder, E) Central offensive-midfielder, F) Winger and G) Forward.

17-Field Penultimate zone: zone on the field of play where the penultimate action of the possession is performed (**Figure 3**). Four categories and sixteen sub-categories were considered (**Figure 2**). Four categories and sixteen sub-categories were considered:

A) Defensive sector: zones 1, 2, 3 and 4.
B) Pre-defensive sector: zones 5, 6, 7 and 8.
C) Pre-offensive sector: zones 9, 10, 11 and 12.
D) Offensive sector: zones 13a, b; 14a, b, c, d; 15a, b, c, d and 16a, b.

Opponent defensive situation

18-Penultimate opponent invasive zone: Area within the space of defensive occupation (SDO) of the opponent where penultimate action is done (**Figure 3**). Four categories and ten sub-categories were considered:

A) Non-invasive zone: a.1: CF.
B) Medium-invasive zone: b.1: CM, b.2 MR and b.3 ML.
C) Very-invasive zone: c.1 CD, c.2 DR and d.3 DL.
D) High-invasive zone: d.1: CB, d.2 BR and d.3 BL.

Table 6 shows the Kappa values for each of the dimensions of the observation instrument. We can observe how the values for the intra-observer analysis are higher than those obtained in the inter-observers. In this sense, according to the criterion of Altman (1991) the intra-observer analysis shows how 83.9% of the dimensions present very good reliability (0.81–1.0) and 16.1% good (0.61–0.80). On the other hand, the intra-observer analysis shows how 96.8% of the dimensions present a very high reliability (0.81–1.0) and the remaining 3.2% show a good reliability (0.61–0.80).

DISCUSSION

The central axis of the work has been to present the process of construction of the observation instrument REOFUT, from the qualitative behavior of the soccer team, to the quantitative recording of data, demonstrating that this tool is suitable and consistent for the analysis of offensive possessions in soccer.

First, this study has presented the design process of REOFUT, which aims to provide a greater contextualization of tactical behavior and offensive performance in soccer supported by a broad theoretical framework as claimed by different authors (Mackenzie and Cushion, 2013; Sarmento et al., 2018a). It is remarkable the fact that it incorporates the concept of SDO as well as the position, numerical balance and pressure of the opponent to analyze the interaction between both teams during different phases of the game. In addition, one of the most novel aspects of the REOFUT is to describe in detail the type of technical-tactical actions that can be carried out during the possession, emphasizing its tactical functionality with respect to the opponent rather than its execution, as some recent studies suggested (McLean et al., 2017). Also, the concept of type of progression in attack of the offensive process is used considering previous studies (Tenga et al., 2009; Sarmento et al., 2010; Lago-Ballesteros et al., 2012) and as main novelty, the offensive performance dimension has been defined by four categories that reflect the degree of offensive penetration achieved by the

TABLE 4 | Description and categories for the dimensions related to the end of the possession.

END OF POSSESSION

Observed team (offensive) final action

19-Last player: it refers to the position that the player that does the last action has into the team system. Eleven categories were considered (**Figure 4**).

20- Last action: technical-tactical action performed by the last player who played the ball in that possession. It considers the spatial situation of the opponent team at the moment in which the action is done (**Figure 2**). Twelve categories were considered:

A) Non-penetrative pass: the possession ends after a pass towards any direction that does not past opponent player (s).
B) Penetrative pass: the possession ends after an unsuccessful pass towards the opponentt's goal past opponent player(s).
C) Pass in behind the defense: the possession ends after a pass from inside zones of field that try to break the defensive line of the opponent.
D) Cross: the possession ends after a pass from the two lateral lanes of the field towards the penalty box in the opponent's half field (Sarmento et al., 2010).
E) Goal pass: the possession ends after any other pass that intended a goal opportunity not categorized into pass in behind the defense nor into cross.
F) Long pass: the possession ends after an aerial pass towards the opponent's goal with no clear advantage for any teammate, before the expected challenge.
G) Dribbling: the possession ends with an unsuccessful dribbling towards the opponent's goal past opponent player (s).
H) Shoot with 1 contact: the possession ends with a shot on goal by means of a single contact (goal or not).
I) Shoot with 2 or more contacts: the possession ends with a shot on goal by means of two or more contacts (goal or not).
J) Header: the possession ends with a head kick on goal.
K) Challenge: the possession ends while a challenge after a long pass.
L) Another action: the possession ends after any other action not categorized into any of the previous categories.

21-Field last zone: zone on the field of play where the last action of the possession is performed (**Figure 3**). Four categories and sixteen sub-categories were considered (**Figure 2**):

A) Defensive sector: zones 1, 2, 3 and 4.
B) Pre-defensive sector: zones 5, 6, 7 and 8.
C) Pre-offensive sector: zones 9, 10, 11 and 12.
D) Offensive sector: zones 13a, b; 14a, b, c, d; 15a, b, c, d and 16a, b.

22-Offensive performance: Degree of offensive success of the possession, based on the degree of penetration over the opposing team and the achievement of scoring opportunities and goals (**Figure 3**). Four categories were considered:

A) Goal: the possession ends in goal.
B) Scoring opportunity: the possession ends with a clear chance of scoring a goal during team possession. This include all the chances of shooting than one player has inside the score pentagon (the player is facing the goal, there is not any opponents between him and the goal and he has enough space and time to make a playing decision). There are also considered scoring opportunities all shoots from outside the score pentagon that pass near the goal (2 meters or less with respect to the goal).
C) Offensive penetration: The team possession achieves to beat the forwards and midfielders' lines of the opponent and face directly the defensive line during the offensive sequence but the possession ends without creating any scoring opportunity. The player(s) facing the defensive line has/have enough time and space to perform intended actions on the ball at the moment of receiving the ball.
D) No offensive penetration: The team possession does not achieve to disorder and beat the forwards or midfielders' lines of the opposing team during the offensive sequence.

23-Final offensive outcome: type of possession that follows to the observed offensive possession considering if the ball is still in play or not, which team has the ball and what type of possession is the following one. Six categories were considered:

A) Set play for: the following possession is a set play for the observed team.
B) Set play against: the following possession is a set play for the opponent team.
C) Restart for: the following possession is an offensive restart but not set play for the observed team.
D) Restart against: the following possession is offensive restart but not set play for the opponent team.
E) Neutral ball: The ball is lost in the field (after clearances or missed passes) but neither team possess the ball, so a physical duel is required to gain or regain the ball possession.
F) Opponent recovery: the following possession is an offensive recovery of the opponent team (by interception, steal or turnover of the ball).

Opponent defensive situation in the final action

24-Last opponent invasive zone: area within the space of defensive occupation (SDO) of the opponent where last action is done (**Figure 3**). Four categories and ten sub-categories were considered:

A) Non-invasive zone: a.1: CF.
B) Medium-invasive zone: b.1: CM, b.2 MR and b.3 ML.
C) Very-invasive zone: c.1 CD, c.2 DR and d.3 DL.
D) High-invasive zone: d.1: CB, d.2 BR and d.3 BL.

team observed on the opponent during possession (no depth, deep attack, goal scoring opportunity and goal). Therefore, the REOFUT provides a methodological framework of analysis that allows future researchers the possibility of studying globally or specifically different dimensions of the game, such as possessions that originate goals or goals, defensive transitions, as well as the study of game patterns at different times of possession.

The first step is to correctly record and code the data, and this is where the *ad hoc* observation instrument (REOFUT) is

TABLE 5 | Description and categories for the defensive dimensions if the following possession is against.

FOLLOWING OPPONENT POSSESSION START

Observed team (defensive)

25-Pressure after losing the ball: Distance between the opponent player with the ball (first attackers) and an immediate pressing player(s) (first defender(s)) during the first three seconds of the ball possession (Tenga et al., 2009; Lago-Ballesteros et al., 2012). Two categories were considered.

A) Pressure: one or several players press the attackers within the first 3 seconds of the possession (the pressing player (s) are always located within 1.5 meters from the first attackers).
B) No pressure: any player presses the attackers during the first 3 seconds of the possession.

Opponent team (offensive)

26-Opponent initial offensive behavior: degree of offensive directness in the first three seconds of the opponent team possession (**Figure 5**). Four categories were considered:

A) Non-penetrative action: technical-tactical actions are performed towards any direction that does not past any player (s) during the first three seconds of the ball possession.
B) Penetrative action: opponent passes or dribbles towards the goal past player (s) performed during the first three seconds of the ball possession.
C) Long ball: aerial pass towards the opponent's goal with no clear advantage for the offensive team, forcing a duel between a teammate and an opposing player.
D) Other initial behavior: any other behavior.

FOLLOWING OPPONENT POSSESSION DEVELOPMENT

Observed team (defensive)

27-Type of attack: degree of offensive directness and elaboration during the offensive process (Bangsbo and Peitersen, 2000; Tenga et al., 2009; Sarmento et al., 2010; Lago-Ballesteros et al., 2012). Three categories and five sub-categories were considered:

A) Organized attack: (a) the possession starts by winning the ball in play or restarting the game; (b) in this type of team possession the opposing team is organized defensively or is able to re-organize its collective defensive system during the possession.

a.1 Combinative attack: the progression towards the opponent's goal has high number of non-penetrative and short passes. The circulation of the ball takes place more in width than in depth (Sarmento et al., 2018b) and the intention of the team is to disorder the opponent using a high number of passes and slow tempo (evaluated qualitatively).
a.2 Direct attack: the progression towards the opponent's goal includes a long pass from the back players or goalkeeper to the forward players (evaluated qualitatively); the circulation of the ball takes place more in depth than in width and the intention of the team is to take the ball directly near the penalty area to have opportunities of finishing by using a reduced number of passes and high tempo.
a.3 Fast attack: the progression towards the opponent's goal is fast, using few passes and high percentage of penetrative and short passes; the circulation of the ball takes place in width and in depth (Sarmento et al., 2018b) and the intention of the team is to disorder the opponent using few passes and high tempo (evaluated qualitatively).

B) Counterattack: the possession starts by winning the ball in play; the opponent is not organized defensively and is not allowed to re-organize their collective defensive system during the team possession; the progression towards the goal attempts to utilize a degree of imbalance right from start to the end with high tempo (Tenga et al., 2010); the circulation of the ball takes place more in depth than in width, using a high percentage of penetrative passes. The intention of the team is to exploit the space left by the opponent when they were attacking.
C) Very short attack: The possession starts by winning the ball in play or restarting the game; and the duration of the team possession is too short to allow the observer to categorize the type of attack.

28-Opponent number of passes: number of passes performed by the opposing team during the possession.

END OF THE FOLLOWING OPPONENT POSSESSION

Observed team (defensive) final action

29-Final observed team invasive zone: Area within the space of defensive occupation (SDO) of the observed team where last action of the opponent team is done (**Figure 3**). Four categories and ten sub-categories were considered:

A) Non-invasive zone: a.1: CF.
B) Medium-invasive zone: b.1: CM, b.2 MR and b.3 ML.
C) Very-invasive zone: c.1 CD, c.2 DR and d.3 DL.
D) High-invasive zone: d.1: CB, d.2 BR and d.3 BL.

Opponent team (offensive) final action

30-Defensive performance: Degree of offensive success of the possession, based on the degree of penetration over the observed team and the achievement of scoring opportunities and goals (**Figure 3**). Four categories were considered:

(Continued)

TABLE 5 | Continued

END OF THE FOLLOWING OPPONENT POSSESSION

Opponent team (offensive) final action

A) Goal: the opponent possession ends in goal.
B) Scoring opportunity: the opponent possession ends with a clear chance of scoring a goal during team possession. This include all the chances of shoot than one player has inside the score pentagon (the player is facing the goal, there is not any opponents between him and the goal and he has enough space and time to make a playing decision). There are also considered scoring opportunities all shoots from outside the score pentagon that pass near the goal (2 meters or less with respect to the goal).
C) Offensive penetration: The opponent possession achieves to beat the forwards and midfielders' lines of the opponent and face directly the defensive line during the offensive sequence but the possession ends without creating any scoring opportunity. The player(s) facing the defensive line has/have enough time and space to perform intended actions on the ball at the moment of receiving the ball.
D) No offensive penetration: The opponent possession does not achieve to disorder and beat the forwards or midfielders' lines of the opposing team during the offensive sequence.

31-Final defensive outcome: type of possession that follows to the opponent offensive possession considering if the ball is still in play or not, which team has the ball and what type of possession is the following one. Six categories were considered:

A) Set play for: the following possession is a set play for the observed team.
B) Set play against: the following possession is a set play for the opponent team.
C) Restart for: the following possession is an offensive restart but not set play for the observed team.
D) Restart against: the following possession is offensive restart but not set play for the opponent team.
E) Neutral ball: The ball is lost in the field (after clearances or missed passes) but neither team possess the ball, so a physical duel is required to gain or regain the ball possession.
F) Team recovery: the following possession is an offensive recovery of the team (by interception, steal or turnover of the ball).

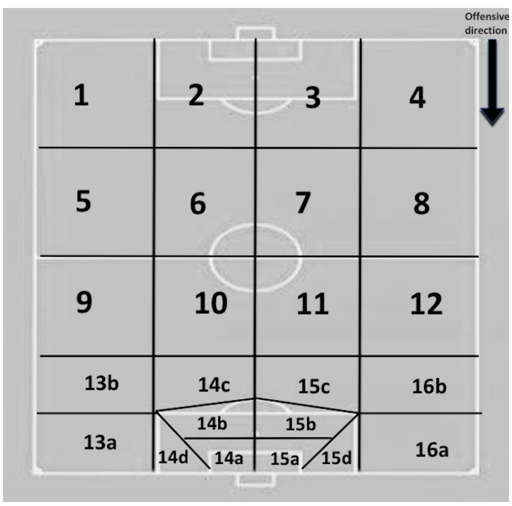

FIGURE 2 | Zones of the field and "score pentagon." The "score pentagon" is subdivided into different zones in order to perform a more specific analysis of the dimensions related to goals and goal scoring opportunities.

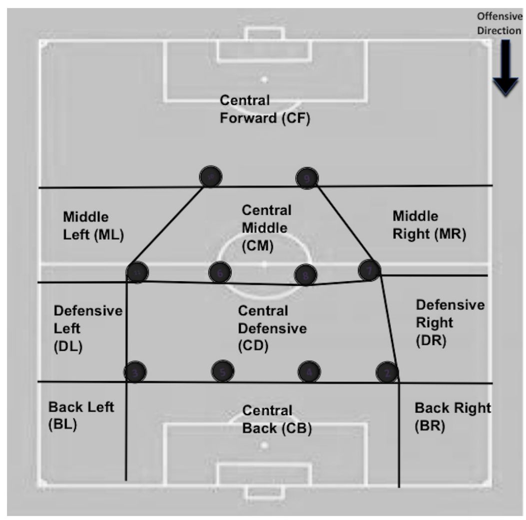

FIGURE 3 | Space of defensive occupation that define the level of invasion over the opponent (Adapted from previous studies, Castellano, 2000; Gréhaigne, 2001; Seabra and Dantas, 2006; Aranda et al., 2009). These zones are dynamic and change every second depending on the positioning on the opposing players.

used. The record can be managed and processed systematically within an empirical research setting that ensures replicability. The recorded data can be transformed into a series of complete or incomplete code matrices containing purely qualitative information (Anguera et al., 2017). This transformation is achieved by organizing the dimensions into columns and adding the behavioral units (possessions) to the corresponding rows, ready for quantitative analysis.

Once the necessary data controls (as Kappa coefficient for inter-observers agreement) has been performed, the researcher now has access to a series of code matrices perfectly suited for analysis using different techniques.

Secondly, quality control of the data was carried out through the analysis of agreement according to the proposal of the Kappa index, considered as an appropriate analytical technique to analyze the measure of agreement for categorical data in the analysis of sports performance (Robinson and O'Donoghue, 2007). In this way, it has been observed how the REOFUT dimensions show very good and good levels of reliability in all the dimensions, according to the criteria of Altman (1991). Intra-observer analysis shows better levels of reliability than inter-observers. This fact may be due to the fact that some

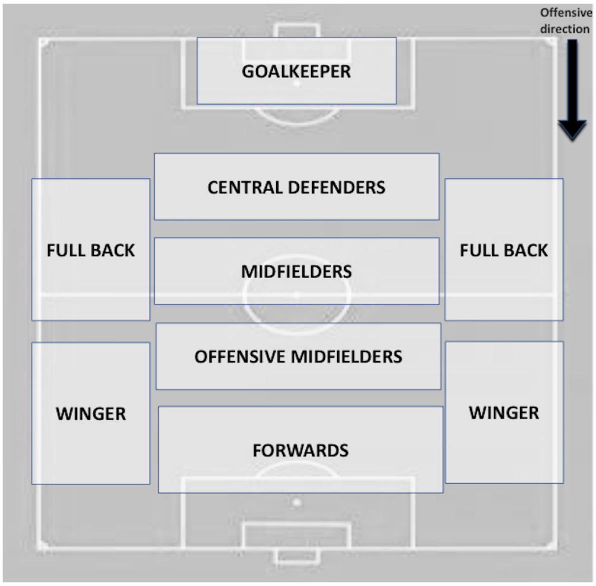

FIGURE 4 | Specific positions within the system of play used by the team in order to determine the player that performs the action. This characterization depends on the system used by each analyzed team.

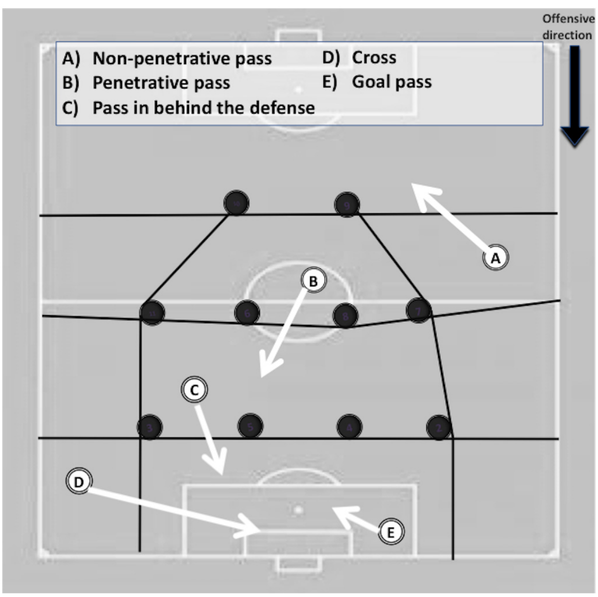

FIGURE 5 | Example of different tactical behaviors related to the penetration over the opponent and their tactical performance.

of the behaviors analyzed require the interpretation by the observers, which may cause discrepancies in the observations in some cases. In this line, James et al. (2007) and Losada and Manolov (2015) argue that the disparity between two observers can be expected especially when the analytical procedure requires considerable skill and experience. In addition, these authors add that factors such as training in the analytical procedure, operational definitions and the nature of the dimensions should be considered in the interpretation of the results. In the present study, high reliability values were obtained with a training period of the observer of 4 weeks and the operational definitions of the analytical procedure were specially specified and studied both theoretically and practically during the exploratory observation phase of the study.

In terms of the nature of dimensions and categories, some observations may naturally be more difficult to perform without errors than others (James et al., 2007). This study has observed how the behaviors in which the interpretation by the observers was more relevant have obtained lower agreement values than the behaviors with lower interpretative demands. For example, the dimensions referred to the location of the initial action, penultimate and last action in the rival invasive space obtained lower values of agreement than the dimensions related to the location of them in the formal game space, both inter-observers (0.800, 0.776, 0.813 vs. 0.958, 0.963, 0.959) as intra-observer (0.862, 0.845, 0.907 vs. 0.947, 0.951, 0.979), respectively. This result must be understood in relation to the fact that the zones of the opponent SDO are changing with the evolution of the game action, which requires more experience for interpretation by the observers, while the formal field zones are invariable and the references on the field help to draw imaginary lines on the playing field that facilitate location.

In relation to similar studies, our results coincide with previous investigations that found how the spatial categorization considering the SDO of the equipment can be a reliable measure for the analysis of the game space in soccer. For example, Seabra and Dantas (2006) divided the SDO into 7 sub-spaces to analyze the finalization space in soccer and showed values between 0.83 and 0.93 for the intra-observer analysis and between 0.73 and 0.90 for the inter-observers, which approximates the values found in the present study. Also, Castellano et al. (2000) created an observational tool to analyze actions and contexts of interaction in soccer considering the actions of the players and their relationship with the positioning of the team itself and rivals, showing satisfactory levels of inter-observer and intra-observer reliability.

On the other hand, the present study presents higher concordance values in comparison with the study carried out by Tenga et al. (2009), who developed an observation instrument for soccer performance analysis with 22 dimensions. It is worth noting that the defensive dimensions presented by Tenga et al. (2009) based on pressure, coverage and positioning of the defenders obtained a very low reliability. In addition, as it occurs with REOFUT, this study showed greater concordance for the intra-observer analysis (73% of the criteria very good, 23% good and 4% moderate) than for the inter-observers (32% very good, 23% good, 32% moderate, 9% reasonable, and 4% poor).

In addition, our study presents lower reliability values with respect to the instrument designed by Sarmento et al. (2010) for the analysis of the offensive process in soccer, which achieved reliability values above 0.95 in all the dimensions studied. This instrument aims to detect temporary patterns at the start, development and end of the offensive sequences and shares with the REOFUT the importance of the dimension related to the type

TABLE 6 | Kappa values obtained for the dimensions of the REOFUT observation tool.

Macro criteria	Moment	Dimension	*n*	*K* inter-observers	*K* intra-observer
OFFENSIVE	START	1. Possession type	128	0.972	1.000
		2. Type of start	128	0.891	0.963
		3. Field starting zone	128	0.958	0.947
		4. Initial player	128	0.951	0.990
		5. Initial behavior	107	0.819	0.963
		6. Initial opponent position	107	0.901	0.943
		7. Initial opponent pressure	107	0.815	0.861
		8. Initial opponent number	107	0.897	0.916
		9. Initial opponent invasive zone	107	0.800	0.862
	DEVELOPMENT	10. Type of attack	107	0.776	0.898
		11. Possession width	107	0.935	0.935
		12. Number of passes	107	0.925	0.947
		13. Number of penetrative passes	107	0.779	0.767
		14. Duration	107	0.958	0.958
	END	15. Penultimate action	16	0.765	0.889
		16. Penultimate action	16	0.938	1.000
		17. Penultimate field zone	16	0.963	0.951
		18. Penultimate invasive zone	16	0.774	0.845
		19. Last player	128	0.979	1.000
		20. Last action	128	0.841	0.883
		21. Last field zone	128	0.959	0.979
		22. Offensive performance	128	0.942	0.942
		23. Possession outcome	128	0.940	0.964
		24. Final opponent invasive zone	107	0.813	0.907
DEFENSIVE	START	25. Pressure after losing the ball	45	0.821	0.940
		26. Opponent initial offensive behavior	45	0.841	0.901
	DEVELOPEMENT	27. Opponent type of attack	45	0.839	0.905
		28. Opponent number of passes	45	0.895	0.948
		29. Last invasive zone	45	0.758	0.946
	END	30. Defensive performance	45	0.824	0.893
		31. Defensive outcome	45	0.905	0.937

of attack, which was divided into categories such as rapid attack, positional attack and counterattack.

REOFUT shows several limitations. On the one hand, as it is a tool based on notational analysis and therefore on the observation, interpretation and recording of events that take place during the game. It may not reflect the total complexity and criteria that the offensive play actions represent. On the other hand, this instrument is fundamentally based on the study of the offensive moment. Although it consists of numerous criteria to describe the different moments of the action of open offensive play, which consists of different moments such as the beginning, the development, the penultimate action and the end, it is not considered an instrument of ideal observation for the study of offensive set pieces, which are actions that have different technical and tactical characteristics to open game situations. It would be fantastic to have a single and simple tool to analyze all types of action that are in a game, but given the diversity of actions that occur in football, to analyze the tactical behavior of the team with a single instrument appears almost impossible.

Finally, this instrument has important practical applications. Firstly, the REOFUT tool can be used for researchers to analyze, describe, predict and compare collective offensive performance. Secondly, soccer coaches and match analysts of all levels can use the theoretical framework of REOFUT to evaluate and register the offensive performance of their teams throughout the season, analyzing the tactical progress and using this information for adjusting and improving the coaching process.

In conclusion, the optimal inter and intra-reliability levels obtained in this work are high enough as for suggesting that REOFUT could be an adequate tool for analyzing offensive play actions and their performance in soccer.

AUTHOR CONTRIBUTIONS

RA developed the project, supervised the design of the study, and drafted the manuscript. JG-R was responsible for the review of the literature and the drafting of the manuscript, codified the data, and contributed to the analysis and the method section. IL-B collected and codified the data, and performed the analysis. RA-M was responsible for the analysis, data collection, and data handling. AT-D codified the data. MA revised the content critically. All authors approved the submitted version of the manuscript.

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Adaptation and Psychometric Properties of the Spanish Version of Child and Youth Resilience Measure (CYRM-32)

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Resilience is defined as a dynamic process that entails a positive adaptation to contexts of adversity. According to the ecological model, resilient behavior emerges as a result of the interaction between individual, relational, community and cultural variables. The Child and Youth Resilience Measure (CYRM-28), developed in Canada and based on the ecological model, has been validated in several countries. The objective of this article is to present the cultural adaptation (studies I and II) and validation (study III) in Spanish at risk youth. A three-study mixed-method design was selected. Study I includes translations and a confirmatory and exploratory factor analysis of a sample of 270 Spanish young persons (56.9% boys) aged between 12 and 18 years (M = 14.65; SD = 1.27) from an urban public elementary school. Study II uses semi-structured interviews with adolescents identified as resilient and presents a content analysis and a reformulation of items with experts. Study III includes the confirmatory factor analysis, internal consistency, test–retest, convergent and discriminant validity, and multivariate analysis of variance to explore group differences of the resulting scale CYRM-32. The sample consisted of 432 at-risk young persons (54.9% boys) aged between 12 and 19 years old (M = 14.99; SD = 2.23). The results confirm the adequate psychometric properties of the CYRM-32 scale. From the original scale, 4 items were eliminated, 5 were reformulated presenting very low saturations. Meanwhile, 6 items were added to the cultural adaptation phase, resulting in a 32-item scale. The confirmatory analysis confirms the 3 factors expected in the CYRM-32 scale with good reliability indexes (Cronbach's α total scale 0.88, family interaction 0.79, interaction with others 0.72 and individual skills 0.78). The scale has convergent and discriminant validity in relation to the Brief Resilient Coping Scale, Coping Scale for Adolescents and Self-Concept. Significant differences were found in the scores of the CYRM-32 scale for the ethnic variable

[$F(71.\ 358) = 1.714$, $p < 0.001$], while no differences appear according to age and gender. This finding confirms the importance of culture in the resiliency processes. The CYRM-32 scale has good psychometric properties and is a new alternative for measuring resilience in Spanish at-risk youth.

Keywords: resilience, at-risk young, social exclusion, reliability, validity, mixed-methods, cultural adaptation

INTRODUCTION

Resilience is a construct used to explain the processes that result in good outcomes despite high-risk situations that pose a threat to positive adaptation and self-development (Masten and Coatsworth, 1998; Masten, 1999, 2007; Masten et al., 1999). Definitions of what constitutes appropriate adaptation however, varies in relation to the cultural, historical and/or social context (Masten and Coatsworth, 1998). Thus, currently there is no a universal definition of resilience (Aburn et al., 2016), but the literature show the influence of the contextual factors in the development of resilience and coping among youth (Clauss-Ehlers, 2008). Moreover, sociocultural aspects of support can promote and contribute to resilience.

For this reason, transcultural research is needed for studying resilience and to determine what can be considered as positive development in different socio-cultural contexts. Masten (1999) has proposed the following questions: "Should successful development be defined only within cultural context? What happens when subcultural norms differ from the majority culture?" (p. 283).

From a contextual and ecological perspective, resilience has been defined by Ungar (2008) as "in the context of exposure to significant adversity, whether psychological, environmental, or both, resilience is both the capacity of the individuals to navigate their way to health-sustaining resources, including opportunities to experience feelings of wellbeing, and a condition of the individual's family, community and culture to provide these health resources in culturally meaningful ways" (p. 225). From this point of view, the resilience process of the child should be understood in relation to the context; it relates to the threats that people have to face and the interactions between risk exposure and the available resources that permit adaptation to the environmental and personal challenges (Ungar et al., 2008). Boyden and Mann (2005) as well as Ungar (2004) have argued that the way we understand resilience is negotiated discursively and influenced by the culture and social context in which it is located. Consequently, it is necessary to continue studying the underlying mechanisms and processes of resilience across different cultures (Boyden and Mann, 2005).

Despite the importance of culture in the development of resilience, many instruments used to measure resilience have neglected these cultural factors (Clauss-Ehlers, 2008).

In this line, according to Ungar (2011), in the measurement of resilience the effects of cultural immersion in dominant cultures and heterogeneity in ethno-racial minorities have been overlooked. This is important because the identification of resilience factors that contribute to the process of adaptation to adversity contribute to the improvement of intervention programs that empower youth to manage the resources that sustain their wellbeing (Ungar, 2004, 2008).

For this reason, it is necessary to have evaluation tools based on an overall theoretical framework of resilience. Several resilience measures have been developed and validated for the use of children and young people. These include Youth Resiliency: Assessing Developmental Strengths (YR:ADS), validated in Canada (Donnon and Hammond, 2007); The Resilience Scale for Adolescents (READ), validated in Norway, Ireland, Mexico, and Italy (Hjemdal et al., 2006; Von Soest et al., 2010; Stratta et al., 2012; Ruvalcaba-Romero et al., 2015; Kelly et al., 2016), and the Child and Youth Resilience Measure (CYRM-28), validated in Canada, New Zealand, and Iran (Ungar and Liebenberg, 2011; Liebenberg et al., 2012; Daigneault et al., 2013; Sanders et al., 2015; Kazerooni et al., 2016).

Additionally, measures that assess resilience-related constructs have been adapted for use with Spanish children and adolescents. For example, the Adolescent Coping Scale (Frydenberg and Lewis, 1996), the Coping Response Inventory for Youth (Forns et al., 2005) and The Adolescent Resilience Questionnaire (Guilera et al., 2015).

Given the need for resilience measures to be adapted to the different cultures, in addition to validation of psychometric properties, in this article we continue with the validation and adaptation of the CYRM-28. We focus on the CYRM-28, reflecting Bronfenbrenner's Ecological Model (Bronfenbrenner, 1979). Additionally, the CYRM-28 was specifically developed to assess resilience in vulnerable adolescents across cultures and contexts (Ungar and Liebenberg, 2011). In their assessment of resilience measures, Windle et al. (2011) found the CYRM-28 to have high content validity and they presented this test as one of the few resilience measures that assesses multiple dimensions of resilience (culture, community, relationship and individual) and shows conceptual adequacy. Initially the CYRM-28 included 14 sites around the world. Later, following this work, the measure has been validated for use in other countries, as we have indicated previously, but not yet in Spain.

This work presents the cultural adaptation and validation of the Child and Youth Resilience Measure (CYRM-32) to a Spanish sample of risk youth. It includes three studies: (1) the exploration of the psychometric properties of the original scale (CYRM-28) after being translated to the Spanish language, (2) the development of new items for the CYRM adapted to the local context and the reformulation of conflicting items, and (3) the validation of the final CYRM-32 adapted scale (**Figure 1**).

We decided to use a mixed methods design was in order to adapt the CYRM-28 scale (Ungar and Liebenberg, 2011; Liebenberg et al., 2012). The relevance of mixed methods

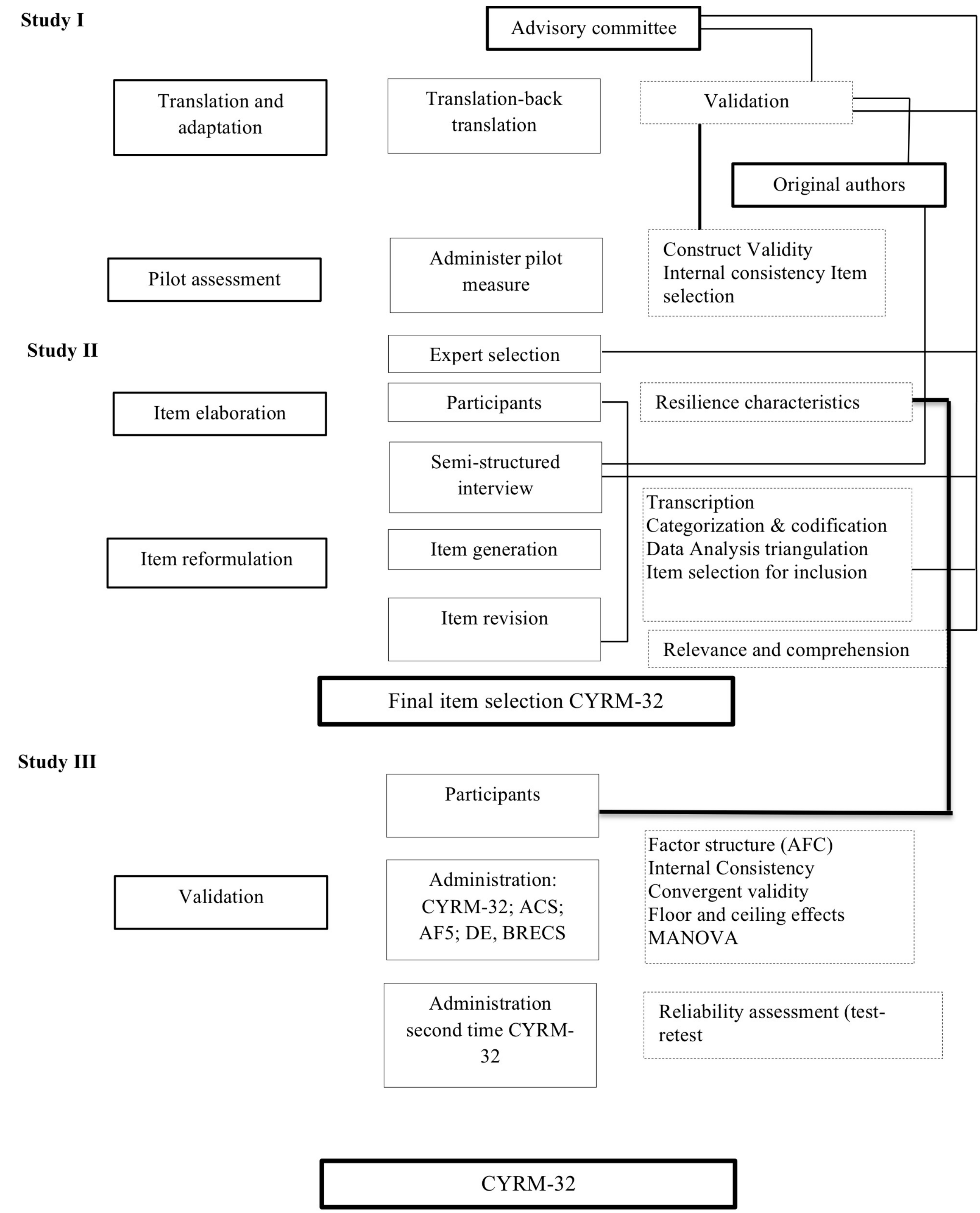

FIGURE 1 | Procedure flow.

to enable the understanding of common and unique aspects of resilience across cultural has been discussed during the development of the original scale (Ungar and Liebenberg, 2011). The mixed methods used here in our study allowed us to compare the results of our quantitative findings with the experiences of young people at risk and the individual and cultural resources that intervened in their resilient processes (Ungar and Liebenberg, 2011).

The study was approved by the Ethics Committee Institutional Review Board of the Consorci Sanitari de Terrassa (Spain). For all the studies, informed consent was obtained prior to data collection, from the high schools' headmasters and participants.

STUDY I

The purpose of this study was the translation of the CYRM-28 scale and a review of its factor structure using exploratory and confirmatory factor analyses.

Participants

An evaluation committee of five professionals with knowledge about children at risk of social exclusion was formed. Specifically, the focus was on youth experiencing increased disconnection from their communities together with a loss of personal and social ties, and their families. This disconnection hinders access to opportunities and resources made available to support individuals living in low socioeconomic contexts and or who have recently experienced immigration.

A total of 270 young people in a high risk of social exclusion were randomly selected from two schools situated in a vulnerable neighborhood. Each year group consisted of four different classes or subgroups (30–35 students each) and two classes per school year (60–70 students) were randomly selected. The average age of the participants was 14.5 years (SD = 1.27, range 12.35 to 18.08); 56.9% were boys and 43.1% girls; 76% lived with both parents, 19% with a single mother and 2% with other people; 75.8% were European, 10.7% Latin American and 8.3% belonged to different ethnic groups.

Instruments

In the first study, the original version of the Child and Youth Resilience Measure-28 (CYRM-28) (Ungar and Liebenberg, 2011) was used. It was designed as a screening tool to explore the resources (individual, relational, communal and cultural) available to youth aged 12 to 23 years, that may bolster their resilience processes (Ungar and Liebenberg, 2011; Liebenberg et al., 2012). The CYRM-28 has 28 items scored on a 5-point Likert scale (1 = not at all to 5 = a lot), and was designed as a self-reported measure which takes approximately 20 min to complete (Ungar and Liebenberg, 2011; Liebenberg et al., 2012). The Cronbach's α of the three components of the scale showed the following values for each dimension: individual (α = 0.80); relational (α = 0.83); and contextual (α = 0.79) (Liebenberg et al., 2012).

Data Analysis and Procedure

Following the guidelines provided by the original authors and the International Test Commission in construction and adaptation areas the back translation method was used to translate the CYRM-28 into Spanish (Beaton et al., 2000; Hambleton and John, 2003). Cycles of corrections and revisions were carried out until a definitive version was obtained for each item.

A confirmatory factor analysis (CFA) using AMOS version 22 was conducted on data gathered from the first youth sample, to explore whether the original factor structure proposed by Liebenberg et al. (2012) fitted our sample. In order to assess model fit, absolute fit indexes (χ^2, χ^2/df), relative fit indexes (IFI) and non-centrality fit indexes (CFI, RMSEA, SRMR) were used, as well as criteria for acceptable fit based on the degree of adjustment described by Hair (2010) (ratio $\chi^2/df < 5$; SRMR < 0.08; RMSEA < 0.08; GFI, CFI and IFI > 0.90). As the previously tested model failed to fit our data, an exploratory factor analysis (EFA) was conducted to ascertain the factor structure of the CRYM-28 with a confirmatory approach (Pett et al., 2003; Cumming et al., 2005). A confirmation of the adequacy of the data by means of the Kaiser-Meyer-Olkin test and the Bartlett's test of sphericity was carried out (Costello and Osborne, 2005). The selection of factors was based on psychometric guidelines and Screen Plot or Screen Test of Cattell (Kline, 1994); coefficients greater than 0.40 and based on Kaiser's criterion of eigenvalue equal or greater than 1.0, were considered (Kline, 1994; Nunnally and Bernstein, 1994). Internal consistency was obtained through Cronbach's α (Cronbach, 1951).

Results

Confirmatory Factor Analysis (CFA)

Results of the CFA show that the three-factor model tested did not provide an acceptable fit to our data. The chi-square statistic was significant, probably due to the sample size (Hair, 2010), the ratio ($\chi^2/df = 2.89 < 5$) was well within the limits that allowed the model to be accepted, RMSEA and SRMR values were acceptable (<0.08), but the CFI (0.61), IFI (0.62) and GFI (0.80) were below the level of acceptance (all of them < 0.90).

Exploratory Factor Analysis (EFA)

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.73 middling but sufficient (Hair et al., 2014) and the Bartlett's test of sphericity was appropriate ($X^2(378) = 1446{,}563$; $p = 0.000$). Following the process of Ungar and Liebenberg (2011), EFA was carried out using Oblimin with Kaiser Rotation with three factors. Three components were identified that explained 30.8% of the total variance. Factor 1 "Family interaction," explained 17.7% of the variance; factor 2 "Interaction with others" explained 7.17%; and, factor 3 "Individual skills," 6% (see **Table 1**).

Four of the 28 initial items (items 2, 5, 10, and 28) failed to load on any of the three factors, and two were identified (19, 23) as conflicting items. As such these items were removed from the scale. A further six more items were removed due to inadequate loadings [items 1 (0.395), 3 (0.380), 9 (0.366) and 22 (0.369)], and conflicting loadings (loadings > 0.3 in more than one factor; items 19, 23). Cronbach's α were: Family interaction (0.720), Interaction with others (0.506), Individual skills (0.622) and for the totality of scale (0.783).

STUDY II

The second study describes the cultural adaptation of the CRYM into the Spanish context, using qualitative interviews with adolescents identified as resilient which were carried out by experts.

TABLE 1 | Summary of factor loadings for principal component analysis for Oblimin three factor solution of the CYRM-28 (Spanish version).

Items components	1 Family interaction	2 Interaction with others	3 Individual skills	Liebenberg et al., 2012	Daigneault et al., 2013
17. My family stands by me during difficult times. (*Mi familia me apoya en los momentos difíciles*)	0.731			Caregiver	Familial
24. I feel safe when I am with my family/caregiver(s). (*Me siento a salvo junto a mis padres o tutores*)	0.721			Caregiver	Familial
6. Mis padres o tutores lo saben todo sobre mí. (*My parent(s)/caregiver(s) know a lot about me*)	0.610			Caregiver	Familial
26. I enjoy my family's/caregiver's cultural and family traditions. (*Disfruto de las tradiciones familiares con mis padres o tutores*)	0.547			Caregiver	Familial
12. I talk to my family/caregiver(s) about how I feel. (*Hablo sobre cómo me siento con mi familia o tutores legales*)	0.486			Caregiver	Familial
27. I enjoy my community's traditions. (*Disfruto de las tradiciones de mi comunidad*)	0.448			Context	Community
15. I know where to go in my community to get help. (*Sé dónde acudir dentro de mi comunidad, cuando tengo algún problema*)	0.431			Individual	Individual
23. I think it is important to help out in my community. (*Creo que es importante ayudar en mi comunidad*)	0.401		0.314	Context	Community
28. I am proud to be Spanish? (*Estoy orgulloso de ser ciudadano de España?*)				Context	-
14. I feel supported by my friends. (*Mis amigos me apoyan*)		–0.774		Individual	Individual
18. My friends stand by me during difficult times. (*Mis amigos me apoyan en los momentos difíciles*)		–0.665		Individual	Individual
11. People think that I am fun to be with. (*La gente piensa que soy una persona divertida*)		–0.562		Individual	Individual
7. If I am hungry, there is enough to eat. (*Si tengo hambre, siempre hay suficiente comida para alimentarme*)		–0.480		Caregiver	Familial
19. I am treated fairly in my community. (*Soy tratado con igualdad dentro de mi comunidad*)	0.316	–0.458		Context	Individual
16. I feel I belong at my school. (*Siento que formo parte de mi escuela*)		–0.403		Context	Individual
22. I participate in organized religious activities. (*Participo en diversas actividades religiosas*)		0.369		Context	Community
2. I cooperate with people around me. (*Coopero con las personas de mi alrededor*)				Individual	Individual
10. I am proud of my ethnic background. (*Me siento orgulloso de mi origen étnico*)				Context	Community
5. Do you feel that your parent (s) watch you closely. (*Me siento vigilado por mis padres o tutores*)				Caregiver	-
21. I am aware of my own strengths. (*Soy consciente de mis puntos fuertes*)			0.717	Individual	Individual
20. I have opportunities to show others that I am becoming an adult and can act responsibly. (*Puedo demostrar a los demás que soy una persona adulta y responsable*)			0.557	Individual	Individual
4. I know how to behave in different social situations. (*Sé comportarme teniendo en cuenta las normas sociales*)			0.529	Individual	Individual
25. I have opportunities to develop skills that will be useful later in life (like job skills and skills to care for others. (*Tengo la oportunidad de desarrollar habilidades que me serán útiles en el futuro* (*Habilidades relacionadas con un oficio y habilidades sociales*)			0.506	Individual	Community
8. I try to finish what I start. (*Intento finalizar todo lo que empiezo*)			0.487	Individual	Individual
13. I am able to solve problems without harming myself or others (for example by using drugs and/or being violent. (*Puedo solucionar mis problemas sin hacerme daño ni hacer daño a terceras personas* (*por ejemplo sin caer en adicciones como la droga y sin usar la violencia*)			0.442	Individual	Familial
1. I have people I look up to. (*Conozco personas a las que admiro*)			0.395	Context	–
3. Getting an education is important to me. (*Tener una educación es importante para mí*)			0.380	Context	–
9. Spiritual beliefs are a source of strength for me. (*Mi fe me da fuerzas*)			0.366	Context	Community
Cronbach's α 0.783	**0.720**	**0.506**	**0.622**		

Bold items indicate factor loadings on more than one factor.

Participants

The second study included youth and resilience expert's adults. Six young people (2 girls and 4 boys, aged 17–19) were purposively selected to participate. The participants were chosen by two experts from institutions that work with vulnerable populations, children, youth and families in high risk situations (i.e., experiencing poverty, low socioeconomic status, social exclusion, exposure to violence and social dislocation for example through immigration). The participants were identified as resilient (i.e., young people that despite having gone through adverse situations have a healthy lifestyle, positive social relationships and positive individual skills). Five professional (psychology, philology, social work and education; 1 male and 4 females), resilience experts participated. They were invited given their expertise in the conceptualization of the resilience in Spain and to explore and formulation the items.

Additionally, four randomly selected participants (2 girls and 2 boys, age 14–17 years old) from the first phase who had previously completed the CYRM-28 scale were also invited to study 2 to review the translated items that showed low loadings in the first phase of the study.

Procedure

The second study included two phases (see **Figure 1**). In the first phase, two semi-structured individual interviews were conducted with the 6 young people and the 5 experts. These interviews were intended to generate new culturally and contextually relevant items for inclusion in the validated Spanish version of the CYRM-28. Accordingly, the interview guide used in the original development of the measure (Resilience Research Centre, 2009), was used in these interviews. All interviews were recorded and transcribed. Content analysis, conducted by two peer researchers, was used to identify themes reflecting culturally and contextually relevant resilience mechanisms and processes, for peer researchers. Identification of themes was guided by the original CYRM-28 factors (individual, caregivers and context). Emerging themes were used to create new items relevant to the local context on the basis of experts' consensus.

The second phase of study two was intended to ensure the rigor of the new items fort this, data was triangulated. First, the five experts reviewed each of the reformulated and new items. Each item was assessed for relevance and comprehension using a 5-point Likert scale (1 = not at all relevant or comprehensive to 5 = extremely relevant or comprehensive). Additionally, a semi-structured interview was conducted with the small group of four youth from the original youth sample, to explore the comprehension and possible ambiguous aspects of the items with low loadings. The interviews were transcribed and a discourse analysis was undertaken in order to ensure that the perspectives each participant gave to issues related with the reviewed items was adequately captured.

Results

New Items

The results were based on the narratives of the participants and the categories established in the CYRM-28. The emergent themes are presented according to the conceptual framework of the first Spanish version of the CYRM-28. For the three factors, 12 new items were generated and nine of them were included (see **Table 2**).

Interviews from the second study highlighted the importance of self-awareness and the capacity to recognize and regulate one's own emotions when managing difficult situations. The adult experts in particular noted that recognizing one's own feelings and emotions caused by adversities is an important factor to cope with adversity. It enables the person to reflect over more effective alternatives and, thus, leading to problem solving. This finding reflects previous research by Troy and Mauss (2011), who found that emotional regulation is connected with resilience through two strategies: attention control and cognitive reappraisal. These findings also point to the need for further research on the benefits and the process of emotion regulation strategies that may help us to better understand resilience (Kay, 2016).

Another theme emerging from the qualitative data was the importance of having a good sense of humor. Humor was described as a resource to cope with problems and to relate with other people within one's immediate environment (Cann and Collette, 2014). A good sense of humor has the function of creating positive emotions, which facilitates communication and releases tensions, while enabling social support (Fredrickson, 2000; Martin and Lefcourt, 2004). The adult experts also mentioned the importance of a sense of humor and laughter as a resource that enables overcoming problems with optimism (Hughes, 2008).

Likewise, having goals can be related with motivation to achieve one's purpose in life. Zolkoski and Bullock (2012), for example, found that it is important to have goals and a positive perspective for the future despite going through moments of adversity. Similarly, the young people interviewed also expressed the importance of following through with the aim they want to achieve.

Another relevant theme for the young participants was adaptation: the capacity to adapt to conflicting situations (Masten and Tellegen, 2012). One participant stated that she tried to adapt to changing situations, that she reflected on these situations to learn from the experience. This is a relevant issue, not only for immigrants that live in cultural contexts, very different from their own, but to reveal the capacity young people have to adapt to changes or situations that are perceived as difficult.

Interaction with others is another subcategory contained in the CYRM-28. The establishment of significant relationships that work as a source of practical and emotional support and offer strength to solve problems, feeling loved and valued, are of great importance. Family attachment is the aspect that appeared most frequently. In addition, having a role model in the family helps young participants to learn how to solve problems. In this sense, a supporting family environment promotes adaptation and positive outcomes in children (Marici, 2015).

Regarding the capacity of looking for support, the participants revealed their ability to ask for help to external people, either institutions, other sources of help or people from their close environment. This is the ability to negotiate with their

TABLE 2 | Generation of new items.

Dimension	Coding theme	New item	Quotations
Individual Factor	Self-awareness	*When I face a problem, I'm aware of my emotions and act according to how I feel in that moment. *Ante algún problema soy consciente de mis emociones y actúo según como me siento en el momento.*	"Sometimes I stay calm, think about what is going on with myself and think about how to solve the situation." (Participant B) "Recognizing her hatred was a protective factor, because during a time she defended herself from the pain that she was feeling, and accepting that her father was an abuser. All those years she had a yearning of having a father by her side. . .but she start accepting that she didn't love him and she felt hurt. The acceptance of this situation let her protect herself." (Expert 1)
	Sense of humor	*Despite difficulties, I usually smile. I think that I have good sense of humor. *A pesar de las dificultades suelo sonreír. Me considero una persona con buen sentido del humor.*	"Even if I'm sad I have to laugh. Laugh about me and everything, because if not I would be crying the whole day and that is not good at all." (Participant B) "She has developed the good sense of humor by learning; as a positive reinforcement. She has a brother that doesn't smile, and then she started to discover that smiling, people pay more attention to her than to her brother." (Expert 5)
	Vision of the future	*My strength helps me to go on and achieve my goals *Mi fortaleza me ayuda a seguir adelante y alcanzar Mis objetivos.*	"I think that going on with my life and not get desperate is good. Have the strength to keep going. . ." (Participant A) "If they talk with their family and agree, they can keep going as champions. It has to do with motivation and remember their purpose of life. . .Especially a tremendous will to move forward." (Expert 4)
		*I have aspirations and a clear and realistic vision of the future *Tengo aspiraciones y una visión de futuro clara y realista.*	"I belief and I want to finish high school and study in a university. . .I think that going on with my life and not get desperate is good. Have the strength to keep going. . ." (Participant A) "Having a realistic optimism. I mean, they can think that everything can have a good result, they have a positive vision of the future and think that they can control the course of their lives, but is important to have a good sense of reality and don't let go over fantasies." (Expert 2)
	Adaptation	*I'm able to adapt to changes. *Soy capaz de adaptarme a los cambios.*	"Now that I'm here. . . I want to adapt where my family has brought me. I try to adapt to everything; to people, neighbors, everyone, to the school. . . I try to adapt little by little to everything." (Participant A) "Maybe during a time I get myself isolated. . . and then I think that maybe that change can be good for me o for another person. . . and I try to adapt to the situation." (Participant C)
	Autonomy	*I usually make my own decisions and don't let myself be influenced by others *Tiendo a tomar mis propias decisiones y no me dejo llevar por los demás.*	"A person can move on by itself, I mean without relying on anyone, that one's objectives can be achieved by oneself no matter what." (Participant C) "When I say that they have to have their head well set, I mean that they have to be responsible; basic competencies, a kid that worries about himself; an autonomous kid." (Expert 4)
Interaction with others	Support to others	*I support my peers. *Doy apoyo a mis compañeros.*	"More than anything is giving your own experience to a person who suffers." (Participant B) "I feel like my friends' counselor and people's counselor, they always trust in me and I help them." (Participant C)
	Significant relationships	*I have role models that serve me as guidance and support *Tengo personas de referencia que me sirven de guía y apoyo.*	"Someone that helps you if you have a problem and you think you can't solve it; someone that helps you to solve the problem and gives you motivation believing in yourself, and that's why you have the strength to keep going until you solve it." (Participant A) "Having an adult role model as mom and dad is essential for their development." (Expert 4)
	Educative context	*My values allow me a positive relation with my environment. *Mis valores me permiten una relación positiva con Mi entorno.*	"Having a good education. Education comes from home, if your parents educate you well on the street you will know how to behave, but if your parents don't pay attention to you, probably other people will take you to the wrong path." (Participant E) "It is convenient to raise the person in an integrate manner, as one that is immersed in the society, foment the holistic education. This means, more than a disciplinary development, a self-development and its environment." (Expert 2)
	Cultural Integration	I feel integrated into the local culture and context. *Me siento integrado/a dentro de la cultura local.*	"There is some people that makes me feel bad. Some of the kids in my school. . .they always talking about my color. They say – you are chocolate color and we are white. . .what do you do in our country? – And that makes me feel bad, because not only in my country there are black people." (Participant A) "There is a stigmatization because there's a conjunction between the immigration and the youth. Prejudices are in both ways and it's about to reconstruct and think . . . culture makes us different but the characteristic is that all of us are human beings . . . when the young people interact with others form different cultures, when they get to know each other they realize about their prejudices and reconstruct all those believes." (Expert 1)

(Continued)

TABLE 2 | Continued

Dimension	Coding theme	New item	Quotations
	Perception of available resources	In my context, there are services that represent a source of support for me. *En mi contexto existen servicios que son fuente de apoyo para mi*	"I think that the most difficult thing in life is not having a job. . .because without a job you don't have money, and people without money can't buy food, clothes, pay the rent, etc. . . . " (Participant A) "I think some resilience strategies are necessary, but with the crisis it's limited. It's clear that the psychosocial attention is necessary for parent and kids. The problem is that there are few professionals that work in public institutions as the CSMIJ and other organisms. And because of that there's no efficiency in the service." (Expert 3)
Family Interaction	Basic needs	I have good conditions of living that meet my needs. *Tengo una vivienda digna que cumple con mis necesidades.*	"Having a good place to live. . .hygienic and having food." (Participant D) "To grow healthy it's important a good nutrition at home" (Participant A)

*Items included in CYRM.

communities and others to find health-sustaining resources (Ungar, 2008).

One of the experts stated that some children tend to make agreements with their parents in order to take adequate actions. Young people consider it important to receive the approval from their parents about the actions they are taking. Another expert explained his personal experience with his daughters to strengthen their self-esteem as a protective factor associated with good psychosocial functioning (Kidd and Shahar, 2008), to enable them to cope in situations where they can be discriminated because of their physical and/or ethnic condition.

Reformulated Items

The experts considered most of the items as understandable. However, both the adult experts and the results of the interviews with youth, highlighted the need to reformulate items 1, 3, 9, 19, and 22.

The reformulated items were: (1): "I have people I look up to." (*Conozco personas a las que admiro*), item reformulated (IR): "I know people who are an example to follow" (Conozco personas que son un ejemplo a seguir); (3): "Getting an education is important to me" (*Tener una educación es importante para mí*), IR: "Getting an academic education is important to me" (*Tener una educación académica es importante para mí*); (9): "Spiritual beliefs are a source of strength for me" (*Mi fe me da fuerzas*), IR: "I have faith and trust in me to achieve my goals" (*Tengo fe y confianza en mí para conseguir mis objetivos*); (19): "I am treated fairly in my community" (*Soy tratado con igualdad dentro de mi comunidad*), IR: "I feel that I am being treated equally by people around me despite differences in ethnicity, gender, religion, culture or beliefs" (*Siento que soy tratado con igualdad por las personas que me rodean a pesar de que haya diferencias de etnia, género, religión, cultura o creencias*); (22): "I participate in organized religious activities" (*Participo en diversas actividades religiosas*), IR: "I participate in activities outside the school" (sports, religious, artistic, volunteering etc.). (*Participo en actividades fuera de la escuela* (*deportivas, religiosas, artísticas, voluntariado* etc.).

Item 23, "I think it is important to help out in my community" was understood by almost all the participants, but, at the same time, was perceived as being irrelevant to the local context. From the results, we could see that the concept of community is not well established within the local context and may be related to item 22 "I participate in organized religious activities." Accordingly, item 23 was erased. Relevance and comprehension was assessed by the advisory committee, together with reformulation of items included in the final version.

STUDY III

The aim of the third study was to explore the psychometric properties of the CYRM-32 adapted to Spanish scale. Three hypotheses were proposed to assess the validity:

> Hypothesis 1: Data will confirm the factor structure of the CYRM-32 adapted scale (3 factors).
>
> Hypothesis 2: The CYRM-32 scale and its subscales will exhibit adequate psychometric properties (internal consistency Cronbach's α, test–retest reliability and convergent and discriminant validity).
>
> Hypothesis 3: There will be significant differences in youth scores on the CYRM-32 adapted depending on the gender, ethnicity and age of participants.

Participants

A total of 432 young people participated in the study. All of them presented one of the following risk factors: having experienced a traumatic event, immigration, poverty, exposure to violence, substances abuse and risk of social exclusion. They were randomly selected from four schools situated in a vulnerable and economically deprived neighborhood, and concurrent users of especial educational supports, community programs and mental health services.

The average age of participants was 14.99 years (SD = 2.23), range 12–19; 45.1% were girls and 54.9% were boys; 61.5% were European, 15.6% Moroccan, 10% Latin American, 7.9% Asian and 4.8% belonged to different ethnic groups. All participants had been in Spain for more than 2 years and understood the language correctly.

Instruments

CYRM-32 Spanish Version

It includes 32 items designed to assess resilience features in children and youth. It was adapted from the original scale CYRM-28, which was designed to explore the individual, relational community and cultural resources, available to youth 12 to 23 years. In Spanish adaptation, only three factors were found and their Cronbach's α were: Family interaction (0.720), Interaction with others (0.506), Individual skills (0.622) and for the totality of scale (0.783). It is a self-reported measured where for each question participants use a 5-point Likert scale (1 = not at all to 5 = a lot).

Item "Are You Depressed or Sad?"

Item "Are you depressed or sad?" was used to assess the depression mood of the participants. This item was adapted from the "Are you depressed?" Screening for depression in the terminally ill (Chochinov et al., 1997) and it was evaluated through numeric scale of 0–10 (0-not depressed, 10-worst possible depression). A high sensitivity (1.00) and specificity (1.00) to identify depressed mood, and absence of false positive and negative rate (0.00) were presented.

Brief Resilient Coping Scale (BRCS)

This scale was composed by four items to assess strategies to cope with the stress in a highly adaptive manner (Limonero et al., 2014). Brief Resilient Coping Scale (BRCS) is a self-reported measured where for each question participants use a 5-point Likert scale where 1 "does not describe you at all" and 5 means "it describes you very well." Higher scores means grater resilient coping. Cronbach's α coefficient was 0.71 (Study 3: α = 0.72) and a Pearson correlation was used to assess the temporal stability (test–retest reliability) and it was 0.69 (6 weeks).

Coping Strategies for Adolescents (ACS)

This scale was used to assess youth coping strategies and was developed by Frydenberg and Lewis (1996) and Frydenberg (1997). This scale is an 80-item checklist and has 18 subscales each contain between 3 and 5 items. Respondents indicate the extent to which the coping activity described was used (1 – "doesn't apply or don't do it," 2 – "used very little," 3 – "used sometimes," 4 – "used often" and 5 – "used a great deal"). In terms of consistency the mean score across the 18 scales is 0.70, while the mean reliability across all scales is 0.68 (Frydenberg, 1997). (Study 3: α = 0.71).

Self-Concept Form 5 (AF5)

Self-concept and self-esteem were related with resilience in the literature (Buckner et al., 2003; Kidd and Shahar, 2008; Wille et al., 2008; Hopkins et al., 2014). This scale was designed by García and Musitu (1999) and is based on the theoretical model of Shavelson et al. (1976). It is made up of 30 items that are rated on a 5-point Likert-type scale ranging from 1 (Never) to 5 (Always) (Shavelson et al., 1976; García and Musitu, 1999). The scale was compost by 5 dimensions and their Cronbach's α were for each one: social self-concept (0.69), academic self-concept (0.88), emotional self-concept (0.73), family self-concept (0.76) and physical self-concept (0.74) and Cronbach's α for the totality of scale was 0.810 (Study 3: range α 0.70 at 0.82; total 0.75).

Data Analysis and Procedure

Using the International Test Commission in context, construction and adaptation areas (Carretero-Dios and Pérez, 2007). Instruments with more than 15% of the data missing were excluded (Davey and Savla, 2010).

Regarding factorial validity, the sample was randomly divided into two subgroups, one for the initial analyses (n = 226) and the other for cross-validation (n = 206). Then, two CFAs were performed with the first subsample to determine which model explained the factorial structure better (Model 1-CFA and Model 2-CFA).

In each of the two models, it was expected that each observable variable would load only on the factor it was intended to measure; that measurement error associated with these variables would be uncorrelated. Model 1-CFA was a hierarchical and thus it considered that all covariance between each of the first order factors would be explained by a higher-order factor. Model 2-CFA was a bi-factor model and thus it considered that all covariance between each of the first order factors would be explained by a general dimension which load on all items at the same as the factors as suggested by Konkolÿ et al. (2014).

Estimates indices were obtained using the maximum likelihood method. So as to assess model fit, absolute fit indexes (χ^2, χ^2/df), relative fit indexes (IFI) and non-centrality fit indexes (CFI, RMSEA, SRMR) were used, as well as criteria for acceptable fit based on the degree of adjustment described by Hair et al. (2010) (ratio $\chi^2/df < 5$; SRMR < 0.08; RMSEA < 0.08; GFI, CFI and IFI > 0.90). Finally, we conducted cross-validation analyses (CVA) with the model, which showed the best fit in order to explore the sample invariance of the model.

Reliability assessment was conducted using Cronbach's α (Cronbach, 1951) for internal consistency and for the reproducibility the test–retest was carried on in two time points (n = 162) separated by approximately 2 months. Paired samples t-test were used to test differences in scores between these two administrations of the CYRM-32 adapted. The Pearson product moment correlation was used to establish construct validity and confirm hypothesis 2, describing the relationship between CYRM-32 scores and BRCS; Coping strategies for adolescents (ACS); Self-concept form 5 (AF5), and the item "Are you depressed or sad?" The floor or celling effect problems were also identified (Terwee et al., 2007).

In order to explore the functioning of resilience among different groups of participants (hypothesis 3) a multivariate analysis of variance (MANOVA) was carried on the study group sample, with gender, age and ethnicity (European, Gitano, Asiatic, African, Caribbean, Latin America, Nord America and Canada or others). The data were analyzed using SPSS v.20. and AMOS v.22.

Results

Confirmatory Factor Analysis

We first tested the hierarchical model (Model 1-CFA) with the first subsample. **Figure 2** shows the standardized estimates, as

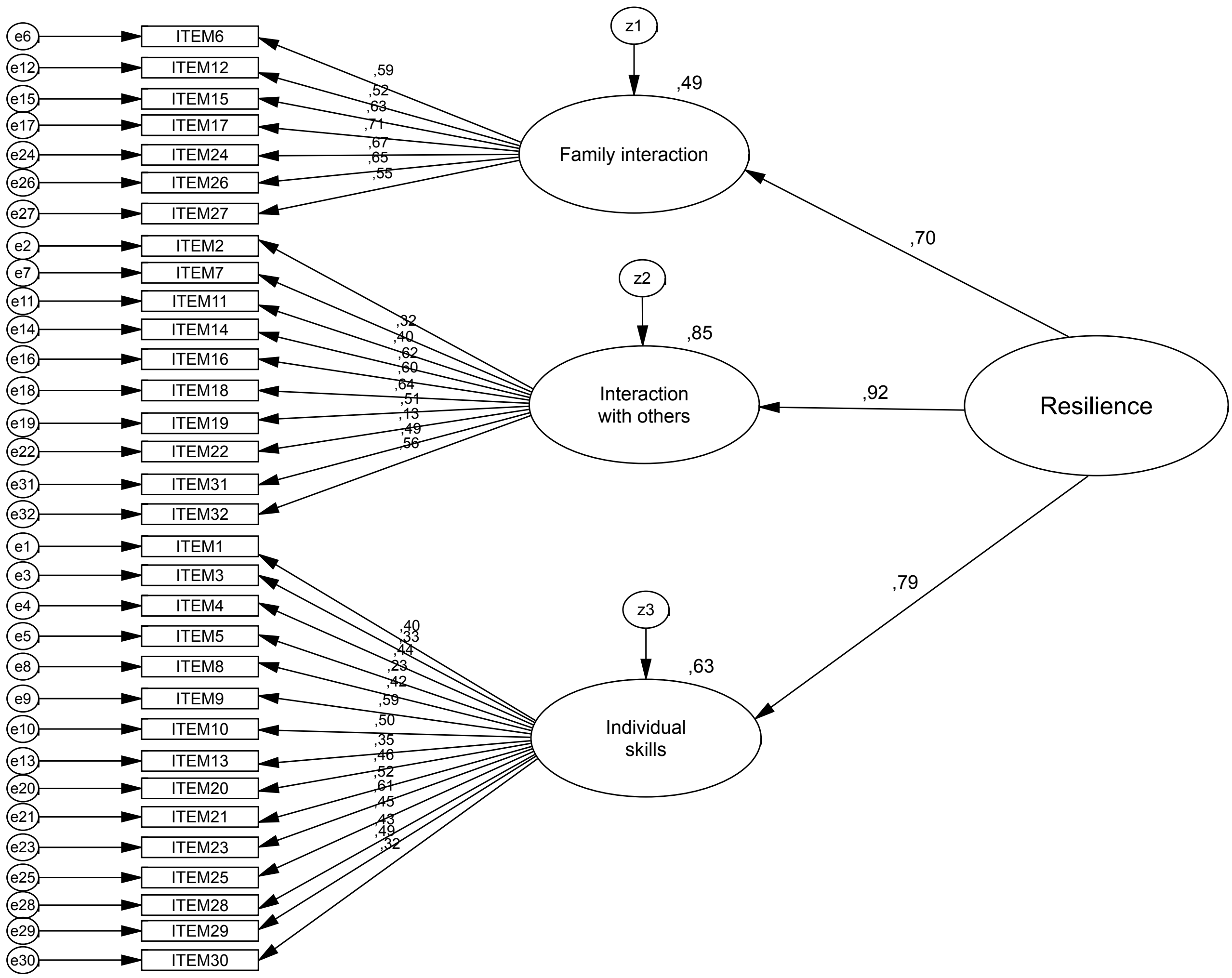

FIGURE 2 | Standardized estimates, as well as the squared multiple correlations for Model 1-CFA.

well as the squared multiple correlations (located at the top of each item). **Table 3** shows Chi-square statistic was significant, probably due to the sample size (Hair et al., 2010). The ratio $\chi^2/df = 1.83 < 5$, the RMSEA < 0.08 and the SRMR < 0.08 were well inside the limits that allowed the model to be accepted. However, the rest of the fit indices fell short of the standard limits of acceptance and thus indicate that the model does not represent the data well.

We then tested the bi-factor model with the same first subsample. **Figure 3** shows the standardized estimates, as well as the squared multiple correlations (located at the top of each item). Regarding fit statistics, Chi-square statistic was significant, again probably due to the sample size (Hair et al., 2010), the ratio $\chi^2/df = 1.71 < 5$ was well inside the limits that allowed the model to be accepted. The RMSEA < 0.08 and the SRMR < 0.08 were well inside the limits that allowed the model to be accepted. The remaining adjustment indexes were slightly better than for Model 1-CFA but fell slightly short of the standard limits of acceptance. So, in order to test the validity of the model, a CVA of Model 2 was carried-out (Model 2-CVA).

The fit statistics for Model 2-CVA (see **Table 3**) were similar to those of Model 1-CFA. However, the model comparison statistics carried out against the unrestricted model, establishing equality restrictions between groups for measurement weights ($\Delta\chi^2 = 12.23$, $p = 0.42$), structural covariance ($\Delta\chi^2 = 31.44$, $p = 0.43$), structural residuals ($\Delta\chi^2 = 33.30$, $p = 0.39$) and measurement residuals ($\Delta\chi^2 = 53.62$, $p = 0.60$), show that fit is not significantly reduced in relation to the model without restrictions, which means that the tested model works similarly in both samples.

Reliability Assessment and Floor and Ceiling Effects

Internal consistency reliability was estimated by Cronbach's α for each of components and for the totality of the scale. The α's were 0.792 (Family interaction), 0.715 (Interaction with others), 0.778 (Individual skills) and for the totality of the scale was 0.877, which demonstrated a consistent scale (see **Table 4**).

TABLE 3 | Goodness of fit statistics for the hierarchical confirmatory factor analysis (Model 1-CFA), the bi-factor confirmatory factor analysis (Model 2-CFA) and the bi-factor cross-validation analysis (Model 2-CVA).

	χ^2	*df*	*p*	χ^2/df	GFI	IFI	CFI	RMSEA	SRMR
Model 1-CFA *N* = 226	841.65	461	0.000	1.83	0.819	0.772	0.768	0.061	0.068
Model 2-CFA *N* = 226	741.63	433	0.000	1.71	0.838	0.819	0.812	0.056	0.060
Model 2-CVA (*N* = 226/206)	1502.58	866	0.000	1.73	0.826	0.815	0.808	0.041	0.060

GFI = goodness of fit index; IFI = incremental fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

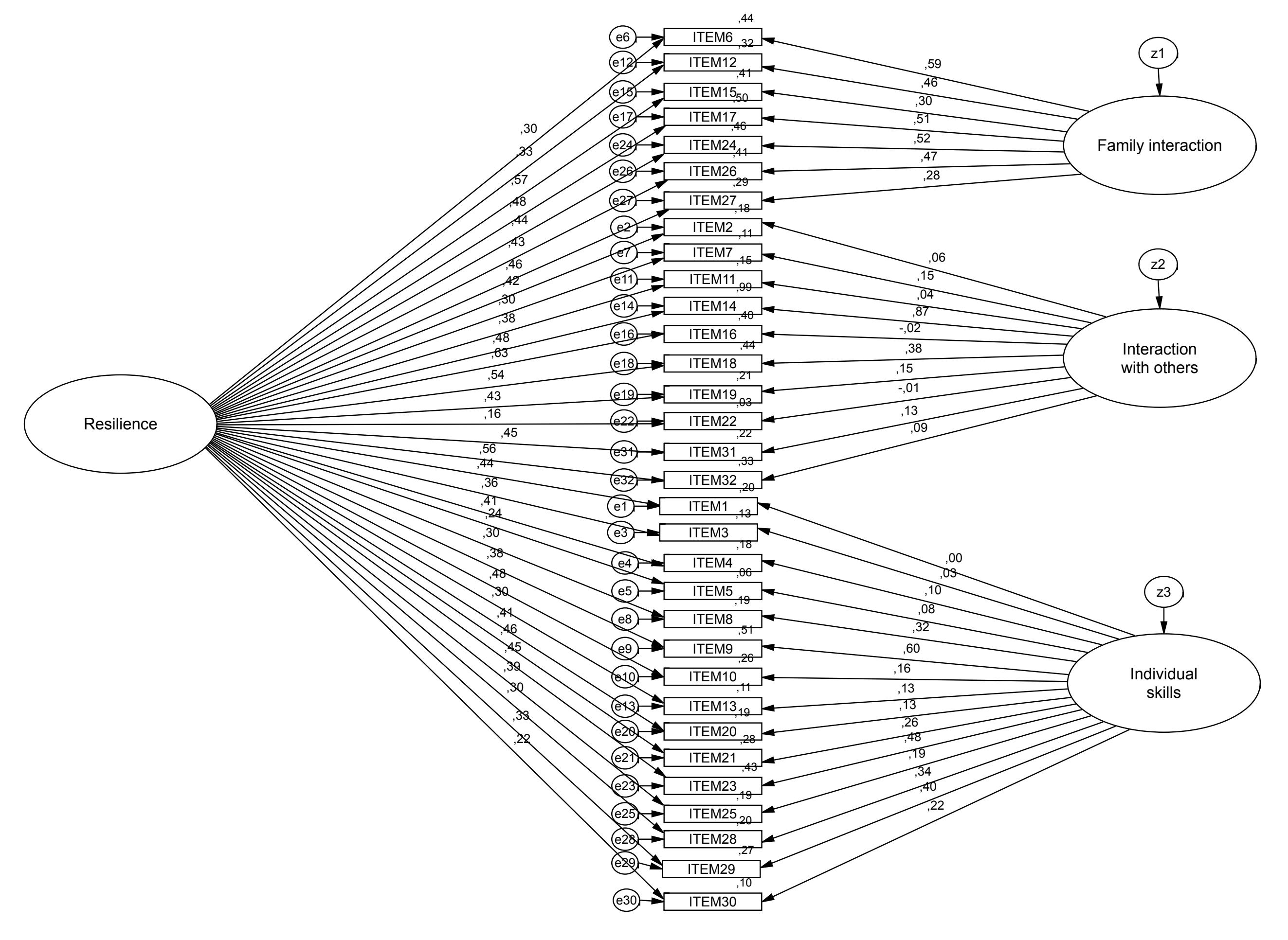

FIGURE 3 | Standardized estimates, as well as the squared multiple correlations for Model 2-CFA.

In a sample of 162 youth, a Pearson correlation was used to assess the temporal stability of the CYRM-32 over 2 months, yielded a value of 0.695 ($p < 0.01$) for the total score of the scale; and for each of the three factors (family interaction, interaction with others and individual skills) this correlation was: 0.784 ($p < 0.01$), 0.781 ($p < 0.01$), 0.787 ($p < 0.01$), respectively.

The highest (157) and lowest (72) score were obtained only once. In addition, none of the participants obtained the lowest and highest CYRM-32 total scores, focusing the absence of floor or ceiling effects problems.

Convergent and Discriminant Validity

Correlations between total score of the CYRM-32 and its three dimensions with four measures of mood, resilience, coping strategies, and self-concept were represented in **Table 5**. The CYRM-32 scale and all of its dimensions were positively correlated with resilience measure, self-concept (except the dimension emotional self-concept) and with thirteen of the eighteen coping strategies (the positive strategies), and negatively correlated with mood depressed or sad and four negative coping strategies: lack of coping, reduction of tension (using drugs), self-incriminating and reserve it for yourself.

TABLE 4 | CYRM-32 item's scale and its three dimensions.

Dimensions and items	Cronbach's α
Family interaction	0.792
6. Mis padres o tutores lo saben todo sobre mí. (*My parent(s)/caregiver(s) know a lot about me*	
12. I talk to my family/caregiver(s) about how I feel. (*Hablo sobre cómo me siento con mi familia o tutores legales*	
15. I know where to go in my community to get help. (*Sé dónde acudir dentro de mi comunidad, cuando tengo algún problema*	
17. My family stands by me during difficult times. (*Mi familia me apoya en los momentos difíciles*)	
24. I feel safe when I am with my family/caregiver(s). (*Me siento a salvo junto a mis padres o tutores*)	
26. I enjoy my family's/caregiver's cultural and family traditions. (*Disfruto de las tradiciones familiares con mis padres o tutores*	
27. I enjoy my community's traditions. (*Disfruto de las tradiciones de mi comunidad*)	
Interaction with others	0.715
2. My values allow me a positive relation with my environment. (*Mis valores me permiten una relación positiva con mi entorno*)	
7. If I am hungry, there is enough to eat. (*Si tengo hambre, siempre hay suficiente comida para alimentarme*)	
11. People think that I am fun to be with. (*La gente piensa que soy una persona divertida*)	
14. I feel supported by my friends. (*Mis amigos me apoyan*)	
16. I feel I belong at my school. (*Siento que formo parte de mi escuela*)	
18. My friends stand by me during difficult times. (*Mis amigos me apoyan en los momentos difíciles*)	
19. I feel that I am being treated equally by people around me despite differences in ethnicity, gender, religion, culture or beliefs. (*Siento que soy tratado con igualdad por las personas que me rodean a pesar de que hayan diferencias de etnia, género, religión, cultura o creencias*)	
22. I participate in activities outside the school (sports, religious, artistic, volunteering etc.). (*Participo en actividades fuera de la escuela* (*deportivas, religiosas, artísticas, voluntariado* etc.)	
31. I support my peers. (*Doy apoyo a mis compañeros*)	
32. I have role models that serve me as guidance and support. (*Tengo personas de referencia que me sirven de guía y apoyo*)	
Individual skills	0.778
1. I know people who are an example to follow. (*Conozco personas que son un ejemplo a seguir*)	**0.877***
3. Getting an academic education is important to me. (*Tener una educación académica es importante para mí*)	
4. I know how to behave in different social situations. (*Sé comportarme teniendo en cuenta las normas sociales*)	
5. When I face a problem, I'm aware of my emotions and act according to how I feel in that moment. (*Ante algún problema soy consciente de mis emociones y actúo según como me siento en el momento*)	
8. I try to finish what I start. (*Intento finalizar todo lo que empiezo*)	
9. I have faith and trust in me to achieve my goals. (*Tengo fe y confianza en mí para conseguir mis objetivos*)	
10. Despite difficulties, I usually smile. I think that I have good sense of humor. (*A pesar de las dificultades suelo sonreír. Me considero una persona con buen sentido del humor*)	
13. I am able to solve problems without harming myself or others (for example by using drugs and/or being violent. (*Puedo solucionar mis problemas sin hacerme daño ni hacer daño a terceras personas* (*por ejemplo sin caer en adicciones como la droga y sin usar la violencia*)	
20. I have opportunities to show others that I am becoming an adult and can act responsibly. (*Puedo demostrar a los demás que soy una persona adulta y responsable*)	
21. I am aware of my own strengths. (*Soy consciente de mis puntos fuertes*)	
23. My strength helps me to go on and achieve my goals. (*Mi fortaleza me ayuda a seguir adelante y alcanzar mis objetivos*)	
25. I have opportunities to develop skills that will be useful later in life (like job skills and skills to care for others. (*Tengo la oportunidad de desarrollar habilidades que me serán útiles en el futuro* (*Habilidades relacionadas con un oficio y habilidades sociales*)	
28. I have aspirations and a clear and realistic vision of the future. (*Tengo aspiraciones y una visión de futuro clara y realista*)	
29. I usually make my own decisions and don't let myself be influenced by others. (*Tiendo a tomar mis propias decisiones y no me dejo llevar por los demás*)	
30. I'm able to adapt to changes (*Soy capaz de adaptarme a los cambios*)	

* *Cronbach's α for totally of the scale.*

Finally, a MANOVA was conducted to test our 3 hypothesis that significant differences exist between different ethnic, gender and age. No significant multivariate main effects were found for age $F(71, 352) = 1{,}437$, $p < 0.05$ or gender, $F(72, 359) = 1{,}062$, $p > 0.05$, but there was a significant main effect for ethnicity $F(71, 358) = 1{,}714$, $p < 0.01$. That suggest only partial support for our hypothesis, but shows that the different cultural aspect of the participants were connected with resilience process.

DISCUSSION

This article includes three studies that reflect the complexity of the development of a culturally adapted scale. The used of mixed methods allowed us to better understand the conflicting items that were found in the original scale and to deepen the interpretation of the resilient processes by developing new items specific to our culture.

The results obtained in the first and third study, showed that the initially Spanish version CYRM-28 and the last CYRM-32 have good psychometric properties. Despite these findings, qualitative assessment of cultural and contextual relevance, highlighted several items that required adaptation to the local context. These findings regarding variation in instrument items reflect the notion that culture and context shape the environment and consequently influence the resilience process of people living there. For this reason, including cultural diversity allows for a better understanding of the construct from a heterogeneous and socio-ecological perspective (Ungar, 2011).

TABLE 5 | Correlations between dimensions of CYRM-32 and others measures.

Measure	Family interaction	Interaction with others	Individual skills	CYRM-32
Are you depress or sad?	– 0.347**	– 0.328**	– 0.314**	– 0.391**
Brief Resilient Coping Scale	0.270**	0.317**	0.389**	0.424**
Coping strategies for adolescent				
Search for social support	0.394**	0.353**	0.328**	0.425**
Concentrate in solving the problem	0.302**	0.380**	0.475**	0.473**
Strive and have success	0.352**	0.357**	0.463**	0.477**
To worry	0.215**	0.213**	0.313**	0.305**
To invest in intimate friends	0.171**	0.314**	0.240**	0.291**
Search release	0.244**	0.285**	0.264**	0.318**
Make illusions	0.024**	0.107**	0.098*	0.094
Lack of coping	– 0.163**	– 0.252**	– 0.231**	– 0.260**
Reduction of tension	– 0.144**	– 0.179**	–146**	– 0.185**
Social action	0.197**	0.069	0.099*	0.140**
Ignore the problem	– 0.067	– 0.064	– 0.073	– 0.083
Self-incriminating	– 0.105*	–127*	– 0.095	– 0.128**
Reserve it for yourself	– 0.227**	–142**	– 0.86	– 0.174**
Search spiritual support	0.222**	0.101*	0.082	0.154**
Focus on the positive	0.357**	0.362**	0.431**	0.464**
Search for professional help	0.357**	0.215**	0.233**	0.316**
Search relaxing amusements	0.190**	0.282**	0.265**	0.296**
Physical distraction	0.240**	0.356**	0.290**	0.350**
Self-concept form 5				
Social self-concept	0.209**	0.470**	0.364**	0.418**
Academic self-concept	0.305**	0.344**	0.346**	0.420**
Emotional self-concept	– 0.014	0.098*	0.076	0.066
Family self-concept	0.486**	0.366**	0.314**	0.455**
Physical self-concept	0.161**	0.349**	0.339**	0.345**

*******Correlation is significant at the* $p < 0.01$ *level (2-tailed).* **Correlation is significant at the* $p < 0.05$ *level (2-tailed).*

The present work includes three studies (**Figure 1**). In the first study, the translated CYRM-28 was assessed for validity of its psychometric properties. The distribution of items was different and the factors did not correspond to all the three theoretical factors of the original scale. Additionally, the emerging factors were provided alternate names, as identified by an expert review panel.

The first factor, "Family interaction" explained 17.7% of the variance, and related to a broad concept of family. It includes eight items that have high loadings and strong internal consistency. The second factor, "Interaction with others" explained 7.17% of the variance and reflects social interaction across various contexts (such as peer group, school, and religious settings). All seven items had significant loadings but less internal consistency. The final factor, "Skills or individual resources," explained 6% of variance, and included nine items, six of them with adequate saturation and loadings with medium internal consistency.

As observed in other studies that obtained similar results (Liebenberg et al., 2012; Daigneault et al., 2013), some items presented problematic factor loading. In our study, items 1, 3, 9 and 22 failed to exhibit strong factor loading on any of the three final components. Also, four items (2, 5, 10 and 28) were excluded due to inadequate factor loadings.

The divergence of the structure of the scale with the original version further emphasizes the cultural and contextual factors that differentiate populations, and how each culture understands the phenomenon of resilience (Ungar, 2004, 2008). These differences are probably due to the fact that the scale validation was conducted with youth in Canada (Liebenberg et al., 2012); a place where there was a difference in the risk context of participants: in Canada the sample included high-risk youth (users of services such as care of children, mental health, justice), whereas in our study, the participants were young people belonging to a neighborhood with high risk and vulnerability indicators. It is however, more probable that the variability is due to cultural and contextual differences. For example, the factor structure identified in New Zealand (Sanders et al., 2015) is also different from that of the factor structure identified in Canada (Liebenberg et al., 2012), while the sample in both sites was the same.

From qualitative data, nine items were developed and were included in the final version of CYRM.

The themes related with the Individual factor were self-awareness ("When I face a problem, I'm aware of my emotions and act according to how I feel in that moment"); Sense of humor ("Despite difficulties, I usually smile. I think that I have good sense of humor"); Vision of the future ("My strength helps me to go on and achieve my goals" and "I have aspirations and a clear and realistic vision of the future"); Adaptation ("I'm able to adapt to changes"); Autonomy ("I usually make my own decisions and don't let myself be influenced by others").

Three of the new themes related to items identified during the original development of the CYRM (Ungar and Liebenberg, 2011): Support for others ("I support my peers"); Significant relationships ("I have role models that serve me as guidance and support"); Education context ("My values allow me a positive relation with my environment").

Only one new item related to basic needs, stemming from Family interaction ("I have good conditions of living that meet my needs"). This item was not included in the final version as it strongly reflected the original CYRM item "I have enough to eat."

To increase their comprehension and relevance five items were reformulated (items 1, 3, 9, 19, 22).

Drawing on the qualitative data, two items were reformulated to better align with youth identified resilience factors. Because participants felt it was more important to believe in themselves that to have spiritual beliefs, item 9 "Spiritual beliefs are source of strength for me" was changed to "I have faith and trust I can achieve my goals." Similarly, item 22 "I participate in organized religious activities" was reformulated to include other activities "I participate in activities outside the school (sports, religious, artistic, volunteering." Here youth noted that young people often interact with their community by participating in extracurricular activities, especially sport, rather than religious activities (see also Moreno et al., 2016).

Our findings show that the Spanish CYRM-32 has good psychometric properties and highlight the importance of the process of prior cultural adaptation of the scale. Two of three hypotheses of the study were confirmed except for the hypotheses three, where only differences in the CYRM-32 scores were found in ethnicity.

With respect to the first hypothesis, the three-factor structure was confirmed, which is consistent with the original CYRM scale (Ungar, 2008; Ungar and Liebenberg, 2009) and with its adaptation among French Canadian youth (Daigneault et al., 2013). The fact that a bi-factor model as the one proposed by Konkolÿ et al. (2014) fitted our data better than a hierarchical model implies that people showing high resilience in an individual dimension, tends to show also high resilience in the dimensions family interaction and interaction with others and also supports the idea of calculating a single overall resilience score in addition to subscales for each of its dimensions (Konkolÿ et al., 2014).

The scale CYRM 32 and its three components: family interaction, interaction with others and individual skills, presented strong internal consistencies, as reveled by high values of Cronbach's α, consistent with other's CYRM-28 scales validation (Liebenberg et al., 2012; Daigneault et al., 2013; Sanders et al., 2015) and with higher values than those obtained in the cultural adaptation process. Furthermore, no participant scored the highest and lowest score of 32, so no floor or ceiling effects were detected (Terwee et al., 2007). Temporal stability of scores over 2 months was also observed in the CYRM-32's total scale and its three dimensions, confirming thus the second hypothesis.

As hypothesized, the results also confirm that CYRM-32 and its three factors, were positively and significantly correlated with measures of resilience (BRCS), Self-Concept form 5 (except emotional self-concept) and thirteen positive coping strategies for adolescent: search for social support, concentrate in solving the problem, strive and have success, to worry, to invest in intimate friends, search release, make illusions, social action search spiritual support, focus on the positive, search for professional help, search relaxing amusements and physical distraction; while showing a negative and significant correlation with four negative coping strategies: lack of coping, reduction of tension (using drugs), self-incriminating and reserve it for yourself; also with the item "Are you depressed or sad" in concordance with the authors who defined resilience how "good mental health" (Klasen et al., 2010; Williams and Nelson-Gardell, 2012; Collishaw et al., 2016). Despite some research show the relationship between emotion and resilience (Troy and Mauss, 2011; Kay, 2016) the emotional self-concept was not significant correlated with CYRM-32. In spite of this, all other correlations provide evidence of the criterion-related validity of CYRM-32.

In regard to the hypothesis tree, where we were expected to find significant differences in youth scores depending on the gender, ethnicity and age of participants, we only found significant differences with ethnicity in concordance with other validation of CYRM-28 such as the one undertaken in New Zealand (Sanders et al., 2015) and in Canada with French speaking youth (Daigneault et al., 2013). Despite the significant main effect that was found for gender in the Canadian validation, the key differences were observed in ethnicity between visible minority youth and visible majority youth (Liebenberg et al., 2012). These findings support the idea that the developed of resilience is influenced by culture and context as others researches (Masten and Coatsworth, 1998; Ungar, 2004, 2011; Clauss-Ehlers, 2008).

The adaptation and validation of this scale using mixed-methods could be used in Spain to evaluate the effectiveness of future interventions projects to promote resilience among children and youth at risk (Liebenberg et al., 2012).

This finding has implications for the assessment practices and interventions for all professionals who work with youth in context of risk.

STUDY LIMITATIONS AND STRENGTHS

The Spanish version of the CYRM-32 is an adequate and validity tool to measure resilience, which will permit to assess the effectiveness of future interventions to promote resilience among children and youth at risk (Liebenberg et al., 2012) and it covers a gap regarding the existence of validated instruments to measure resilience in this population.

Different samples of at risk youth were represented in the groups of participants. They were randomly selected. Furthermore, persons from different ethnic groups were included in the final sample. Concerning limitations of the study, the items of the scale were all phrased positively and that might have decreased the reliability of the CYRM-32. However, the results show a high internal consistency.

In future research, the predictive validity of the CYRM-32 (Terwee et al., 2007), and the scale's sensitivity to change over the course of intervention would need to be established.

Despite these limitations, the Spanish version of the CYRM-32 presents good psychometric properties and could be an alternative tool to measure resilience in Spanish-speaking at risk youth.

DATA AVAILABILITY

All relevant data is contained within the manuscript. All datasets generated/analyzed for this study are included in the manuscript and the supplementary files.

ETHICS STATEMENT

The Ethics Committee Institutional Review Board of the Consorci Sanitari de Terrassa (Spain) was approved the study. In all three studies, the written informed consent was obtained prior to data collection, from all adult participants and from the parents/legal guardians of all non-adult participants, as well as the directors of secondary schools who collaborated in the research.

AUTHOR CONTRIBUTIONS

ML, TGR, and JTL contributed in the conceptualization, design, methodology, results and discussion. ML led the Study I and Study III and wrote the first draft of the article. TGR supervised and integrated all revisions and formal aspects, and performed the submission. RRR performed part of the statistical analyses of Study III. LL provided important guidance as the author of the original scale and supervised the mixed methodology. ÁB carried out the empirical part of Study II. JGB supervised and reviewed the statistical analyses of Study III. All the authors revised and approved the final version of the manuscript.

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Coaches' Emotional Intelligence and Reactive Behaviors in Soccer Matches: Mediating Effects of Coach Efficacy Beliefs

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In the last 10 years, emotional intelligence (EI) has become a current issue of research in psychology, and there are indicators to consider that EI should be analyzed to help the coach to behave effectively during competitions. According to Boardley's (2018) revised model of coaching efficacy, coaches' EI is predictive of their efficacy beliefs, which, in turn, is predictive of coaching behavior. However, little is known about the mediating effects of coaching efficacy dimensions on the relationships between coach's EI and reactive behaviors in competitive settings. Thus, the purpose of this study is to examine mediating effects of coaching efficacy dimensions on the relationship between EI and coaches' reactive behaviors during a game using a multimethod approach. Participants were 258 coaches of youth football players aged 9 to 17 years old. Observations *in situ* using Coaching Behavior Assessment System (CBAS) were carried on 258 football games during two seasons. At the end of each game, coaches completed the Wong and Law Emotional Intelligence Scale (WLEIS) and the Coaching Efficacy Scale (CES). Structural equation modeling (SEM) analyses revealed that motivation efficacy and character building mediated the relationship between regulation of emotion and positive and negative coaches' reactions during game. Specifically, motivation efficacy mediated the association between regulation of emotion and positive coaches' reactions, and the relationship between regulation of emotion and negative coaches' reactions were mediated by motivation efficacy and character building. In addition, coaching level moderated the relationships between EI, self-efficacy and coaches' reactive behaviors. Findings of the present study showed that coaching efficacy dimensions (i.e., motivation efficacy and character building) that have the capacity to influence their confidence in ability to affect the psychological mood and positive attitude of athletes, transfer the effects of EI (i.e., regulation of emotion) on coaches' verbal reactions during a youth soccer game. Specifically, a coach who feels competent to regulate their own emotions would perceive high beliefs of efficacy to motivate and to build character of their athletes, and this insight has an impact on their positive verbal reactions in response to athletes' performances.

Keywords: coaching behaviors, coaching efficacy, emotional intelligence, multimethod research, motivation efficacy, soccer, structural equation modeling

INTRODUCTION

Coaches exert an influential role in creating an emotional climate in youth sports (Keegan et al., 2014). This emotional climate can be provided by several coaches' psychosocial characteristics, such as leadership styles (e.g., Price and Weiss, 2012), goal orientations (e.g., Smith et al., 2009), expectations (e.g., Coatsworth and Conroy, 2009) and coaching behaviors in competitive settings (e.g., Cumming et al., 2006). In fact, evidence suggest that coach behavior during competition influences their relationship with the athletes and their psychological development (Smith et al., 2007). Thus, the impact of coaches' behaviors on athletes' performance and well-being have received considerable attention in youth sport literature.

Research revealed that the interaction between behavioral, cognitive, and situational variables appear to influence coach behavior (e.g., Smoll and Smith, 1989; Chelladurai, 2007; Horn, 2008). For example, Smith et al. (1977) suggested a model that put emphasis on coach behavior toward athletes' perceptions of those behaviors, and that these elements are influenced by three factors: coaches' personal characteristics (e.g., coach's personal goals, behavioral intentions, self-monitoring), athlete individual characteristics (e.g., age, perceptions of coaching norms, competition anxiety), and situational factors (e.g., competitive level, team cohesion). Smith and Smoll (1997) suggested some practical guidelines for the behavior of youth coaches, including the use of a positive coaching approach. This includes the systematic use of reinforcement in response to athletes' effort, encouragement after failures and technical instruction given in a positive way. A negative approach based on different forms of punishment (verbal or non-verbal) to eliminate inappropriate behavior or attitudes are associated with athletes' anxiety and motivational climate, as well as being able to provoke conflicts of interpersonal nature with the coaches (e.g., Smith et al., 2007).

Chelladurai (2007) reported that coach behavior is mostly a function of personality, expertise and experience, and will be preceded by athletes' preferences of specific forms of behavior (e.g., instructional and guidance, social support, feedback), and situational requirements (e.g., social background of the group, goals of the group, type of task). Other researchers proposed that variables such as coaches' emotional ability, expectancies, values, beliefs and goals are predictive of coaches' behavior (Horn, 2008). In addition, coaches encounter a wide range of stressors (i.e., competition preparation, organizational conflicts), and must be aware of how to cope with the stressors (Olusoga et al., 2014). Hence, given that coaches establish emotional climates (i.e., the way the majority of team members feel in a particular situation) to facilitate (or detract) appropriate functioning with their athletes, manage various emotions, and have the need to improve interpersonal skills, it could be suggested that for a coach to behave effectively, they need emotional intelligence (EI) (Chan and Mallett, 2011).

Chan and Mallett (2011) argue that establishing appropriate emotional climates in teams has been associated with leaders' EI, including the engagement in appropriate behaviors informed by the ability of the coach to perceive, use, understand, and regulate emotions (Mayer and Salovey, 1997). This conception follows the original definition of EI as a "subset of social intelligence that involves the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions" (Salovey and Mayer, 1990, p. 189). Two conceptual approaches can be identified in this field: ability EI and trait EI. The ability approach results from the contributions of Mayer and colleagues (e.g., Mayer and Salovey, 1997; Mayer et al., 2008), who emphasized a cognitive element of EI. Meta-analytic evidence advocates EI abilities as a set of progressive hierarchical specialized skills, such as to perceive emotions, to use and understand emotions, manage them and use them consistent with individual's goals (Joseph and Newman, 2010). The hierarchical functioning and increasing complexity of these skills play an important role in facilitating individuals' thinking and optimizing performance, thus contributing to their emotional and intellectual development. The trait approach conceives EI as a composite construct that includes individual dispositions belonging to the domain of personality and affect, but also encompasses cognitive and motivational aspects. Consequently, attributes such as stress tolerance, adaptability, impulsivity, or social competence can be found under the overarching designation of EI (Petrides et al., 2007). Following evidence of somewhat contradictory findings with trait EI (e.g., Joseph and Newman, 2010; Laborde et al., 2014b; Wagstaff and Hanton, 2016), the current study will focus the ability EI approach based on Salovey and Mayer's framework using Wong and Law EI scale (WLEIS; Wong and Law, 2002).

In sport, EI has been linked with a wide range of outcomes among athletes, parents, and coaches (see, for a review, Meyer and Fletcher, 2007; Laborde et al., 2016; Wagstaff and Hanton, 2016). Researchers have focused on the relationship among athletes' EI and psychosocial and behavioral correlates, including relationships with individual athletic performance (e.g., Zizzi et al., 2003; Laborde et al., 2014a), pleasant emotions that athletes experience on the day of competition, such as happiness, vigor and calmness (e.g., Lane and Wilson, 2011), use of psychological skills during and outside competitions (e.g., Lane et al., 2009), physiological responses (e.g., Laborde et al., 2011), cooperative behaviors in highly competitive conditions (Perry and Clough, 2017), and organizational functioning (e.g., Wagstaff et al., 2013). Recently, evidence showed that EI appears to play an important role in regulating parents' sideline verbal behaviors during youth soccer games (Teques et al., 2018).

According to Hwang et al. (2013), EI is also associated with coaching efficacy. This finding suggests that coaches' perceived ability to regulate and be aware of their own and athletes' emotions would indicate their sense of efficacy to stimulate the performance of their athletes. Based on the original work of Bandura (1997), Feltz et al. (1999) conceived coaching efficacy as the amount to which coaches believe they have the ability to influence athletes' learning and performance, and proposed a multidimensional model of coaching efficacy beliefs that contains four efficacy dimensions: motivation (e.g., confidence in ability to affect athletes' psychological mood and skills), game strategy (e.g., confidence in ability to lead during the game), technique (e.g., confidence in instructional skills), and character building efficacy (e.g., confidence in ability to impact athletes' moral attitude).

Feltz et al.'s (1999) model also suggests that coaching efficacy dimensions could be considered mediators between a variety of sources and outcomes. Empirical evidence showed that coaching experience or preparation, prior success, perceived skill of athletes and social support are positively associated with specific-dimensions of coaching efficacy (Myers et al., 2017). Nevertheless, the work of Bandura (1997) also include emotional states as a source of self-efficacy beliefs. For example, people with high levels of self-efficacy are proactive in regulating their cognitions, motivations and emotions, which allows them to take advantage of the challenges they face (Feltz et al., 2008). In this sense, Boardley (2018) developed a revised coaching efficacy model that include links between coach EI, coaching efficacy dimensions and coaching behavior. For example, Thelwell et al. (2011) showed that coaches' emotional regulation (i.e., ability to manage their own emotions) and self-emotions appraisal (i.e., ability to evaluate their own emotions) leads to motivation and technique coaching efficacy beliefs, respectively.

Beyond sources of coaching efficacy, Feltz et al. (1999) also proposed various outcomes that should result from enhanced coaching efficacy, such as coaching behavior, player/team satisfaction, performance and efficacy. Myers et al. (2005) demonstrated the influence of perceived coaches' engagement in efficacy-enhancing coaching behaviors and team outcome variables. Specifically, all dimensions of coaching efficacy predicted use of self-reported coaches' engagement in coaching efficacy-enhancing behaviors (e.g., verbal persuasion, act with confidence, encourage positive talk). Sullivan and Kent (2003) also evidenced that motivation and technique efficacy were associated with athletes' perceptions of coach leadership styles, such as perceptions of training and instruction and positive-feedback behaviors. Other studies (e.g., Sullivan et al., 2012; Hwang et al., 2013) incorporated all leadership styles (i.e., training and instruction, positive-feedback, social support, and situational consideration) demonstrating relationships with overall coaching efficacy. Altogether, these studies establish robust links between coaching efficacy and leadership styles using self-reported questionnaires. However, methodologically, what is less well-known is how coach behavior is influenced by coaching efficacy dimensions using direct observation (Boardley, 2018).

Methodological Principles

To address this limitation in the literature, we consider a multimethod design using self-reported questionnaires about EI and coaching efficacy, and observational methods in natural settings to assess coach's behaviors. The choice for a multimethod design was driven by the desire to have low interference on the coach's actions in competition, observing and evaluating in natural context the genuineness of his/her behavior. Another possibility for study design could be the mixed method approach to address the research question. However, the mixed method contains qualitative and quantitative components that must be integrated to ensure the mixing of the information and would be far more elusive to assess EI, coaching efficacy, and coach's behavior (Anguera et al., 2018).

The mixing of the data could be designed through structural equation modeling (SEM) analyses. Researchers initially used univariate and bivariate analysis to understand their data and relationships. However, to understand the complexity between variables is increasingly necessary to apply sophisticated methods of multivariate analysis, which involve the application of statistical methods (Hair et al., 2014). SEM analyses simultaneously analyze multiple variables that can represent measurements associated with latent (psychosocial) or observable (behavior). These measurements are often obtained through surveys or observations that are used to collect data.

SEM can be used to confirm *a priori* theories or identify patterns of data and relationships. Specifically, they are confirmatory in testing the hypotheses of existing and exploratory theories and concepts when they look for patterns in the data if there is little or no prior knowledge about how the variables are related. Hence, two types of SEM analyses can be performed: Covariance-based Structural Equation Modeling (CB-SEM) and Partial Least Square Structural Equation Modeling (PLS-SEM). SEM (CB-SEM) based on covariance is mainly used to confirm (or reject) theories. Specifically, a set of systematic relationships among multiple variables that can be empirically tested, determining how well a proposed theoretical model can estimate the covariance matrix for a set of sample data. In contrast, PLS-SEM, also called PLS path modeling, is mainly used to develop theories in exploratory research, using smaller samples, and is focused on explained variance in the dependent variables when examining the model (regression analysis). Although different paths can be used to test SEM models, all structural equation models are distinguished by three characteristics: (1) estimation of multiple and interrelated dependency relationships; (2) ability to represent concepts not observed in these relationships and correct measurement error in the estimation process; and (3) definition of a model to explain the whole set of relations (Hair et al., 2017). Considering the characteristics of this study that includes consistent theoretical models, a relatively large sample, and the need to test mediation between variables, CB-SEM was performed to test the study hypothesis.

The Purpose of This Study

The main purpose of this study was to examine the mediation effects of coaching efficacy beliefs on the associations between EI and reactive behaviors in soccer games. We followed Joseph and Newman's (2010) progressive pattern of EI levels in which emotion perception, use and understanding causally precedes regulation of emotion, and Boardley's (2018) revised model of coaching efficacy (Feltz et al., 1999, 2008), hypothesizing that coaches' EI (i.e., regulation of emotion) will be positively associated with positive reactive behaviors and negatively associated with negative reactive behaviors (Hypothesis 1). Furthermore, we hypothesized that coaches' EI will be associated with all coaching efficacy dimensions (i.e., motivation, game strategy, technique, and character building efficacy) (Hypothesis, 2); all coaching efficacy dimensions will positively mediate the link between EI and positive reactive behaviors (Hypothesis 3), and negatively mediate the association with negative reactive behaviors (Hypothesis 4). Finally, considering evidence of

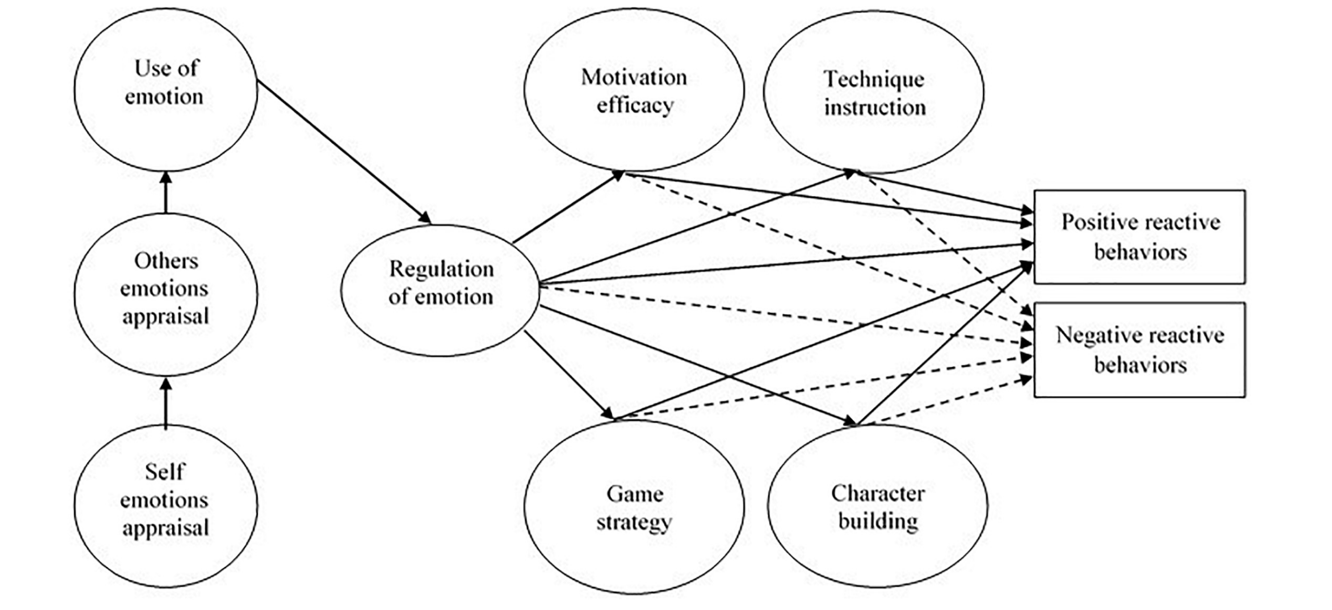

FIGURE 1 | The hypothesized mediational model for the relationships between coach's emotional intelligence (EI), coaching efficacy dimensions and reactive behaviors during soccer games. Positive paths in continuous lines; Negative paths in dashed lines.

moderating effects of different levels coached (Myers et al., 2017), we were also interested in how coaching level (Hypothesis 5) moderate the links estimated in the structural model (**Figure 1**).

MATERIALS AND METHODS

Participants

Participants were 258 Portuguese head coaches (*M* = 246, *F* = 12) of youth soccer players aged 9 to 17 years old. Coaches aged between 19 and 62 years old (*M* = 31.47, *SD* = 9.78); 2.7% of them had completed lower secondary education, 24.5% upper secondary education, 46.5% had an undergraduate degree, 24.1% had a master's degree, and 2.2% had a doctorate degree. Coaches experience ranged from 1 to 33 years (*M* = 7.26, *SD* = 6.18). Coaches were involved in a long competition (soccer season) in a district standard, and coaching levels were initiation (9 – 12; *n* = 122) and specialization (13–17; *n* = 94) stages.

Design and Procedures

Following approval from the Ethical Review Board of the Scientific Committee of the Polytechnic Institute of Maia Research Center under the reference N2I/006/04/2017, observations *in situ* were carried out in 258 soccer games over two seasons. The duration of the games were 60 min for games in the initiation stage and 80 min for games in the specialization stage, with mixed-gender participation only in the initiation stage.

Observer Training

Before conducting the observations of coach behaviors, a research team composed by two senior researchers and twelve undergraduate honors students were trained following the procedures of McKenzie and van der Mars (2015). The following phases were performed: (1) identification of the categories of the system (i.e., definition of behavioral categories); (2) discussion of the observation manual (i.e., team discussion about behavioral scenarios); (3) evaluation of the learning of the categories (i.e., interpretation of video clips); and (4) practice and application of the observation system *in situ*, simultaneously by all research team members. This first observation took place in three under-12 soccer games. For each of the observed categories, we found acceptable interobserver reliability values greater than or equal to 75% (Cohen's kappa $\geq$ 0.75).

Participant Recruitment

The purpose of the study was explained to the participants and that they were observed during the game. The observers were on the field seating with adequate proximity to record coach verbal behaviors using a paper-and-pencil observation system, without giving any indication of behavior observation to avoid any socially desirable conduct. At the end of each game, coaches were approached and invited to participate in the study. Prior to the administration of the questionnaires, all participants provided signed informed consent, ensuring that they could leave the study at any time, and that the information they provide is confidential and anonymous. Then they were directed to a classroom-type setting to complete the questionnaires. Almost all coaches agreed to complete the questionnaires (99.9%). Coaches who did not agreed to participate in the study were excluded and their observational data were eliminated (*n* = 2), including only those who agreed (*n* = 258).

Measures

Emotional Intelligence

The Portuguese version (Rodrigues et al., 2011) of the Wong and Law Emotional Intelligence Scale (WLEIS; Wong and Law, 2002) was used to analyze coaches' perceptions of their EI abilities. It is a 16-item scale based on Salovey and Mayer (1990) original definition of EI: self-emotions appraisal (e.g., "I have good understanding of my own emotions"), other's emotions appraisal (e.g., "I am a good observer of others' emotions"), use of emotion (e.g., "I am a self-motivated person"), and regulation of emotion (e.g., "I have a good control of my own emotions"). All items were responded on 7-point Likert-type scale ranging from 1=totally disagree to 7=totally agree. Cronbach's alpha coefficients for this study ranged between 0.77 (use of emotion) and 0.86 (regulation of emotion) for the WLEIS subscales.

Coaching Efficacy

The Portuguese version (Duarte et al., 2012) of the 24-item Coaching Efficacy Scale (CES; Feltz et al., 1999) was considered to examine the amount to which coaches believe they have the ability to influence athletes' learning and performance. Participants were questioned to indicate "How confident are you in your ability to...," and in a 5-point Likert type scale that ranges from 1=low confidence to 5=high confidence. CES measure dimensions of coaching efficacy: motivation (e.g., "build team confidence"), teaching technique (e.g., "detect skill errors"), game strategy (e.g., "recognize opposing team's weakness during competition"), and character building efficacy (e.g., "promote good sportsmanship"). In this study, all dimensions of coaching efficacy revealed adequate Cronbach's alpha coefficients: motivation (0.88), teaching technique (0.78), game strategy (0.86), and character building efficacy (0.74).

Coaching Behavior

The Coaching Behavior Assessment System (CBAS; Smith et al., 1977; Cruz et al., 2001) was used to code, record and analyze coach's behavior during youth soccer games. CBAS examines 12 dimensions of coach behavior, categorized into two main types of coach behavior: reactive and spontaneous behaviors. Reactive behaviors are responses to positive athlete behaviors or effort and athletes' mistakes and errors. According to Smith and Smoll (1997), coach reactive behaviors can be divided into positive and negative: positive reactive behaviors are (a) reinforcement (i.e., positive reaction by the coach to a desirable performance), (b) technical instruction (i.e., telling or showing a player who has made a mistake how to make play correctly), and (c) encouragement (i.e., encouragement to a player by a coach following a players mistake); negative reactive behaviors are (d) non-reinforcement (i.e., a failure to reinforce a positive behavior), (e) punishment (i.e., a negative response by the coach following an undesirable behavior), (f) punitive technical instruction (i.e., whenever a coach gives technical instruction in a punitive or hostile manner), and ignoring mistakes (i.e., a lack of response, either positive or negative, to a mistake on the part of a player or the team). The spontaneous categories include general technical instruction, general encouragement, organization, and general communication. For the present study, we focused on coach positive and negative elicited responses preceding athlete or team actions.

Data Analysis

A two-step robust maximum likelihood method of SEM approach was performed using IBM AMOS version 23 (Hair et al., 2014). First, a confirmatory factor analysis was implemented to analyze the quality of the variables adjustment to its indicators. Second, the structural model was estimated to test mediation effects, as recommended by Danner et al. (2015). Specifically, EI (i.e., self and other's emotions' appraisal, use of emotion, and regulation of emotion) were conceptualized to have an indirect association with coaches' positive and negative reactive behaviors, and coaching efficacy dimensions (i.e., motivation, game strategy, technique, and character building efficacy) were considered as mediators. Bootstrap resampling procedure (1,000 bootstrap samples) with 95% bias corrected confidence intervals (CI) was used to test the significance of the direct and indirect effects. An indirect effect is considered significant (at ≤ 0.05) if its 95% CI does not include zero (Williams and MacKinnon, 2008). Four indexes were considered to estimate the adjustment of the model to the data (Hair et al., 2014): CFI and TLI > 0.90; RMSEA and SRMR < 0.08.

Also, a multigroup analysis was performed to examine the extent to which coaching level moderate the path coefficients assessed in the hypothesized model. Cheung and Rensvold's (2002) criteria was considered to assess differences between models: chi-square ($\chi 2$) tests of significance and CFI difference (ΔCFI) values. The significance of the path coefficients was evaluated using critical ratio for differences produced by AMOS (significance ≥ 1.96).

RESULTS

A prior analysis to the data revealed 0.8% of missing data, without any missing pattern. Thus, missing data were managed using AMOS's regression procedure. Furthermore, Mardia's coefficient surpassed criteria (<5.0) for multivariate normality. Hereupon, following Nevitt and Hancock (2001) a Bollen-Stine bootstrap was used for further analysis. Additionally, variance inflation errors (VIF) with values ranging from 1.67 (game strategy) to 2.05 (motivation strategy) showed acceptable conditions to conduct regression analysis (VIF < 10; Hair et al., 2014).

Measurement Model

Means, standard deviations, and bivariate correlations between study variables are presented in **Table 1**. Participants revealed a moderate-to-high level of self-emotions appraisal (M = 4.21, SD = 0.47), and moderate levels of game strategy efficacy (M = 3.33, SD = 0.42). Concerning coach reactive behaviors, participants expressed a mean of 49.85 (SD = 13.42) behaviors per game (in total 12863 coach's reactive behaviors were recorded). Coach's reactive behaviors were more positive (M = 12.64, SD = 6.64) than negative (M = 4.74, SD = 1.33). Regarding correlations between variables, all EI variables are associated between each other, and between all dimensions of coaching

TABLE 1 | Descriptive statistics and bivariate correlations for all variables.

	1	2	3	4	5	6	7	8	9	10
1. Self-emotions app	–									
2. Others-emotions app	0.25**	–								
3. Use of emotion	0.30**	0.29**	–							
4. Regulation of emotion	0.37**	0.42**	0.26**	–						
5. Character building	0.28**	0.18*	0.20**	0.31**	–					
6. Technique instruction	0.25**	0.32**	0.47**	0.18**	0.25**	–				
7. Game strategy	0.32**	0.39**	0.54**	0.09	0.19**	0.60**	–			
8. Motivation efficacy	0.31**	0.26**	0.38**	0.33**	0.32**	0.65**	0.61**	–		
9. Positive reactions	0.07	0.08	0.16*	0.12*	0.16**	0.23**	0.21**	0.17**	–	
10. Negative reactions	−0.02	−0.18*	−0.13*	−0.26**	−0.22**	−0.12*	−0.18**	−0.07	0.75**	–
Mean	4.21	4.10	4.17	3.97	3.74	3.47	3.35	3.50	12.64	4.74
Standard deviation	0.47	0.52	0.55	0.61	0.33	0.35	0.42	0.37	6.64	1.33

*$p < 0.05$, **$p < 0.01$.

efficacy, excluding regulation of emotion with game strategy ($r = 0.09$, $p > 0.05$). In turn, regulation of emotion, motivation efficacy, character building and game strategy correlated positively with positive reactive behaviors ($r = 0.12$, $p < 0.05$; $r = 0.17$, $p < 0.01$; $r = 0.16$, $p < 0.01$; $r = 0.21$, $p < 0.05$), respectively. Also, regulation of emotion, character building and technique instruction correlated negatively with negative reactive behaviors ($r = -0.26$, $p > 0.05$; $r = -0.22$, $p > 0.05$; $r = -0.12$, $p > 0.05$), respectively.

The assessment of the measurement model included coach's own and others' emotions appraisal, use of emotion, regulation of emotion, and all coaching efficacy dimensions (i.e., motivation, teaching technique, game strategy, and character building efficacy) as latent variables. The measurement model fit to the data ($\chi 2/df$ = 790.40 (436), $p < 0.001$, TLI = 0.939, CFI = 0.946, SRMR = 0.052, and RMSEA = 0.051; 95% CI [0.045, 0.056]).

Structural Model

The hypothesized structural model demonstrated an acceptable fit to the data ($\chi 2/df$ = 1165.13 (512), $p < 0.001$, TLI = 0.894, CFI = 0.903, SRMR = 0.091, and RMSEA = 0.064; 95% CI [0.059, 0.068]). Some criteria had values slightly below acceptable levels (TLI < 0.90 and SRMR > 0.08); however, given that other criteria showed acceptable fit to the data (CFI > 0.90 and RMSEA < 0.08), the complexity of the model, and its theoretical adequacy to the original, we have decided to preserve the current model (**Figure 2**).

Figure 2 showed standardized direct effects for the hypothesized structural model. As provided, EI variables were associated in a sequential model. Moreover, regulation of emotion was associated with motivation efficacy ($\beta = 0.36$, $p < 0.05$), character building ($\beta = 0.21$, $p < 0.05$), and positive and negative reactive behaviors ($\beta = 0.28$, $p < 0.05$; $\beta = -0.19$, $p < 0.05$), respectively. Furthermore, motivation efficacy, game strategy, and technique instruction, showed significant relationships with positive reactive behaviors ($\beta = 0.31$, $p < 0.05$; $\beta = 0.21$, $p < 0.05$; $\beta = 0.22$, $p < 0.05$), respectively. Finally, motivation efficacy and character building were negatively related with negative reactive behaviors ($\beta = -0.23$, $p < 0.05$; $\beta = -0.26$, $p < 0.05$). Overall, EI and coaching efficacy dimensions account for approximately 16% of the variance of positive reactive behaviors and 21% of negative reactive behaviors (**Figure 2**).

Mediation and Moderation Analysis

Table 2 showed findings from the mediating effects between EI, coaching efficacy dimensions, and positive and negative coach's reactive behaviors. Regulation of emotion displayed significant indirect effects on positive coaches' reactions via motivation efficacy ($\beta = 0.20$, CI [0.12, 0.36]). Also, regulation of emotion had significant indirect effects on negative coaches' reactions via motivation efficacy ($\beta = -0.11$, CI [−0.28, −0.06]) and character building ($\beta = -0.35$, CI [−0.35, −0.08]).

Another goal of the study was to analyze the moderation effects of coaching level in the hypothesized model ($n_{\text{initiation}} = 122$; $n_{\text{specialization}} = 94$). Accordingly, a multigroup confirmatory factor analysis were performed. The fit of both unconstrained [$\chi 2/df$ = 1834.59 (1024), $p < 0.001$, TLI = 0.893, CFI = 0.904, RMSEA = 0.050 (CI = 0.046, 0.054)] and constrained structural paths [$\chi 2/df$ = 1123.89 (1195), $p < 0.001$, TLI = 0.890, CFI = 0.898, RMSEA = 0.051 (CI = 0.048, 0.056)] models was slightly below the acceptable levels. However, non-significant $\chi 2$ statistic indicated that these models were invariant [$\Delta\chi^2(34) = 18.33$, $p > 0.05$]. Critical ratios for differences demonstrated that structural paths from regulation of emotion to positive coaches' reactions was significantly different ($Z = 2.44$, $p < 0.05$). The path coefficient for initiation ($\beta = 0.61$, $p < 0.01$) was greater than the coefficient for specialization ($\beta = 0.19$, $p < 0.01$), indicating that initiation coached with high regulation of emotion strategies were more likely to use positive reactive behaviors than specialization coached.

DISCUSSION

The main purpose of this study was to examine the mediating effects of coaching efficacy dimensions on the association among coach's EI and reactive behaviors during soccer games. Findings revealed that coaches' regulation of emotion was positively associated with positive reactive behaviors, and negatively with

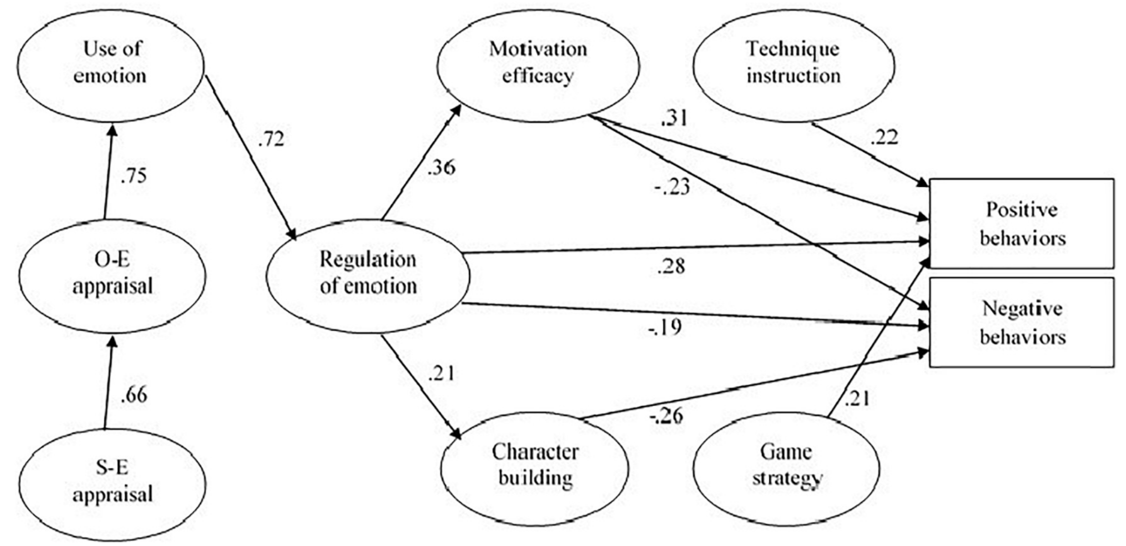

FIGURE 2 | The path model. All the standardized path coefficients arc significant at the 0.05 level. Non-significant paths were excluded for visual simplicity.

TABLE 2 | Standardized indirect effects and confidence intervals.

Mediating paths	Estimate	95% CI	
		Lower	Upper
Emotion regulation → Motivation efficacy → Positive reactions	0.20	0.12	0.36
Emotion regulation → Motivation efficacy → Negative reactions	−0.11	−0.28	−0.06
Emotion regulation → Character building → Negative reactions	−0.18	−0.35	−0.08

95% confidence intervals (CI) do not include zero for indirect effect significance.

negative reactive behaviors (Hypothesis 1). As high levels of coaches' regulation of emotion are related with behaviors evidenced as positive for youth athlete's development (e.g., Smith and Smoll, 1997), high emotion regulation coaches are likely to exhibit fewer negative behaviors (i.e., punishment, punitive technical instruction, ignoring mistakes) in reply to undesirable emotion-eliciting situations during soccer games. These promising results suggest that improvement of coaches' regulation of emotion may have the potential to be enhanced in order to improve coaches' desirable behaviors during athletes' participation in competitive sport.

In line with earlier studies (Thelwell et al., 2011; Hwang et al., 2013), EI (regulation of emotion) was positively associated with coaching efficacy dimensions (Hypothesis, 2). However, this study provides more consistency than previous evidence that reported problems with the reliability of the scales (Boardley, 2018). A closer look into the methodology of the present study, suggest that the use of the SEM analysis allows to test the global adjustment of simultaneous relationships between variables, which supports Boardley's (2018) revised coaching efficacy model, as well as the individual significance of the parameters in a single methodological framework.

Additionally, regulation of emotion was associated with coach's reactive behaviors via coaching efficacy dimensions (i.e., motivation and character building efficacy). These results expanded previous studies demonstrating mediating effects of coaching efficacy dimensions on the link between EI and individuals' behaviors (e.g., Hwang et al., 2013). Furthermore, as noted above, those who better regulate emotions will enhance their sense of efficacy to affect athletes' psychological mood and positive attitude. In turn, these coaching efficacy dimensions were associated with short-term elicited responses preceding athlete or team actions. In other words, the mediating effects of coaching efficacy suggests that coaches with high emotional regulation can manage emotions effectively and are thus more likely to believe that they have the capacity to affect the learning and performance of their athletes, as well as to adopt favorable behaviors during the game.

Furthermore, the results regarding moderating effects of coaching level showed that the mediational model was invariant across initiation and specialization levels (Hypothesis 5). However, an analysis of the structural paths exposed that a path coefficient for initiation (i.e., regulation of emotion ? positive coaches' reactions) was greater than the coefficient for specialization. While the research on potential moderators has provided inconsistent results (Myers et al., 2017), the results of the present study corroborate the idea that coaching level moderated the relationships between the proposed sources of coaching efficacy and the dimensions of coaching efficacy.

Methodological Considerations

Researchers described the multiple types of data sources using diverse research designs – qualitative, quantitative, observational, electronic, images, and sensor data, among others – that might be used to improve the level of detail to understand behavior in sport (Anguera et al., 2018). This form of research represented methodological challenges for researchers to understand the relationships between coaches' EI, efficacy beliefs and reactive behaviors in soccer games. These challenges included the need for extensive data collection, intensive analysis of both observational and statistical data, and the requirements that researchers be familiar with quantitative and qualitative forms of research. These methods were applied to converge data from naturalistic observation of coach behavior with data of self-reported EI and efficacy beliefs questionnaires.

The convergence of the data was performed through CB-SEM analyses to achieve the primary purpose of the study to examine the mediation effects of coaching efficacy beliefs on the relationships between EI and reactive behaviors in soccer games. Thus, CB-SEM was performed to test and confirm consistent theoretical models (e.g., EI, coaching efficacy). However, future studies may consider the alternative PLS-SEM when the sample is smaller (because is costly to have large samples combining data from systematic observations) (Hair et al., 2017).

Multivariate statistical analyses have long been used to improve the quality of research designs that use a large amount of data from surveys, and we noted how a number of studies are currently published using SEM analysis in social and sports sciences. These investigations share common features, specifically related with data from surveys (Kline, 2011). However, our approach within the present study was that information from other different sources (e.g., systematic observation, surveys) could be combined. In this study, we showed statistical methods for combining information, identifying research needs, and proposing steps that can be taken to facilitate answers for understating precursors of coach's behavior. Future research should shift from sole reliance on surveys to a system that relies on surveys along with *in situ* observations and other research methods, making use of the strengths of each data source.

Limitations and Future Research

The results of the present study seem to open new avenues for the exploration of a traditional theme of sports psychology, but limitations should be considered. First, due to the cross-sectional nature of the study it is difficult to establish causality of effects and thus the application of the findings to applied contexts are limited. Hence, future studies should analyze these relationships considering a season-long perspective, in order to understand for example how EI, dimensions of coaching efficacy, and coaches' reactive behaviors reciprocally impact each other. Second, for researchers on coaching science (e.g., Smoll and Smith, 1989; Chelladurai, 2007; Horn, 2008) there are variables that influence the coach-athlete relationship, such as athlete performances, coach personality, or situational characteristics (e.g., culture, gender, age, collective/individual sports, group size). For example, personality traits have been shown to play a relevant role in the dyadic function between coach and athlete (Jackson et al., 2011). In particular, a greater dissimilarity between extraversion and openness was related with less commitment between coach and athletes. As studies in sport are rare, researchers should consider coach personality traits to understand the links between coaches' EI, efficacy beliefs, and reactive behaviors. Also, researchers should consider that EI may be a learning process. John and Gross (2004) found that older adults were more likely to use effective emotional regulation strategies, including positive construction of emotion-eliciting events, than young adults; thus, researchers should explore how coaches' regulation of emotion in competitive settings change depending on the age and years of coaching experience. Likewise, there is also considerable body of work pointing to cross-cultural differences in leaders' EI. Leaders' EI and subordinates' performance is stronger in cultures that give priority to group membership, good work relationships with others, and tolerance toward ambiguities (Miao et al., 2018). It would be interesting to extend this study to other cultures that are likely to regulate emotions and express different coach behaviors in competitive settings. Third, from a measurement point of view, although WLEIS (Wong and Law, 2002) have presented once again good psychometric characteristics in sport (e.g., Lee and Chelladurai, 2016; Teques et al., 2018), more research is needed to develop and validate a sport-specific self-report EI ability measure. This would involve the steps commonly used to create a sport-specific scale in sport settings and an in-depth examination of the relationships between the measure and other established constructs associated with EI, such as personality or achievement motivation (Mayer et al., 2008), to clarify any redundancies often associated with EI trait approach (e.g., Joseph and Newman, 2010). Finally, the type of sport may influence the relationships between EI and efficacy beliefs (e.g., Myers et al., 2017). In this sense, future research should investigate the structural invariance of the model between the various modalities and levels of performance, trying to perceive any differences in their relationships.

CONCLUSION

In synthesis, the main finding of this study revealed that coach's motivation efficacy and character building mediated the association between regulation of emotion and positive and negative coaches' reactions during game. From a practical standpoint, this indicates that coaches who are competent to regulate their own emotions would perceive high beliefs of efficacy to stimulate and to enhance positive attitudes of their athletes, and this is reflected in more positive (e.g., positive reactions by the coach to desirable athletes' performances) and less negative behaviors (e.g., negative responses by the coach following undesirable athletes' actions) during the game. Additionally, this study showed that coaching level moderated the associations between EI, efficacy beliefs and coaches' reactive behaviors. Specifically, moderation analysis indicated that coaches of soccer teams in the initiation stage tended to feel more competent to regulate their own emotions, and this is reflected in more positive behaviors during the game, in comparison with coaches of teams in the specialization stage. Also, at an elementary descriptive level of study results, the majority of coach reactive behaviors were more positive (e.g., positive reinforcement, technical instruction, and encouragement) than negative (e.g., non-reinforcement, punishment, punitive technical instruction, and ignoring mistakes). Thus, whereas negative coach's behaviors may be mainly concerning for sport psychologists in coach training programs (e.g., Smith et al., 2007), this study suggests that these reactive behaviors are less frequent. Finally, the findings support Boardley's (2018) conceptual assertion that EI and coaching efficacy beliefs are determinants of coach behaviors by revealing that coaches' EI (i.e., regulation of emotion) is linked positively with desirable coach behaviors and negatively with undesirable coach behaviors via relevant coaching efficacy dimensions (i.e., motivation and character building efficacy). In general, this study elucidates coach's emotional experiences in their technical area during a soccer game and suggests that EI and coach's efficacy beliefs strategies may be useful approaches to include in coach training programs.

DATA AVAILABILITY

The datasets for this manuscript are not publicly available because ethical restrictions (contain information that could compromise the privacy of research participants), but are available from the corresponding author on reasonable request. Requests to access the datasets should be directed to pteques@ipmaia.pt.

ETHICS STATEMENT

Ethical approval for this study was obtained from the Scientific Committee of the Polytechnic Institute of Maia Research Center under the reference N2I/006/04/2017. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Scientific Committee of the Polytechnic Institute of Maia Research Center.

AUTHOR CONTRIBUTIONS

PT and DD were enrolled in study design, data collection, and writing the first draft of the manuscript. PT and JV participated in data analysis, and writing of the methodology and results. PT, DD, and JV participated in final revisions of the manuscript. All authors read and approved the final version of the manuscript and agreed with the order of presentation of the authors.

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Mixed Methods in Decision-Making Through Polar Coordinate Technique: Differences by Gender on Beach Handball Specialist

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The aim of this research was to analyze decision making of the specialist in beach handball in the framework of mixed methods, and through the observation of their actions. To do this, and distinguishing it by genre, an analysis of polar coordinates was realized using the assist and completion of this specific position as behavior criteria. A total of 24 sessions were observed with the HOISAN computer software, using an *ad hoc* design tool. Observation design used was nomothetic, punctual, and multidimensional. The obtained results showed significant relations between the behavior criteria and conditional behaviors (pairing), showing significant relations different for male and female categories. Significant differences were estimated statistically about the importance of the specialist in the development of the static attack in beach handball and their influence in the final result of the match, based on their greater or lesser success in decision making. In the male category it is highlighted that the specialist's assists are not positively related to a favorable score and that the attack usually ends up in the central areas against closed defensive systems; in addition, their successful completion decisions are produced by means of launches in the central zone, also against closed defensive systems; however, in the female category, specialists' assists lead to end the attacks in flight on the far right against open defensive systems.

Keywords: mixed methods, systematic observation, decision making, polar coordinates, beach handball

INTRODUCTION

The available literature has brought to light how in collective sports there has been a progressive increase in the physical, technical and tactical demands of competition in recent decades (Carling, 2011; Sarmento et al., 2017). This has generated the necessity of increasing the specific knowledge about these aspects to be able to plan training sessions properly and make a better preparation of the team (Nunes et al., 2015).

Beach handball is not unaware of this situation, as shown by the evolution developed in the modality in all aspects of the game since its inception in the 1990s to the present (Morillo-Baro and Hernández-Mendo, 2015), generating the need for continuous updating and innovation in the professionals of this sport. In the last years, it has undergone a very significant increase, due to the investment that the corresponding sports institutions have made in this sport: European handball federation (EHF), international handball federation (IHF) and the respective national federations developing championships at the state, continental and world level, both of clubs and of the respective national teams (Zapardiel Cortés, 2015).

This modality presents substantial differences with the handball court, both at the regulatory level and in the different facets of the game, turning it into a very new modality, which has successfully broken into the national and international scene. Its own rules of the game make it very attractive, uncertain and interesting (Belančić, 2005). One of the main differences is the way of scoring depending on the different actions: one-point goals can achieve by a classic launch from any player other than the goalkeeper-specialist, or two-point goals can be scored by spin shot of 360-degree, flight shots or by the specialist's shots (Ostoić and Ohnjec, 2015).

The situation of numerical superiority of the opposing team by means of the defense-attack change of the goalkeeper by the specialist gives him a decisive role in the creation of the offensive game (Gruić et al., 2011). When the game is always developed in offensive numerical superiority, and the possibility of this player to score a two-point goal through a classic shot, makes the player a focus of attention from the defenders of the opposing team. This aspect generates spaces that can be used by teammates through an individual action or an assist. These tactical considerations turn the position of the specialist into one of greater responsibility in decision-making, as the analysis of the international competitions held show (Tezcan, 2013).

The decision making is one of the main heuristics in sports practice, it is defined as the process by which the athlete decides how to act or react according to the demands of the environment to achieve different performance objectives (Hodges et al., 2007); in short, it is about guessing the right information from the environment to plan future actions. In recent years, the study of the decision-making process in collective sports has received considerable attention; in football, it has studied the influence of contextual factors on decision-making by highly skilled players through semi-structured interviews, where the importance of considering the dynamic and static context in which players make decisions was demonstrated (Levi and Jackson, 2018); in volleyball, the relationship between decision-making and performance in three actions of the game (reception, scenario, attack) has been analyzed, through which, it was clear that the relevance of the decisional skills in the performance of the actions of the game, which contribute to the final performance of equipment (Conejero et al., 2018); a study made with players from NFL and NCAA about the theory of the risk sensitivity showed that athletes risk-sensitive decisions were made when the needs motivational interviewing were stronger (Gonzales et al., 2017); finally, in handball, players have been studied, showing the influence of game time for decision-making in relation to tactical media used (Prudente et al., 2017), and the referees, showing how the spatial situation of the same ones influences the success or error (Morillo-Baro et al., 2017b). And in beach handball, the influence of different contextual factors on decision-making by players in competition has been analyzed (Vázquez-Diz et al., 2019a).

Araújo et al. (2016) propose to study the process of decision making, based on the ecological perspective, observing the trace or behavioral traces of athletes through success patterns against unsuccessful patterns considering different factors such as space, teammates and rivals. The observation of this trace of behavior can be done through a mixed observation tool of Field Format and Category Systems E/ME (exhaustive and mutually exclusive) (Araújo et al., 2016). Systematic observation is a technique and/or methodology to analyze behavior in sports (Anguera and Hernández-Mendo, 2013) and several tools have been created to analyze what happens in the situations of game of handball (González, 2012; González et al., 2013; Sousa et al., 2014; Loffing et al., 2015; Helm et al., 2016; Jiménez-Salas and Hernández-Mendo, 2016) and beach handball (Morillo-Baro and Hernández-Mendo, 2015; Vázquez-Diz et al., 2019b).

Studies in the field of sport, in the framework of mixed methods, need to connect qualitative and quantitative elements (Plano-Clark and Sanders, 2015), and the ideal solution is to apply the successive steps defined within systematic observation, that is the main procedure to collect sport data in event analysis and there is ample experience with its use and evidence of its potential (Portell et al., 2015). Also, systematic observation is widely applicable and offers an optimal balance between rigor and flexibility. The observational records are qualitative, but the quantitizing (Tashakkori and Teddlie, 1998) is particularly robust, because apart from simple frequency counts, it contemplates other essential primary parameters, such as order and duration. This specific consideration of the order parameter is crucial for detecting hidden structures through the quantitative analysis of relationships between different codes in systematized observational datasets (Anguera et al., 2017). Just the wide scope of opportunities available for processing data derived from observation supports the idea that purely observational studies should be considered as mixed methods research studies, even though they constitute a somewhat special case and do not follow traditional patterns (Anguera et al., 2017).

Systematic observation is developed in natural or habitual contexts, and consists in a scientific procedure that, based on the considered objectives, reveals the occurrence of perceptible behaviors, to proceed to its registration organized by means of a specifically elaborated instrument and using the appropriate parameters. The motor behavior can be studied through the most characteristic analysis of the observational methodology, the sequential analysis of delays and the polar coordinate analysis (Anguera and Hernández-Mendo, 2013, 2014, 2015). The sequential analysis of delays is aimed at the detection of sequential patterns of behavior and is carried out by means of the search of sequential contingencies between categories or codes of behavior, through an observation instrument configured through a system of categories, field format or mixed instruments between category system and field format (Anguera et al., 2007).

Taking into account all this background on beach handball as an object of study, the aim of this research has been to observe the decision making of the specific position of the specialist through the observation of their actions. Identify, for each gender, the different significant associations between the behaviors of this specific position and those of the rest of the observation tool by analyzing polar coordinates.

MATERIALS AND METHODS

In the framework of mixed methods, the observational design used was nomothetic, punctual and multidimensional (Anguera et al., 2011). The unit of observation was the sequence of positional attack, which in this investigation will be defined from when the figure of the specialist appears in the attack until the change of possession occurs.

Participants

Of the 24 teams that participated in the 2016 Senior Spanish Cup, six teams of each gender were selected to be observed ($M \pm$ SD: age male = 26.67 $\pm$ 5.85; age female = 23.27 $\pm$ 5.74). The six teams have been selected randomly. The research was conducted on a total of 24 observation sessions, twelve for the male category and twelve for the female category. The number of sessions estimated to generalize accurately (Morillo-Baro et al., 2015). **Table 1** shows the matches that have been analyzed.

Instruments

The Royal Spanish Handball Federation (RFEBM) recorded the matches. The HOISAN v. 1.6.3.3.2 computer software was used (Hernández-Mendo et al., 2012) to perform the sequential analysis, the polar coordinate analysis and its vectorial representation, as well as the codification of the observations before to the sequential analysis. An *ad hoc* design tool has been used which has passed the quality tests of the data required in OM, (Morillo-Baro and Hernández-Mendo, 2015). It is built through a mixed system of field formats and exhaustive and mutually exclusive category systems (E/ME). The tool consists of 11 criteria and 90 categories that are complementary to the chronological development of an attack (Morillo-Baro and Hernández-Mendo, 2015). **Table 2** shows the composition of the instrument of observation and **Figure 1** the division of game spaces:

TABLE 1 | Analyzed matches.

Category	Matches
Male	C. BMP. Alcala – Zonabalonmano Cadiz
	C. BMP. Ciudad de Malaga – C. BMP. Bahia de Algeciras (team no observed)
	C. BMP. Ciudad de Malaga – C. BMP. Barbate “B” (team no observed)
	BHC Plan B Barcelona – C. BMP. Barbate
	BHC Plan B Barcelona – Zonabalonmano Cadiz
	Pinturas Andalucia BMP Sevilla – C. BMP. Barbate
	Pinturas Andalucia BMP Sevilla – C. BMP. Alcala
Female	C. BMP. Algeciras – C. BMP. Ciudad de Malaga
	C. BMP. Algeciras – Deporte y Empresa Clinicas Rincon Malaga
	C. BMP. Ciudad de Malaga – C. BMP. Getasur juvenil Madrid
	C. BMP. Getasur junior Madrid – Deporte y Empresa Malaga
	C. BMP. Getasur junior Madrid – C. BMP. Getasur juvenil Madrid
	Jugui SOS Valencia (team no observed) – Deporte y Empresa Málaga
	Grupo Llopis BMP Sevilla (team no observed) – C. BMP. Algeciras

Procedure

Data Quality

Once the data collection is done, the observer must have the necessary guarantee about its quality (Anguera, 2003). Pearson’s, Spearman’s, Tau b of Kendall’s correlation coefficients and the Coefficient Phi have been evaluated. In addition, Cohen’s Kappa concordance index was calculated for the complete session, the results are shown in the **Table 3**.

Cohen’s Kappa index of this research exceeds the score of 0.90 for intra-observer (0.94) and inter-observer (0.91) reliability. Therefore, observing the values of Gelfand and Hartmann (1975) or Landis and Koch (1977), it can be considered that there is a high reliability.

Generalizability Analysis

For the application of the Theory of Generalizability, SAGT computer software has been used (Hernández-Mendo et al., 2016), This software has been used to determine the intra-observer and inter-observer concordance, through a design of two facets, categories and observers = C/O, in addition to assessing the homogeneity of the categories, but this time with a two-faceted design, likewise, but with an O/C design. The Theory of Generalizability unifies the definitions of reliability, validity and precision. The Generalizability study consists basically of four phases: (1) definition of the facets of study; (2) analysis of variance of the scores obtained on the study facets; (3) calculation of the error components; (4) optimization of the Generalizability coefficients (Blanco-Villaseñor et al., 2014).

A two-faceted design (categories and observers = C/O) has been established, as discussed above, to determine the reliability among observers (inter-observer concordance). The results shown by the report obtained through the SAGT program indicate that almost all the variability is associated with the facet categories (97.12%), being 0 for the facet observers and 2.28% for the interaction of the facets categories/observers. The coefficients of generalizability in this design structure determine results of 0.98, which means excellent results.

For the determination of intra-observer reliability, the same design has been taken. The results indicate that almost all the variability is associated with the facet categories (97.99%), being 0 for the facet observers and 2.01% for the interaction of the facets categories/observers. The coefficients of generalizability in this design structure determine results of 0.99, which means excellent results.

To assess the homogeneity of the categories, a two-faceted design has been used (observers and categories = O/C), this

TABLE 2 | Observation instrument: criteria and corresponding categories and codes.

Criterion	Categories	Criterion	Categories
1. Minute	M1: minute one of first half M2: minute two of first half M3: minute three of first half M4: minute four of first half M5: minute five of first half M6: minute six of first half M7: minute seven of first half M8: minute eight of first half M9: minute nine of first half M10: minute 10 of first half M11: minute one of second half M12: minute two of second half M13: minute three of second half M14: minute four of second half M15: minute five of second half M16: minute six of second half M17: minute seven of second half M18: minute eight of second half M19: minute nine of second half M20: minute 10 of second half MGOL1: golden goal of first half MGOL2: golden goal of second half	2. Score	MPATE: tie 1FAV: observed team is ahead by one point 2FAV: observed team is ahead by two points M2FAV: observed team is ahead by more than two points 1CON: observed team is trailing by one point 2CON: observed team is trailing by two points M2CON: observed team is trailing by more than two points
3. Numerical balance	IGUAL: equality 1SUP: advantage of one M1SUP: advantage of more than one 1INF: disadvantage of one M1INF: disadvantage of more than one	4. Defensive system	S30: 3:0 defensive system S21: 2:1 defensive system S2M1: 2 + 1 defensive system SPRES: individual defensive system SREPL: retreat defensive system S20: 2:0 defensive system
5. Zone of end of attack	ZF1: attack ends in zone 1 ZF2: attack ends in zone 2 ZF3: attack ends in zone 3 ZF4: attack ends in zone 4 ZF5: attack ends in zone 5 ZF6: attack ends in zone 6 ZF7: attack ends in zone 7 ZF8: attack ends in zone 8 ZF9: attack ends in zone 9	6. Substitution area	BCSI: attack ends in one of the zones adjacent to the observed team's substitution area BCNO: attack ends in one of the zones adjacent to the opposing team's substitution area. BCMED: attack ends in one of the central zones.
7. Assisting player	APETO: assist by specialist AXTRI: assist by left wing AXTRD: assist by right wing ACENT: assist by center APIV: assist by pivot NASIS: no assist	8. Player who ends attack	FPETO: specialist ends attack FXTRI: left wing ends attack FXTRD: right wing ends attack FCENT: center ends attack FPIV: pivot ends attack
9. How attack ends	FLY: attack ends with in-flight shot GIRO: attack ends with spin shot LANZ: attack ends with shot 6M: attack ends with 6-m throw ERRPR: attack ends with passing or catching error FTECN: attack ends with foul	10. Result of end of attack	GOL1: one-point goal GOL2: two-point goal ERLAN: missed shot CPOSE: change of possession G1SA: one-point goal and suspension G2SA: two-point goal and suspension 6MGOL: goal scored by 6-m throw 6MFA: missed 6-m throw GOL1R: one-point rebound goal GOL2R: two-point rebound goal 6MGSA: goal scored by 6-m throw and suspension 6MFSA: missed 6-m throw and suspension GOL1RSA: one-point rebound goal and suspension GOL2RSA: two-point rebound goal and suspension
11. Duration	D05: between 0 and 5 s D610: between 6 and 10 s D1115: between 11 and 15 s D1620: between 16 and 20 s D2125: between 21 and 25 s D2630: between 26 and 30 s DM30: more than 30 s		

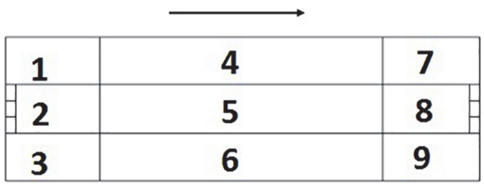

FIGURE 1 | Division of game spaces. The numbering is related to the sense of attack.

TABLE 3 | Intra and inter-observer agreement.

Coefficient for entire session	Intra-observer agreement (Obs. 1 vs. Obs. 1bis)	Inter-observer agreement (Obs. 1 vs. Obs. 2)
Pearson's	0.98	0.97
Spearman's (ρ)	0.95	0.89
Kendall's tau-b	0.95	0.91
Kappa	0.94	0.91
Phi	0.89	0.85

design allows to check the degree of differentiation of the proposed categories. The generalization coefficients for this design are invalid (0.000), this indicates that the homogeneity of the categories is optimal in the sense of differentiating.

Polar Coordinate Analysis

The polar coordinate analysis is an analysis technique widely used in recent years in the field of Sports Science is (Araújo et al., 2016; Maneiro et al., 2019; Vázquez-Diz et al., 2019a). There are numerous works that have been used to analyze different sports, football is the sport on that more research are published (Robles et al., 2014; Castañer et al., 2017; Maneiro and Amatria, 2018), although it can also be found in other sports such as taekwondo, basketball or karate (López-López et al., 2015; Nunes et al., 2015; Riveiro-Bozada et al., 2016). In handball, Sousa et al. (2014) characterized and detected effective behavioral vectors in offensive situations of two against two. And specifically, in the modality of beach handball, Morillo-Baro et al. (2015) analyzed the positional attack establishing differences by gender.

This technique has its origin in Sackett's (1980) work and subsequent optimization with the "genuine technique" (Anguera, 1997), which allows to make a drastic reduction of data and a vectorial representation of the interrelationships established between the different categories that constitute the proposed taxonomic system (Hernández-Mendo and Anguera, 1999; Gorospe and Anguera, 2000). This technique is supported by a lag sequential analysis of prospective and retrospective delays (Sackett, 1980), with the genuine technique (Anguera, 1997) of the occurred successive conducts. The values obtained in the calculation of the conditioned probability will allow obtaining the parameter Z_{sum} ($Z_{\text{sum}} = \Sigma z/\sqrt{n}$, where n is the number of delays) (Cochran, 1954). The distribution of this parameter Z_{sum} has a $\bar{x} = 0$ and a SD = 1.

In obtaining these values the interrelation map of behaviors or a map of polar coordinates can be built (Gorospe and Anguera, 2000). For the construction of behavioral maps, it is necessary to determine the vector modules (to be considered significant they must be equal to or greater than 1.96). The radius or length of the radius is calculated by the square root of the sum of the square of the Z_{sum} of the X (prospective) and the square of the Z_{sum} of the Y (perspective).

$$\text{Radius } = \sqrt{x^2 + y^2}$$

The angle of the vector (φ) (which will depend on the quadrant where it is located) showing the nature of the relationship (Castellano and Hernández-Mendo, 2003). This angle (φ) is calculated as φ = Arc sine of Y/radius.

For coding and analysis of polar coordinates, the HOISAN computer program has been used (Hernández-Mendo et al., 2012). First, a sequential analysis is performed for each category of all the observations made with the selected criteria behavior, obtaining the Z results with a range of delays of −5 and 5. Once these values were obtained, the calculations were made to determine the Z_{sum} parameters (prospective and retrospective) (Sackett, 1980), the quadrant assignment, the radius, the angle, and the transformed angle (AT) for the rest of the categories (Castellano and Hernández-Mendo, 2003). The characterization of each quadrant is the following (Castellano and Hernández-Mendo, 2003):

Quadrant I [+, +]: The given behavior is motivated with respect to the pairing performance behavior in retrospective and prospective perspective.
Quadrant II [−, +]: The given behavior has a relation with respect to the pairing of motivation in retrospective perspective and of inhibition in prospective perspective.
Quadrant III [−,−]: The given behavior has a relation with respect to the pairing of inhibition in retrospective and prospective perspective.
Quadrant IV [+,−]: The given behavior has a relationship with the behavior of a motivated pairing performance in prospective perspective and inhibition in retrospective perspective.

The behavior selected as (focal) criteria have been: APETO and FPETO. These are the behaviors in which the role of the specialist is the main protagonist, in APETO (*peto* assists) the player who acts as a specialist makes the last pass to one of his/her teammates so that he/she finishes the positional attack by means of one of the ways of completion that are collected in the observation tool. While in FPETO (*peto* finalizes) is the specialist player who ends the action of the positional attack.

RESULTS

Therefore, the results obtained can be observed by analyzing polar coordinates for the selected behaviors as a criterion. **Table 4** shows the mating behaviors that are significantly linked when the criterion behavior is APETO.The results show, by quadrant and category, that when the criterion behavior is APETO, in quadrant I, where it is augmented in respect to the pairing

TABLE 4 | Relationships between focal behavior APETO and conditional behaviors.

Criterion behavior	Q	Male			Female		
		Pairing behavior	**Vector module**	**T.A.**	**Pairing behavior**	**Vector module**	**T.A.**
APETO	I	FPETO	2.22	64.5	ERLAN	2.59	66.98
		ZF5	1.98	52.45	GOL1	2.82	4.88
		BCMED	2.61	31.49	IGUAL	2.92	14.99
		1CON	3.33	37.52	S21	2.92	51.19
					M2FAV	3.01	32.28
					FLY	3.45	45.86
					FXTRD	3.5	53.59
					ZF9	3.56	23.59
					2CON	5.19	70.36
	II	M2CON	4.31	168.58	D2125	2.8	128.52
		SPRES	2.21	124.66			
		LANZ	2.81	99.65			
	III	FXTRI	2.04	202.56	1INF	2	207.19
		6MGSA	2.09	236.98	ERRPR	2.23	224.14
		ZF4	2.37	191.17	1SUP	2.29	181.01
		D1620	2.57	232.89	S20	2.62	192.03
		S2M1	2.75	198.33	CPOSE	2.69	235.12
		M2FAV	2.77	208.08	2FAV	2.7	199.88
		GIRO	3.03	209.48	EMPATE	4.23	261.4
					D05	2.89	182
					ZF4	3.2	234.86
					1FAV	3.23	224.86
					SPRES	3.58	244.38
					1CON	3.77	229.08
	IV	FPIV	2.02	339.59	D610	2.78	320.55
		FLY	2.45	345.2			
		2CON	2.95	348.74			
		2FAV	3.21	271.17			
		6MGOL	3.33	352.09			

Legend: Q, Quadrant; T.A., transformed angle; FPETO, specialist ends attack; ZF5, attack ends in zone 5; BCMED, attack ends in one of the central zones; 1CON, observed team is trailing by one point; ERLAN, missed shot; GOL1, one-point goal; IGUAL, equality; S21, 2:1 defensive system; FLY, attack ends with in-flight shot; FXTRD, right wing ends attack; ZF9, attack ends in zone 9; 2CON, observed team is trailing by two points; M2CON, observed team is trailing by more than two points; SPRES, individual defensive system; LANZ, attack ends with shot; D2125, between 21 and 25 s; FXTRI, left wing ends attack; 6MGSA, goal scored by 6-m throw and suspension; ZF4, attack ends in zone 4; D1620, between 16 and 20 s; S2M1, 2 + 1 defensive system; M2FAV, observed team is ahead by more than two points; GIRO, attack ends with spin shot; 1INF, disadvantage of one; ERRPR, attack ends with passing or catching error; 1SUP, advantage of one; S20, 2:0 defensive system; CPOSE, change possession; 2FAV, observed team is ahead by two points; EMPATE, tie; D05, between 0 and 5 s; 1FAV, observed team is ahead by one point; FPIV, pivot ends attack; 6MGOL, goal scored by 6-m throw; D610, between 6 and 10 s.

behavior in retrospective and prospective perspective, in the male category it is associated with four pairing behaviors, highlighting the zone of completion five (ZF5), the band of medium change (BCMED), and the result of a goal against (1CON); whereas in the female category it is associated with nine pairing behaviors, highlighting the throwing error (ERLAN), the flight (FLY), the player that finishes is the far right (FXTRD) for the finishing area nine (ZF9) and a defensive system two in line and one in advance (S21).

In quadrant II, where the criterion behavior has a relationship with respect to that of augmented performance in pairing in retrospective perspective and of inhibition in prospective perspective, in male category, it is only associated with three pairing behaviors, being the result more than two in against (M2CON) the one that greater intensity in the relationship presents. Meanwhile, in the female category, only a pairing behavior appears, which is the duration of the attack between 21 and 25 s (D2125).

In quadrant III, the criterion behavior has a relationship with respect to the pairing of inhibition in retrospective and prospective perspective. In the male category, there are seven pairing behaviors, of those it can stand out the way of ending in spin shot (GIRO), the defensive system of the opposing team two plus one (S2M1), the player that ends is the left wing (FXTRI), the zone of end four (ZF4) and the result of more than two goals in favor (M2FAV). In the female category, it is related to twelve pairing behaviors, of which can distinguish the defensive system of the opposing team (SPRES), the pass or reception error (ERRPR), the change of possession (CPOS) and the duration of the attack less than 5 s (D05).

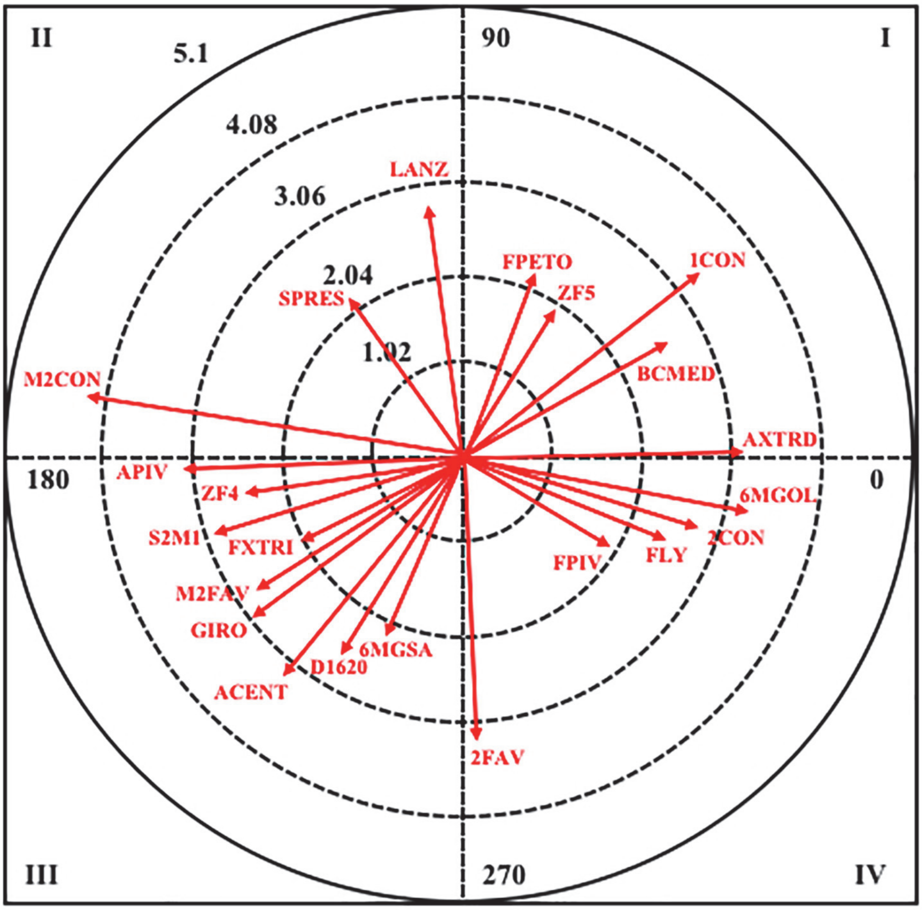

FIGURE 2 | Vector map for focal behavior APETO in male category.

Finally, in quadrant IV, the criterion behavior has a relationship with the behavior of augmented pairing in prospective perspective and inhibition in retrospective perspective. In masculine category, it is related to five pairing behaviors, being the result of two goals in favor (2FAV) the behavior that greater radio has shown, while, in feminine category, it is associated only with a pairing behavior, the duration of the attack between 6 and 10 s (D610).

Next, in **Figure 2**, it can be observed the resulting graphical representation from the analysis of polar coordinates for this criterion behavior in male category.

In **Figure 3**, is represented the graphical representation for the female category.

Table 5 shows the results obtained when the criterion behavior is FPETO.

In quadrant I, in male category, it is related to seven pairing behaviors, being the most important the finishing zone five (ZF5) and six (ZF6), the finishing mode in launch (LANZ), the defensive system of the opposing team 3:0 (S30), and the result of a goal in favor (1FAV) and a goal against (1CON). In female category, on the other hand, it can stand out the finishing zone four (ZF4) and the defensive system two in line plus one player in advanced individual defense.

In quadrant II, in the male category, a pairing behavior appears only as the result of two goals against (2CON), as in the female category, the duration of the attack between 6 and 10 s (D610).

In quadrant III, in the male category, it is related to eleven pairing behaviors, highlighting the missed shot (ERLAN) and the defensive system of the opposing team, two players in line and one advanced (S21), this being the one with the largest module of vector. In the female category, only two pairing behaviors appear, the result of more than two goals ahead (M2FAV), which is the one with the highest radius, and the zone of completion seven (ZF7).

In quadrant IV, in the male category only one pairing behavior is found, the zone of completion nine (ZF9); while in the female category four can be found, emphasizing the duration of the attack of 5 s (D05) over the rest.

Next, in **Figure 4**, the graphical representation resulting from the analysis of polar coordinates for this focal behavior can be observed.

In **Figure 5** the graphical representation for the female category is represented.

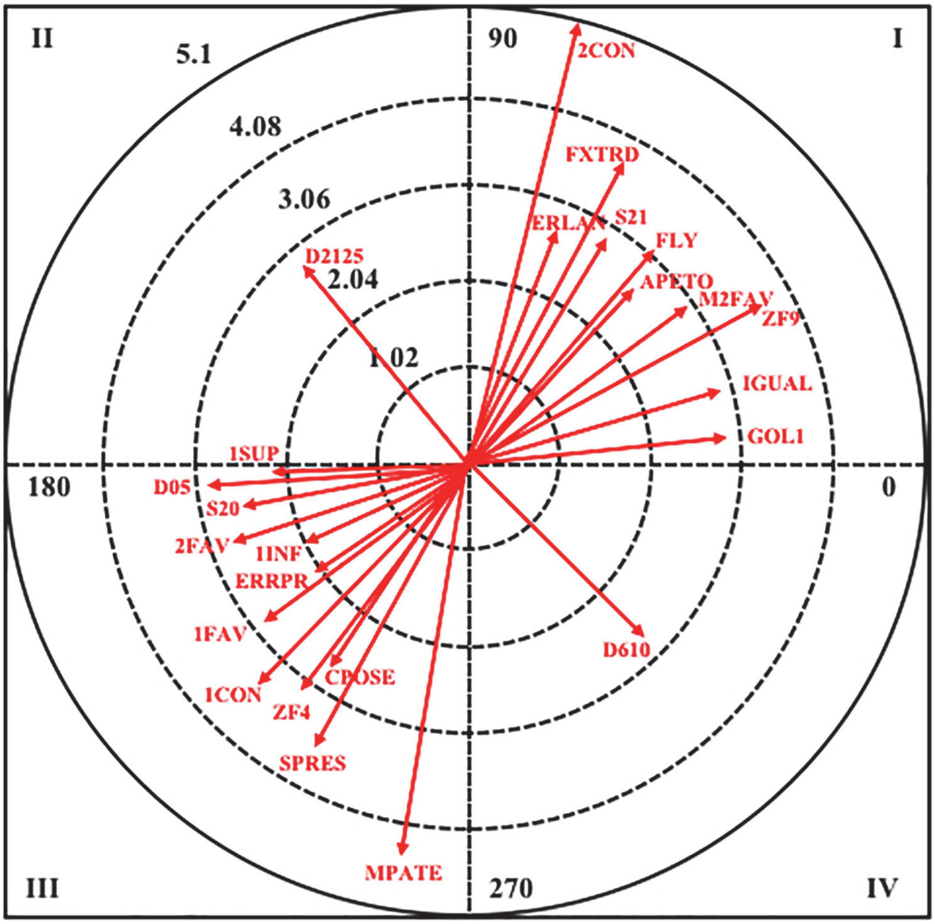

FIGURE 3 | Vector maps for focal behavior APETO in female category.

DISCUSSION

The aim of this study was to analyze the decision making of beach handball players who acquire the role of specialist according to the behavior they have shown, from the framework of mixed methods. To do this, the aim has been to identify the relationships that were established between behaviors used as a criterion, those that showed their decision-making by performing assists and completions, with pairing behaviors of the selected criteria of the tool: score, defensive system of the opposing team, zone of end of the attack, player that ends, end mode and duration of the attack. The results showed differences between the flow of behaviors that are significantly linked in the male category compared to the female category, which coincides with the results obtained in the studies published on this modality so far (Morillo-Baro et al., 2015; Vázquez-Diz et al., 2019a).

Firstly, and in the male category, the specialist's assists are associated with the score against, which is manifested in the four quadrants of the table of results. These indicate that the situation of numerical superiority and his ability to fix opponents do not positively relate the score with the performance of assists, therefore, it seems that the participation of this position goes more toward decisions of continuity in actions and completion of the attack than toward decision making of the last pass. In this sense, the research by Vázquez-Diz et al. (2019a) relates the success in the decision making in a positive way with a favorable score. Another remarkable result is that the area of the court where male teams tend to end their attacks when the assist is made by the specialist is in the central zone, results that do not coincide with those obtained by Morillo-Baro et al. (2015). Data that shows a tactical evolution in the game in male category, either to solve the absence of left-handed players or to look for solutions before the increasingly better defensive systems. In addition, the assist of the specialist player cannot be associated with the completion in turn, a result that falls within the logic, since this gesture does not need tactical collaboration unlike the shot in flight (Morillo-Baro et al., 2017a). When inhibiting the behaviors referring to the defensive pressing systems, it is reasonable to think that this player performs his actions before closed defensive systems, a result that agrees with the research of Morillo-Baro et al. (2015). Individual defensive systems have a negative performance improvement in the women's category, specifically with errors of pass and reception, as shown, the results of the study by Vázquez-Diz et al. (2019a).

TABLE 5 | Relationships between focal behavior FPETO and conditional behaviors.

Criterion behavior	Q	Male			Female		
		Pairing behavior	Vector module	T.A.	Pairing behavior	Vector module	T.A.
FPETO	I	ZF5	2.17	34.71	ZF4	2.28	32.94
		LANZ	2.74	34.58	S2M1	2.54	71.6
		BCSI	3.34	52.87	MPATE	2.84	35.19
		ZF6	3.48	78.49	2FAV	3.99	53.07
		1FAV	3.97	8.29			
		1CON	5	48.87			
		S30	5.39	28.5			
	II	2CON	2.3	148.77	D610	2.04	149.28
		D610	1.98	216.47	ZF7	2.46	197.64
		MPATE	2.06	191.46	M2FAV	3.8	208.53
		2FAV	2.27	265.28			
		ZF8	2.29	227.09			
	III	6MGSA	2.32	191.5			
		ERLAN	2.39	188.04			
		M2FAV	2.92	219.93			
		FLY	3.42	240.37			
		BCNO	3.49	214.29			
		AXTRD	3.7	212.82			
		S21	6.72	215.09			
	IV	ZF9	2.42	308.21	2CON	2.13	273.57
					6M	2.16	334.60
					DM30	2.41	343.01
					D05	2.51	341.55

Legend: Q, Quadrant; T.A., transformed angle; ZF5, attack ends in zone 5; LANZ, attack ends with shot; BCSI, attack ends in one of the zones adjacent to the observed team's substitution area; ZF6, attack ends in zone 6; 1FAV, observed team is ahead by one point; 1CON, observed team is trailing by one point; S30, 3:0 defensive system; ZF4, attack ends in zone 4; S2M1, 2 + 1 defensive system; MPATE, tie; 2FAV, observed team is ahead by two points; 2CON, observed team is trailing by two points, D610, between 6 and 10 s; ZF8, attack ends in zone 8; ZF7, attack ends in zone 7; M2FAV, observed team is more than two points; 6MGSA, goal scored by 6-m throw and suspension; ERLAN, missed shot; FLY, attack ends with in-flight shot; BCNO, attack ends in one of the zones adjacent to the opposing team's substitution area; AXTRD, assist by right wing; S21, 2:1 defensive system; ZF7, attack ends in zone 7; ZF9, attack ends in zone 9; 2CON, observed team is trailing by two points; 6M, attack ends with 6-m throw; DM30, more than 30 s; D05, between 0 and 5 s.

On the other hand, in relation to the specialist's completion in the male category, both the score for and against the central and right end zone and by a launch faced with a closed defensive system can be associated, as behaviors are inhibited related to open and pressing defenses; data that agree in part with those of the Morillo-Baro et al. (2015), since in that research the closed defensive system and the favorable score are also augmented. A result that could be due to the entrance of the specialist player in his most effective shooting area and, being the majority of the players that act in this position of right-handed players, to the natural tendency to play toward the players strong point, where he has more guarantees to shoot. Finally, when he decides to finalize he does it successfully, because shoot errors are inhibited and they are not linked to other possible negative completion options for the team, such as technical fouls or pass-reception errors, aspects that show his correct choice in the game of numerical superiority.

For the female category, the specialist's assist activates the completion by the extreme right in flight, in her usual area of action and before an open defensive system. This is a result that could be due to the fact that the majority of players who occupy the position of specialist are right-handed, and therefore they tend to play toward their strong point, from left to right. The open defensive systems chosen by the women's teams are based on the need to limit the specialist's actions, since their participation in decision making and completion is more decisive than in the male category (Morillo-Baro et al., 2015). It is worth mentioning that, although the error in shooting is also activated, it should not be interpreted as an erroneous decision of the specialist since, although the right end fails the shot, the attack always ends with the option to score. Reasoning that is reinforced with the inhibition of pass-reception error behavior and change of possession in quadrant III; the inhibition of these behaviors, related to the failure of the positional attack, could be associated with a correct decision making by the specialist. The results of this quadrant, like those of the fourth, also indicate that the specialist's assist is usually given once the first 10 s have passed.

Regarding the specialist's finalization, the fact that it occurs toward the left end zone stands out, toward her weak point if it is a right-handed player and faced with an open defensive system. And comparing the duration of the attack when she decides to finish instead of assisting, the players elaborate the attack less, developing it in less time. Contrary to the results shown by

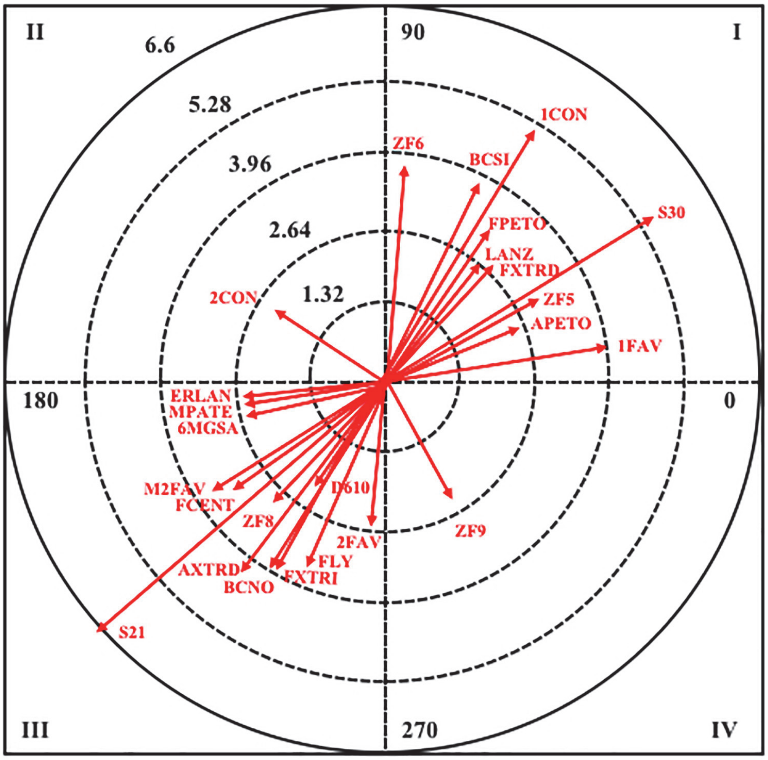

FIGURE 4 | Vector maps for focal behavior FPETO in male category.

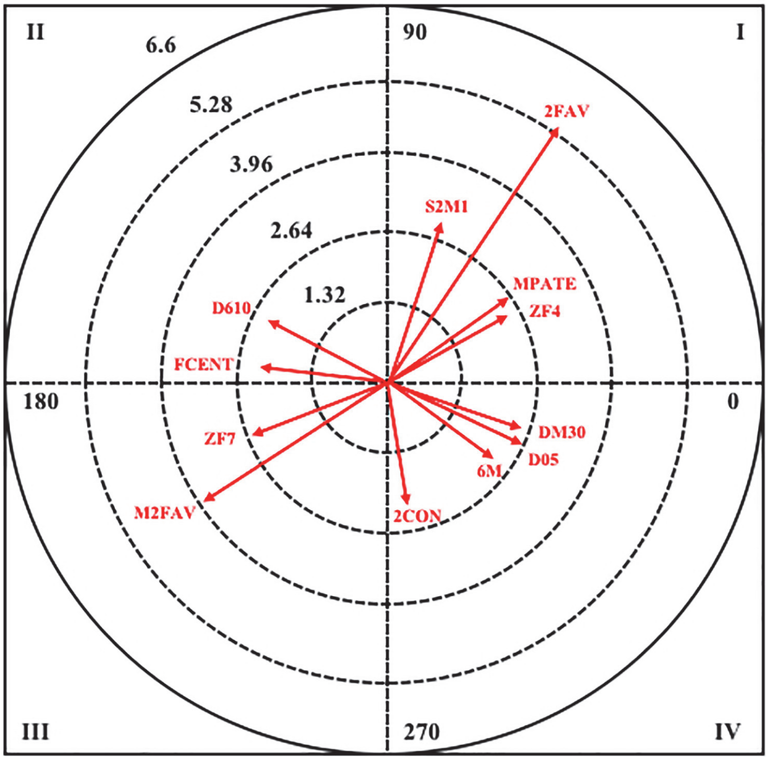

FIGURE 5 | Vector maps for focal behavior FPETO in female category.

Vázquez-Diz et al. (2019a) where a longer length of attack is related to behaviors of success.

Based on all these results, one might think that in the male category the decision of the specialist's decision-making when he assists is linked to an unfavorable score, while in the female category that decision making is independent of the score. On the other hand, when the specialist decides to finish it is interpreted as a correct decision making since it inhibits behaviors related to the failure, while, in the feminine category, there are no behaviors to link to the result of the completion, therefore, it can mean success or not in the decision making. It is also noteworthy that in the male category both the completion and assistance of the specialist is given defensive closed system, a logical issue that allows greater freedom of action on the part of this player, while in the female category despite having open defensive systems they do not decrease the actions of this player, data that reveals the importance of this role, more if possible, in this category. Finally, the specialist's assist is not related to the turn in the male category and in the female category it is related to the flight, this means that both categories use the flight as a main resource against the turn, data that do not agree with those obtained by Morillo-Baro et al. (2015) and Ostoić and Ohnjec (2015), where the turn proved to be the main resource to obtain double scoring goals in both categories.

There is hardly any published research on this modality, which suggests some caution to draw conclusions about the estimated data. One of the cautions is the limitation that means to interpret decision making by observing behaviors, being unaware of other cognitive variables that surely influence. Finally, it is also important to note that the sample was composed only by Spanish players; therefore, this study is focused solely on the development of the game of Spanish teams. All these results have shown the importance of the specific position of the specialist in the development of the attacks within the offensive systems of the teams, and the greater or lesser accuracy that they have when the decision making of this player is correct or not. The use of systematic observation to analyse specific actions and behaviors, in the framework of mixed methods, can provide complementary ideas on the complex process of decision making in sport (Araújo et al., 2016). This has been possible thanks to the use of polar coordinate analysis, a tool that has become very useful to detect the significant relationships of the criterion behaviors chosen with the different pairing behaviors that correspond to the different facets of the game. For all this, it would be of great interest to continue exploring this line of research on beach handball, creating new investigations with different focal behaviors to be able to establish the different patterns of the game in both categories.

AUTHOR CONTRIBUTIONS

AH-M, VM-S, and RR designed the study and acquired, analyzed, and interpreted the data. JM-B acquired, analyzed, and interpreted the data. JV-D acquired and analyzed the data. All authors drafted, revised, and approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

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Post-processing T-patterns Using External Tools From a Mixed Method Perspective

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Researchers of behavioral science often work with time-aligned annotation data based on video and/or audio recordings. Various platforms are available to process these data, offering various kinds and ways of data analysis. It often happens that one would wish to use one platform for a certain kind of analysis, and another platform for another kind. It may also happen that one would keep the results of the first analysis and continue processing the data using another platform—all as a chain of analyses on the way to discovery. When it comes to T-pattern analysis, the task of further analyzing already identified patterns across platforms requires a general framework within which virtually any kind of data can be processed in a cross platform environment: that of a database. Data (including patterns) from one platform are then imported into this database, where these patterns are further processed to uncover further properties, then the patterns can be exported to another platform, including the one the data originated from. This contribution aims at introducing a new methodology and a tool implemented as a web-based service for these purposes.

Keywords: theme, mixed methods, observation, annotation, post-analysis

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1. INTRODUCTION

Mixed methods research represents "a new movement, or discourse, or research paradigm (with a growing number of members) that has arisen in response to the currents of qualitative research and quantitative research" (Johnson et al., 2007, p. 113). Many researchers do not mix qualitative and quantitative approaches in optimal ways, according to Powell et al. (2008), but qualitative techniques can be used to enhance the development of quantitative instruments, as scales, and vice versa (Collins et al., 2007). Their potential is very broad, and includes instrument fidelity, "maximizing the appropriateness and/or utility of the instruments used, whether quantitative or qualitative" (Onwuegbuzie et al., 2010, p. 57).

The aim of our work goes in this direction and focuses on some concrete methodological issues which are related to post-processing techniques of hidden patterns detected in time-aligned data. The development is motivated by the research questions of the HuComTech project (Hunyadi et al., 2016a,b) to explore the temporal structure of multimodal communication based on an annotated spontaneous speech corpus. For *T-pattern* detection (Magnusson, 2000), we used the *Theme 6 Full* (Pattern Vision, 2018) program. Although it has several excellent functions for post-analyzing the resulting hidden patterns of behavior (e.g., visualizing pattern structures, filtering results by event types and quantitative attributes, separating markers, predictors etc.), it cannot be really required to satisfy all the needs of every custom research. If any special demands arise which cannot be handle within the tool, one can achieve other ways of processing by using the built-in option of data extraction. After this first step, we have to face with another problem. The conversion of behavioral data (as the input of detection) is supported by ELAN (Wittenburg et al., 2006), but there is no available tool for importing the resulting T-patterns back into ELAN or other annotation tools in which the data was originally created, or into any other framework supporting further analysis. However, it would be beneficial to see the patterns as "part of the data" aligned with the source media (audio and video files) and explore their uncovered properties and interrelations. Another issue arises if we need to apply T-pattern analysis separately on different sources of behavioral data (without creating "multisample files" in *Theme*) but we are also interested in the common patterns that originated from different sources. These common patterns cannot be easily identified, because in *Theme*, the *uniqueness* of T-patterns is determined within one single source of data (where they were detected), and it can result in multiple instances of the very same pattern type.

The current methodological contribution aims to demonstrate a practical solution for the above mentioned issues, using PHP, Javascript and MySQL (Widenius and Axmark, 2002) as development tools for implementation. The outcome is a web-based interface which we developed for re-organizing the outputs of T-pattern detection in a relational database where their management is much more effective and transparent, and they can also be exported into ELAN or other tools for further analysis. Similarly to the *Subjectbook* project (Taamneh et al., 2016), it is a crossplatform interface for exploring and analyzing behavioral data, and in the narrower context of our particular field of interest, it can be considered as a supplementary component of the *Data Exchange Platfrom* (Pattern Vision, 2019). *Theme* users already have a software and an exchange annotation format (Schmidt et al., 2009) to import behavioral data for T-pattern detection from various data collection tools, and now, we would like to facilitate access to data in the opposite way: import back the resulting T-patterns for post-analysis.

In the next section 2, we introduce some sample data (exported from *Theme* projects) which we used for development purposes. Then in section 3, the main issues of data analysis are discussed. It is followed by sections 4, 5, where we introduce the details of our methodology and the results of development using explanatory examples.

2. RESEARCH MATERIAL

Two sample resources were used for development purposes. Both of them were collection of T-patterns exported from *Theme* projects based on the data of the HuComTech corpus[1]. All annotations were available in EAF and Praat TextGrid (Boersma and Weenink, 2019) format and they were converted to *Theme* using a custom Praat script. Since our contribution aims at demonstrating a special methodology of data processing without going into details about the output itself, we only mention the relevant characteristics of the development data.

[1]"HuComTech Corpus" from The Language Archive: https://tla.nytud.hu/MTARIL/01-0003-0000-0000-0000-1@view

The HuComTech multimodal corpus contains ∼50 h of behavioral data based on annotated audio and video recordings of spontaneous dialogues. The interactions were performed by Hungarian native speakers (between the age of 18 and 30) using two types of interview scenarios for every participant (111 in total): a simulated job interview and a subsequent informal conversation. Beyond the transcribed speech, the annotation of the corpus follows various perspectives and modalities including time-aligned labels for nonverbal gestures, expressed emotions, speech acts, prosody and syntax. However, in the actual experiments, we limited the set of labels (*event-types* in *Theme*'s terminology) to some specific ones (see details in the subsections below). The imported samples are also reduced to one formal and one informal interview from 2 different speakers (4 datafiles in total). For making the detection even faster and the amount of resulting patterns more manageable, we also exlude *univariate patterns* and set the *maximum search level* to 3 with an extremely rigorous significance level ($p < 0.000005$) to estimate the probability that the patterns discovered were not the result of chance.

2.1. Experiment 1: Structure of Turn-Taking

In the first experiment, the input of T-pattern detection was limited to the labels of *turn-taking* in the formal and informal conversation. Following a basic principle of segmentation, we only have four types of events: (1) speech of the interviewer, (2) speech of the interviewee, (3) silence, (4) overlapping speech. They were represented as four *actors* (*agent*, *speaker*, *overlap*, *silences*) with one possible corresponding event (*speech* for the first three and *silence* for *silences*) in the VVT file (the special template format of *Theme* used for declaring the type of data to be imported). Since the events of input sequences were extracted from time intervals of the original annotations, they were also extended with (*b*)*egin* and (*e*)*nd* specifications (for instance, "b, agent, speech" means that the interviewer starts speaking and "e, agent, speech" means that the interviewer ends speaking). Despite the applied constraints (maximum search and significance level), the T-pattern detection resulted in 6,516 patterns (including redundant ones) with 115,683 occurrences in the 4 datafiles.

2.2. Experiment 2: Topic Shift and Prosody

In the second experiment, prosodic labels (namely, silences and intonation shapes of speech) and topic shifts (the beginning of those speech acts where the interviewer asks a new pre-planned question) were imported into *Theme*. Topic shifts are represented as topic boundaries under the category name of *topics* (e.g.,: "b, topics, topic" means that a new topic has started). For silences, the same representation was used as in the previous experiment. Segments of *intonational events* (the term was adapted from Taylor, 2000) were generated by a rule-based algorithm (Szekrényes, 2015) which was developed for automatic annotation of stylized shapes of intonation. This labeling method was applied to the speech of every related actor (*agentf0mov*, *speakerf0mov*, *overlapf0mov* - overlapping speech was considered as a "third speaker" here) using five possible categories: *rise*, *fall*, *level*, *ascending* and *descending*.

The T-pattern detection resulted in 22,092 patterns with 229,019 occurrences in the 4 datafiles.

3. ACTUAL ISSUES OF DATA ANALYSIS

In this section, two issues of data analysis are discussed as the motivation of the current methodological contribution:

1. In a Theme project, we cannot easily find out which patterns are detected in more than one datafile, because their uniqueness is interpreted locally (within one datafile) and not globally (within the whole project). However, it is very likely that some of the patterns are shared among individual files as different instances of the same pattern type.
2. Beyond spreadsheet and simple text processing programs, there is no available tool for post-processing the exported T-patterns in an effective way. However, it would be beneficial to have a cross-platform framework to manage the output data supporting conversion to other tools including those ones where the input data was originally created.

3.1. T-patterns From Various Sources of Data

The first issue we mention here is particularly important in case of *Theme* projects with a number of various and categorizable sources of data. For instance, in the HuComTech corpus, the recorded conversations can be separated by both speakers and the type of the interview scenario (formal and informal). Technically, they are *independent variables* and the related samples may contain various temporal patterns. The question is how to find the "common" T-patterns that are detected in more than one source of data given that they are interesting from any perspective.

If one uses a so-called *multisample file* option available in *Theme* by merging data from various sources based on one of the independent variables (e.g., every informal conversation of the HuComTech corpus), the resulting patterns will show us what types of patterns are repeated if we considered individual sources of data as subsequent parts of the global timeline of observation. Although it is a very interesting and adequate research question, it must be taken into account that T-pattern detection can collect such patterns in a multisample file, which were not originally

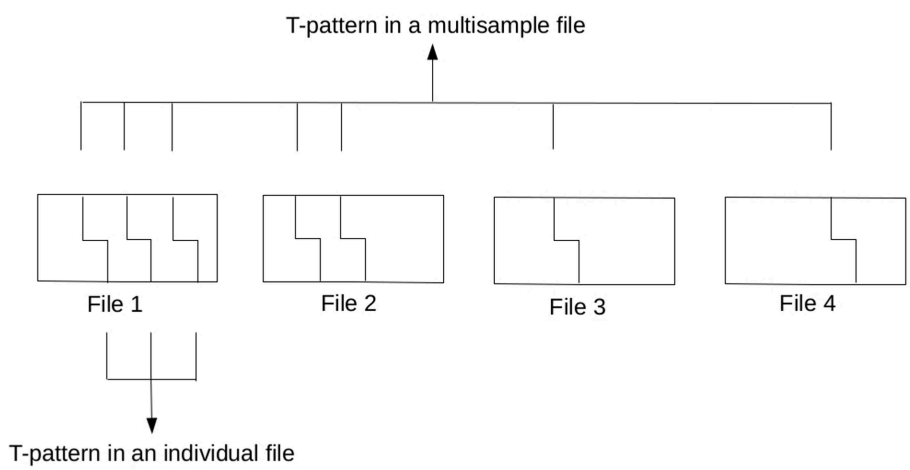


FIGURE 1 | Difference between detecting a T-pattern in an individual and a multisample file (the *minimum occurrence* parameter was set to 3 in this example).

TABLE 1 | Identification of patterns using *dataname* and *id* attributes in *patstring.txt*.

Dataname	Id	N	Length	Level	N_actors	N_switches	Patstring
f006mc22f	58	21	2	1	1	0	(b,agentf0mov,level e,agentf0mov,rise)
f006mc22f	59	9	2	1	1	0	(b,agentf0mov,rise b,agentf0mov,descending)
f006mc22f	60	46	3	2	1	0	(b,agentf0mov,rise (e,agentf0mov,rise b,agentf0mov,fall))
f006mc22f	61	13	3	2	1	0	(b,agentf0mov,rise (b,agentf0mov,level e,agentf0mov,rise))
f006mc22f	62	8	2	1	1	0	(b,agentf0mov,rise e,agentf0mov,descending)
f015mv26f	58	26	3	2	1	0	(b,agentf0mov,rise (e,agentf0mov,rise b,agentf0mov,fall))
f015mv26f	59	4	2	1	1	0	(b,agentf0mov,rise e,agentf0mov,ascending)
f015mv26f	60	4	2	1	1	0	(b,agentf0mov,rise e,agentf0mov,descending)
f015mv26f	61	29	2	1	1	0	(b,agentf0mov,rise e,agentf0mov,fall)
f015mv26f	62	7	2	1	1	0	(b,agentf0mov,rise e,agentf0mov,level)

The samples are from Experiment 2.

repeated (and would not have been detected) in some of the individual datafiles (as can be seen in **Figure 1**) or it is also possible that some of the resulting T-patterns would not have been detected in any file. Of course, it is not necessary an issue, moreover, this is the main benefit of using the method. However, in certain cases, we would like to reword the question exactly interested in those types of *common* patterns which are similarly repeated in multiple sequences and/or different types of data. For

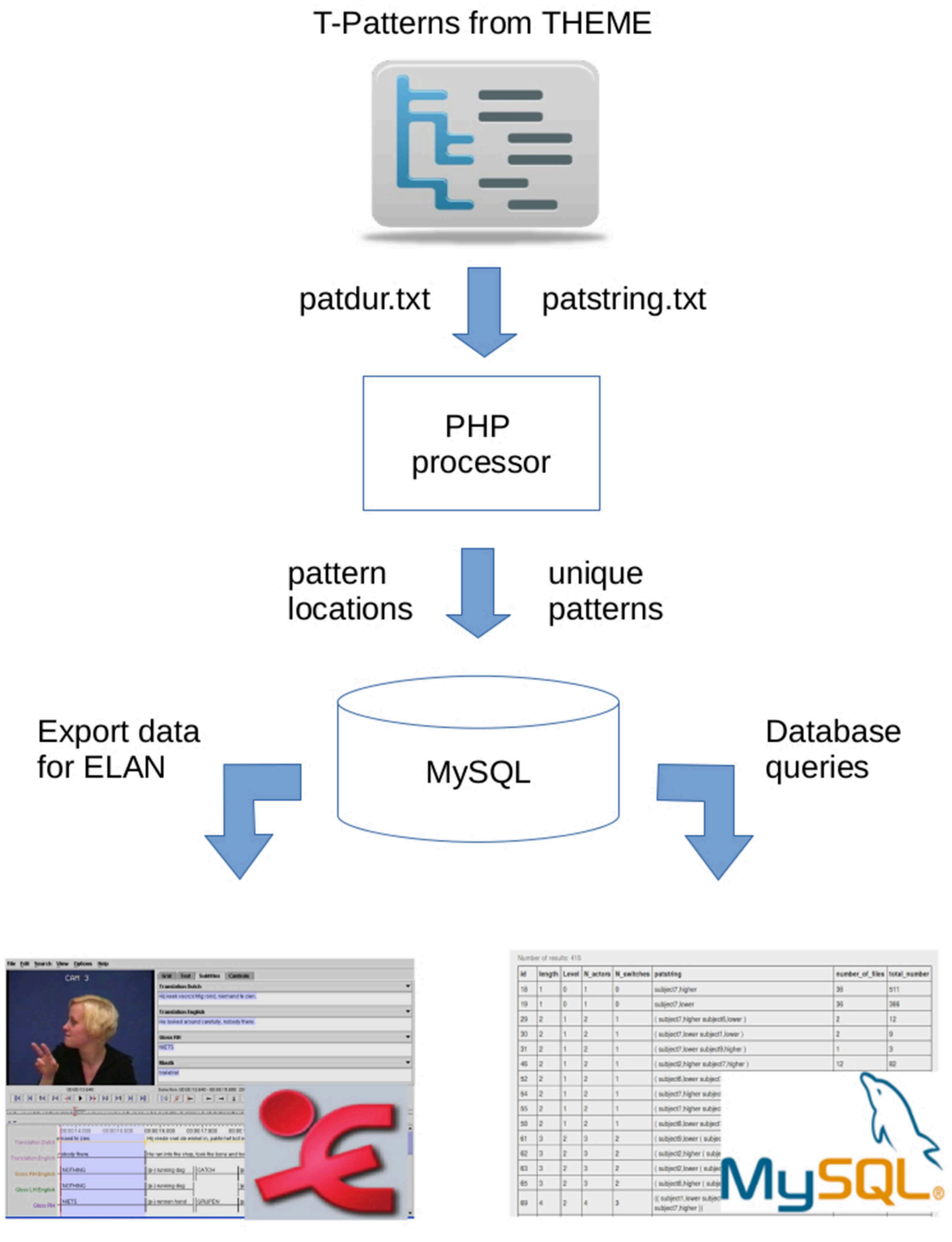


FIGURE 2 | The overview of data flow and the main components of the interface.

instance, we would like to know about those patterns which can be found in both the formal and the informal conversations of HuComTech corpus. Actually, the same type of information is required if we are interested in the individual characteristics of a certain dataset (based on a given independent variable) focusing on those patterns which *cannot be found* in other sources of data.

If one exports T-patterns from a *Theme* project consisting several datafiles (they can also be multisample files), the *uniqueness* of patterns must be interpreted *locally*, i.e., they are unique within the file where they were found. If the same pattern (having the same structure of event types described by the corresponding *patstring* attribute) occurs in more than one datafile, the different instances (cases of detection) are represented as different patterns. As can be seen in the exported *patstring.txt* file (see **Table 1**), every pattern is identified by two kinds of attributes: the source of data (*dataname*) and an identifier (*id*). The last one is not unique for the whole project, but it distinguishes patterns only within the particular source of data. Therefore a specific pattern structure is functionally dependent on both the *dataname* and the *id* attributes in the logical model of this data collection. Our goal is to replace this logic with a *global scope* of T-pattern identification where "uniqueness" is interpreted *globally* (for the whole project) ignoring multiple cases of detection by referring to a list of abstract event-structures wherever any of them was detected.

3.2. Post-processing of T-patterns

To implement the above mentioned way of data representation, we need a post-processing method and an external database where the exported data can be imported and re-organized using a suitable logical model, then custom database queries can be constructed to uncover further properties (e.g., the number of datafiles where the pattern was detected) and interrelations of the resulting T-patterns and their physical locations. The framework also has to support further exportation of data into existing annotation tools where the input of T-pattern detection was originally created. We used ELAN and Praat for video and audio annotation. These tools are very popular, widespread, free and open source software, moreover, we can export data into several other tools from ELAN, therefore it seemed to be the most ideal destination for data export. If one uses time-aligned labels associated with media files as an input to T-pattern detection (and this is a very common case in behavioral science), there are reasonable advantages to associate the resulting patterns as well.

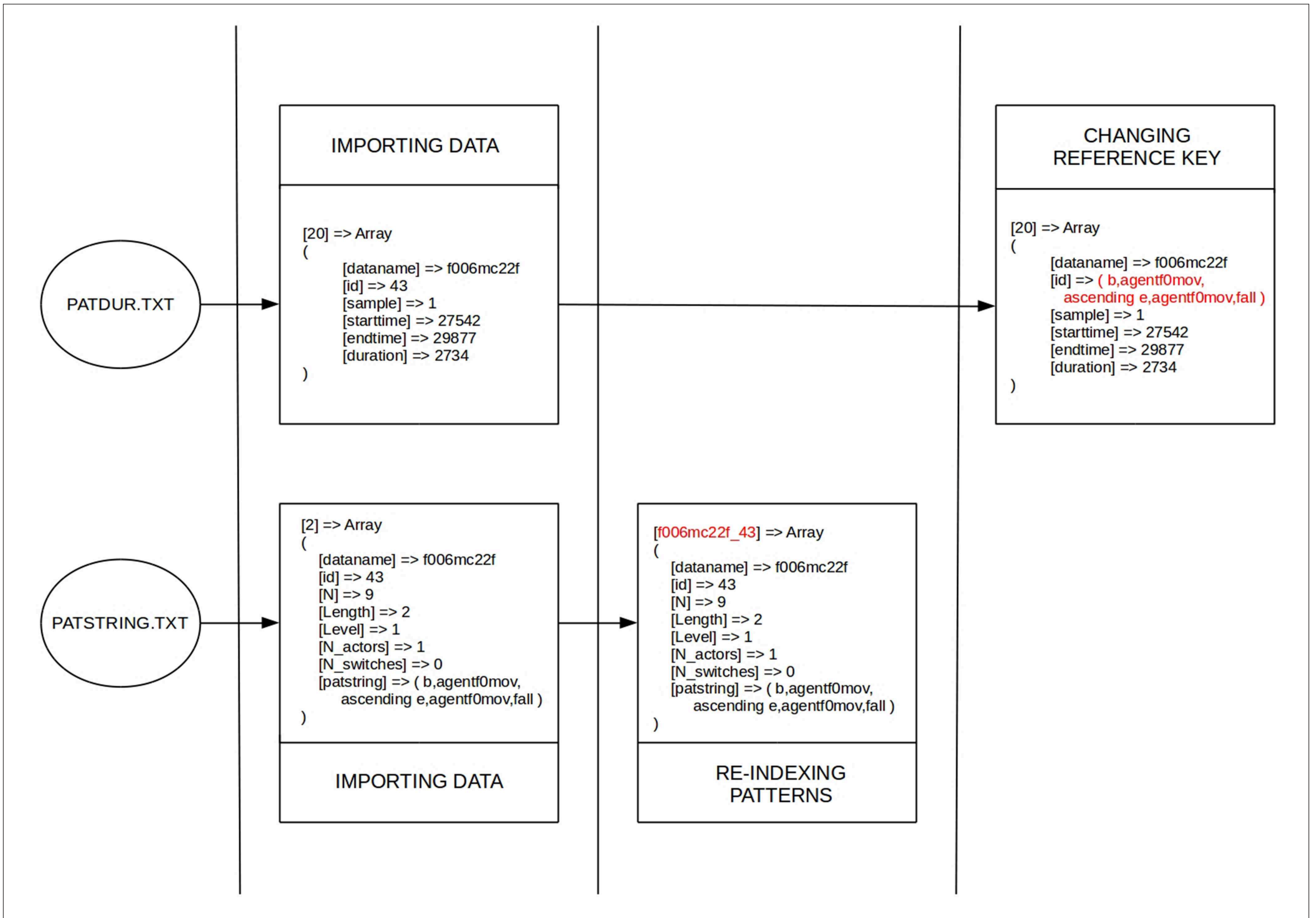


FIGURE 3 | First steps of data processing: working with multidimensional arrays.

Having T-patterns aligned with annotated media significantly expands the possibilities of post-analysis by exploring pattern locations using speech or image processing algorithms for media, structured queries in annotations and even qualitative methods to interpret and gain a deeper understanding of the specific context of repeated event-structures. In these types of post-analysis, we can also include such kinds of data which were previously ignored from T-pattern detection (e.g., the textual transcriptions in case of the HuComTech corpus). After the exportation of a *Theme* project, all the necessary information is available (the structure of resulting T-patterns with their locations), we only have to process and represent the exported data in an appropriate way.

4. METHODOLOGY

Since we wanted to implement a platform independent solution for handling the above mentioned issues, a web-based interface was developed where the exported *Theme* projects can be uploaded and managed using a simple web browser. For the development, standard and open source W3C tools and technologies were used such as CSS bootstrap, PHP, MySQL (community version), Javascript, Ajax (Zakas et al., 2006; Zhang et al., 2008; Dong et al., 2011). **Figure 2** shows the main components of the processing chain starting with a *PHP processor* which is to convert and import data into a *MySQL database*. In the subsections below, we describe the complete flow of data processing in details.

4.1. Converting, Re-indexing and Filtering Unique T-patterns

The exportation of a *Theme* project results in two plain text files using tab-separated table format. The first table (*patstring.txt*) contains special attributes of T-patterns: the source of detection (*dataname*), a "unique" index of pattern (*id*), the number of occurrences in the source of detection (*N*), the number of events the pattern contains (*Length*), the search level where the pattern is detected (*Level*), the number of event categories associated with the pattern (N_{actors}), the frequency this category subsequently changes in the pattern ($N_{switches}$), and finally, the complete string of events the pattern consists of (*patstring*). The other exported table (*patdur.txt*) lists the exact locations (source of data and temporal properties: *starttime*, *endtime* and *duration*) of every T-pattern referring to both the *dataname* and the *id* attributes (used as *complex keys* in the first table) to link a specific location to a particular pattern.

After uploading the input data to our interface, a PHP script processes these tables and converts the data into two

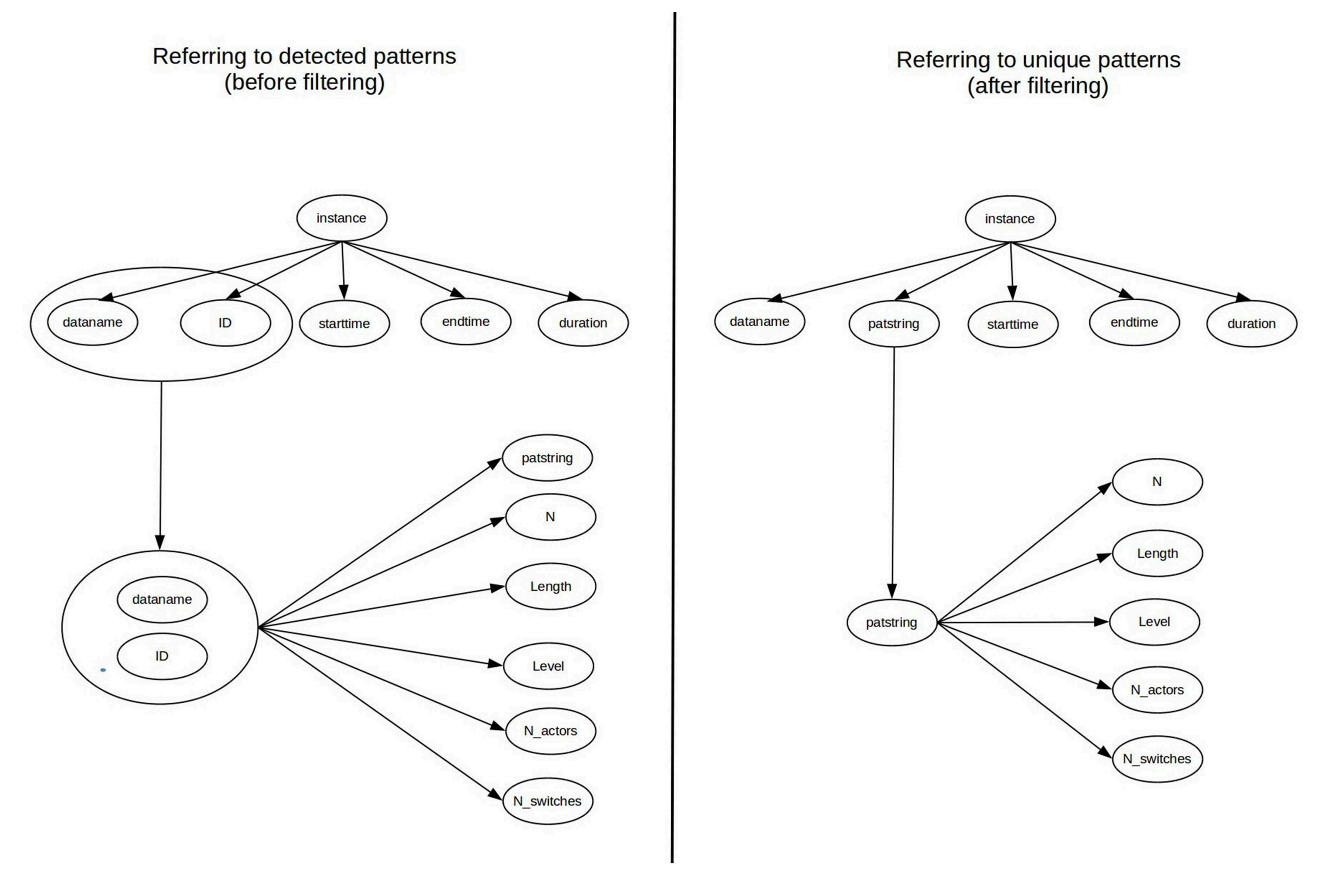


FIGURE 4 | Data dependency graph of the exported data before and after filtering T-patterns.

multidimensional arrays (one for T-patterns from *patstr.stx* and another one for their locations from *patdur.txt*) using column names for indexing the attributes of array elements. As can be see in **Figure 3**, each element of array of T-patterns are re-indexed in the next step using the combination of its key attributes (*dataname* and *id*) instead of the original numeric indexes. It makes the connection between T-patterns and their locations more transparent for processing algorithms. Based on the new indexes, we can easily associate pattern locations with the corresponding T-pattern, therefore the value of the *id* attribute

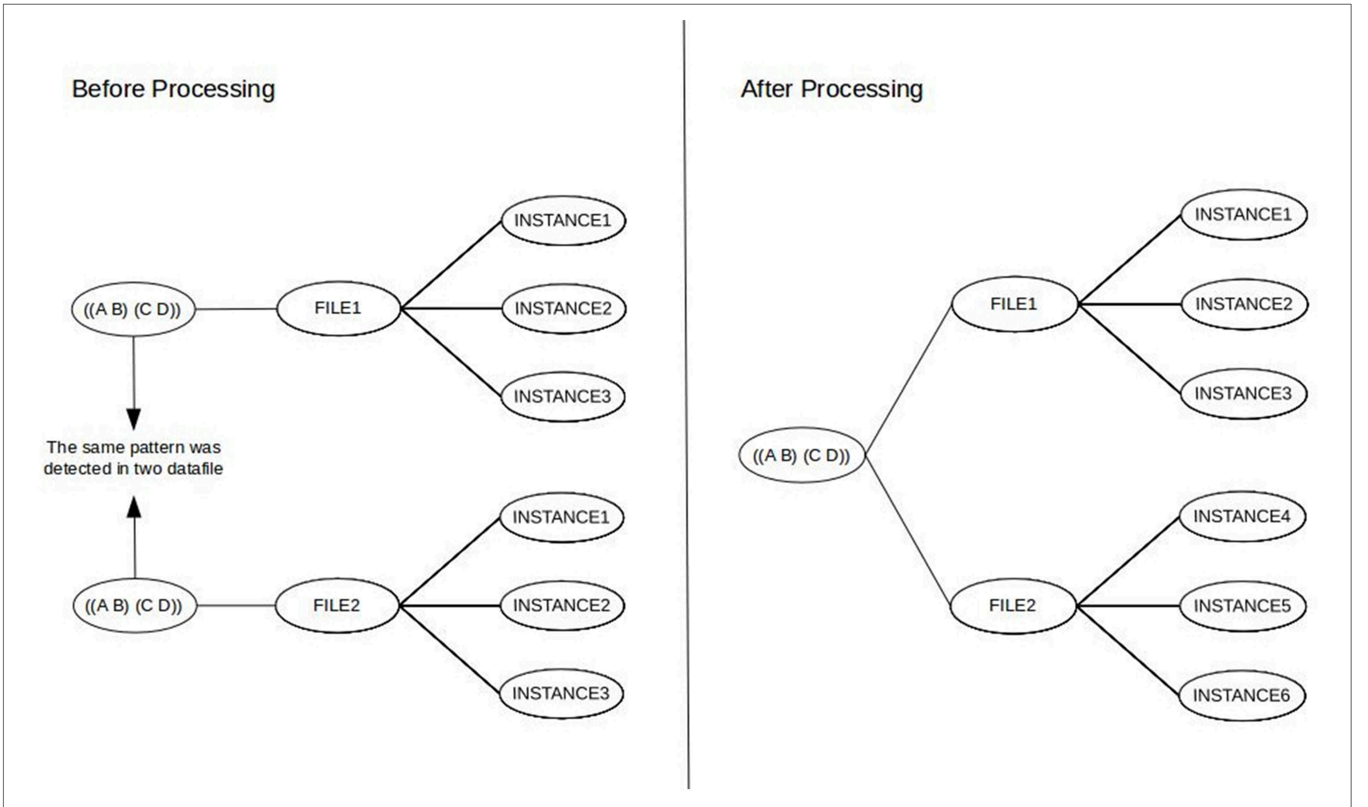


FIGURE 5 | The original **(Left)** and the resulting global scope **(Right)** of T-pattern identification.

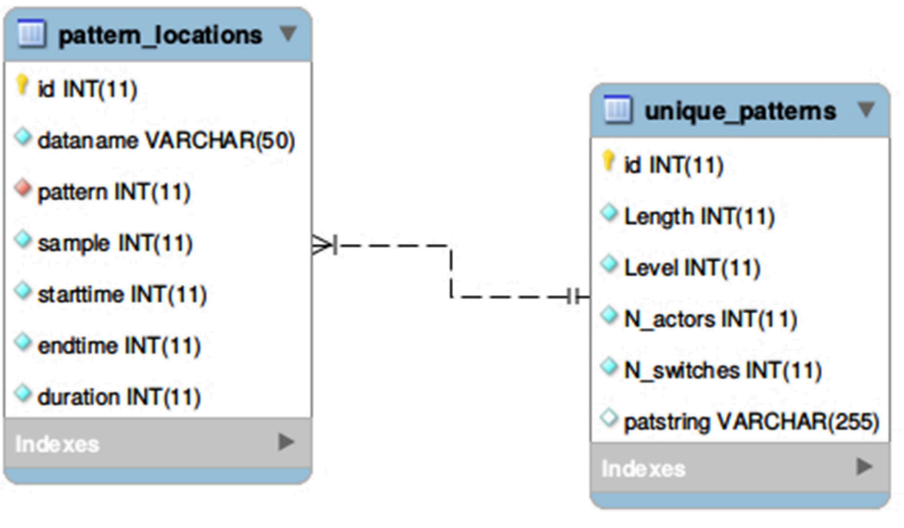


FIGURE 6 | Representing the result of T-pattern detection in a relational database.

in the array of pattern locations can be replaced with the value of *patstring* attribute of the referenced pattern. It is needed before we eliminate redundancy in the array of T-patters (in the next step) by filtering elements based on the uniqueness of the *patsrting* attribute. After the filtering, *id* and *dataname* attributes are not further needed for the T-patterns and they cannot be used as reference key in pattern locations either, since there is a chance that the corresponding array element does not exists any more. As can be seen in **Figure 4**, every pattern instance (with the data of an exact location) refers to a unique pattern using the *patstring* attribute at this stage of processing.

As can be seen in **Figure 5**, the issue of multiple pattern instances (the first issue in section 3) is already solved by the above data normalization as a result of the global scope of T-pattern identification. However, we also need to implement this logical model as a real database.

4.2. Creating the Relational Database

For creating the database, we applied a standard relational data model (Codd, 1990) supported by the SQL Data Definition Language and the MySQL program. Even though, there are other open source platforms also available to implement a similar database, we choose our logical model as a typical example for $1:n$ type relation of entities (between patterns and their locations) to be best represented in a relational schema. Following other, NoSQL paradigms (Pokorny, 2011), such as the document-oriented concept of *MongoDb* would not have been really well-founded four our purposes. Therefore after having the final state of the two multidimensional arrays, all data are inserted into a MySQL database using two relational tables for *Theme* projects preserving every attributes of the entities. As can be seen in **Figure 6**, the *unique-patterns* table contains the result of filtering (the unique T-patterns detected in the project), while the *pattern-locations* table provides information about their physical instances occurring in one or more datafiles.

The *id* attribute has an auto increment *integer* value in both of the tables. They are generated during insertion and used as *primary key* for database records. The *pattern* attribute of the *pattern-locations* table is a *foreign key* which refers to the primary key of unique patterns. During inserting data into *pattern-locations*, we used an embedded query to find the corresponding index that can be used as *foreign key* instead of the value of *patstring* attribute which would cause redundancy. In case of huge amounts of T-patterns, importing a new project is a quite long procedure, but it is managed by a background PHP process on the server (logging progression into a JSON file), therefore the user can perform other operations on the site in parallel (e.g., run queries in other projects) and they can also check the actual state of importation in their browser. In the resulting database, one can store and query the data using various ways and communication protocols (PHP, node.js, Python etc.). In our framework, we use the database to explore *Theme* projects via SQL queries and as an intermediate storage for exporting the data to other platforms as a solution for the second issue we mentioned in section 3.

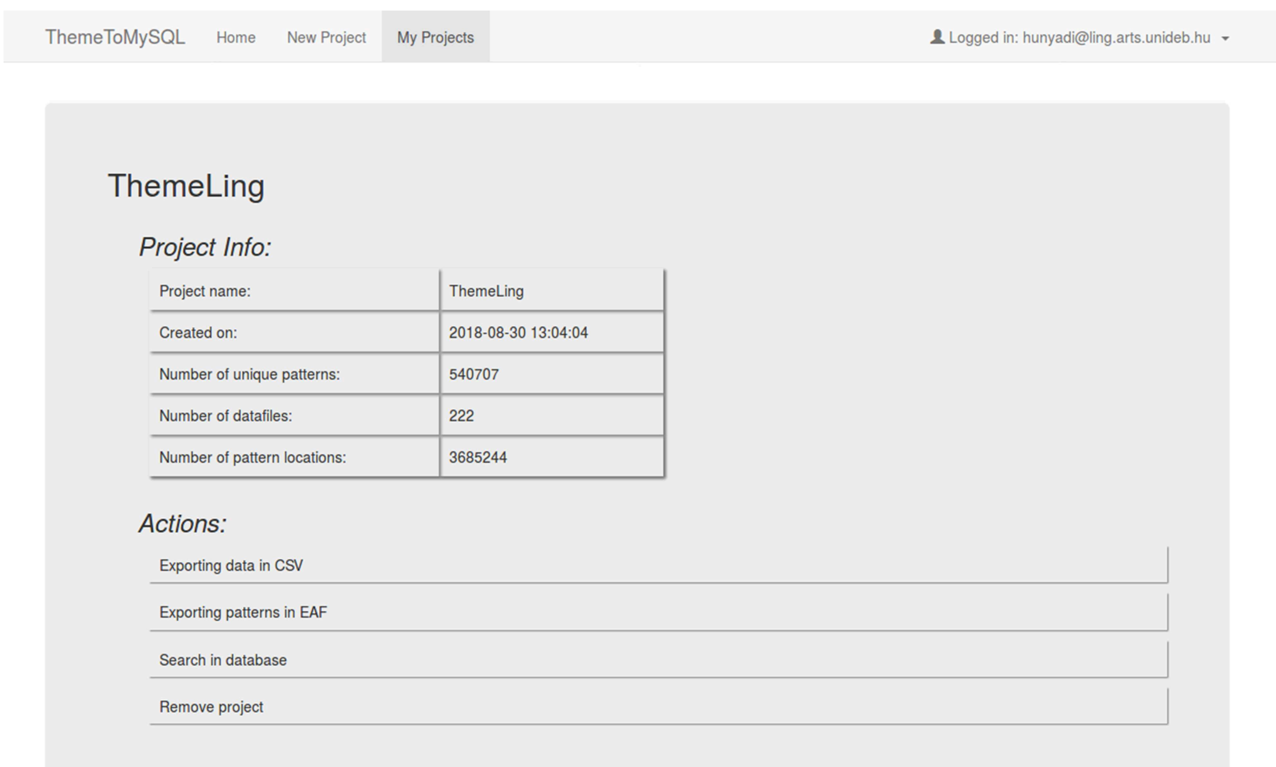
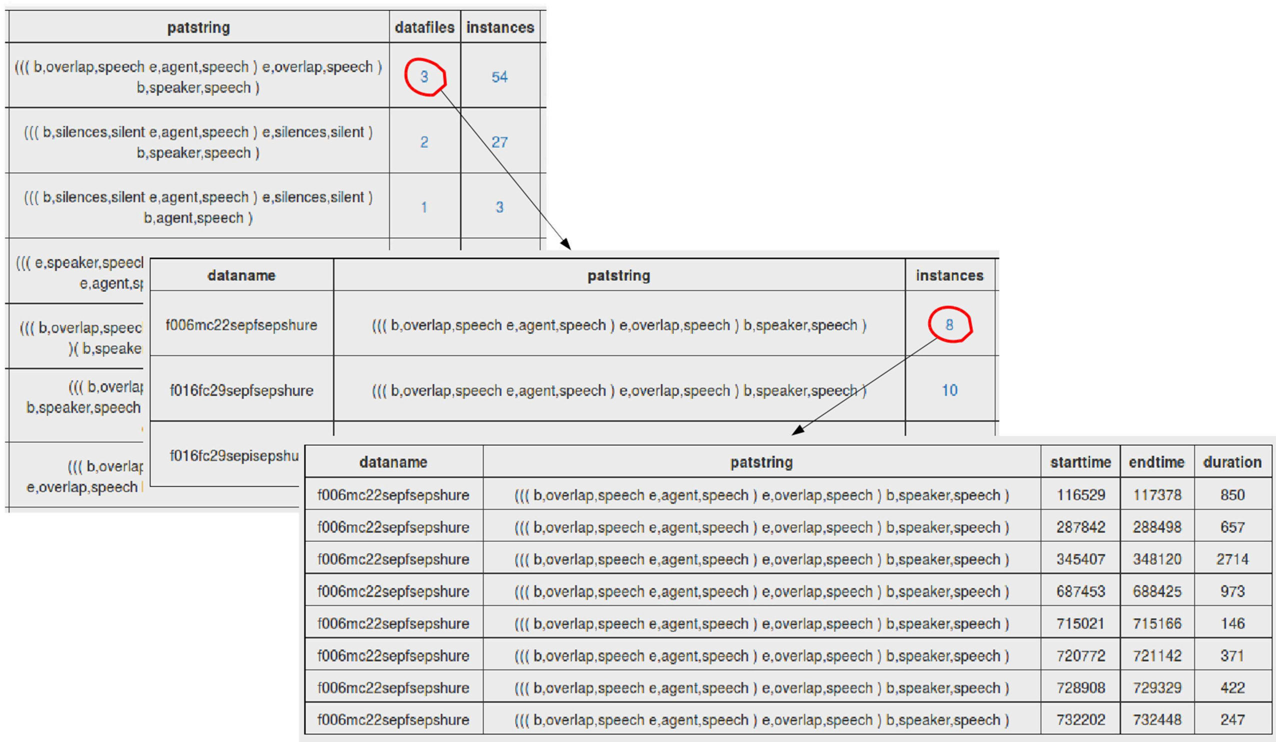


FIGURE 7 | Overview of an imported *Theme* project: general statistics and management possibilities.



patstring	datafiles	instances
(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	3	54
(((b,silences,silent e,agent,speech) e,silences,silent) b,speaker,speech)	2	27
(((b,silences,silent e,agent,speech) e,silences,silent) b,agent,speech)	1	3

dataname	patstring	instances
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	8
f016fc29sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	10

dataname	patstring	starttime	endtime	duration
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	116529	117378	850
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	287842	288498	657
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	345407	348120	2714
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	687453	688425	973
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	715021	715166	146
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	720772	721142	371
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	728908	729329	422
f006mc22sepfsepshure	(((b,overlap,speech e,agent,speech) e,overlap,speech) b,speaker,speech)	732202	732448	247

FIGURE 8 | Sequence of database queries: based on the resulting table of T-patterns, one can check the datafiles for a particular pattern, then the exact locations (timing properties) inside that file.

4.3. Exploring Imported Projects

Once the project is imported to a MySQL database, it can be easily managed with a simple menu-system (see **Figure 7**). In addition to dump export of processed data (EAF and CSV format are supported currently), one can also explore the imported project within the interface by composing SQL queries on an HTML form. Users can add various conditions to the query and filter the resulting table by any attributes of the given T-patterns.

Unique T-patterns can be queried using various filters. In the resulting table, besides the usual attributes of patterns (N_{actors}, $N_{switches}$ etc.) one can check how many physical instances a specific T-pattern has and in how many datafiles. As can be seen in **Figure 8**, these datafiles and the exact locations can also be queried by clicking on the respective number in the selected record.

4.4. Exporting T-patterns Into EAF

Since EAF (the acronym means *ELAN Annotation File*) is an XML-based annotation format, the exportation method itself is quite simple: the required data (containing the structure of the selected T-patterns and the exact locations of their instances) is queried from MySQL, then a PHP script generates the XML file using the DOM Document parser. In the resulting EAF files every T-pattern is represented as a unique *annotation tier* where the annotation labels contains the pattern structure in textual format using brackets to express the hierarchy of events.

As can be seen in **Figure 9**, ELAN displays these annotation tiers as parallel timelines aligned with the media file (the original source of observation) where we can locate the occurrences of T-patterns as intervals of time. We can also merge the output with the original annotation files (ELAN has a built-in function for that) that makes the post-analysis more efficient, since we have the whole context including those annotated events (or textual transcriptions of speech) which are not part of the pattern but co-occur with it. Unfortunately, a dump export of the internal temporal structure of T-patterns (the times of events that the pattern contains) is not supported by the current version of *Theme* and neither ELAN supports labels without any duration. However, Praat could display them in a special annotation tier (it is called "PointTier" in Praat), and one of our future plans is to create an alternate XML structure, as soon as the exportation is solved from *Theme*.

5. RESULTS AND AVAILABILITY

The results of this development were already presented during the 10th meeting of MASI (Research Network on Methodology for the Analysis of Social Interaction, University of La Laguna, Tenerife, Spain, September 13-15, 2018.), but in the meantime, we made a demo interface available[2] for the

[2] https://altnyelv.unideb.hu/ThemeToMySQL/login.php

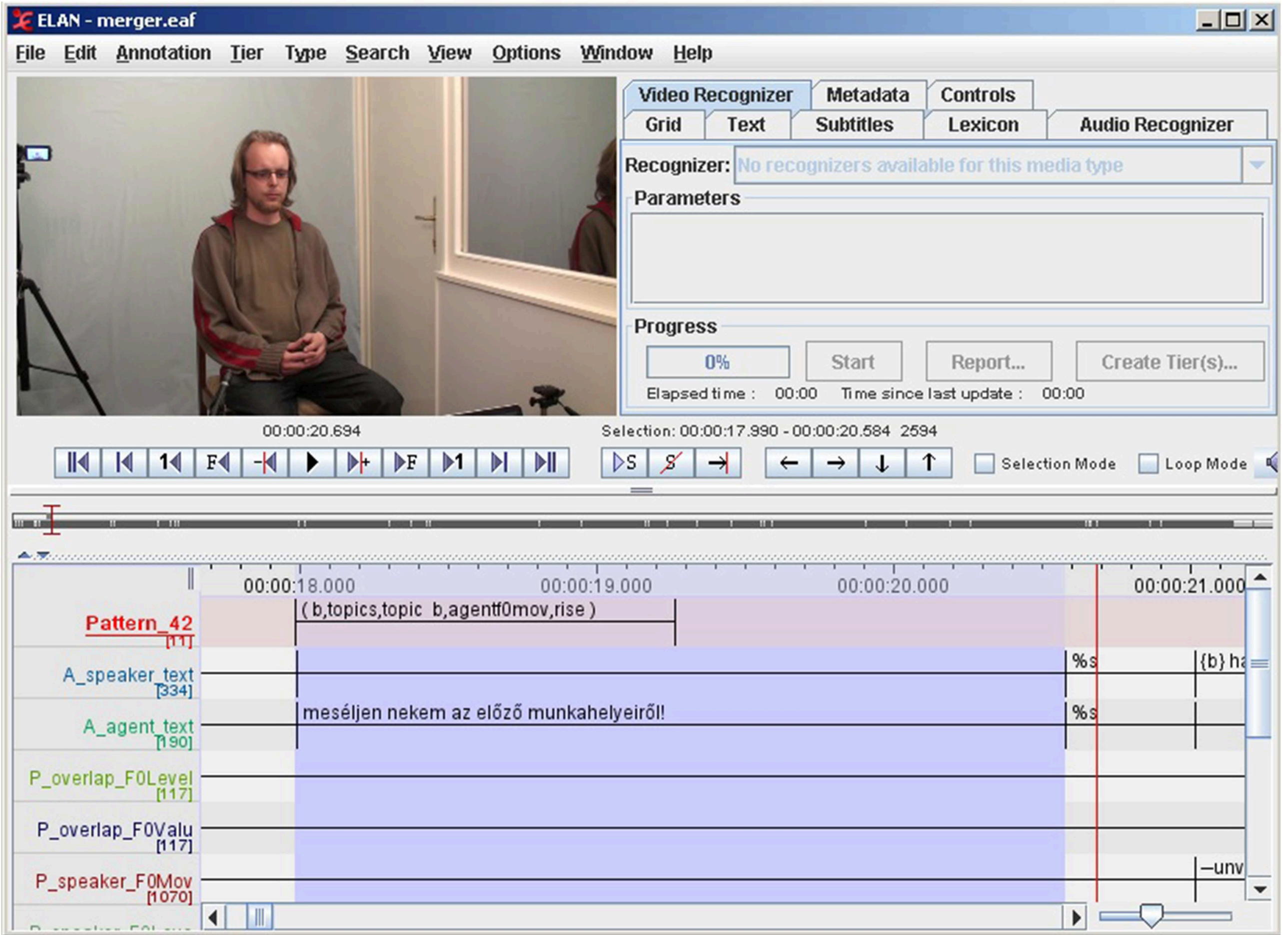


FIGURE 9 | Representing T-patterns in ELAN. In this example, the exported EAF was previously merged with the original annotation file. The first annotation tier displays the instances of $Pattern_{42}$.

TABLE 2 | Resulting table of the first query containing T-patterns (only the relevant attributes are preserved here).

Patstring	Datafiles	Instances
((e,agent,speech (b,speaker,speech e,speaker,speech)) b,overlap,speech)	4	102
(e,overlap,speech ((b,speaker,speech e,speaker,speech) b,agent,speech))	4	98
((e,speaker,speech (b,agent,speech e,agent,speech)) b,overlap,speech)	3	98
(e,agent,speech ((b,speaker,speech e,speaker,speech) b,overlap,speech))	4	93
((e,overlap,speech (b,speaker,speech e,speaker,speech)) b,agent,speech)	4	90
((e,overlap,speech (b,agent,speech e,agent,speech)) b,speaker,speech)	4	89
((b,agent,speech e,agent,speech) (b,overlap,speech (b,speaker,speech e,overlap,speech)))	4	87

community of *Theme* users. The project is published under the name *ThemeToMySQL* referring to that component of the interface where projects are imported. Alternatively, it could be called "ThemeToELAN" as well, since we made the conversion bidirectional between ELAN and *Theme*. In any case, the central part of what we are offering now is the database which can serve as the basis for any further kind of exportation.

Because of the limited computer capacity (we currently have 2 CPU cores and 16 Gbyte RAM available on the server), the demo interface also has some limitation on the allowed number of importable projects and the size of data files. But if the user would like to install a custom version using their own resources, the source code can be freely downloaded from a GitHub repository[3].

[3]https://github.com/szekrenyesi/ThemeToMySQL

TABLE 3 | Resulting table of the second query showing the distribution of the pattern's locations.

Dataname	Type	Instances
006mc22sepf	Formal	8
f006mc22sepi	Informal	38
f016fc29sepf	Formal	6
f016fc29sepi	Informal	35

The interface was tested with several *Theme* projects including a very complex one in which the T-patter detection resulted in 967,447 patterns with 3,685,245 occurrences based on 20 datafiles from the HuComTech corpus, but here, we only report some results from the two experiments described in section 2. It has to be emphasized that these results are based on a very small amount of data. As explanatory examples, they only serve demonstration purposes.

5.1. Experiment 1: Structure of Turn-Taking

In a former research (Szekrényes and Kovács, 2017), we trained Deep Neural Networks to distinguish the type of interview (formal or informal) based on similar sequences of turn-taking resulting in surprisingly high accuracy (81.5%) of automatic classification. Therefore it seemed very interesting to test whether we can evince some differences between the two interview types based on the results of T-pattern detection.

After processing the project on the interface, the total number of unique T-patterns was reduced to 4,952. Since overlapping speech can be a possible distinctive feature between formal and informal interviews, let us query the most frequent T-patterns which contain at least 3 actors including *overlap*. The results can be seen in **Table 2**.

The last record appears to be interesting, since this pattern structure expresses a kind of impolite way of turn taking (the speaker takes turn by using overlapping speech). However, we have to be careful with this interpretation, because we cannot surely know if these events (agent, overlap, speaker) are subsequent ones (unless we check the patterns in ELAN). Finally, we can also query the distribution of this pattern in formal and informal interviews. As can be seen in **Table 3**, this particular pattern is much more frequent in the informal ones.

5.2. Experiment 2: Topic Shift and Prosody

In case of this experiment (containing 20,741 unique patterns), those T-patterns could be interesting where both topic shifts and prosodic events are presented in the pattern's structure expressing possible prosodic markers of topic change. Therefore we should concentrate on T-patterns which contain *topic shift* event with another actor occurring across all the datafiles. Unfortunatelly, there is no such a pattern in our dataset. However, if we set the "minimum number of datafiles" threshold lower, the resulting table contains a pattern "$(b, topics, topicb, agentf0mov, rise)$" which occurs in all the formal interviews but none of the informal ones.

6. SUMMARY

Here, we introduced a new methodology for post-processing T-patterns exported from the *Theme* program. The project has two important outcomes highlighted here:

1. Using a relational database model, the interrelations of T-patterns and the input source of data became more transparent and manageable,
2. In support to mixed method research, our interface makes T-pattern analysis more flexible and externalized by offering tools where the patterns can be associated with the source media and the original context of behavioral data.

The method was implemented as a web-based interface which is freely available for research purposes. Any kinds of *Theme* projects can be imported, explored or converted into XML-based annotation files. For further development, we have several future plans including: (1) optimizing database-import of T-patterns, (2) making database queries more customizable, (3) supporting more data formats for exportation.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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A Mixed-Methods Approach Using Self-Report, Observational Time Series Data, and Content Analysis for Process Analysis of a Media Reception Phenomenon

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Due to the complexityof research objects, theoretical concepts, and stimuli in media research, researchers in psychology and communications presumably need sophisticated measures beyond self-report scales to answer research questions on media use processes. The present study evaluates stimulus-dependent structure in spontaneous eye-blink behavior as an objective, corroborative measure for the media use phenomenon of spatial presence. To this end, a mixed methods approach is used in an experimental setting to collect, combine, analyze, and interpret data from standardized participant self-report, observation of participant behavior, and content analysis of the media stimulus. T-pattern detection is used to analyze stimulus-dependent blinking behavior, and this structural data is then contrasted with self-report data. The combined results show that behavioral indicators yield the predicted results, while self-report data shows unpredicted results that are not predicted by the underlying theory. The use of a mixed methods approach offered insights that support further theory development and theory testing beyond a traditional, mono-method experimental approach.

Keywords: presence, measurement, blinking, structure, mixed methods

INTRODUCTION

Background

Experimental research in media psychology and communications focuses on complex human experiencing and behavior, and often uses complex theorizing to explain respective phenomena. To examine these theories, researchers regularly use complex stimuli, such as movies, video games, or virtual reality environments. In addition to this inherent complexity, further challenges can arise if researchers are not only interested in outcomes of media use, but also in the dynamic process aspects of media phenomena. In this case, summative, post-session self-report scales may not be sufficient to describe the dynamic nature of media use phenomena. Instead, more sophisticated measurement instruments, such as continuously recorded observational measures can be used to corroborate self-report measures.

In this article, we describe a study on the media use phenomenon of spatial presence, or "the conviction of being located in a mediated environment" (Wirth et al., 2007, p. 495), and put particular focus on the study's mixed methods aspects. The goal of the study is to evaluate structural aspects of spontaneous eye-blink behavior as a possible objective, corroborative measure for presence. Based on theoretical assumptions on the emergence of presence from attentional and other cognitive processes on the one hand, and research findings on the sensitivity of spontaneous eye-blink timing to attentional and other cognitive processes on the other hand, we test if presence experiences co-occur with a higher degree of stimulus-dependent blink timing during reception of a movie as an externally valid media stimulus.

Mixed Methods Approach

To address this research question, it is necessary to consider subjective viewer experience, objectively observable viewer behavior, and aspects of the media stimulus. The present study collects, integrates, and analyzes data from all three involved domains: First, self-report data on presence experiences is collected with an established, standardized questionnaire instrument (Spatial presence experience scale, SPES; Hartmann et al., 2015), that also serves as a validation standard for the blink-related measure. Second, the media users' spontaneous eye-blink behavior is recorded with observational methods. Third, data on the media stimulus is obtained from two different approaches to content analysis with a focus on content-blind, computational quantification of change in visual information, and on theory-derived, presence-relevant cinematic techniques. Data from observation and content analysis is then jointly analyzed with the method of T-pattern detection (Magnusson, 1996, 2000; Casarrubea et al., 2015, 2018) to determine the degree of stimulus-dependent structure in blinking behavior, which is then compared to the self-report measure.

Regarding the mixed methods aspect, the approach in the present study is in accordance with existing guidelines and research approaches. The study is in line with guidelines for the conduction of observational studies for behavior analysis in the movement sciences (Anguera et al., 2012, 2017; Castañer et al., 2013), and also with media-related applications of mixed methods research, such as studies on the analysis of children's movement quality during use of exergames (Castañer et al., 2011, 2016). In the present study, participant behavior in the context of media use is, as a first step, captured in video recordings. Second, computer-assisted coding using an *ad hoc* observational instrument produces descriptions of blinking behavior as annotated, sequential, qualitative time-series data. This set of data then allows data quality control and quantitative analysis with T-pattern detection to obtain structured categorical data which are, finally, further analyzed with quantitative methods.

Consequently, the mixed methods approach in the present study is characterized by collecting, analyzing, and interpreting quantitative and qualitative data to obtain deeper insights into a phenomenon of interest (Leech and Onwuegbuzie, 2009). By providing a precise description of the media stimulus, and by describing and analyzing the relation between self-reported recipient experience and observed recipient behavior during media use, the study aims at obtaining a more holistic understanding of the phenomenon under research (Venkatesh et al., 2013). Moreover, the sequential analysis procedure with quantitative and qualitative data allows for an unconventional analysis approach (Anguera et al., 2018). In this case, the approach aims at the analysis of temporal structure in user behavior and its relation to self-reported experience, thus providing a process-oriented perspective on the presence phenomenon.

Spatial Presence

Presence can be defined as the perceptual illusion of non-mediation (Lombard and Ditton, 1997). Wirth et al. (2007) model the emergence of spatial presence as part of a fluctuating, binary state, in which media users either enter a state of presence and temporarily overlook the mediated nature of their media use experience or they do not. In a state of presence, media users experience themselves as located within the medium and their action possibilities as determined by the medium. Further, the user's mental capacities are assumed to be no longer bound by the real environment in which media use takes place, but by the mediated environment. Wirth et al. (2007) propose a two-stage process model for the formation of spatial presence: First, the user needs to construct a spatial situation model (SSM) from spatial cues presented by the medium. This first step is supported by media factors that attract automatic attention allocation, by user factors that support controlled attention allocation on the medium, and by additional media and user factors that support the creation of an SSM. Once an SSM has been established, the new SSM rivals the user's existing SSM of the real environment. According to the model, presence occurs after a second step, if processes under influence of further user factors and media factors result in the viewer favoring the mediated SSM over the real-world SSM as the viewer's primary ego-reference-frame.

Wirth et al. (2007) point out that presence formation is a continuous process, since it depends on repeated confirmation of the medium as the primary ego-reference-frame. It is necessary for this process that the medium presents a stable stream of coherent information that the user continuously attends to and processes this information, and that the SSM is continuously updated. In this process, the model sees attention as a necessary, but not sufficient condition for the emergence of presence: automatic and controlled attention support the intake of media information, so that the further cognitive processes are provided with the necessary information. Continuous attention allocation occurs with both "short-term orienting responses and more persistent attention allocation" (Wirth et al., 2007, p. 499), and media factors can support attention allocation, for example, by presenting topics that match the user's domain-specific interest in media content, or by rapid stimulus changes in media form. Attention is also a crucial component of the model after creation of an SSM, when the mediated SSM is repeatedly tested against the real-world SSM. Then, attention and other cognitive processes related to SSM updating and testing of the rivaling situation models are engaged in continued processing of mediated information.

A sensible way to assess subjective presence experiences is self-report (Wirth et al., 2008), which is commonly achieved by means of standardized self-report scales (e.g., Usoh et al., 2000; Lessiter et al., 2001; Hartmann et al., 2015). However, inherent limitations of questionnaires have led researchers to criticize the self-report approach (e.g., Usoh et al., 2000; Slater, 2004; Slater and Garau, 2007; Liebold et al., 2017), in particular when focusing on the process nature of the presence phenomenon (Brill, 2019). To overcome these limitations, several objective indicators for presence experiences have been tested. For example, Böcking et al. (2008) report evaluations of think aloud, eye-tracking, secondary task reaction time, and functional magnetic resonance imaging. Other researchers focused on breaks in presence, that is, instances at which the users become aware of the mediated nature of their experience, and have used a range of psychophysiological measures to objectively describe observable correlates of user experience (Slater et al., 2003; Rey et al., 2011). Liebold et al. (2017) linked experimentally induced orienting responses on formal media features to breaks in presence, and observed concomitant changes in psychophysiology and blink timing. In the present study, we examine structural aspects of spontaneous eye-blink behavior as an indicator for presence-related processing of a stimulus.

Spontaneous Eye-Blink Behavior

Spontaneous eye-blinks are a ubiquitous behavior that serves the physiological function of maintaining clarity of vision and tear film stability (Cruz et al., 2011). However, research suggests that blinks are not purely following physiological necessities, but are subject to other internal and external influences, as well. Researchers have described blinking behavior as an indicator for cognitive activity (Malmstrom et al., 1977), and have found that blink timing depends on complexity and attentional demands of a task (Stern et al., 1984). Blinking has been described as an indicator for, or possibly even a component of processes around shifts in cognitive state (Oh et al., 2012). Blinks have been seen as an indicator for cognitive processing, possibly for finalized stimulus evaluation in tasks with and without need for motor responses, and as a "reliable marker of cognitive processing speed even in no-go situations" (Wascher et al., 2015, p. 1216). Blinks have even been attributed an active role in cognitive processing: they may possibly support switching between internal and external orienting networks, and could thus facilitate memory retrieval and support information processing by contributing to attention disengagement (Nakano, 2015).

Specifically for media use, Nakano et al. (2009) observed synchronized blinking behavior in recipients of video stories as a natural film stimulus. Synchronization effects were found as an intra-individual effect, whereas recipients showed similar blinking behavior during repeated viewing of the stimulus, and as an inter-individual effect, whereas recipients of the same stimulus independently showed similar blink timing. Nakano et al. (2009) assumed that the mechanism for blink synchronization would primarily depend on content aspects of the presented story, such as implicit break-points in the story, and not so much on low-level stimulus aspects, such as cuts. Synchronization effects were not found for a video stimulus without explicit story, or for an audio stimulus with story. Nakano et al. (2009) thus assumed the existence of "a mechanism for controlling the timing of blinks that searches for the appropriate timing to prevent the loss of critical information from the flow of visual information" (p. 3642). Nomura et al. (2015) related structural aspects of blinking behavior during reception of comedy performances to self-reported transportation experience, and also found synchronization effects in the blinking behavior of recipients, including differences between novice and advanced users of the stimulus.

Study Rationale

Based on the body of research on presence, on the adaptive nature of blink timing, and on media-use-related synchronization phenomena of spontaneous eye-blink behavior, we hypothesize a link between presence-related processes and blinking behavior. If recipients continuously allocate their attention on the media stimulus and engage in continued cognitive processing of media content, then the impact of the respective processes on blink timing should lead to a higher degree of stimulus-dependent structure in spontaneous eye-blink behavior. If, on the other hand, users do not engage in attention on and cognitive processing of a media stimulus, with their attentional and cognitive resources operating independently from the stimulus content, then their blink timing should be more independent from the media stimulus.

Regarding the question which exact features of the stimulus contribute to the structuring of blinking behavior, the present study tests two possible stimulus features. First, optical flow (Burton and Radford, 1978) as a low-level, content-blind feature of stimulus form is tested. With high amounts of optical flow, that is, a high change rate in visual information, a large amount of new visual information is presented to the recipient, and this information can be used to update or reconstruct the recipient's SSM. The cognitive activity during intake and processing of this information should affect blink timing. Second, cinematic form is tested as a factor of influence. Media content is rarely presented as unedited, raw footage from an observing camera perspective, but rather makes use of a cinematic, formal language that supports presentation of narrative content (Ohler, 1994; Zacks et al., 2010; Magliano and Zacks, 2011; Monaco, 2015). Parallel to the consideration of optical flow, the second approach to content analysis also aims at identifying instances in the stimulus where a reconstruction or updating of the recipient's SSM would be necessary. However, the second approach uses the definition of the *scene* in films (Monaco and Bock, 2011, p. 239) to identify relevant events in cinematic structure. As existing media research shows, T-pattern detection can be used to analyze movie-viewers' anticipations of, and reactions toward a film's moments of impact and narrative structure (Suckfüll and Unz, 2013, 2016). Further, the latter research informs the present study since it used T-pattern detection to relate media events to observe psychophysiological and behavioral variables in order to infer on internal processes in viewers, in this case raising and disappointing of viewer expectations.

MATERIALS AND METHODS

Following the rationale of existing evaluation studies for objective presence indicators (Böcking et al., 2008), we conducted an experiment with a between-subjects design, in which participants were randomly assigned to conditions with either a high, or a low presence potential. Because established experimental manipulations to increase a medium's presence potential, such as presentation in stereoscopic 3D or larger screen size (see Cummings and Bailenson, 2016, for a meta-analysis of technological presence factors), or to decrease presence potential, such as dual task paradigms (e.g., Böcking et al., 2008), could possibly affect blinking behavior, a visually neutral manipulation with identical stimulus was intended. The intended manipulation considered the distinction between media form and media content (e.g., Ohler, 1994), and the assumption that attention to aspects of media form will interfere with presence formation (Liebold et al., 2017): Media recipients should not experience presence if they pay attention to the medium itself, because then, they should be unable to overlook the mediated nature of their experience. Therefore, a manipulation by different instructions intended to hinder or support presence formation by directing the participants' attention to the narrated media content, or to media form features. While participants in the high-presence condition were asked to consume the stimulus as they would regularly do in a cinema, participants in the low-presence condition were explicitly asked to pay attention to and analyze cinematic form features of the stimulus. The manipulation effectiveness was controlled with short, custom items that were designed to ask for the participants' attentional focus and reception mode (Vorderer, 1992; Suckfüll, 2004) during the reception situation, and with a standardized presence questionnaire (Spatial presence experience scale, SPES; Hartmann et al., 2015).

This approach represents a rigorous testing of the hypotheses, because both experimental groups presented an identical stimulus, and observed differences in behavioral structure of blinking can be attributed to different attention allocation on, and processing of this stimulus. In addition, this approach is superior to use a non-media low presence condition, since spatial presence in the sense of the theory (Wirth et al., 2007) can only emerge during media use.

Stimulus

As a natural media stimulus, we presented the first 20:23 min from the academy award-winning motion picture *Birdman or* (*The Unexpected Virtue of Ignorance*) (Iñárritu, 2014). The movie is produced without visible cuts or transitions, so the camera follows the actors through sets in fluid movements, and no abrupt changes by cuts disrupt the flow of visual information. As in Nakano et al.'s (2009) experiment, a baseline video was presented prior to the actual stimulus. Here, we used a 1:55 min long video showing a large fish tank in a public aquarium (Rawlinson, 2009). Before, in between, and after the two videos, a 5 s countdown on the screen served as a transition indicator.

Apparatus

The experiment was conducted in a cinema-like, acoustically optimized, darkened laboratory with identical technical setup for all sessions. The stimulus video was available in Blu-ray quality, and was presented on a 150″ projection screen at a viewing distance of 4.3 m in upscaled 4 K resolution. Audio was presented with a room-calibrated 7.2 channels surround sound system. Synchronized observations of the screen and of participants were recorded with unobtrusively placed near-infrared pan-tilt-zoom dome cameras and the Noldus Media Recorder 2 software. Before each session, temperature and relative humidity were recorded with a consumer-grade digital thermometer and hygrometer. Environmental conditions in the laboratory were relatively stable (temperature: M = 20.26°C, SD = 0.27, range: 19.50 – 20.90; relative humidity: M = 39.79%, SD = 1.82, range: 38.20 – 44.00).

Participants

The study was carried out in accordance with the research institution's ethical guidelines. All participants provided written informed consent in accordance with the Declaration of Helsinki. Sixty-one participants (age M = 22.39 years, SD = 2.73, range: 19 – 33 years, 63.9% female) with normal or corrected to normal vision participated in the study, and were granted course credit, if desired. Twenty participants or 32.8% of the sample were already familiar with the stimulus; however, due to existing findings on intra-subject eye-blink synchronization during repeated viewing of a stimulus (Nakano et al., 2009; Nomura et al., 2015), these participants were still included in the study. Exclusion criteria were a very high blink rate of more than 60 blinks per second or more than two standard deviations above the sample's mean, reporting no sufficient vision acuity, failure to comply with experimental instructions and procedures, or not declaring or retracting consent to participate. Depending on the recruitment situation, group-size of the different experimental sessions varied between 1 and 5 participants (group size in high presence condition: n = 13; M = 2.31, SD = 1.32; low presence condition: n = 16; M = 1.94, SD = 1.12).

Measures

To collect self-report data, post-session questionnaires were handed out in print in two versions with different, randomized item sequence within scales. The Spatial presence experience scale with its sub-scale "spatial presence: self-location" (SPES; Hartmann et al., 2015) with 5-point Likert scales served as the standardized measure for subjective presence self-reports. Four additional short items were used as manipulation check, and asked for their focus on content aspects, focus on media form aspects, and for the degree of involved and reflective reception mode (Vorderer, 1992).

To collect observational data, videos of the individual participants were recorded in non-participative observation during presentation of baseline video and stimulus video. The observer had only standardized contact with participants during the instruction phase, and was not present in the room during the observation period. Participant recordings were captured in HD resolution with 30 frames per second, and were either recorded from a slight downward angle or in half profile, so blinks were clearly visible (see **Figure 1** for an overview of experimental and analytical procedures).

Procedure

After participants had been introduced to the experimental setting and procedures and declared informed consent, the experimenter instructed them with a standardized text, and then started video recordings and stimulus presentation from a separate room. After the video presentation, recordings were stopped, the participants answered the questionnaire, and were then debriefed and dismissed (see **Figure 1**).

Coding and Data Preparation

User Behavior

Several participants were excluded from behavior coding and subsequent analysis. One participant reported abnormal blinking behavior due to a foreign object in the eye; four participants did not comply with instructions on conduct during the experiment; two participants were excluded from coding, because it became obvious in an early stage of coding that their blink rate throughout the session was near or above 60 blinks per minute. This reduced the sample size for behavior coding to 53 participants.

Blinks were coded manually by two independent coders with the Noldus Observer XT 11.5 software. Blinks were to be coded if a rapid downward movement of the upper eyelids, followed by re-opening of the lids, covered at least part of the pupils. The video frame with maximum eyelid closure was coded as the time of blink occurrence. Coder one coded the whole observation periods of each participant with baseline video and stimulus video. Coder two coded a randomly determined subsample of the same recordings. To this end, a random timestamp was generated for each participant recording, and from that timestamp on, 10% of the participant's observation period were coded by the second coder.

Concordance between the two independent coders for the 10% subsample of the observation period was calculated for a 170 ms or five frames tolerance window. Mean percentage of agreement was 92.72% (SD = 8.64, range: 64.30 − 100). Average inter-rater agreement with Cohen's kappa was very low (M = 0.15, SD = 0.39, range: −0.2 − 1). Because very low kappa has been reported to possibly occur under certain conditions despite high agreement percentage (Feinstein and Cicchetti, 1990), the codings were nevertheless accepted.

The 53 participants showed during baseline, transitions and stimulus video a total of 24,361 blinks. During stimulus presentation, the participants showed 22,546 blinks, with an average blink rate of 20.88 blinks per minute (SD = 11.07). Four participants were excluded from further analyses because

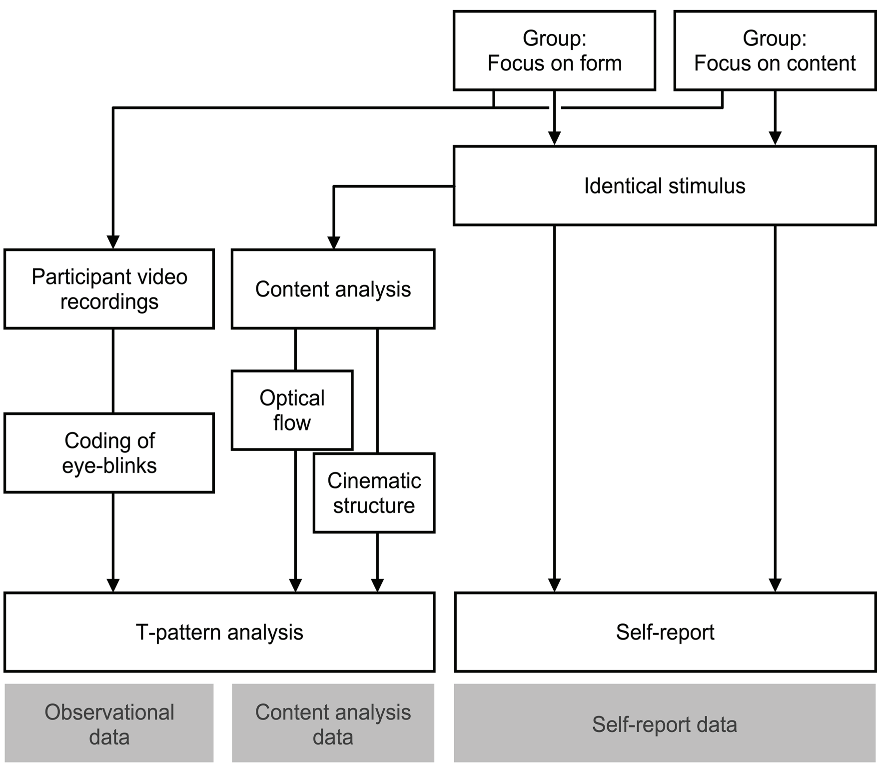

FIGURE 1 | Schematic overview of the experimental and analytical procedures in the present study's mixed methods approach.

their blink rate was more than two standard deviations above the coded sample's mean.

Media Events: Optical Flow

For the first type of media events, optical flow in the stimulus video was analyzed to identify instances with a high change rate in visual information. To quantify optical flow, the Birdman excerpt was processed with the *OpenCV* toolbox (Bradski, 2000; OpenCV, 2014) and an included algorithm for the detection of optical flow (Farnebäck, 2003). The algorithm was used to compute optical flow between all consecutive frames of the stimulus video. The resulting vector with optical flow values between video frames was processed further in *GNU Octave* (Eaton and Octave Community, 2015; Eaton et al., 2015a,b): first, the signal was smoothed with a 12 frames or 0.5 s moving average filter. Then, the *findpeaks* function from the Octave signal processing package (Various authors and Miller, 2015) was used to identify peaks with a height of at least two standard deviations of the detrended, smoothed optical flow vector, with a minimum peak width of one frame, and a minimum distance between peaks of 48 frames or 2 s. According to visual inspection, these parameters represented the signal's peaks sufficiently well. The detection algorithm identified 55 peaks. These peaks were numbered consecutively, and their timestamps were integrated with individual blink time stamps from behavior coding.

This computational approach can be used to analyze video material efficiently, and is useful to test assumptions according to which blink timing is sensitive to the flow of information in the visual channel. However, this approach is content blind, since it is irrelevant what exactly caused optical flow in the stimulus. Therefore, in order to gain more interpretative capacity, we also coded theoretically derived media events in the stimulus video to increase content sensitivity of analyses.

Media Events: Cinematic Structure

The second approach to content analysis focused on formal aspects of cinematic structure to identify instances in the stimulus that could cause reconstruction or updating of the SSM. Starting from the definition of the *scene* as a basic unit of film that consists of one or more shots connected by place, plot, or present persons (Monaco and Bock, 2011, p. 239), we derived several events that present new, SSM-relevant information to the viewer: First, changes of location, that is, a new room is shown in the video. Second, the camera movements of camera panning, tracking shots and spinning shots, because they make visible new parts of the mediated environment. Third, the emergence of new characters interacts with the protagonist. In addition, unpredicted events in the movie's story were included, because they present new information which needs to be attended to, and needs to be integrated in the situation model. A code book was created with categories, definitions, coding rules, and coding examples. Two coders assessed the Birdman sequence independently in the Noldus Observer XT 11.5 software, and coded onsets for all relevant media events. Due to the fluid changes of most aspects, event onsets were less defined, so a larger tolerance window of 2 s was used for calculation of coder agreement. Initial codings showed a low coder agreement of 59.1%, with a Cohen's kappa of κ = 0.49. Independent recoding of disagreements led to a coder agreement of 90.1%, with a Cohen's kappa of κ = 0.87 with a 2 s tolerance window. For the final definition of media events, all cases of agreement were used, resulting in 183 events: 40 changes of location, 64 panning shots, 5 spinning shots, 51 tracking shots, 18 appearances of characters, and 5 unexpected events. With respect to the subsequent T-pattern detection, the earlier timestamp of both codings was used to define event onsets, because different timing in a sequence of events would have less impact on analysis than different order in a sequence. As for peaks in optical flow, the events in each category were numbered in sequence, and all media events were integrated with individual eye-blink data for T-pattern analysis.

T-Pattern Analysis

To test the hypothesis that users in the presence-supporting content condition would show a higher degree of stimulus-dependent structure in spontaneous eye-blink behavior, T-pattern analysis (Magnusson, 1996, 2000) was used to analyze temporal relationships between user events and media events. T-pattern analysis is based on repeated, binomial-statistics-based analysis steps that identify higher-than-chance co-occurrences of events. This process identifies a T-Pattern, if an event B follows an event A with greater than chance timing within a critical interval. In a level-by-level process, identified T-patterns are used as new events in subsequent analysis steps, so the analysis allows for the identification of complex hierarchical structures. Going beyond other methods of group statistics or sequential analysis, the T-Pattern method enables researchers to analyze, for example, structural aspects of human behavior in dyadic interaction (Magnusson, 2000), in the interaction within and between sports teams (Lozano et al., 2016; Fernández-Hermógenes et al., 2017), or during use of non-interactive and interactive media (Suckfüll and Unz, 2016; Brill, 2019). However, for the given research question, only a limited, very basic T-pattern analysis was performed. Since the research focus was on instances in which a media event was either preceded or followed by a blink with greater-than-chance timing, only T-patterns with a length of two events, that is a level of 1, were searched for. This approach does not use the method's full analytical capacity for structured data, but suits the current research purpose well. T-pattern analyses with identical search parameters were conducted in the Theme, (2017) 6 software for datasets with the participants' individual, time-stamped blink data as user events, and either maxima in optical flow or coded scene-related events as media events. For each experimental group and each of the two types of media events, individual participant data files were imported into a Theme project, and were concatenated into a multi-sample data file, that is the series of all individual observation periods formed one virtual observation period. The level of significance for the critical interval was chosen as the standard α = 0.005, and only T-patterns were considered that appeared at least three times in a detection process. For validation purposes, the search process was repeated 40 times each with shuffled and rotated randomized versions of the data sets. Since the identical structure of media events during each observation leads to a large number of irrelevant patterns, only patterns including blinks were selected in detection results from real and randomized data.

RESULTS

Manipulation Check

We hypothesized that participants in the high presence condition, who were instructed to view the movie, report higher presence scores than participants in the low presence condition, who were explicitly instructed to focus on form aspects of the movie. The four item SPSL scale showed good internal consistency with a Cronbach's alpha of $\alpha = 0.93$. Since test requirements were fulfilled, a one-tailed independent samples t-test could be calculated and showed that, contrary to hypothesis, SPSL scores in the content group were not significantly higher than SPSL scores in the form group ($t(47) = -1.69$, $p = 0.951$, $d = -0.48$). In fact, participants in the form condition reported higher presence scores (content: $n = 24$, $M = 3.27$, SD = 0.95; form: $n = 25$, $M = 3.72$, SD = 0.92). A follow-up one-tailed independent samples t-test showed that this difference was statistically significant ($t(47) = -1.69$, $p = 0.049$, $d = -0.48$; see **Figure 2**).

Compliance with instructions was tested for both groups using the additional, corroborative manipulation check items. Since t-test requirements were not met, one-tailed Mann-Whitney U tests were calculated, and showed that participants in the form condition reported significantly higher attention to technical aspects than the content group ($U = 153.50$, $p = 0.001$, $d = 0.30$), but did not differ significantly from the content group on the other measures (attention to content aspects: $U = 339.50$, $p = 0.198$, $d = 0.32$; immersion into the mediated environment: $U = 283.00$, $p = 0.647$, $d = 0.17$; critical reception of the stimulus: $U = 344.50$, $p = 0.827$, $d = 0.34$).

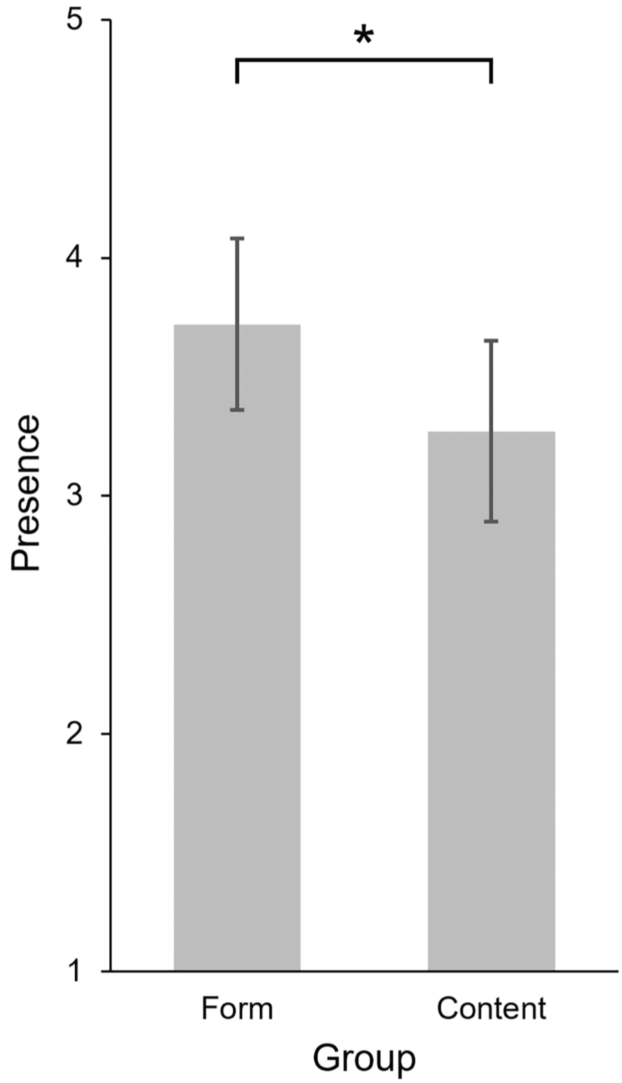

FIGURE 2 | Spatial presence self-report scores in the form condition and content condition. Higher values indicate stronger presence experiences. Error bars indicate 95% CIs of the SEM. $^*p < 0.05$.

T-Pattern Analysis and Group Comparisons

Optical flow

T-pattern analysis with consecutively numbered peaks in optical flow as media events, and blinks as user events identified 43 different T-patterns in the content group, with 580 combined occurrences, and 42 different T-patterns in the form group, with 541 occurrences. Comparison of detected T-patterns of length 2 in real data and randomized data showed that considerably more T-patterns were detected in real data (see **Table 1**), thus supporting the validity of the results. Individual pattern occurrences, that is the occurrences of all different patterns for each participant, were used for group comparisons of the high and low presence condition (high presence: $n = 24$, $M = 24.17$, SD = 5.72; low presence: $n = 25$, $M = 21.64$, SD = 4.76). The requirements for a one-tailed, independent samples t-test were met, and the test showed that significantly more T-patterns with blinks and media events were identified in participants in the content group ($t(47) = 1.68$, $p = 0.050$, $d = 0.48$; see **Figure 3**).

Cinematic structure

T-pattern analysis with consecutively numbered, scene-related changes as media events, and blinks as user events identified 139 different T-patterns with 1,758 combined occurrences in the content group, and 134 different T-patterns with 1,556 occurrences in the form group. Comparison of detected T-patterns of length 2 in real data and randomized data showed that considerably more T-patterns were detected in real data (see **Table 2**), thus supporting the validity of the results. Again, individual pattern occurrences for each participant were used for group comparisons of the high and low presence conditions

TABLE 1 | T-patterns with blinks as viewer behavior and peaks in optical flow as media events in real data and randomized data.

Group	Real		Randomized				Difference in SD	
			Shuffle		Rotation			
	Unique	Total	*M*	SD	*M*	SD	Shuffle	Rotation
Content	43	580	13.06	3.53	17.43	3.76	8.47	6.80
Form	42	541	10.83	3.09	15.86	3.35	10.10	7.81

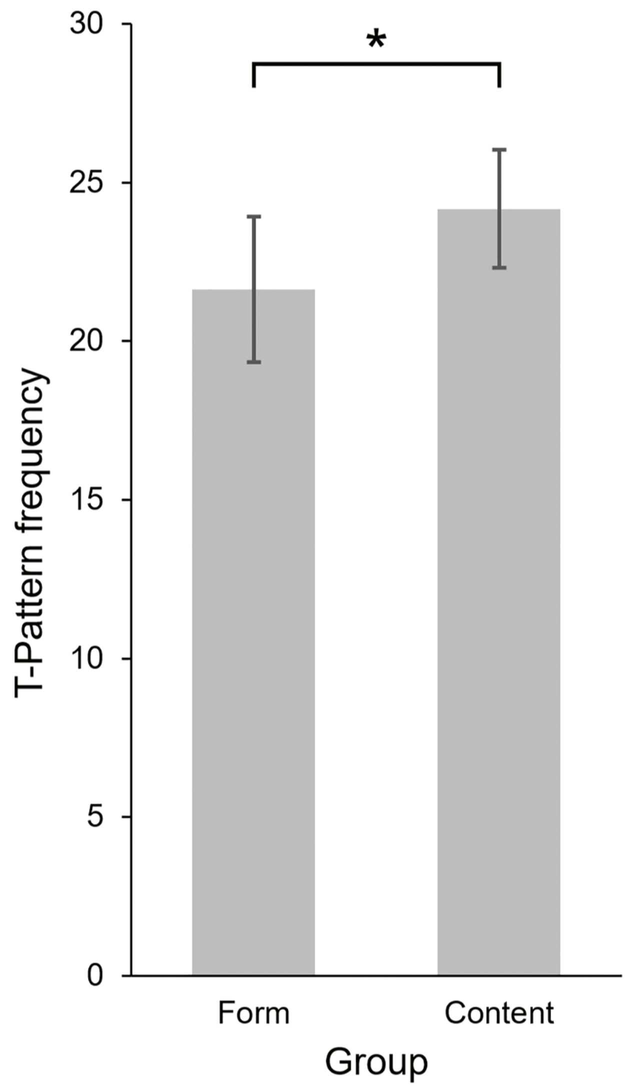

FIGURE 3 | Mean frequencies of T-patterns with blinks and peaks in optical flow in the form condition and content condition. Error bars indicate 95% CIs of the SEM. $^{*}p < 0.05$.

(high presence: $n = 24$, $M = 73.25$, SD = 15.05; low presence: $N = 25$, $M = 62.24$, SD = 15.76). The requirements for a one-tailed, independent samples t-test were fulfilled. The test showed that significantly more T-patterns with blinks and media events were identified in participants in the content group [$t(47) = 2.50$, $p = 0.008$, $d = 0.71$; see **Figure 4**].

DISCUSSION

Summary, Integration, and Meta-Inferences

The present study aimed at evaluating stimulus-dependent temporal structure in spontaneous eye-blink behavior as a possible alternative measure for spatial presence experiences. To this end, data from self-report, observation, and content analysis have been collected in an experiment with externally valid stimulus and setting, and two conditions with low and high presence potential. The various data have been integrated and analyzed to assess the degree of convergence between the objective indicator and an established self-report measure for presence. While analysis of data from observation and content analysis showed the predicted result of more stimulus-dependent structure in blinking behavior in the high presence condition, the different self-report measures showed divergent and unpredicted results. Participants in the low presence condition reported a stronger focus on the medium itself, but, at the same time, higher levels of presence experiences.

Thus, the mixed methods approach revealed an overall pattern of results that contradicts predictions of the underlying theory. According to the manipulation check items, participants in the low-presence condition paid more attention to stimulus form features, but according to the standardized SPES questionnaire, they also reported higher presence experiences. If all measures are valid, then this pattern of results is in conflict with the underlying presence theory, since presence should emerge from not paying attention to the medium itself, and should be diminished when viewers focus on the medium itself (e.g., Wirth et al., 2007; Liebold et al., 2017). Even when considering the high immersive potential of the experimental setup that may have interfered with the extended, media-focusing task in the low presence condition, the results are still not in line with the theory's prediction. After all, the reported levels of presence were not equal to the natural viewing condition, but were significantly higher. On the other hand, T-pattern analysis of the observational data showed, as predicted, a higher degree of stimulus-dependent structure in blinking behavior in the high-presence condition. This result was found with two different approaches for the

TABLE 2 | T-patterns with blinks as viewer behavior and cinematic structure as media events in real data and randomized data.

Group	Real		Randomized				Difference in SD	
			Shuffle		Rotation			
	Unique	Total	*M*	SD	*M*	SD	Shuffle	Rotation
Content	139	1,758	43.23	49.60	59.80	65.72	15.03	13.39
Form	134	1,556	34.40	39.89	50.45	57.12	18.16	12.53

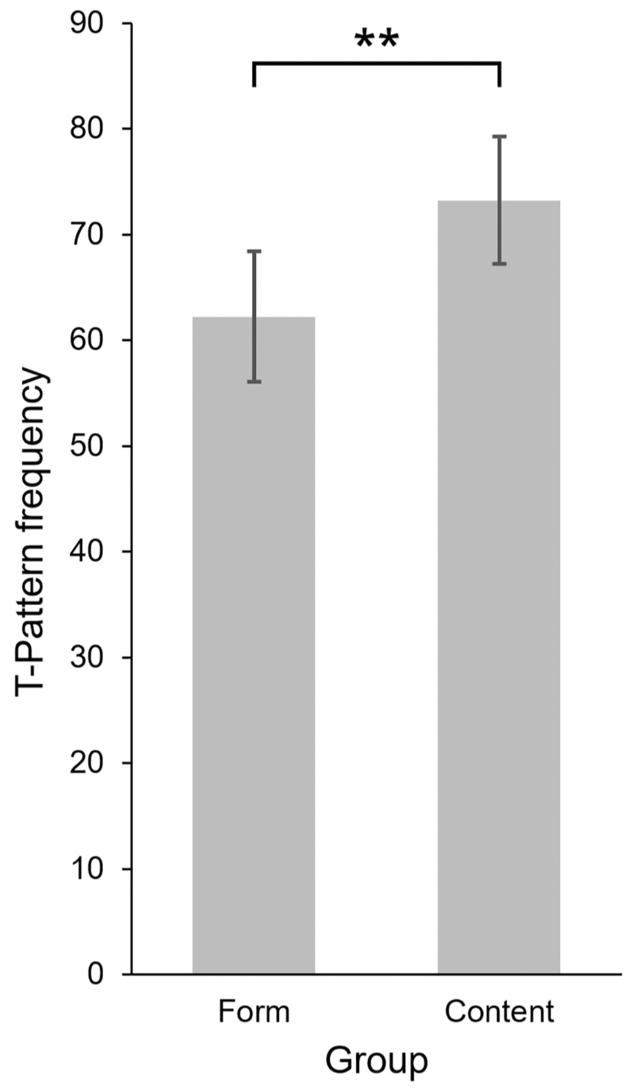

FIGURE 4 | Mean frequencies of T-patterns with blinks and events of cinematic structure in the form condition and content condition. Error bars indicate 95% CIs of the SEM. **$p < 0.01$.

definition of media events. In addition, results that are not reported in this paper support the findings with another, media-event-independent analysis method for behavioral structure (Brill, 2019).

Limitations and Future Directions

Aside from the study's specific results, structured blinking behavior as a measurement approach for presence has limitations in itself due to its theoretical and conceptual foundations. First, structured blinking behavior is not directly influenced by presence experiences. It rather reflects the activity of attentional and other cognitive processes that should engage in processing of mediated information when recipients are in a state of presence, such as orienting responses on media content (Liebold et al., 2017). Like other suggested corroborative measures (e.g., Böcking et al., 2008), it could thus serve as an indirect indicator for presence by allowing to infer on presence-related processes. However, this limitation is inherent to all objective presence measurement approaches, since there is no known direct indicator for presence experiences. Even methodically sophisticated neuroimaging studies resort to observing indicators for presence-related processes, such as activation of brain areas for spatial processing and navigation, emotional processing, or executive control systems (Baumgartner et al., 2006). Second, attention is theorized to be not only a crucial component of presence formation, but also of other media use phenomena, so it would probably not be an indicator exclusively for presence. On the other hand, this may also broaden the applicability of a measure based on structure in blinking behavior. Third, attention is modeled as a necessary, but not sufficient condition for the emergence of presence (e.g., Wirth et al., 2007). However, at least in the present study, we found differences in behavioral structure in recipients who allocated their attention to the same stimulus, but with different intentions during reception. This suggests that the measure may in principle be sensitive to different attention on, and processing of a stimulus.

In the present study, two approaches have been used to identify relevant media events for T-pattern detection: optical flow as a basic, perception-related property of the stimulus, and media events related to the cinematic presentation of stimulus content. Future studies could extend the focus on media features further to the domain of media content by considering, for example, suspenseful media events and their relation to attentional focus, as has been addressed for the media use phenomenon of narrative transportation (Bezdek et al., 2015; Bezdek and Gerrig, 2017), or by considering media events with evolutionary and affective relevance (Brill et al., 2018). Regarding methodological aspects, T-pattern analysis offers the researcher several parameters to adapt the analysis to the specific behavior. The analytical approach in this study largely used the detection software's standard analysis parameters that were, most importantly, identical for analysis of all experimental groups. However, the precision of analysis could possibly be improved further by adapting analysis parameters specifically to blinking behavior, for example regarding limits for the critical interval in T-pattern detection, or randomization procedures in validation of results.

Conclusion

Different from a mono-method study design, the present study included data from several sources. Standardized self-report measures and computationally defined media events were included as purely quantitative measures. Theoretically derived media events were included as data that has been obtained by considering qualitative aspects during content analysis of the stimulus. Above all, our procedures of collecting observational data on viewer behavior, and the subsequent analysis of behavioral structure, can be regarded as an important component of a mixed methods approach (Anguera et al., 2018). Detailed reports on procedures of data collection, assessment of data quality, and data analysis were provided for both quantitative and qualitative measures (Venkatesh et al., 2013). Further, the employed mixed methods design is theoretically grounded (Venkatesh et al., 2013), since it has been derived from existing research on presence and on evaluations of alternative presence measurement approaches. An advantage of mixed methods research is the possibility to draw meta-inferences from the study results for the underlying theory (Venkatesh et al., 2013). In the present study, we aimed at a comprehensive description and explanation of recipient experience and behavior in a media use situation in order to evaluate a possible alternative measurement method. While this was not possible due to an unpredicted pattern of results, the study nevertheless provided new evidence on contradictions or boundary conditions of the underlying theory, an aspect that has been suggested as an essential outcome of mixed methods research (Venkatesh et al., 2013). In addition, the present study's laboratory setup, stimulus, and measurement methods converge to a certain extent with human ethology's calling for "direct, objective, non-intrusive and open-minded observation of each species' behavior in its natural environment" (Magnusson, 2016). Further, the study follows an unconventional analysis approach by not only considering frequencies, rates, or sequences of behavioral units, but focusing on the temporal structure of behavior to describe a dynamic process phenomenon (Anguera et al., 2018).

While the overall, conflicting pattern of results does not allow for a conclusive answer to the original research question, the mixed methods approach nevertheless allowed for a level of insight into the research topic that could hardly be obtained in a mono-method study. Theory development on presence, and probably on other media use phenomena, as well, can benefit from more complex studies and measures that offer researchers a process perspective on the dynamic nature of media use phenomena.

DATA AVAILABILITY

The datasets collected for this study are available upon request from the corresponding author.

ETHICS STATEMENT

This study was carried out in accordance with the ethical guidelines of the German Psychological Society (Deutsche Gesellschaft für Psychologie, DGPs), the American Psychological Association (APA), and the Declaration of Helsinki. All participants provided written informed consent. The stimulus movie has been released for audiences as of 12 years of age by the German movie rating board (Freiwillige Selbstkontrolle der Filmwirtschaft, FSK), and was thus assessed as appropriate. Due to the use of standard stimulus material and measurement methods, no approval of the local ethics committee had been requested.

AUTHOR CONTRIBUTIONS

The major part of the study was conducted as part of the doctoral thesis of MB, with FS as thesis supervisor. MB and FS contributed conception and design of the study's extension with content-analysis-defined media events, and MB contributed the additional analyses in this part. All authors contributed to manuscript drafting and revision, and have read and approved the submitted version.

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This paper presents and expands an experimental study from a doctoral dissertation (Brill, 2019). Compared to the study in this thesis, the present study added the analysis with content-analysis-defined media events, and puts particular focus on the study's mixed methods aspect.

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A Psychoanalytical Perspective on the Co-therapeutic Relationship With a Group of Siblings of Children With Autism: An Observational Study of Communicative Behavior Patterns

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A child diagnosed with autism may have a negative psychological and behavioral impact on their siblings, whose participation in a group with children in the same situation is a preventive measure. Our group study was conducted by two therapists (T1 and T2) assigned to co-therapy (CT) work. Both therapists shared the theoretical bases and understanding of the group and the needs of the individual subjects, and complemented each other in terms of the direction of their interventions, given that shared impressions and continuous exchanges that integrate countertransference aspects are essential to successful co-therapy. The objectives of this study were as follows: (a) to detect patterns of clarification, confrontation, and interpretation interventions by T1 and T2 in the group; and (b) to detect patterns of clarification, confrontation and interpretation interventions considering T1 and T2 as the only focal subject of the CT. Design was mixed-methods based on systematic observation, for which we developed a qualitative *ad hoc* instrument that combined a field format and a categorizing system. Interobserver agreement was analyzed quantitatively using Cohen's kappa and Krippendorf's canonical concordance. Once data reliability was confirmed, lag sequential analysis using GSEQ5 software was performed to search for behavior patterns. The results show (a) different behavior patterns in the clarification, confrontation, and interpretation interventions by T1 and T2; and (b) different behavior patterns when T1 and T2 are considered as the focal subject (CT). Our study offers a new perspective on the impact of therapist interventions on participants in this kind of group.

Keywords: co-therapy, siblings, autism spectrum disorder, group psychotherapy, therapeutic communication, mixed method, systematic observation

INTRODUCTION

Family centered care in the autism spectrum disorder (ASD) field has attracted growing interest in the past decade in early care units (Gabovitch and Curtin, 2009; Christon and Myers, 2015). Studies focused on children with siblings with ASD (ASD-Sibs) have adopted different approaches. Hypothesizing genetic vulnerability (Cassel et al., 2007), a number of follow-up studies have sought to identify early stage ASD-Sibs predictors (Yoder et al., 2009). Another perspective has sought to identify the benefits of the sibling bond for autistic children, with a retrospective study reporting that older siblings positively influence the social skills of younger ASD-Sibs (Ben-Itzchak et al., 2018). In recent years, interest has grown in whether ASD-Sibs have a greater risk of developing emotional and behavioral problems than the general population, with empirical results pointing to enormous variability (Griffith et al., 2014; McHale et al., 2016): some studies affirm an increased risk (Meyer et al., 2011; Shivers et al., 2013; Hastings and Petalas, 2014), others suggest a similar risk (Macks and Reeve, 2007; Ferraioli and Harris, 2009; Walton and Ingersoll, 2015), and yet others argue that ASD-Sibs demonstrate better social adaptation and more positive sibling relationships (Hastings, 2003; Petalas et al., 2012). A recent meta-analysis (Shivers et al., 2018) of 69 studies that compared siblings with ASD-Sibs with siblings without ASD-Sibs found that, for some 800 individual comparisons, children with ASD-Sibs had significantly poorer – albeit small in magnitude – outcomes, specifically in their internalization of behavioral problems, psychological functioning, beliefs, social functioning, and relationships between siblings. No significant results were obtained for adaptation, externalization of behavioral problems, attention-deficit/hyperactivity disorder, coping or family functioning.

Support groups for ASD-Sibs are key to the prevention and early detection of developmental and emotional disorders and also in terms of therapeutic strategies when difficulties appear (Shivers et al., 2018). Traditionally, interventions for ASD-Sibs are implemented through support groups for family members, focused on communicative strategies that foster positive relations between siblings and a climate of trust in the family that facilitates the revelation of thoughts and feelings (Harris and Glasberg, 2003). Programs are available that seek to empower ASD-Sibs to stimulate and play with their siblings with autism and help them acquire social skills (Tsao and McCabe, 2010; Tsao et al., 2012). Since the behavioral problems frequently associated with ASD may lead to the emergence of negative emotions in the siblings (Tsao et al., 2012), some studies have underlined the need for siblings to be able to express feelings and thoughts (Mascha and Boucher, 2006; Angell et al., 2012), although – as if they recognize that there is no room in the family for further problems – ASD-Sibs often appear to have no difficulty in adapting and are understanding and responsible. However, it has also been observed that these children may deliberately hide their need for a space to be someone other than "the brother or sister of" their sibling (Centre Educatiu i Terapèutic Carrilet, Alcácer et al., 2013; Farrés, 2014).

The goal of our sibling support group is to offer a space where ASD-Sibs can freely express feelings and thoughts that may remain silenced in their everyday life or that may be perceived as contradictory. In the group the children explore the ambivalence of wanting to care for their sibling with special needs while also feeling guilt, anger and maybe even hate because of the special treatment their sibling receives from parents or at school. **Figure 1** shows, as an example, an excerpt from a session in which siblings are discussed (Centre Educatiu i Terapèutic Carrilet, Alcácer et al., 2013; Farrés, 2014).

T2: What was it like at home with your brothers and sisters? Was it ok? Was it difficult?
P2: Not good for me.
T2: What happened P2? Do you want to tell us about it?
T1 drags the boxes of materials to part of the table where nobody is sitting.
P2: On Christmas Eve, I think it was …
T2: What?
P2: We were left in the dark.
T2: In the dark? Why, what happened?
P2: Because my brother wanted to turn off the light.
T2: Really?
T1: And what happened?
P1: I…
T1: Wait, it's important. And what happens if he wants to be in the dark? Must everyone be in the dark?
P2 nods his head.
T1: And couldn't you have supper or look at your presents?
P2: We could look at our presents. Yes.
T1: Sure? But in the dark
P2: By candlelight.
T1: By candlelight.
T2: By candlelight.
T1: Why didn't your brother want the light on?
P2 shrugs his shoulders and hands in doubt.
T1: What happened if the light was on?
T2 looks at the camera and moves the boxes of materials closer to his side.
P2: Well, he asked for it to be turned off.
T2: If you turned it on, what happened? Could he have got very cross, or what?
P2 nods his head.
T2: Wow!
T1: The whole family frightened and in the dark like that, it's very complicated.
T2: Wow, I guess so.
T1: It's very difficult.
T2: I suppose you must get a bit angry and say: 'Why does your brother want everyone here in the dark?'
P2 nods his head.
T2: What do you think? Have your brothers ever been as angry as P2's?
P4 nods her head.
P1: No.
T2: Look, P4 says yes.
P1: My sister, when she turns off the light, she wants to have a party. We had a thing that makes music. It's called Twister.
T1: Hmm.
T2: Hmm.
P1: It is a thing that makes music, then she dances and turns off the light.
P4 nods her head.
T2: P4 knows. She's nodding her head.
T2 imitates P4 nodding her head.
T2: I know what it is.
P1: Yes.
T2: But, it makes your sister happy, right?
P1: Yes, it gives off light.
T2: Ok, but P2 says that when his brother wants to turn off the light, he's angry and makes the whole family.
T1: He doesn't want to see anyone.
T2: Exactly.
T1: He doesn't want to see anyone or anything.
T2: And P4 said that her brother got angry, sometimes, right?
P4: Yes.
T2: What happens? Do you want to tell us, like P2 did?
T1: What makes your brother angry, P4?
P4: When he's in my room ...
T2: Yes…
P4: … he wants to turn off the light.
T1: Wow!
T2: You are in your room, and he wants to turn off the light?
P4 nods her head.
T1: That's a bit like P2's brother. There are times when he doesn't want to see anything.
T2: Of course. I suppose both of you have to put up with it.
P2 nods his head.
P4 nods her head.
T2: It's very tiring. It's worse than the homework we were talking about.
T1: Homework is common, but I guess there's homework that families have, which is to adapt to your brothers and sisters and find a way to do things all the same. To find the way to light a candle. To find out whether P2's brother can put up with a candle or not. You've found a way that won't make him get cross and that isn't too bad for the rest of you.
P2 subtly raises his eyebrows.
T2: Perhaps this is something that your siblings have in common. That sometimes things have to be exactly as they want, because if not, they get angry.

FIGURE 1 | Fourth group session transcriptions.

In this research, we wanted to study the spontaneous interaction between children and psychoanalytical therapists in a group. This required a flexible methodology adaptable to all behaviors and contexts. Mixed methods research offers an excellent combination of rigor and flexibility while allowing qualitative and quantitative techniques to be used within the same paradigm (Creswell et al., 2003; Johnson et al., 2007; Tashakkori and Teddlie(eds), 2010). Indeed, qualitative and quantitative techniques are gradually progressing toward integration (Hesse-Biber and Johnson, 2013; Fetters and Freshwater, 2015; Onwuegbuzie et al., 2018), although some problems remain, such as how to achieve that integration (Bryman, 2007; Bazeley, 2012, 2017) and its translation into practice (Onwuegbuzie and Leech, 2005; Happ et al., 2006). Mixed methods, which involve combining inductive logic with deductive logic (Bergman, 2010) throughout the entire research process, has an integral role to play in "complete" methodological development. Observational methodologies have been pioneering in achieving this methodological complementarity (Anguera et al., 2001; Anguera and Izquierdo, 2006; Sánchez-Algarra and Anguera, 2013), e.g., the recent conceptualization in indirect observation (Anguera et al., 2018).

The conceptual framework for this study gave rise to four essential dimensions reflected in the observation instrument: ASD-Sib, turn-taking, group, and play. However, although all the small children in the support group shared the fact of having a sibling with ASD, there were few explicit interventions about the sibling. Group activities focused on plasticine models and wooden doll families. The plasticine figures made by the children were kept, which led to some becoming characters in the group (Venturella et al., 2015).

In this mixed-methods study we focus on the group and turn-taking dimensions of the therapists. From a psychoanalytical theory perspective, the group interventions of the therapists were divided into clarification (I1), confrontation (I2), and interpretation (I3). Clarification allows the therapist to emphasize essential elements in communications and perceptions, confrontation stimulates an interest in thinking, reflecting, and understanding behavior in relation to others, and interpretation is a hypothesis as to how a group participant may feel in the here and now of a session (Coderch, 2009; Ferro and Civitarese, 2016).

In this study we were especially interested in observing how the two therapists related and interacted as co-therapists with each other and with the children.

Co-therapy is very frequent in group work (Roller and Nelson, 1996), with advantages and benefits as follows: (a) co-therapy expands creativity and the range of interventions and techniques and so improves transfer and control of countertransference; (b) the therapists complement each other with their knowledge, skills and personalities, while still being able to adopt different positions; (c) the therapy process is improved and shortened; (d) there is mutual support and supervision; (e) responsibilities and decision-making are shared; and (f) the interaction between therapists facilitates the outsourcing of covert conflicts and ambivalence. Furthermore, co-therapy is a highly versatile tool that can be used in many ways and in numerous configurations (Kosch and Reiner, 1984; Hoffman and Laub, 2006). From a psychoanalytical perspective, co-therapy has been focused on pair therapy (Sommantico, 2016). In work with children and adolescents, however, and specifically in the ASD-Sibs setting, there is a research vacuum.

The Society of Group Psychology and Group Psychotherapy provides some arguments against psychotherapy groups conducted with a single therapist (Breeskin, 2013): (a) lone therapists, no matter their expertise, will likely fail to keep up with the richness of the group experience, expressed in non-verbal signals and parallel conversations, which are important details that are at risk of being lost; (b) lone therapists could fail to keep pace with the group's needs, harming themselves and the participants; and (c) lone therapists in charge of a group means offering professional practice without minimum reference values for the same participants. In short, a therapy partnership offers the opportunity to interpersonally shape a powerful model for the group of participants. A study of 54 co-therapy pairings found that predictors of satisfaction were aspects such as theoretical compatibility and differences in confrontation styles; also significant was being able to select the experience of working together in co-therapy (Bridbord and DeLucia-Waack, 2011). From our perspective, because of the complexity of the interactions, the group phenomenon and the co-therapy relationship, we focused our study on communication, specifically on the interventions and complementarity of the co-therapy relationship.

The training of the therapists is the solid foundation that ensures the studied group become therapeutic. Since the group in question is not a self-help group or a group with a specific requirement, but rather resembles a parent or family group, we may define it as a support group. Support groups, in contrast with *ad hoc* crisis intervention groups, are designed to offer emotional support to persons sharing a common problem or handicap (Scheidlinger, 2005). But unlike a standard support group working on the subject that links it, our intervention group reinforces individual and group work so that the therapeutic work is self-validated.

Also relevant here is Scheidlinger's idea of the mother-group, which refers to an aspect of identification with the group entity that connotes a covert wish of group members to restore a state of unconflicted well-being, characteristic of an earlier tie to the mother (Scheidlinger, 1974). This longing for a return to that relationship and its unequivocally positive need-gratifying elements is brought directly to bear in and by the group.

The main objective of our research was to study the interaction of therapists and children using a mixed methods framework, an approach that has acquired a certain tradition in recent years (Arias-Pujol and Anguera, 2017; Del Giacco et al., 2019), in accordance with the Guidelines for Reporting Evaluations Based on Observational Methodology (Portell et al., 2015). Specifically, we wanted to identify the existence of possible patterns of behavior in the communicative interactions between children and therapists (a) in turn-taking and (b) breaking down interventions involving clarification (I1), confrontation (I2), and interpretation (I3) for therapist 1 (T1) and therapist 2 (T2) separately and for the two therapists as a single focal subject (co-therapists, CT).

MATERIALS AND METHODS

Design

The observational methodology offers eight types of observational designs (Anguera et al., 2011; Sánchez-Algarra and Anguera, 2013; Anguera and Hernández, 2015) based on three criteria: the number of participants (idiographic or nomothetic), the continuity of the recording (one moment or follow-up) and the number of criteria observed (unidimensional or multidimensional). The design of our research was N/F/M, i.e., it was nomothetic (N) because we studied six subjects (two therapists and four children), it consisted of follow-up (F) because we transcribed six consecutive and multidimensional group sessions, and it was multidimensional (M) because we coded different dimensions of the observed behaviors with concurrent and event-base data from quadrant II of the systematic observation design.

Participants

The six participants were two women therapists (T1, T2) and four children aged 6–9 years old (P1, P2, P3, P4).

The therapists are clinical psychologists with decades of experience with groups and with autism from a psychoanalytical perspective, and T1, who is older than T2, is also a psychoanalyst.

Regarding the participating children, inclusion criteria were (a) age 6–9 years, (b) attendance at a standard school, and (c) having an ASD-Sib. Exclusion criteria were a diagnosis of pervasive developmental disorder (PDD) and attendance at psychotherapy. The therapists requested the permission of the parents to include their children in the group.

Intervention Design

The support group intervention was offered in Carrilet Education and Therapy Center (Barcelona, Spain), which specializes in the care of people with autism and their families. A sibling support group offers siblings a space where they can express their feelings and talk about issues in their relationship with the ADS-Sib without fear of hurting their parents. The group has both an educational and therapeutic focus. Autism is discussed with other children who are living a similar experience and with adults who are not members of the family. In words and through play, using plasticine, drawings, etc., the children express feelings, including fear, jealousy, anger, guilt, etc. The psychoanalytical therapists legitimize the ambivalence of the children's feelings and help them understand and contain their emotions. Through conversation and play these children share feelings that could easily be silenced within the family and this helps them develop their own differentiated identity (Fieschi et al., 2011; Venturella et al., 2014).

The setting is a 1-h monthly meeting over 2 years. Before each session, the therapists send a reminder letter to the children's home regarding the upcoming session. As material, the group uses two shared boxes, one with colored plasticine and the other with two foldable wooden figures of families (father, mother, girl, and boy), paper, colored crayons and pencils, rubbers, scissors, and a folder for drawings. The group's activities focus mostly on the wooden dolls and the plasticine, and the plasticine figures made by the children are kept, with some becoming like persons in the group.

At the family level, there are three meetings with parents, two in groups (one each before and after the main sessions) and an individual meeting (Fieschi et al., 2011; Venturella et al., 2014).

In accordance with the principles of the Declaration of Helsinki and the Ethical Code of the General Council of the Official College of Psychologists of Spain, the participants were informed that they were being filmed and parents signed a written informed consent, authorizing the participation of their children in this research. In relation to this study, on the first day of therapy, the reason for filming was explained to the subjects, along with the privacy and confidentiality conditions regarding session content. During the sessions, an observer (a psychologist in training) sat at a distance from the table where the group's conversation was taking place and took notes.

Instruments

We used both observation and recording instruments.

Our *ad hoc* observation instrument, following observational methodology canons (Sánchez-Algarra and Anguera, 2013; Portell et al., 2015), combined field format with category systems (Anguera and Izquierdo, 2006; Anguera et al., 2007) and was structured according to the dimensions identified from the conceptual framework. A system of categories was built from the dimensions, which was hierarchical in some of the dimensions (i.e., macro-categories that unfolded into categories). This instrument was designed to fulfill exhaustiveness and mutual exclusivity requirements for each of the category systems. For this reason, all verbal/vocal expressions by the children and the therapists were first transcribed in full. Their analysis resulted in an instrument of 27 codes in four dimensions: (1) turn-taking, (2) group, (3) ASD-Sib, and (4) play. The turn-taking dimension, which reflected turn-taking in speaking, was divided into two macro-categories: therapists and children. The group dimension, which considered the participatory interactions in each turn, was distributed in five macro-categories: body, sound, brief, relationship, and intervention. The ASD-Sibs dimension – the common element among the participating children – reflected all comments regarding the sibling with autism. Finally, play reflected the techniques used to foster interaction and expression within the group.

Figure 2 depicts the observation instrument with the dimensions along with a description of the macro-categories and codes (the number of the codes does not reflect range or quantity).

We focused on the intervention macro-category (the group dimension) and on specific communications between therapists in relation to the emotional field of the children. To better exemplify the data analyzed below, **Figure 3** shows fragments of text that could potentially represent the intervention macro-category (indicated in dark gray).

Used as the recording instrument – to ensure maximum accuracy in data collection – was a video camera. To minimize the reactivity bias of the participants, the camera was positioned discreetly at a high viewing angle in the room.

Group			
Macro category	*Description*	*Code*	*Description*
Bodily	Gesture and action of the hands or body used to communicate a message to another person.	**C1**	When the participant does not answer a question verbally and shrugs their shoulders.
		C2	When the participant does not answer a question verbally and moves their head from side to side to say 'no'.
		C3	When the participant does not answer a question verbally and nods to say 'yes'.
Sound	The presence or absence of sounds that interrupt the group communication and the turn-taking	**S1**	Silence, without verbal or body communication.
		S2	Voluntary or involuntary reflex, such as a cough or sneeze.
		S3	Laughter or other sounds of humor.
Brief	Very short expressions that do not express a question or therapeutic intervention.	**B1**	Very short answers that express agreement.
		B2	Very short answers that express disagreement or doubts.
		B3	Greetings expressed at the beginning or end of the session or short answers with positive connotation.
Relationship	Verbal communication that promotes and advances the conversation. Transmits the thought or speaker's feeling.	**R1**	Literal repetitions of the other person's speech in a declarative or interrogative way.
		R2	Speech that interrupts turn-taking that does not fulfill a function of containment by the therapists.
		R3	Relationship and interaction, which give flow and follow-up to the conversation.
Intervention	Interventions of the therapists that move to the emotional field.	**I1**	The interventions that summarize, synthesize and emphasize the communication of group participants, seek to clarify the content and collect previous facts, also place limits on the subject change or other interference outside the issue of common interest.
		I2	The interventions that stimulate the participants and/or the group, the interest in their behaviour, allow associations that would not otherwise occur. They include empathic and confrontational interventions.
		I3	The interventions that explain to the participant and/or the group the unconscious sense of their verbal statements and their behaviour, seeking to connect the behaviour with their emotion.

Sibling ASD			
Macro category	*Description*	*Code*	*Description*
Sibling	Turn-taking that refers to ASD siblings.	**H1**	He/she talks about the sibling diagnosed with ASD at a more descriptive and explanatory level. It does not directly express an emotion or a conflict.
		H2	He/she talks about the sibling diagnosed with ASD explaining some situation of conflict that can be experienced as confusing or contradictory.
		H3	He/she talks about the sibling diagnosed with ASD explaining some situation of structuring function that exerts influence in the processes of identification of the self and the group.

Play			
Macrocategory	*Description*	*Code*	*Description*
Game Material	Situations in which the game and the game material prevail.	**M1**	Talk about the material or the game in a descriptive and explanatory way or request some material.
		M2	Through the game there is a discharge of anxiety, of guilt, of displeasure. From a more visceral game damaged objects, violence, hunger, sadness, loneliness and anger appear.
		M3	Through the game there is a compensation for conflicts. From a mentalized affectivity foods that satisfy, gifts, surprises, friendships, queens, princesses, parties, tranquility and protection appear.

FIGURE 2 | Code description.

Procedure

For the purposes of this study, we used recordings of six sessions from the first year with the group, but excluded three of these as not being fully audible.

All sessions were video-recorded and subsequently transcribed in full. For the transcribed conversations between the children and the therapists, intervention turns were considered as the units of analysis, which were assigned the codes reflecting each dimension from the observation instrument.

Data Quality Control: Interobserver Agreement

Data quality control was implemented to ensure that codes were correctly assigned. Three observers, previously trained using the approach described by Anguera (2003), analyzed and coded two of the sessions.

Interobserver agreement was measured using Cohen's kappa (k) (Cohen, 1960, 1968), following Bakeman and Quera (1996, 2011), resulting in values of 90–97% (rated as "very good agreement"). To discriminate interrelationships between the different observers and their standard errors, canonical concordance with a third observer was calculated (Anguera, 1997, 2003; Krippendorff, 2004, 2013), resulting in a Krippendorf's alpha (α) value of 96% (with values above 80% indicating reliable data). These values indicate that the categories were well defined and had good consistency, with the fact that the system was highly concordant guaranteeing the reliability of the material encoded for subsequent analysis.

Data Analysis

Since our goal was to detect the existence of possible patterns of behavior in communicative interactions between the therapists and the children, we used intersessional sequential analysis, considered to be the most suitable data analysis technique for our purposes. The sequential analysis technique, developed by Bakeman (1978) and Sackett (1978, 1979) more than 40 years ago, essentially detects whether certain stable behavioral patterns have a greater probability of occurrence than would be expected by chance (Bakeman, 1978; Bakeman and Gottman, 1989; Bakeman and Quera, 2011). Since sequential analysis detects hidden patterns, it is considered an excellent methodology for studying communication in psychotherapy research groups. It has proven to be especially suitable for studying changes that occur over sessions (Arias-Pujol and Anguera, 2004, 2005, 2017; Vaimberg, 2010, 2012; Arias-Pujol, 2011; Roustan et al., 2013; Del Giacco et al., 2019), as well as in families (Gimeno et al., 2006), education (Rodríguez-Dorta and Borges, 2017; García-Fariña et al., 2018), and sports (Lapresa et al., 2013).

In our study we applied it to an analysis of concurrent and event-based quadrant II data. For our analysis, we used GSEQ v.5.1 software (Bakeman and Quera, 2011), in which an algorithm compares the unconditional and conditional probabilities of behavioral occurrences (in our case, Text extracted from session 3:

Excel Line	TURN	TEXT	GROUP	S.ADS	PLAY
681	TE	TE: PMi, is a nativity scene that has done?	R3	ø	M1
682	PMi	PMi: Yes.	B3	ø	ø
683	TE	TE: I thought now that you finish what you're doing, because it is our time to end this meeting.	I1	ø	ø
684		PMe pick up the dolls	ø	ø	ø
685	PMe	PMe: Two…	R2	ø	ø
686	TN	TN: The father, sisters and mother.	I1	ø	ø
687	TE	TE: See if there is a place for everyone to be nearby. At heart he is doing the PM. How do you say?	I1	ø	ø
688	TN	TN: PMi!	R3	ø	ø
689	TE	TE: PMi… it's a family are all together.	I2	ø	ø
690	TN	TN: The cave.	I3	ø	ø
691	TE	TE: Nativity, and a family are all together.	I3	ø	ø
692	TN	TN: We are not a family, but we are a group that we put together here to talk about things that are important.	I2	ø	ø
693	PMe	PMe: Yes.	B3	ø	ø
694	TN	TN: It's good have a families and groups that we can feel nearby and that allow us not to feel invisible, right?	I2	ø	ø
695	TE	TE: Yes.	B3	ø	ø

Text extracted from session 6:

Excel Line	TURN	TEXT	GROUP	S.ADS	PLAY
195	TE	TE: And that is making doll, what's it, as they say. PMi has a name?	R3	ø	M1
196	PMe	PMe: Yes or not?	R3	ø	M1
197	TN	TN: The PMi is very quiet today.	I1	ø	ø
198	TE	TE: She is highly concentrated.	I2	ø	ø
199	TN	TN: She is as mysterious.	I3	ø	ø

Text extracted from session 9:

Excel Line	TURN	TEXT	GROUP	S.ADS	PLAY
741	TE	TE: Of course, everyone is happy everyone is a little difficult. There are times that …	I1	ø	ø
742	TN	TN: There is always a bit fear…	I2	ø	ø
743	TE	TE: A bit of disgust.	I3	ø	ø
744	TN	TN: As a bit like today, we had some violent messages, some messages of spring, there is always a little bit of everything, of course.	I3	ø	ø

FIGURE 3 | Transcription examples.

prospectively and retrospectively) in the form of frequencies of transition to a criterion behavior, established according to the objectives of the study.

Since the study refers to communication processes, in an initial analysis, we separately considered the intervention turns of the therapists (T1 and T2) and of the grouped children (children) as the criterion and conditional behaviors. In a second analysis, we separately considered the criterion behavior of each therapist for the three forms of intervention, i.e., clarification (T1I1, T2I1), confrontation (T1I2, T2I2) and interpretation (T1I3, T2I3), and used the remaining codes as the conditional behaviors. In a third analysis, the co-therapy (CT) macro-category was taken as the criterion behavior for the three intervention forms (CTI1, CTI2, CTI3) and the remaining codes were taken as the conditional behaviors.

Using the binomial test and the Allison-Liker correction (Allison and Liker, 1982), residuals in lags adjusted from −2 to +2 were calculated [**Table 1** shows an example of the adjusted values (RSAJ)]. The analyses were done separately for each of the ten criterion behaviors. Using the GSEQ software, data were entered as .SDS files using the multievent option and then compiled to obtain the .MDS files proposed via the respective. GSQ files were the criterion and conditional behaviors for each analysis and the corresponding lags. The results in .OUT files for each analysis pointed to the existence of various excitatory behavior patterns (>1.96, for $\alpha = 0.05$) (Bakeman and Quera, 1996, 2011).

RESULTS

Our results are described in four sections: the first reflects turn-taking between the therapists and the children, while the remaining three reflect behavior patterns in relation to use of clarification, confrontation, and interpretation by each therapist separately (T1 and T2) and then together in co-therapy (CT). The

TABLE 1 | Example of adjusted values (RSAJ) obtained for turn-taking between T1, T2 and the child subjects.

Given:	T1	T2	P1	P2	P3	P4
−1						
T1	−21.58	7.15	6.29	6.61	2.24	4.95
T2	9.72	−28.75	12.24	2.82	7.83	4.97
P1	2.61	15.15	−14.46	−4.35	−5.58	0.2
P2	6.09	2.72	−3.43	−1.64	−2.66	−4.91
P3	4.83	8.91	−7.02	−3.34	−3.82	−5.58
P4	3.7	4.01	−0.07	−3.98	−2.51	−6.13
0						
T1	77.78	−31.29	−21.75	−11.3	−14.25	−14.94
T2	−31.29	77.78	−25.14	−13.06	−16.47	−17.27
P1	−21.75	−25.14	77.78	−9.08	−11.45	−12.01
P2	−11.3	−13.06	−9.08	77.78	−5.95	−6.24
P3	−14.25	−16.47	−11.45	−5.95	77.78	−7.86
P4	−14.94	−17.27	−12.01	−6.24	−7.86	77.78
1						
T1	−21.58	9.72	2.61	6.09	4.83	3.7
T2	7.15	−28.75	15.15	2.72	8.91	4.01
P1	6.29	12.24	−14.46	−3.43	−7.02	−0.07
P2	6.61	2.82	−4.35	−1.64	−3.34	−3.98
P3	2.24	7.83	−5.58	−2.66	−3.82	−2.51
P4	4.95	4.97	0.2	−4.91	−5.58	−6.13

*See **Figure 4** for a pattern formed from significant results, with values >1.96, for α = 0.05.*

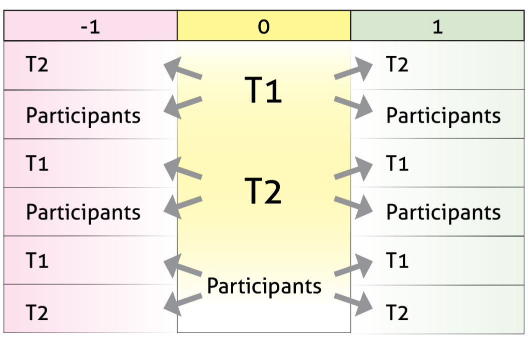

FIGURE 4 | Results for significant behavior patterns corresponding to turn-taking by therapists T1 and T2 and child participants P1, P2, P3, and P4.

analysis yielded ten distinct interactive behavior patterns between lags −1 and +1 responding to the question: what precedes and what succeeds therapeutic interventions?

Relationships Between Separate Turn-Taking by T1 and T2 and the Children as a Group

This first set of patterns with arrows, as shown in **Figure 4**, point to clear symmetry and reciprocity between T1, T2 and the children. This suggests that communication in the group is fluid and that each person is stimulated by the others to participate.

Relationships Between T1 Turn-Taking Interventions Using Clarification, Confrontation, and Interpretation and T2, P1, P2, P3, and P4 Turn-Taking

The second set of results, depicted in **Figure 5**, points to differing behavior patterns. In the first pattern, we see how the clarification intervention by T1 arises after the same kind of intervention by T2 or after a brief response by one of the children (P2 B1). These interventions generate short responses (B1, B3) by two other children (P2, P4).

The use pattern of confrontation by T1 is this time much more complex. T1 confrontations follow T2 interpretation interventions (T2 I3) or involuntary behaviors, such as a cough or sneeze (T2 S2), and lead to clarification (I1) and confrontation (I2) interventions by T2. Regarding the children, we see that P1 stimulates T1 with brief interventions (B1) or follow-ups to the conversation (R3), P2 uses non-verbal resources (C1, C3, and S2) and verbal follow-ups to the conversation (R3), whereas P4 laughs. After the therapist has intervened, one of the children (P2) responds with non-verbal approval gestures (C3). The pattern also reflects the possibility of a response in the form of silence (S1) or of a comment regarding the game (M1).

In relation to T1 interpretations, we also see that these follow interpretation interventions (I3) or laughs (S3) by T2 and, in turn, generate confrontation (I2) and interpretation (I3) interventions. As for the children, of note is humor (S3), short answers (R1) and comments regarding the game (M1) by P3 or involuntary reflexes, such as coughs or sneezes (S2) by P4 prior to the interpretation by T1. *A posteriori*, the interpretation generates brief expressions of disagreement or doubt (B2) in two of the children (P1 and P4) and interruptions (R2) by another child (P3).

Figure 6 shows an example of a communicative behavior pattern in the use of confrontation by T1.

Relationships Between T2 Turn-Taking Interventions Using Clarification, Confrontation, and Interpretation and T2, P1, P2, P3, and P4 Turn-Taking

This third set of results, depicted in **Figure 7**, is even more complex that the previous set. In the first pattern we see how the clarification intervention (I1) by T2 follows the clarification intervention (I2) by T1 or a brief response (B1), non-verbal response (C3) or coughing or sneezing (S2) by the children (P2, P3, P4, respectively). T2 clarification interventions generate coughing or sneezing (P2 S2), very short responses or verbal agreement (P3 B1), silence, or comments regarding the game.

As for confrontations (I2) by T2, these follow interpretation or laughter by T1. *A priori* of the confrontation intervention, the children (P1) briefly express agreement (B1) or doubt (B2), or respond non-verbally, defensively or with laughter (P2), or express their collaboration with the conversation (P3). The confrontational interventions by T2 generate short responses, positive answers or interruptions by P1, collaborative

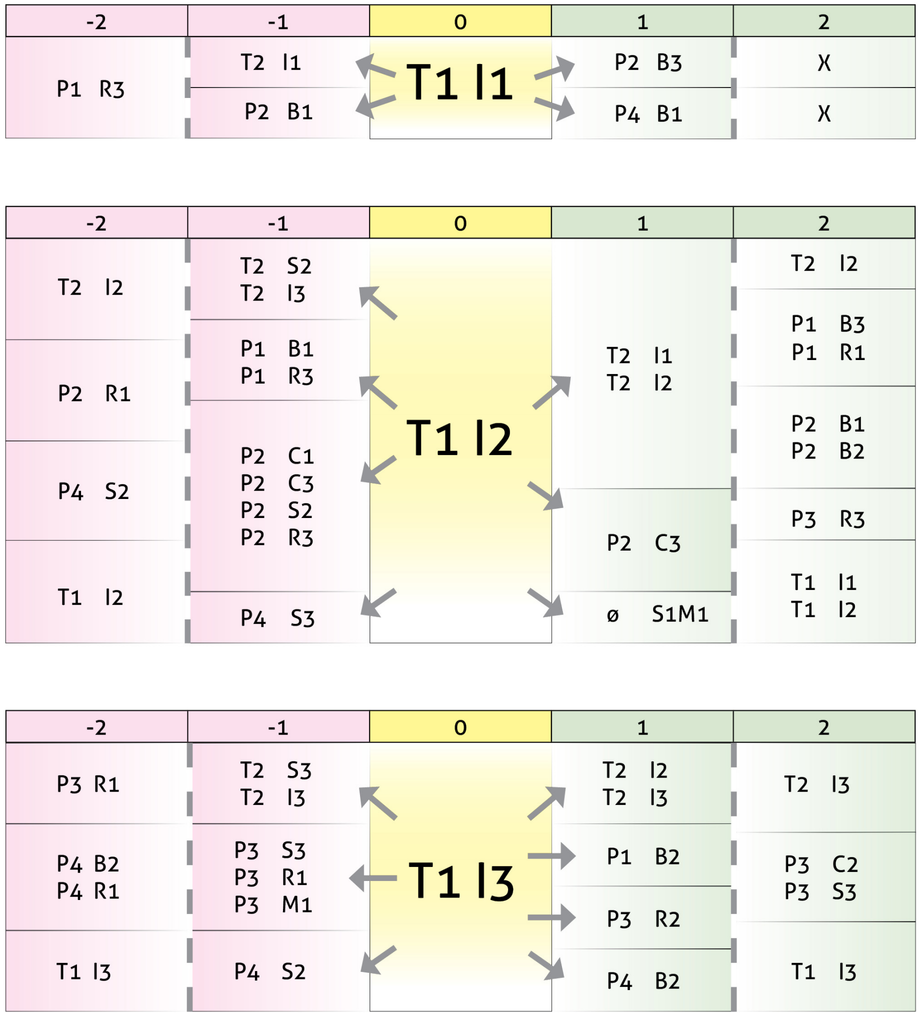

FIGURE 5 | Results in the form of behavior patterns for interactions between turn-taking interventions by therapist T1 as the focal subject, using clarification (I1), confrontation (I2), and interpretation (I3), and turn-taking by therapist T2 and child participants P1, P2, P3, and P4.

Turn	Text	Group	Sibling ASD	Play
P2	P2 shrugs his shoulders and hands in doubt.	C1		
T1	**T1: What happened if the light was on?**	**I2**		
Ø	T2 looks at the camera and moves the boxes of materials closer to his side.	S1		M1

FIGURE 6 | T1 – Significant pattern example.

responses by P3, coughing or sneezing by P4 or silence in the whole group.

In relation to the children, the interpretations of T2 arise from brief expressions of gratitude or collaborative interventions by one child (P1), interruptions by another child (P4) and a non-verbal response by yet another child that stimulates laughter (P2). The interpretations of T2 stimulate interpretation (I3) or confrontation (I2) interventions, and also coughing or sneezing (S2) by T1 and laughter or other sounds reflecting humor in P2.

Figure 8 shows an example of a communicative behavior pattern in the use of clarification by T2.

Relationships Between CT Turn-Taking Interventions Using Clarification, Confrontation, and Interpretation and P1, P2, P3, and P4 Turn-Taking

This final set of results shows that when T1 and T2 are grouped together (i.e., CT), communicative patterns are simplified

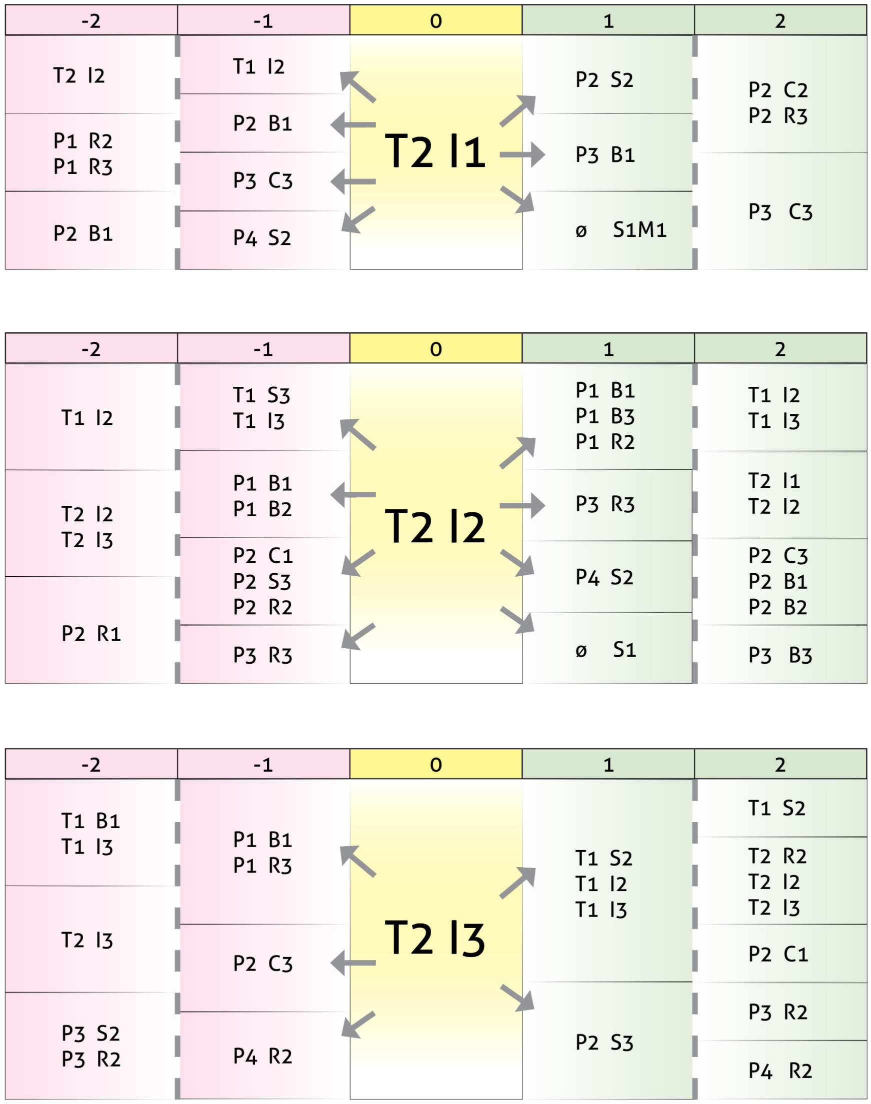

FIGURE 7 | Results in the form of behavior patterns for interactions between turn-taking interventions by therapist T2 as the focal subject, using clarification (I1), confrontation (I2), and interpretation (I3), and turn-taking by therapist T1 and child participants P1, P2, P3, and P4.

Turn	Text	Group	Sibling ASD	Play
T2	It might be what you said P3, that one of the difficulties your sister might have is that it's difficult to play with her, so maybe it's hard to figure out how to play with her.	I1	H2	
P3	Yes, because if she hooks up to something.	R3	H2	
T2	**And you don't find her.**	**I1**		
P3	And there's noone who can get her out of there.	R3	H2	
T2	Does this happen with your sister P4? Is it hard for your sister to play?	I2		
Ø	At this point there's 3 seconds of silence.	S1		

FIGURE 8 | T2 – Significant pattern example.

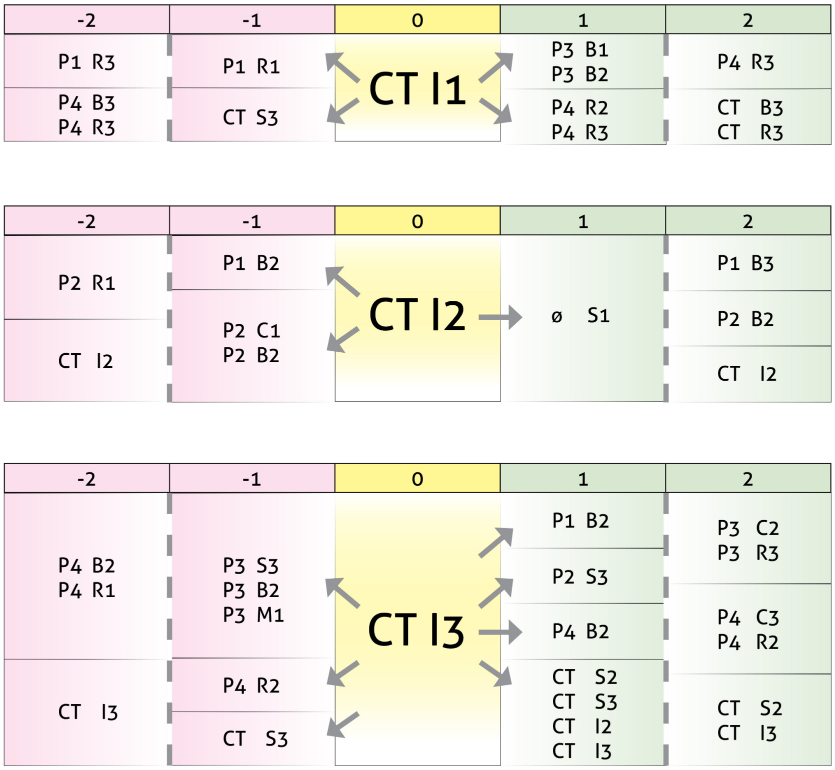

FIGURE 9 | Results in the form of behavior patterns for interactions between turn-taking interventions by the therapists together (CT) as the focal subject, using clarification (I1), confrontation (I2), and interpretation (I3), and turn-taking by child participants P1, P2, P3, and P4.

Turn	Text	Group	Sibling ASD	Play
P2	Shrugs shouders and raises hand to signal doubt.	C1		
T1 o T2 = CT	**And what happened if the light was turned on?**	**I2**		
Ø	T2 looks in the direction of the video camera and sets the boxes of play materials to one side.	S1		

FIGURE 10 | CT – Significant pattern example.

somewhat, as shown in **Figure 9**. The first detected pattern is clarification interventions following repeated questions by one child (P1 R1) or laughter or other sounds reflecting humor by the therapists, generating brief assent (B1) or doubt (B2) interventions in another child (P3) or interruptions (R2) or interventions that foster progress (R3) in yet another child (P4).

When the focal subject is CT, confrontation interventions arise after non-verbal responses by P2 or brief interventions expressing doubt or disagreement by two of the children (P1, P2), generating silence in the group.

Finally, CT interpretation interventions arise after laughter or other sounds reflecting humor in one of the children or the therapists (P3, CT), or brief interventions expressing doubt or disagreement (B2) by one of the children (P3) or interruptions (by P4). These interpretations generate other brief interventions expressing doubt or disagreement (P1, P4), laughter (P2, CT) or other confrontation interventions by the therapists (CT).

Figure 10 shows an example of a communicative behavior pattern in CT use of confrontation.

DISCUSSION

The intervention macro-category was designed as a resource and as a means of communication for psychoanalytical therapists T1 and T2. Unlike the other categories, interventions introduce new variables and new emotional experiences and help to develop new mental models. The changes seen in the children were the result of the attitudes and verbal interventions of the therapists, whether clarification (I1), confrontation (I2), or interpretation (I3).

In the group, both therapists perform clarification after a brief communication (body or sound). As the therapists do not introduce feelings or ideas that the children have not expressed, these continue with a similar discourse in the form of a brief response, some sound or silence, followed by manipulation of the material. Given its simplicity and neutrality, this intervention generates confidence and helps improve connections between participants (Coderch, 2009).

Confrontation arises when thoughts are explored in depth (Ferro and Civitarese, 2016). In the group, this type of intervention occurs after brief, body and sound responses, as well as after responses of a more relational nature. Since the therapist highlights omitted aspects, the response is mostly silence, in some cases accompanied by manipulation of the material, by a brief communication (body or sound) and, occasionally, by a more relational tracking response. To a lesser or greater extent, the response is directive. The fact that the main objective may be to facilitate the transition from clarification to interpretation would explain a downward tendency during the group session.

Confrontation helps children overcome their difficulties in expressing themselves. It also facilitates clarification and interpretation interventions (Lichtenberg, 2016). Interpretation is a basic psychoanalytic instrument. To interpret is to explain the unconscious meaning of statements to patients. In the group, interpretation interventions are also represented after brief, body, sound, and relational communications. However, they add to the sequence of material and play, through which therapists inform children of unconscious mental processes that direct and condition their relationships with others. Subsequent responses are usually given by the therapists themselves or, briefly, by the children.

The therapist's efforts focus on bringing the patient to an understanding of how to balance their inner fantasies with influences from the external world.

The emergence of behavioral patterns of silence or of responses that reflect collaboration or dissatisfaction in the children in response to the interventions of the therapists is consistent with results obtained in previous research on the role of the psychoanalytic therapist in group sessions (Arias-Pujol and Anguera, 2004, 2005) and in individual sessions (Arias-Pujol et al., 2015).

In our sequential analysis it was found that T1 activates clarification and confrontation interventions by T2 but does not follow up on these interventions. The opposite happens in the interpretation interventions, where T1 does not activate T2 interventions, but does follow up. T2 activates all the three types of interventions by T1 and follows up on confrontation and interpretation interventions.

Both therapists are women. T1 (the older therapist) seems to assume a greater role in containment, tolerance, and follow-up. The younger T2 seems to play a role that is more activating, verbal and available (Kosch and Reiner, 1984). As noted in the results, therapeutic interventions present significant sequences in the response patterns that precede and succeed them.

The co-therapy (CT) analysis, more global than the analysis of individual relationships within the group, is characterized by more general aspects and issues reflecting the group as a whole. Along these lines, it can be observed that in the CT clarification intervention, P1 is hidden in previous analyses of this category, and, at the same time, the leadership of the other children is obscured. While the subsequent responses are similar to those of the therapists in isolation, there is no room for the silence represented above.

In the confrontation, the two protagonists of separate interventions by the therapists stand out, but therapists conceal what the other children express and leave silence evident. In this case, if the game is not followed up, then this is the only possible response.

Interpretation implies deeper intervention. The co-therapeutic result helps protect the children, since previous and subsequent follow-ups to the interpretation intervention take place between the therapists themselves (Blum, 2016). Thus, T2 activates T1's interpretation and follows up, and T1 activates T2's interpretation and follows up.

These functions do not follow a rule, nor are they permanent. The therapists adapt them to the requirements of the children and complement them in their interventions. Noteworthy is the sum of the attitudes of T1 and T2 in their co-therapeutic work. The fact that they share a theoretical framework and have experience of working together boosts their expertise in creating a facilitating space and in allowing interactions through dialog and play (Bridbord and DeLucia-Waack, 2011). However, we consider that one of the most valuable aspects of this kind of group is the possibility of representing a certain "family model," where therapists are representatives of adults and of children as siblings. Scheidlinger (1974) specifies the need for group members to establish wellbeing regarding the mother (therapists), as a powerful force of identification and connection for the group as a whole.

Of course, there is no differentiation of functions other than those determined by the personal and professional characteristics of each therapist; however, alternating between different functions means they participate in the transference process.

As observed in our results, analyzing the profiles of the therapeutic partners (co-therapists) draws attention to children and responses not observed in the individual analyses of each therapist's interventions.

The results also show that children speak little of their siblings with autism and participate in the sessions spontaneously with all kinds of interventions (liking, disliking, laughter, play, etc.). The communicative richness evident in their behavior patterns reinforces the importance of offering this type of intervention for children with ASD-Sibs (Shivers et al., 2018). The support group helps them think about and of themselves and facilitates their development of a differentiated identity (Fieschi et al., 2011; Centre Educatiu i Terapèutic Carrilet, Alcácer et al., 2013; Venturella et al., 2014).

CONCLUSION

In addition to our sequential study of the interventions, we were able to observe parallels and interwoven relationships for the two therapists, who complement each other in the direction in which their interventions are intended. Basic aspects of co-therapy include shared impressions, continuous exchanges and integrated countertransference aspects (Cabré, 2002). As noted by Scheidlinger (2005), most group therapists tend to adhere to a pluralistic-integrative orientation that appears to be suited to the complexity of individual and group-level manifestations.

A limitation of our study is the fact that results cannot be generalized, given the small size of our sample, both in terms of the number of sessions and the variety of attitudes. Rather, the group should be considered as a unique case analyzed in depth in terms of individual processes.

The methodological characteristics used are highly appropriate for a study of group processes and human interactions (Anguera and Hernández, 2015). However, the complexity and diversity of behaviors to be observed meant we were unable to use a standard instrument. Therefore, a great deal of time was devoted to preparing a tailormade instrument, based exclusively on the profile of the studied group. Our experience suggests that, as proposed by Breeskin (2013), it would be of great interest to broaden the theoretical foundations of co-therapy, as, with further monitoring and evaluation, other groups may benefit from the developed *ad hoc* instrument and so evolve to new lines of research.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of "Comitè d'Ètica de la Recerca (CER-URL)" with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the "Comitè d'Ètica de la Recerca (CER-URL)."

AUTHOR CONTRIBUTIONS

MV developed the project and performed the sequential analysis. VC and XC contributed to the documenting and writing of the manuscript. EA-P supervised the project, designed the study, developed the methodology, and drafted the manuscript.

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Data Mining in the Mixed Methods: Application to the Study of the Psychological Profiles of Athletes

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Data mining is seen as a set of techniques and technologies allowing to extract, automatically or semi-automatically, a lot of useful information, models, and tendencies from a big set of data. Techniques like "clustering," "classification," "association," and "regression"; statistics and Bayesian calculations; or intelligent artificial algorithms like neural networks will be used to extract patterns from data, and the main goal to achieve those patterns will be to explain and to predict their behavior. So, data are the source that becomes relevant information. Research data are gathered as numbers (quantitative data) as well as symbolic values (qualitative data). Useful knowledge is extracted (mined) from a huge amount of data. Such kind of knowledge will allow setting relationships among attributes or data sets, clustering similar data, classifying attribute relationships, and showing information that could be hidden or lost in a vast quantity of data when data mining is not used. Combination of quantitative and qualitative data is the essence of mixed methods: on one hand, a coherent integration of result data interpretation starting from separate analysis, and on the other hand, making data transformation from qualitative to quantitative and 1 vice versa. A study developed shows how data mining techniques can be a very interesting complement to mixed methods, because such techniques can work with qualitative and quantitative data together, obtaining numeric analysis from qualitative data based on Bayesian probability calculation or transforming quantitative into qualitative data using discretization techniques. As a study case, the Psychological Inventory of Sports Performance (IPED) has been mined and decision trees have been developed in order to check any relationships among the "Self-confidence" (AC), "Negative Coping Control" (CAN), "Attention Control" (CAT), "Visuoimaginative Control" (CVI), "Motivational Level" (NM), "Positive Coping Control" (CAP), and "Attitudinal Control" (CACT) factors against gender and age of athletes. These decision trees can also be used for future data predictions or assumptions.

Keywords: data mining, clustering, sport, sport psychology, mixed methods

INTRODUCTION

Data Mining Added to Mixed Methods and Cluster Algorithms

Data mining is a technique that tries to find behavior patterns in large data sets in order to explain them. There are many data mining techniques. One of them is clustering. Clustering technique allocates data into subsets that share some characteristics. Elements in each cluster are or have some features similar to the other elements in the cluster, but they also are or have some features different to elements. This is a very useful tool because it allows you to find or identify unknown groups that frequently are not identified by humans (Zaki and Meira, 2014; Witten et al., 2016).

Cluster analysis is often used to learn about data distribution, raising common features of the data and noticing interesting clusters that can be analyzed in detail. Clustering is also taken as a previous step for several algorithms, such as "classification" or "attributes selection," which would work better and faster over selected smaller set of attributes. Clustering is usually called automatic classification because it distributes data into sets (Dutt et al., 2015; Thomas et al., 2018).

Main clustering features are as follows:

- *Scalability*: Although many clustering algorithms can work reasonably well on small data sets with less than hundred elements, they work even better with a large database containing millions or even billions of elements like Web search results.
- *Ability to deal with different types of attributes*: As we cannot make any supposition about data, clustering algorithms are designed to work on numeric (interval-based) data, binary, nominal (categorical), ordinal data, or all of them.
- *Ability to deal with noisy data*: Data from real world has outliers, missing, unknown, or erroneous data, so clustering algorithms have to be strong and resilient to filter and reject the "noise" (Patel and Thakral, 2016).

In the following, the main clustering methods and their characteristics (Ramesh and Nandhini, 2017) will be described: (1) partitioning methods (look for mutually exclusive clusters of spherical shape; they are distance-based and frequently use the mean to represent the cluster center; they are effective for small to medium size data sets); (2) hierarchical methods (based on the idea that clustering is a hierarchical decomposition and cannot correct erroneous merges or splits; they may add other techniques like microclustering or see object "linkages"); (3) density-based methods (they look for arbitrarily shaped clusters; they work on the supposition that clusters are dense object zones in space separated by low-density zones; they set each point must have a minimum number of neighbor points to take outliers out); and (4) grid-based method (they put data into a grid that allows a fast processing dependent only on the size of the grid).

Building a Classifier

A classifier identifies an instance's class (Fayyad, 1996; Otero and Sánchez, 2006) based on a training set of data. WEKA is a software tool that implements some classifier algorithms. The "J48" algorithm has been used for data analysis in the current studio in order to generate decision trees.

The J48 decision tree algorithm is a classification tool (Kaur et al., 2015). It creates one acyclic graph structure (a tree) where attributes are represented in the internal nodes and the arcs represent how values are split. Each leaf node will be a value from goal class. Decision trees are often built from a training set and then they will be used as a model of the problem in order to predict a future behavior.

A frequently used technique in data mining is the decision tree learning. As previously mentioned, it will create a model based on one input training set of data that can be used to predict values in the target variable. Each leaf node represents one value of the goal class and each top-down route in the tree will be the decisions taken in the other variables of our study.

The decision tree algorithm involves three steps:

(1) One attribute I selected as target or goal class.
(2) Choose the attribute splitting data in the smallest number of subsets.
(3) Each generated node has to go to step #2 (Iterative Dichotomiser).

The ID3 algorithm was developed by Quinlan in 1986. It uses the concept of Information gain as its splitting criterion for splitting nodes. Root node will be the best predictor. In the following, the highest information gain attribute is selected as the splitting one.

It develops tree classifiers following three steps:

(1) Goal attribute is selected and its entropy is calculated.
(2) The characteristic with the highest information gain is taken.
(3) Build a node for that characteristic and repeat steps 1 and 2 for the built one until the ending criterion is obtained.

The ID3 decision algorithm uses two main concepts for tree building: entropy and information gain. Entropy will be the measure that represents the degree of randomness inside the set of data. So, entropy is zero when the sample is totally homogeneous; on the contrary, entropy will be one when the sample is absolutely uncertain.

Sport and Gender

Sport is a way of having fun; it also helps to make relationships with other people and helps to develop psychological and social skills. However, in order to achieve that goal, it must be done in specific circumstances. Sportsmen should not be under immense pressure from coaches or parents, and physical requirements must be adapted to the features of the participants (DiFiori et al., 2018; Markati et al., 2018). In addition, the sport can help in other aspects such as moral development, leadership formation, or the promotion of prosocial behaviors. It is so important that, in those contexts, it works in such a way that sport can break social barriers due to aspects such as gender, race, or socioeconomic level (Misener and Mason, 2006).

In recent decades, there has been an increment of women's participation in sport. Not just as athletes, but women have reached relevant roles in several fields such as technical teams or sports directions. Although there are still problems of gender discrimination in some sports disciplines, the progress made by women is clear (Gregg and Gregg, 2017; Carson et al., 2018). In fact, although women's participation increased throughout the 20th century, women acceptance in traditional masculine sports did not occur until the last decades of the 20th century (Messner, 1988; Birrell and Theberge, 1994).

In recent years, researchers have been interested in the behavior and characteristics of both genders in the sport, as can be observed in multiple investigations (Hall and Oglesby, 2016; Schwesig et al., 2016; Gregg and Gregg, 2017). The advancement of female in sports has increased the number of studies carried out on women, finding jobs related to physiology, technical skills, or the psychology of sport (Eys et al., 2015; Kozina et al., 2016; Gross et al., 2018). Therefore, it is interesting to investigate the participation and behavior of women in sport, as well as to check the differences and similarities between both genders and their own characteristics.

The Sports Performance Psychological Inventory (IPED)

The IPED tool was developed in Spain by Hernández-Mendo (2006). This questionnaire is an adaptation of the Psychological Performance Inventory (PPI) (Loehr, 1986, 1990). The study of psychological profile factors is important in sports psychology, because it can determine sports performance (Reigal et al., 2018a). This tool describes a series of skills that enable an athlete to cope with different tasks and circumstances during training and competition (Raimundi et al., 2016). Because of that, it is very important in sports, so the psychological skills training should be a part of the common training of athletes (Weinberg and Gould, 1999; Massuça et al., 2014).

The IPED (Hernández-Mendo, 2006; Hernández-Mendo et al., 2014) is a widely used tool to assess psychological skills in athletes. IPED has been used in sports such as triathlon, swimming, soccer, taekwondo, and beach-handball for male and female evaluations (e.g., López-Cazorla et al., 2015; González-Reyes et al., 2017; Martínez-Moreno, 2017; Reigal et al., 2018a). This questionnaire assesses the following factors: "self-confidence," "negative coping control," "attention control," "visual-imagery control," "motivational level," "positive coping control," and "attitude control" (Hernández-Mendo, 2006).

The main goal of this paper is to analyze more than 500 answers given with the IPED and develop a decision tree in order to find factors that influence gender and age in basketball players.

MATERIALS AND METHODS

Participants

We have collected 10,944 records from the Sports Performance Psychological Inventory IPED survey where we have information about sport, age, etc., 51.59% of the record set were male and 48.41% were female (age: M = 24.97; SD = 7.32). Participants were users of MenPas[1], which is an online psychosocial assessment platform (González-Ruiz et al., 2010, 2018). We try to set a relation between gender and basketball practice (592 records; 59.63% male and 40.37% female; age: M = 21.70; SD = 8.15).

Instruments

The IPED tool (Hernández-Mendo, 2006; Hernández-Mendo et al., 2014) is a Spanish adaptation of the PPI (Loehr, 1986, 1990). It is used to evaluate several psychological skills used by athletes during competition. The IPED is one of the most widely used tools to evaluate psychological profiles in sports in recent years (e.g., Gómez-López et al., 2013; Morillo-Baro et al., 2016; Martínez-Moreno, 2017). It consists of 42 items, divided into the following dimensions: "self-confidence" (e.g., "I see myself as more like a loser than a winner in competition"), "negative coping control" (e.g., "I get angry and frustrated during competition"), "attention control" (e.g., "I become distracted and lose my focus during competition"), "visual-imagery control" (e.g., "Before a competition, I picture myself performing perfectly"), "motivational level" (e.g., "I am highly motivated to play my best"), "positive coping control" (e.g., "I can keep strong positive emotion flowing during competition"), and "attitude control" (e.g., "I am a positive thinker during competition"). The items are rated on a five-point Likert-type scale ranging from 1 ("almost never") to 5 ("almost always"). The internal consistency values per dimension, again assessed by Cronbach's alpha, were 0.77 for self-confidence, 0.66 for negative coping control, 0.61 for attention control, 0.81 for visual-imagery control, 0.78 for motivational level, 0.78 for positive coping control, and 0.80 for attitude control.

Procedure

Participants took the IPED between 2016 and 2018 using the online psychosocial evaluation platform *MenPas* (González-Ruiz et al., 2010, 2018). Before, to be able to log in, any participant has to register him/herself. In order to complete the IPED, MenPas informs about instrument characteristics and instructions. In addition, contact information of researchers and managers of the computerized tool is shown to solve any doubt. Subsequently, researchers can log into the platform to gather the information generated.

Initially, we gathered 10,944 records from the Sports Performance Psychological Inventory IPED, but only 592 records were analyzed in this paper (people who played basketball). We also have classified data in order to get any relationship between IPED factors ("self-confidence," "negative coping control," "attention control," "visual-imagery control," "motivational level," "positive coping control," and "attitude control") and the gender and age of people practicing that sport. Those relationships are modeled in J48 decision trees, which are a model of the data and also a tool to predict future data behaviors.

Helsinki Declaration principles were followed throughout the study (World Medical Association, 2013). In addition, participants authorized us to use their information for research when they have been registered in the platform. So, we obtained

[1] www.menpas.com

written and informed consent from them. The current study was approved by the Ethics Committee of the University of Málaga (19-2015-H). When it comes to minors, we have chosen to use at least one of the following procedures: (1) the parents or legal guardians will register and therefore sign the informed consent, or (2) if the minors are the ones who will register, the informed consent of the parents is requested.

Data Analysis

The WEKA tool has been used for data mining analysis. WEKA stands for "Waikato Environment for Knowledge Analysis." It has been developed in Java programming language and it has a lot of options for "data preprocessing," "data classification," "clustering," "association rules," and "visualization." The saved archives can be used in several file formats such as ARFF ("attribute relation file format"), CSV ("comma separated values"), C4.5, and binary. Those archives can be loaded from one URL or from one SQL database using JDBC. One more option could be that data sources, classifiers, etc., are invoked as beans and they can be connected graphically (Srivastava, 2014).

Classification algorithms develop a model starting from a set of data. As aforementioned, decision tree algorithms allow us to build a model of the problem based on a training data set, which is easily understandable and which also allows us to predict a future behavior. We have used the WEKA J48 algorithm for data processing, which is an ID3 algorithm extension adding features such as pruning, working with missing values, managing continuous value attributes, etc.

The J48 classifier algorithm has been used in order to build our model. J48 generates a decision tree that represents a model of the problem based on supplied samples and covering the biggest amount of given samples (TP or true positive). A decision tree represents the information using tree-like graph decisions where nodes represent labeled classes and each branch represents one split subset (Moertini, 2003).

Algorithm Steps

(i) When every instance belongs to the same class, then that class labeled leaf is returned.
(ii) For each attribute, potential information must be calculated in order to calculate the gain in information that resulted.
(iii) Using that criterion, the best attribute is taken for branching.

Calculating Gain

"Entropy" is a data disorder measure that will be calculated for any sample ($\vec{y}$) as

$$Entropy(\vec{y}) = -\sum_{j=1}^{n} \frac{|y_i|}{|\vec{y}|} \log\left(\frac{|y_i|}{|\vec{y}|}\right)$$

$$Entropy(j|\vec{y}) = \left(\frac{|y_i|}{\vec{y}}\right) \log\left(\frac{|y_i|}{\vec{y}}\right)$$

Gain is calculated as

$$\mathrm{Gain}(\vec{y}, j) = |Entropy(\vec{y}) - Entropy(j|\vec{y})|$$

The algorithm will maximize the gain, by dividing overall entropy because of split argument $\vec{y}$ by j.

Pruning

Pruning is a very useful step for taking outliers out. This will allow rejecting not well-defined data or those very different from neighbor data, which will decrease the number of classification errors and help obtain a more normal tree.

Features of the Algorithm

One of the advantages of the algorithm is that it can handle either discrete or continuous attributes, or both attributes together. Continuous attributes are handled by selecting a threshold value of the attribute and splitting those that are less than, more than, or equal to it. In addition, this algorithm prunes the tree, removing branches that are not useful for reaching a leaf (goal node).

RESULTS

We have developed seven decision trees (one for each IPED factor) (**Figures 1–7**), taking IPED factors as a goal to determine the influence of age and gender on IPED scores. **Figure 1** shows that gender only had an influence on self-confidence in people from 25 to 44 years old, and the highest scores of self-confidence were in people from 45 to 64 years old.

Figure 2 shows that gender only had influence on negative coping control in people from 15 to 24 years old, and the lowest scores of negative coping control were in people over 65 years old.

Figure 3 shows that age only had an influence on attention control for male gender from 25 to 44 years old.

Figure 4 shows that gender had no influence on visual-imagery control. Age made some differences among groups. The highest scores were for people from 25 to 44 and people under 15 years old.

Figure 5 shows that gender had some influence on motivational level, but age had no influence.

Figures 6, **7** show that gender had some influence on people between 15 and 44 years old on positive coping control and attitude control. However, age had some influence on these scores. The lowest score on positive coping control was for people over 65 years. The lowest score on attitude control was for males between 25 and 44 years old.

DISCUSSION AND CONCLUSION

This paper analyzed 592 answers given to the Sports Performance Psychological Inventory (IPED) and developed decision trees in order to find the influences of gender and age on IPED scores. Results showed that decision trees have allowed classifying the IPED factor scores according to gender and age. Data have shown differences by age and gender in all factors except motivational level (age) and visual-imagery control (gender). This shows that there are differences in sports psychological skills between men and women, and among young people, adults, and elderly. Because of this, in order to carry out more precise analyses of

FIGURE 1 | Self-confidence (IPED).

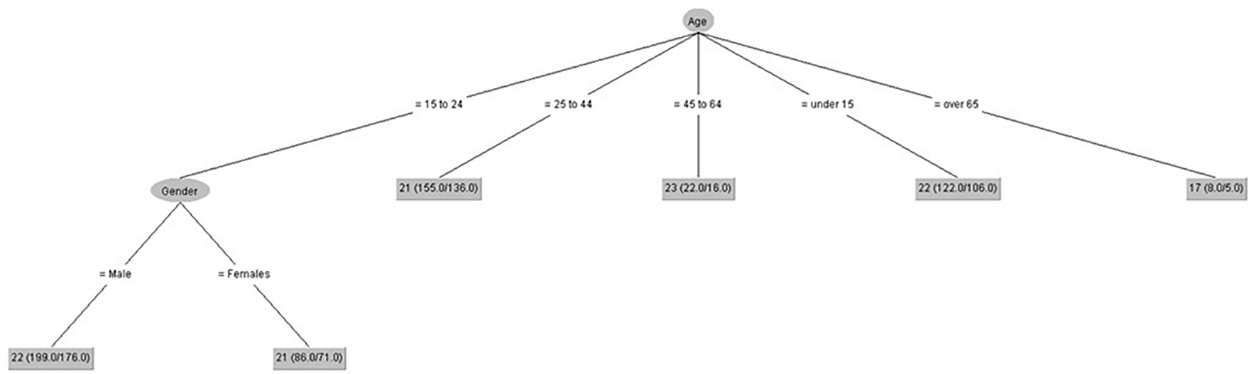

FIGURE 2 | Negative coping control (IPED).

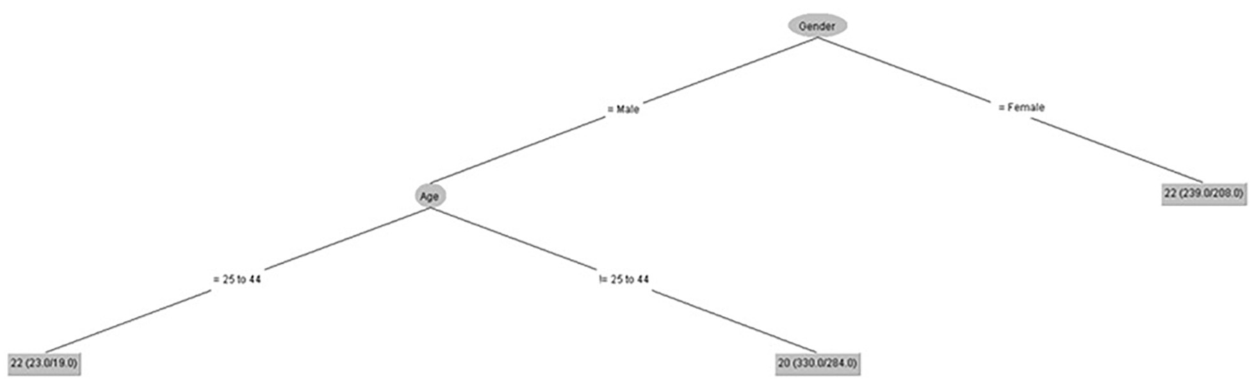

FIGURE 3 | Attention control (IPED).

these constructs, the differences shown between the groups must be taken into account.

The techniques used have shown useful information on how the scores are distributed and they observe how the groups are classified. The results have shown great sensitivity to classify the data, observing different distributions by factor. The structure for each factor has been specific, which allows analyzing the behavior of each psychological skill evaluated with Sport Performance Psychological Inventory (IPED) by gender and age. This helps to make decisions about how to approach the interpretation of these dimensions for the studied sample. The findings suggest that these techniques are suitable to be applied in sports psychology to explore different variables that are usually studied in this field of knowledge.

FIGURE 4 | Visual-imagery control (IPED).

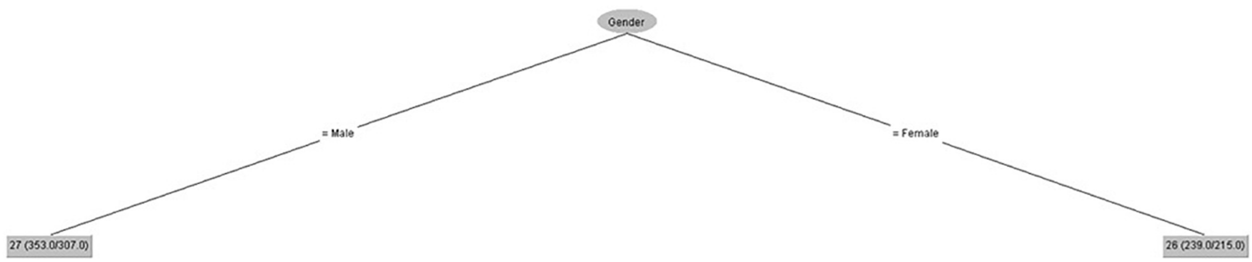

FIGURE 5 | Motivational level (IPED).

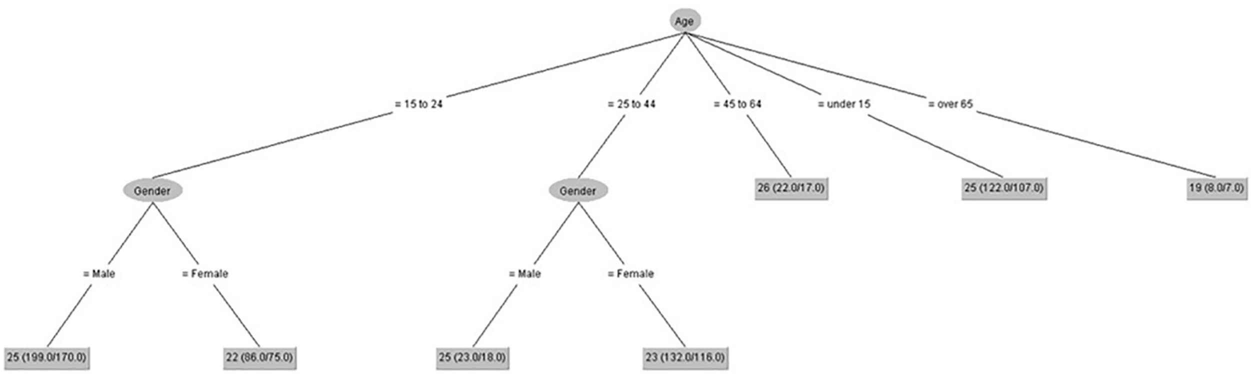

FIGURE 6 | Positive coping control (IPED).

FIGURE 7 | Attitude control (IPED).

Previous research has indicated that psychological skills of athletes can influence their performance, so it is interesting to analyze how they develop in athletes. Previous studies show how different psychological profiles have been observed (López-Cazorla et al., 2015; Martínez-Moreno, 2017; Reigal et al., 2018b). IPED scores change according to age, type of sport, or gender. Thus, it is interesting to obtain a score map structured by the variables that may be relevant in sports practice.

In the case study, we showed how data mining techniques could be applied to analyze and obtain information about quantitative and qualitative data in a set of data sample. Combination of quantitative and qualitative data analysis is the essence of mixed methods: on one hand, a coherent integration of result data interpretation starting from separate analysis, and on the other hand, making data transformation from qualitative to quantitative and vice versa (Cresswell and Plano Clark, 2011).

LIMITATIONS AND FUTURE WORKS

This paper has some limitations that should be addressed in future work. On one hand, only basketball player answers have been analyzed. Future researches should evaluate other sports in order to check similarities and differences. In addition, other variables such as level or sporting experience could be included to observe the scores awarded. On the other hand, these analysis techniques have been sensitive with a heterogeneous sample. It would be interesting to determine if they effectively differentiate between more homogeneous groups according to specific sports variables (sports performance, competitive anxiety, minutes played, sports role, motivation, etc.).

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

AUTHOR CONTRIBUTIONS

AH-M, VM-S, JP, RR, JM-B, RJ-R, and JA participated in the study design and data collection, performed statistical analyses, contributed to the interpretation of the results, wrote the manuscript, approved the final manuscript as presented, and reviewed and provided feedback to the manuscript. JP, RR, and AH-M conceived the study and participated in its design and coordination. All authors made substantial contributions to the final manuscript.

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ORIGINAL RESEARCH
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Improvement of Planning Skills in Children With Autism Spectrum Disorder After an Educational Intervention: A Study From a Mixed Methods Approach

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The literature confirms that individuals with autism spectrum disorder (ASD) have planning deficits. However, few interventions have targeted these deficits. The aims of this study were to: (1) show that the mixed methods approach can be useful in studying planning skills of children with ASD during and after an educational intervention; (2) assess whether the planning skills of two groups of children with ASD improved during the intervention and if this progress was maintained 1 month after completing the intervention. The groups were formed depending on each child's severity level (SL) of ASD according to DSM-5: SL1 (requiring support) and SL2 (requiring substantial support). Each group was composed of four children. In the framework of mixed methods, we used observational methodology, which is considered as mixed methods in itself because it integrates qualitative and quantitative elements. A nomothetic/follow-up/multidimensional observational design was used. Planning skills manifested by children during the intervention were codified, as well as the scaffolding behaviors provided by the educational specialist. These skills and behaviors were also coded in one session, which took place 1 month after the intervention. Coded data of each group were submitted to prospective and retrospective lag sequential analysis. This informed of the sequential structure of planning skills performed by children in interaction with the educational specialist at the beginning and at the end of the intervention, as well as 1 month later after the intervention. The comparison of the patterns obtained in these three temporal moments allowed us to know the improvement of the two groups in the use of planning skills. Results showed that both groups improved their autonomous use of planning skills. However, SL1 group used successfully and autonomously complex planning skills, while SL2 group were unable to achieve this gain. SL2 group progressed in autonomy, but only using basic planning skills. Both groups can further improve their use of planning skills; therefore, the intervention should be adjusted to their characteristics and temporarily extended. These findings contribute to the, as yet, little studied field of intervention and assessment of planning skills in children with ASD using a mixed methods approach.

Keywords: mixed methods, systematic observation, autism spectrum disorder, children, executive functions, planning, lag sequential analysis, educational practice

INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by: (1) persistent deficits in communication and social reciprocity and (2) patterns of restricted and repetitive behavior, interests, or activities. The consideration of the disorder within a continuity of severity and involvement in each of the two domains facilitates the identification of the great symptomatic heterogeneity within the spectrum. Thus, depending on the severity of the symptoms (and therefore, the support that individuals with ASD require), Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) establishes three severity levels (SL): SL1 = "requiring support"; SL2= "requiring substantial support"; SL3= "requiring very substantial support."

Under these diagnostic criteria, certain cognitive styles characterize a peculiar learning and a specific daily functioning in people with ASD, which could be explained by the deficit in executive functions (Ozonoff, 1995; Poljac and Bekkering, 2012). Executive functions are high-level cognitive and affective processes that direct thoughts, emotions, and behaviors during an active problem solving, especially those that require a novel approach (Carlson et al., 2013; Diamond, 2013). These set of differentiate skills are both interactive (Ozonoff, 1995) and integrate a wide range of cognitive functions such as planning, monitoring, working memory, flexibility, inhibition, and generativity (Hill, 2004b). An executive dysfunction in ASD is evidenced by numerous empirical studies. This dysfunction includes difficulties in different executive domains that extend to all areas of life and are present in all ages and SL, generating in the person a serious adaptive deterioration that affects their daily functioning (Hill, 2004a; Smithson et al., 2013; Geurts et al., 2014; Panerai et al., 2014; Demetriou et al., 2018; Vogan et al., 2018; Valeri et al., 2019).

Among all the executive deficits present in people with ASD, the one referred to planning is one of those with the highest prevalence and which generates the most difficulties in the individual's daily life. Planning deficit implies problems to choose and implement a sequence of actions to achieve a pre-specified goal (Lezak, 2012). For such planning to be effective, this sequence of actions must be checked, evaluated, and constantly updated. However, people with ASD manifest difficulties in these processes (Hill, 2004a; Olde Dubbelink and Geurts, 2017).

The abundant literature confirming these executive deficits in ASD contrasts with the shortage of cognitive intervention programs aimed at their improvement (Russell, 1997; Ozonoff et al., 2005; Kenworthy et al., 2014; Vogan et al., 2018). Therefore, much more work is needed in order to design effective early interventions. In this regard, it has pointed out the usefulness of ecological environments in which children with ASD participate in game-based activities (Traverso et al., 2015; Rice, 2016; Hillman, 2018; Vogan et al., 2018). Playing is a child's natural way of expression and provides opportunities for his/her development and learning. This makes games an essential tool for children's teaching-learning process and for the systematic observation and analysis of their progress (Fasulo et al., 2017; Otsuka and Jay, 2017; Zosh et al., 2018). However, despite its importance, there are few works that carry out a valid and reliable child intervention and evaluation based on games (Salcuni et al., 2017; Hillman, 2018).

Another aspect that has also shown influence on the development of executive functions in children is social interaction (Carlson, 2009; Lewis and Carpendale, 2009; Amadó et al., 2016; Sosic-Vasic et al., 2017). Modeling, anticipation, and scaffolding are the most common social interaction strategies (Bibok et al., 2009; Hughes and Ensor, 2009; Devine et al., 2016). In this study, we focus on scaffolding. It refers to the process by which adults help, plan, and organize the activity of children so that they can carry out a task that goes beyond their skill level (Wood et al., 1976; Vygotsky, 1978). In this regard, the importance of reinforcing messages providing emotional support in favoring the performance of certain executive capacities has also been evidenced (Vandenbrouck et al., 2017). In short, the literature indicates that fundamental aspects for an effective intervention of executive functions in children with ASD are: (a) that it takes place in an ecological context, (b) where the child develops playful activities, and (c) in company of an adult who offers an adequate scaffolding.

Regarding the methodological issues for the evaluation of executive functions in children with ASD, the mixed methods approach is the most appropriate strategy as it integrates qualitative and quantitative elements. Within this perspective, the idoneous option is systematic observation since it allows to capture spontaneous behaviors as they occur in a natural context (Portell et al., 2015a,b), and therefore, is the most appropriate methodology for assessing interventions in young children in ecological environments (Anguera, 2001; Whitebread and Pino-Pasternak, 2013). Taking into account the aforementioned benefits of the children's games, and given that playing is a ubiquitous and universal aspect of childhood, the systematic observation of a child's behavior in a playful context offers a wealth of information and a variety of nuances that allow describing, explaining, and understanding fundamental aspects of child development and learning imperceptible with other methodologies (Escolano-Pérez et al., 2017).

Observational methodology nowadays is considered in itself as mixed methods because it integrates qualitative and quantitative elements in QUAL-QUAN-QUAL phases (Anguera et al., 2017, 2018a,b; Arias-Pujol and Anguera, 2017; Del Giacco et al., 2019; Portell et al., 2019). In a first QUAL phase an *ad hoc* observation instrument must be elaborated and data must be codified based on an order or sequence criterion, thus making it possible to capture in a natural context the spontaneous behaviors that indicate the competences under study. After, a QUAN phase follows in which the quality of the coded observational data is tested (intra-observer and/or inter-observer agreement analysis) and its analysis is carried out. Precisely because the initial dataset, which is derived from an extremely rich qualitative component, can be analyzed using different quantitative techniques suitable for qualitative data (as lag sequential analysis) a set of quantitative results (as patterns of behavior) are obtained. Finally, the interpretation of the results (considering the objective of the study and prior researches) returns the process to the QUAL phase.

Taking into account: (a) all aspects mentioned above; (b) the minimum quality criteria and fundamental indicators that should guide the intervention targeted at people with ASD (Kasari and Smith, 2013) and specifically the educational interventions for children with ASD (Bond et al., 2016; Otero et al., 2017); and (c) the general principles of intervention in executive functions (Diamond and Lee, 2011; Diamond, 2014), an educational intervention aimed at improving planning skills in children with ASD was developed. (It is described in Procedure section).

There were two objectives of this study, one methodological and one educational: (1) show that the mixed methods approach can be useful in studying planning skills of children with ASD during and after an educational intervention; (2) assess whether the planning skills of two groups of children with ASD (grouped according to their SL) improved during the intervention and if this progress was maintained 1 month after the end of the intervention.

METHODS

Design

We applied a mixed methods approach as an ongoing method of assessment that is characterized by the integration of qualitative and quantitative elements. In this study, the integration was carried out from the "connect" option (Creswell and Plano Clark, 2011).

The observational design employed, according to the observational designs described by Anguera et al. (2001) and Anguera et al. (2018a), was Nomothetic/Follow-up/Multidimensional. It was: "nomothetic" because eight children with ASD were observed individually and their observational data were later treated jointly in two units of analysis (depending on each child's SL of ASD according to DSM-5); "follow-up" at both the inter-sessional and intra-sessional levels because 25 sessions were observed for each child and also recorded from beginning to end of each session; and "multidimensional" because different levels of response were observed referring to the children's planning skills and adult scaffolding behaviors that supported the observation instrument.

The systematic observation carried out was non-participative and active and behaviors observed were fully perceivable (Anguera, 2001; Bakeman and Quera, 2011).

Participants

The final sample included eight Spanish children with ASD, male gender between 5 years 6 months and 12 years (M = 92.37 months; SD = 23.24). Four participants presented SL1 (requiring support) according to the DSM-5 criteria and four participants SL2 (requiring substantial support). **Table 1** shows the characteristics of the participants of each group. They all received a formal diagnosis of ASD made by a multidisciplinary team according to the DSM-5 criteria for ASD. According to the current regulations in Spain, their diagnosis was additionally confirmed by at least one child psychiatrist with expertise and considerable experience in autism not associated with the current study through the ADOS-2 (Lord et al., 2000).

The inclusion criteria for participation in the study were: (1) confirmed diagnosis of ASD (DSM-5); (2) age 5–12; (3) sufficient verbal skills: score less than 5 in each of the three dimensions of the Autism Spectrum Inventory communication and language scale (Autism Spectrum Inventory, IDEA) (Rivière, 2002); (4) informed consent of the students' parents authorizing their participation in the study. Moreover, exclusion criteria were: (1) IQ $\leq$ 49; (2) diagnosis of physical disability; (3) co-morbidity with a psychiatric disorder.

The information referring to the inclusion criteria (1), (2), and (3) and the exclusion criteria (2) and (3) were provided by the educational guidance team of the school to which each participant attended. For the information referring to the exclusion criterion (1), the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) was administered in the Spanish version (Corral et al., 2005).

Participants were treated according to the international ethical standards and Spanish Organic Law 15/1999 of December of Protection of Personal Data (Spanish Government, 1999). Research was evaluated and approved by the Education Doctoral Program Academic Commission of Zaragoza University and by the management teams of the schools attended by the participants. No ethics special approval was required for this research since the Spanish public education system and national regulations require no such approval.

Instruments

Observation Instrument

An observation instrument was built *ad hoc* to allow us to observe the children's actions indicating planning skills, in addition to adult scaffolding behaviors. Since our study was multidimensional, the observation instrument combined a field format with category systems. It contained seven criteria and each criterion was broken down into an exhaustive and mutually

TABLE 1 | Characteristics of the participants of each group.

Group	Participants	Age (months)	IQ	Mean Age (months)	SD Age (months)	Mean IQ	SD IQ
SL1	1	82	105	83.5	12.79	101.25	12.34
	2	94	107				
	3	92	83				
	4	66	110				
SL2	5	144	54	101.25	29.77	62	10.46
	6	76	72				
	7	97	52				
	8	88	70				

exclusive category system. The instrument was developed according to: (a) previous recordings of children of similar characteristics to those of the participants. In these recordings, children were solved habitual tasks of their daily life and whose resolution required the use of planning skills; (b) the theoretical framework related to the executive function of planning, especially in ASD (Zelazo et al., 1997; Hill, 2004a; Ward and Morris, 2005; Olde Dubbelink and Geurts, 2017) and scaffolding (Wood et al., 1976; Vygotsky, 1978; Bibok et al., 2009; Bernier et al., 2010); (c) observation instruments used by other researchers to capture, among other issues, planning skills in children (Whitebread et al., 2009; Escolano-Pérez and Sastre-Riba, 2010). The constructed observation instrument is presented in **Figure 1**.

Criteria 1 and 2 were related to the adult behaviors and the remaining provided information about child behaviors. Each criterion was broken down into categories that implied directly observed behaviors during the intervention sessions. Criterion 1 (*Adult help for the children to understand the activity*) was broken down into four categories. In category *Repetition,* the adult updated the information to the child if she detected working memory fails. *Command* indicated the help offered by the adult when child showed inhibitory difficulty to resist his impulse to start the task before the adult ordered it. Due to comprehension problems in ASD, the category *Ensuring child knows the activity* revealed behavior executed by adult to check if the child had understood the activity. *Activity proposal* meant that the adult was explaining the activity to the child. In this category, the adult helped the child to focus attention to the explanation of the activity. Criterion 2 (*Adult help for the child to carry out the activity*) was broken into four categories. This criterion was referred to different scaffolding behaviors that adult provided to the child to help him during the execution of the activity. The categories of this criterion was graduated according to levels of support, from those that involved more help to the child (*Error correction*) to those that implied less support to him (*Motivating help*). Criterion 3 (*Child's previous behavior*) was broken down in four categories. *Evasion* showed the child's inability to maintain his attention while the adult explained the activity. *Anticipation* referred to the child's difficulty in inhibiting their impulses. *Recall* was directly related to the use of working memory. *Waiting* showed an adequate inhibitory process. *Anticipation* indicated an inadequate inhibitory process. Criterion 4 (*Execution*) showed the child's behaviors during the resolution of planning activities. It was broken down in six categories. *No response* denoted the child inability to generate strategies to resolve the activity. *Unrelated behavior* involved child failures in attention. *Wrong*

Criteria	Category Systems	Category description	Category code
1. Adult help for the child to understand the activity	Repetition	The adult repeats, in whole or in part, the same intervention that she has previously performed. This repetition can be verbal and/or gestural and occurs immediately after her last intervention. It includes the presentation of visual stimuli.	Rep
	Command	The adult issues a verbal and/or gestural order that serves to regulate the beginning of the activity.	Ord
	Ensuring child knows activity	The adult checks that, after having explained the activity to the child, he has understood it.	Ast
	Activity proposal	The adult performs introductory actions aimed both at the presentation of the material necessary for the realization of the activity and at the explanation of the activity itself (including the initial demonstrations).	Prt
2. Adult help for the child to carry out the activity	**Error correction**	The adult carries out verbal and/or gestural behaviors that correct the child's wrong action and explicitly show the correct answer.	**Adc**
	Direct help	The adult conducts directive verbal and/or gestural behaviors in order to fix the child's attention to something. This help constitutes a concrete guide that points and directs the child towards the adequate resolution of the activity. This category also includes the specific answer to a question that the child issues in reference to the activity.	**Adp**
	Indirect help	The adult uses a verbal strategy that in itself does not contain the answer to the problem that arises, but that tries to modulate a more adequate access to the activity and/or promote the reflection on the part of the child about the resolution.	**Ayi**
	Motivating help	The adult, to generate a correct behavior in the child, encourage him verbally or offers attractive material to him.	**Aym**
3. Child´s previous behavior	Evasion	While the adult is explaining the activity, the child performs a voluntary or involuntary behavior that causes him to be distracted and separates his attention from the explanation. These behaviors may hinder the understanding of the activity to be performed.	Se
	Anticipation	The child tries to start the activity before the adult has explained it or before she gives the order to start it.	An
	Recall	The child shows that he knows the rules of the game that the adult is presenting. These behaviors occur at the same time that the adult is explaining the activity, without respecting the turn of speech, and before the child begins his execution.	Cn
	Waiting	The child is able to wait while the adult explains the activity and until the order is given to start it. The child remains attentive to the explanation and his action does not interfere with the adult's behavior. Although the child can carry out verbalizations related to the activity he is going to face, he respects the turn of speech.	E
4. Execution	**No response**	The child does not perform any action (either verbal or gestural) to solve the activity. That is, he does nothing.	**NR**
	Unrelated behavior	The child, voluntarily and in order not to continue with the activity, performs a verbal and/or a gestural behavior that is not related to the activity and that interferes with its optimal performance. It differs from the category *Evasion* in that this category *Unrelated behavior* occurs during the execution of the activity and *Evasion* occurs before it.	**Ds**
	Wrong use of strategy	The child performs an inappropriate verbal and/or gestural behavior to resolve the activity. This behavior constitutes a child execution not adjusted to the demands of the activity. This category implies both intermediate incorrect behaviors that approach the resolution of the activity and those that involve completing it incorrectly.	**UesEr**
	Change to a wrong strategy	The child performs an incorrect verbal and/or gestural behavior to try to solve the activity after using a different one. This category implies both those intermediate incorrect behaviors that approach the achievement of the activity and those that involve completing it incorrectly.	**CesEr**
	Correct use of strategy	The child performs an appropriate verbal and/or gestural behavior to resolve the activity. This behavior implies an adequate adjustment between the child's execution and the demands of the activity. This category encompasses both the correct intermediate behaviors that approach the achievement of the activity and those that involve completing it correctly.	**UesC**
	Change to a correct strategy	The child performs a correct verbal and/or gestural behavior to try to solve the activity after using a different one. This category may involve both those intermediate correct behaviors that approach the achievement of the activity and those that involve completing it correctly.	**CesC**
5. Control	Implicit question/Ignorance	Throughout the activity, the child reveals through gestural behaviors that he does not know how to do something or that he has doubts, and implicitly requests the adult's help. This category includes those gestures that indicate that the child seeks adult support such as: stand during execution and look at the adult for approval or assistance, look at the adult and shrug.	Pi
	Explicit question/Ignorance	Throughout the activity, the child shows that he does not know how to do something or that he has doubts and explicitly requests the help of the adult, either declaratively, acknowledging that he does not know how to do what is demanded, interrogatively or imperatively. The gestures that are accompanied by words are included.	Pr
	Checking break	The child involuntarily loses attention while he is verifying his action. This category includes flutter movements, echolalias, lost looks and other verbal and/or gestural behaviors of the child that abruptly interrupt the process of checking his action.	**Ic**
	Regulation	The child verifies his own performance throughout the activity. It includes: 1) looks comparing his execution with the proposed model; 2) related comments about his execution during the activity.	**Rg**
6. Error detection	**No error detection**	The child is not able to locate the mistake he has made.	**Nde**
	Error detection with aid	The child locates the mistake he has made thanks to the fact that the adult has verbally and/or gesturally pointed out the existence of it. Subsequently, the child may: a) be able to solve this error (for example, by performing a different behavior, but adequate to solve the activity -which would imply the use of the category *Change to a correct strategy*-); b) try to solve the error but not achieve it (for example, by carrying out a different behavior but inappropriate to solve the activity -which would imply the use of the category *Change to a wrong strategy*-); c) do not even try to solve his error (for example, avoid continuing in the activity -which would imply the use of the category *Unrelated behavior*-).	De
	Error self-detection	The child finds for himself the mistake he has made. Subsequently, the child may: a) be able to solve this error (for example, by performing a different behavior, but adequate to solve the activity -which would imply the use of the category *Change to a correct strategy*-); b) try to solve the error but not achieve it (for example, by carrying out a different behavior but inappropriate to solve the activity -which would imply the use of the category *Change to a wrong strategy*-).	**Ade**
7. Evaluation	**Non adjusted evaluation**	The child makes an inappropriate judgment when comparing his execution/result with the demand of the activity. This category implies both the judgments issued during the activity and at the end of it.	**Ena**
	Adjusted evaluation	The child makes an appropriate judgment when comparing his execution/result with the demand of the activity. This category implies both the judgments issued during the activity and at the end of it.	**Eva**

Bold = Categories (and their codes) considered in the sequential analysis as criterion behaviors. (See explanation in the Data analysis section).

FIGURE 1 | Observation instrument.

use of strategy indicated child used incorrectly his executive process and committed a mistake. *Change to a wrong strategy* was linked to an inadequate cognitive flexibility. Although the information was updated, it was not been done properly. *Correct use of strategy* entailed the child used correctly his executive process during the resolution of the activity. *Change to a correct strategy* was related to an adequate cognitive flexibility: the child was able to update, to check and to make his actions more adaptable to achieve a specific goal. Criterion 5 (*Control*) was broken down in four categories. *Implicit question/Ignorance* indicated a break in the sequence of actions. In this category, child realized he was stuck and he indirectly asked for help. *Explicit question/Ignorance* also indicated a break in the sequence of actions. Child also realized he was stuck but in this case, he verbally asked for help. *Checking break* implied a disruption during the child verification process. The child was unable to hold his attention until the end of this process. *Regulation* showed that the child verified his actions to solve adequately the activity. Criterion 6 (*Error detection*) was broken down in three categories. *No error detection* meant failures in planning (particularly as regards updating process). *Error detection with aid* implied that these failures persisted but the child could correct it with adult help. *Error self-detection* showed a greater functioning in updating process due the child was able to realize his mistake. Criterion 7 (*Evaluation*) was broken down in two categories. *Non adjusted evaluation* involved deficits in planning. The child was unable to evaluate properly the result of his actions. *Adjusted evaluation* involved the child was able to evaluate adequately the result of his actions.

Recording Instruments

A digital video camera was used to record the infant and adult action in each session of intervention.

For the coding process we used LINCE (v.1.2.1) (Gabín et al., 2012). This software can be downloaded free from http://lom.observesport.com/.

Data Analysis Instrument

The software GSEQ5, v.5.1 (Bakeman and Quera, 2011) was used for the data quality check (intra- and inter-observer reliability) and the lag sequential analysis. It can be downloaded for free[1].

Procedure

The management team of 10 schools from a northeastern city of Spain where students with ASD can attend were informed about the research. Six schools were interested in participating in the research. After informing the parents, collecting their informed consent and applying the inclusion and exclusion criteria in the sample, nine potential participants were obtained: five presented SL1 and four presented SL2. Since, one participant did not attend all intervention sessions because of illness, the final sample was configured by eight participants (4 of each SL).

Each of the participants individually received the intervention designed to improve planning skills. This intervention (**Figure 2**) consisted of six tasks whose resolution required the implementation of planning skills. All tasks were oriented to real life and had a functional nature. In task 1, children were asked to order a sequence of facts showed out of order in different pictures. Task 2 consisted that children had to outline an action plan in order to find the maze's right exit avoiding the obstacles along the way. In task 3, children had to select the necessary ingredients to elaborate a specific sandwich. Task

[1]http://www.ub.es/comporta/sg/sg_s_download.htm

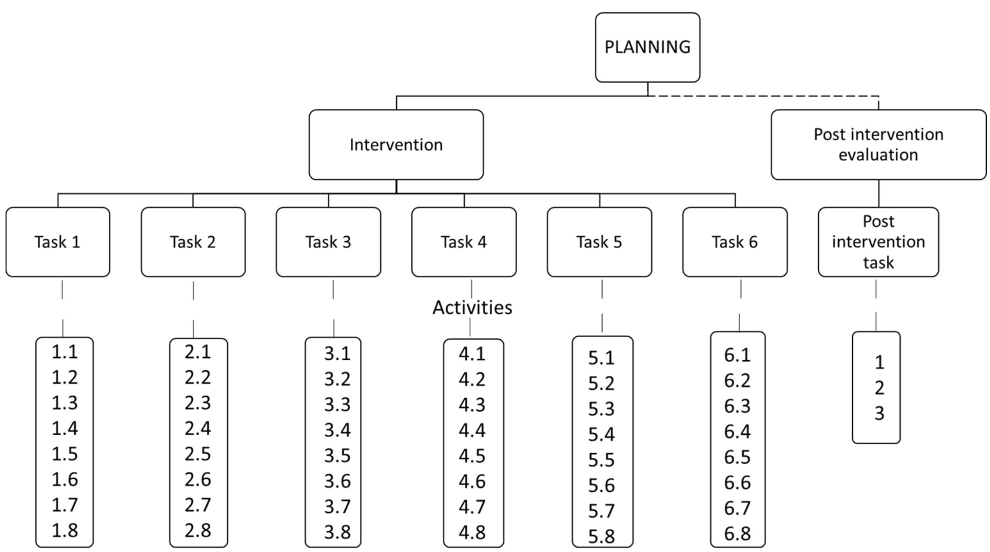

FIGURE 2 | Structure of intervention and post intervention evaluation in planning skills.

4 required children to choose among several dishes alternatives, the food they needed to prepare a whole menu. In task 5, children had to pack up in a suitcase with forethought all the clothes they will need to go to the beach on summer. In task 6, children were asked to program in a map their visit route to a village while visiting several places (school, library, fire station…). Children were instructed to follow some rules (i.e., do not cross the walls, walk only on the sidewalk…) and to avoid using the same route twice. Each task consisted of eight playful activities of increasing difficulty. Thus, the whole intervention was composed of 48 activities.

The intervention for each participant took place over 24 sessions of half an hour each. In each session, two activities were carried out. The intervention lasted 3 months, with 2 sessions per week on non-consecutive days.

One month after the end of the intervention, a session was held in which each participant was given one post intervention evaluation task similar to those of the intervention. More exactly, in this task, children are asked to organize the correct order of different clothes to dress up a puppet step by step. This task consisted of three activities of increasing difficulty. The purpose of this post intervention evaluation task was to check if the level of planning skills of the participants was maintained over time.

All sessions were carried out at the children's schools by the same educational specialist and were recorded for later viewing and analysis.

The video recordings were imported into the LINCE software and coded by an expert observer in executive functions and ASD using the *ad hoc* observation instrument.

Control of the Quality of the Data

The quality of the observational data was controlled using two guidelines (Anguera, 2003): (a) Qualitative: consensual agreement was used in the first session to be coded for each participant (therefore, a total of eight sessions) by three expert observers in observational methodology, ASD and executive functions; (b) Quantitative: (b1) intra-observer reliability was calculated in three sessions for each child: one belonging to task 1, another to task 6 (both sessions randomly chosen) and the post intervention task session. We selected sessions of these three tasks because these tasks were the ones analyzed in this study, as will be explained later; (b2) inter-observer reliability was also calculated in three sessions for each child: one of task 1 and one of task 6 (randomly selected sessions but taking care that they were different from those used for the calculation of intra-observer reliability) and the post intervention task session. Cohen's kappa coefficient (Cohen, 1960) was calculated using software program GSEQ5, v.5.1. All results obtained are between 0.84 and 1.00, which according to the scale suggested by Landis and Koch (1977) corresponds to a very good agreement. Therefore, the quality of the observational data obtained was excellent.

Data Analysis

Lag Sequential Analysis

Lag sequential analysis was proposed by Bakeman (1978), and subsequently extended by Bakeman and Gottman (1986), Bakeman and Quera (2011), and Quera (2018). It is a highly effective data analysis technique for analyzing datasets compiled from observation that contain sequences of behaviors that are coded using an *ad hoc* observation instrument. It allows to detect those patterns of behavior, which occur with greater probability than would be predicted by chance. That is, starting with a behavior considered as a pattern generator (criterion or given behavior), and that tends to be chosen according to the objectives of each study, it looks for which other behaviors appear associated with the same with a probability greater than mere chance (conditional behaviors), both later (positive lag: +1, +2, etc.), and earlier (negative lag: −1, −2, etc.). In this way, prospective and retrospective patterns are obtained. In our investigation, these patterns allowed us to identify the sequential structure of the behaviors that the participants performed in interaction with the adult at the beginning and end of the intervention, as well as 1 month after the end of the intervention. The comparison of the patterns obtained in these three temporary moments allowed us to know their progress in the use of planning skills.

This technique has been widely used in studies that analyze sports behavior, but its use in studies in the educational field is somewhat sparse (Herrero-Nivela and Pleguezuelos, 2008; Santoyo et al., 2017; García-Fariña et al., 2018; Escolano-Pérez et al., 2019). Especially, scarce are the studies with ASD students in which this data analysis technique has been used (Canal and Rivière, 1993; Rodríguez-Medina et al., 2018). We are unaware of works in which this data analysis technique has been used to evaluate planning skills in ASD children, a novel issue that is addressed in this work.

In our study, the records of the participants were joined according to their SL (SL1 or SL2) and the task to which they corresponded.

In each group of participants (SL1 and SL2), three tasks were analyzed: task 1 and task 6 (as they were the tasks that best allowed us to know the improvement of each group during the intervention when comparing the planning skills used at the beginning and at the end of the intervention) in addition to the post intervention task (this reflected the possible maintenance of the improvement after 1 month without intervention). To perform lag sequential analysis for each group and task: (1) the same criteria behaviors were chosen: those categories considered most relevant depending on the objective of the study given that they play a central role in planning skills and the resolution of daily activities. Specifically, the following categories—appearing alone or co-occurring with others—were chosen (categories indicated in bold in **Figure 1**): (1a) of those referring to participants: (i) all of criterion 4 *Execution*: *No response* (*NR*), *Unrelated behavior* (*Ds*), *Wrong use of strategy* (*UesEr*), *Change to a wrong strategy* (*CesEr*), *Correct use of strategy* (*UesC*) and *Change to a correct strategy* (*CesC*), as they indicated the accuracy of the response/answer that the participants issued during the execution of the activity as well as their flexibility to change the strategy; (ii) of criterion 5 *Control*, categories *Checking break* (*Ic*) and *Regulation* (*Rg*) given that they showed the existence of check behaviors of the participants on their own action and its quality; (iii) of criterion 6 *Error detection*, categories *No error detection* (*Nde*) and *Error self-detection* (*Ade*) as they showed the ability of the children to update their own activity during the performance of the task and therefore to detect or not the errors produced; (iv) all categories of criterion 7 *Evaluation*: *Non adjusted evaluation* (*Ena*) and *Adjusted evaluation* (*Eva*) because the evaluation informs about the children's ability to distinguish whether an objective has been achieved or not, and examine their execution/result comparatively with the demands of the task; (1b) of those categories referring to the adult, all ones of the observation instrument belonging to criterion 2 *Adult help for the child to carry out the activity: Error correction* (*Adc*), *Direct help* (*Adp*), *Indirect help* (*Ayi*), and *Motivating help* (*Aym*). They were chosen because they involved scaffolding strategies that provided support for the children in carrying out the tasks; (2) as given behaviors, all the categories that make up the observation instrument (**Figure 1**) were considered; (3) lag sequential analysis were performed prospectively (from +1 to +5 lags) and retrospectively (from −5 to −1 lags); (4) the level significance was set at $p < 0.05$.

RESULTS

Of all the patterns obtained (61 retrospective and 45 prospective patterns in SL1 group, 34 retrospective and 35 prospective patterns in SL2 group), the most relevant for this study are described below. They are the most relevant because: (a) are generated by the children or (b) they are generated by the adult but contain infant's and adult's behaviors. Therefore, these patterns are those allow us to know the use of infant's planning skills. Consequently, the patterns generated by the adult that only contain adult's behaviors are not relevant and they are not described.

Hence, the patterns generated by each group of participants in each task analyzed are presented, in addition to the patterns generated by the adult that included behaviors of the participants of each group in each task. Thus, **Figures 3–5** contain the patterns of SL1 group and the patterns of the adult in task 1, task 6, and in the post intervention task, respectively; **Figures 6–8** contain the patterns of SL2 group and the adult's ones in the same tasks. Within each figure, the patterns of the participants appear organized increasingly based on the suitability that the criterion behavior implies for the resolution of the task. Therefore, those patterns of the participants whose criterion behavior is less suitable are presented first and then those in which their criterion behavior is more appropriate. Adult patterns are presented starting with those whose criterion behavior implies more direct adult help to the participants and ending with those who assume less direct adult help. **Figures 9–11** show the comparison of patterns obtained in each task for each group.

To facilitate the jointly reading of the patterns described and its representation in the Figures we indicate at the beginning of each paragraph the code and name of the criterion behavior that generated the patterns described.

Figures 3–5 show that in SL1 group the categories of participants considered as criterion behavior that have generated patterns occurring alone and/or co-occurring with other categories are: *Wrong use of strategy* (*UesEr*), *Change to a wrong strategy* (*CesEr*), *Correct use of strategy* (*UesC*), *Change to a correct strategy* (*CesC*), *Regulation* (*Rg*), *No error detection* (*Nde*), *Error self-detection* (*Ade*), and *Adjusted evaluation* (*Eva*). The categories of participants considered as criterion behavior that have not generated patterns are: *No response* (*NR*), *Unrelated behavior* (*Ds*), *Cheking break* (*Ic*), and *Non adjusted evaluation* (*Ena*).

UesEr (*Wrong use of strategy*): We begin by presenting the patterns generated by the criterion behavior less suitable for the resolution of the tasks: *Wrong use of strategy* (*UesEr*). It is appreciated that these patterns appear in the three tasks. In task 1 (**Figure 3**), *UesEr* generates three prospective patterns and one retrospective pattern. This retrospective pattern indicates that children use wrongly a strategy (*UesEr*) despite the fact that the adult previously offers them a concrete guide that points and directs them toward the adequate resolution of the activity (*Direct help -Adp-* in lag −1). Previously, participants execute more *Wrong use of strategy* (*UesEr*): in lag −2, *UesEr* co-occurs with verification behaviors (*Regulation -Rg-*) and incorrect evaluation behaviors (*Non adjusted evaluation -Ena-*) which hamper the participants from being able to change the type of response given; in lag −3, *UesEr* occurs in isolation. Participants persist executing these wrong actions despite the adult offers them more and different helps: help to understand the activity (*Repetition -Rep-* in lag −4) and, again, help to execute it (*Direct help -Adp-* in lag −5). In brief, this retrospective pattern indicates that *Wrong use of strategy* (*UesEr*) is a repetitive behavior in the action of participants despite the numerous adult helps. Prospective patterns indicate that a more direct and explicit adult intervention such as *Error correction* (*Adc*) is necessary for participants to perform correct strategies (either *Change to a correct strategy -CesC-* or *Correct use of strategy -UesC-*). In task 6 (**Figure 4**), this criterion behavior *UesEr* only generates three prospective patterns. After *UesEr*, the adult offers an *Indirect help* (*Ayi*). This help can sometimes be effective and can be followed by correct answers from the participants (*Change to a correct strategy -CesC-*). However, other times this adult help cannot be effective and then: (a) children can continue executing incorrect answers (more exactly, they can commit errors and do not detect them: *Change to a wrong strategy* with *No error detection -CesErNde-*) or (b) adult can offer more direct help to participants (*Error correction -Adc-*). In the post intervention task (**Figure 5**), this criterion behavior *UesEr* generates a single prospective and retrospective linear pattern, which implies a lower variability of child behavior. The pattern is prospective and retrospectively similar, as the participants can perform both *Change to a correct strategy* (*CesC*) and *Change to a wrong strategy* (*CesEr*). It is important to note that when errors occur, participants are always able to self-detect them for themselves (*Ade, CesErAde*). In addition,

Executor	Lag -5	Lag -4	Lag -3	Lag -2	Lag -1	Criterion Behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5
SL1 Group	AdpDs (3.1)	Rep (4.61)	UesEr (2.45)	UesErRgEna (4.66)	Adp (4.46)	UesEr	Adc (7)	Adp (2.93) CesC (4.64) UesC (3.14)			
	Rg (4.44) UesErRg (3.1)	Ayi (4.61)	RepUesErNde (4.64)	Pr (4.66)	Ayi (2.55) Ord (3.99)	UesErRg	Adc (2.04) Adp (3.23) AyiNde (4.66)				
						UesC	Aym (2.69)				
Adult					Rep (2.86) UesErRgEna (2.86) UesErRg (3.14)	Adp	UesErRg (2.84) UesC (2.84) UesErRgEna (2.84) UesEr (4.16)	Adc (3.11)	CesC (2.83) UesC (4.02)		
					Aym (2.42) UesEr (2.71)	Ayi	CesC (2.69) Ds (2.69) UesErRg (3.83)				

FIGURE 3 | Prospective and retrospective patterns obtained in SL1 group. Task 1.

Executor	Lag -5	Lag -4	Lag -3	Lag -2	Lag -1	Criterion Behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5
SL1 Group						UesEr	Ayi (3.55)	Adc (2.16) CesErNde (3.35) CesC (3.35)			
				UesCRg (2.67)		UesErRg	Adp (4.84)	CesCRg (5.43)			
						CesErNde	Adp (4.84)	CesC (11)	Aym (2.39)		
						UesC	UesC (3.7)				
		AyiUesCRg (2.46) CesC (2.46)		AyiUesCRg (2.48)	Ayi (3.32)	UesCRg	Eva (2.48)	AyiUesCRg (2.48)	Eva (2.47)		Eva (2.54)
				UesEr (2.31)	Adp (3.3)	CesC	Aym (3.2)		UesEr (2.94)	UesC (2.12)	
	UesCRg (2.63)	Ayi (3)	UesCRg (3.01)	Ayi (2.89)	UesCRg (2.58)	Eva					
Adult		UesC (2.51)	UesEr (2)		CesErNde (4.07) Ord (4.07) UesErRg (4.07)	Adp	Adc (2.7) CesC (2.7) Ord (4.05)	Aym (3.1)	AyiUesCRg (4.38) CesC (2.94)	Ayi (3.33)	
	AyiUesCRg (2.85) CesErNde (2.85) Ord (2.85)	Adp (3.15)	AyiUesCRg (2.88) CesC (2.88)	Aym (2.82)	AyiUesCRg (2.79) UesEr (2.95)	Ayi	CesErNde (2.78) UesErRg (2.78) UesCRg (3.48)	Eva (2.78)	CesC (2.76) UesErRg (2.76)	Eva (2.75)	

FIGURE 4 | Prospective and retrospective patterns obtained in SL 1 group. Task 6.

Executor	Lag -5	Lag -4	Lag -3	Lag -2	Lag -1	Criterion Behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5
SL1 Group	Ade (7.04)	CesC (7.07)	CesErAde (7.07)		Rep (4.95)	UesEr	Ade (7.07)	CesC (7.04)	CesErAde (7)		
			UesEr (7.07)	Ade (10.1)	CesC (10.1)	CesErAde		Rep (7.04)	UesEr (7)		CesC (9.85)
						UesC	Aym (2.43)	UesC (3.37)			
				UesCRg (2.68)	Ayi (5.85)	UesCRg	Aym (3.66)	UesCRg (2.78)			
				UesEr (7.11)	Ade (10.1)	CesC	CesErAde (10.05)				
					UesEr (7.11)	Ade	CesC (10.05)	CesErAde 10)			
Adult					Aym (4.62)	Ayi	UesC (4.06) UesCRg (6.04)	Aym (4.8)			

FIGURE 5 | Prospective and retrospective patterns obtained in SL 1 group. Post intervention task.

Executor	Lag -5	Lag -4	Lag -3	Lag -2	Lag -1	Criterion Behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5
SL2 Group						UesEr	Adp (4.14	CesC (10.34)			
					Ord (2.06)	UesC	Aym (5.55)		UesC (3.56)		
					Adp (4.16) Ayi (2.39)	UesCRg	Aym (3.38)	Adp (3.78) UesCRg (3.08)	UesCRg (4.38)	Ayi (4.06)	Adp (2.78) UesCRg (4.01)
Adult			AdpDs (3.82)	UesCRg (3.44)	NR (3.83) Rg (3.83) UesEr (3.83)	Adp	CesC (3.82) Ord (2.52) UesCRg (3.42)				
		CesC (3.13) UesCRg (4.11)	Ayi (3.17)	UesC (2.35)	Aym (4.78)	Ayi	Rg (3.15) UesC (4.11) UesCRg (2.6)	Aym (4.72)	Ayi (2.56) AyiDs (2.13)		

FIGURE 6 | Prospective and retrospective patterns obtained in SL2 group. Task 1.

Executor	Lag -5	Lag -4	Lag -3	Lag -2	Lag -1	Criterion Behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5
SL2 Group		UesC (2.4)	CesEr (4.52)		Nde (4.56)	UesEr	CesC (4.54)	CesCRg (4.52)	UesCRg (4.49)		
						CesEr	Rep (5.1)	Nde (10.3)	UesEr (4.49)		
				UesC (3.94)	Adp (2.47)	UesC	Aym (3.74)	UesC (2.96)			
	Ayi (2.36) Ord (3.02)	CesC (4.49)	Ord (3.05) UesCRg (4.35)	CesCRg (4.54)	Rep (2.4)	UesCRg	Aym (2.43)		UesCRg (4.33)	Adp (2.97)	CesCRg (4.45)
						CesC	Aym (2.1)		Ayi (2.94)	UesCRg (5.02)	Aym (2.34)
						CesCRg	Aym (2.1)	UesCRg (5.07)			
Adult		UesCRg (2.61)		Adp (4.57)	Ord (3.19)	Adp	CesCRg (2.23) UesCRg (2.23) Ord (2.23) Rg (2.23) UesC (2.05)				
	UesCRg (2.78) Rg (2.78)	UesEr (4.07)	CesC (2.81)		Adc (2.84) CesC (2.84) UesCRg (2.84)	Ayi	CesC (2.83) UesEr (2.51)				

FIGURE 7 | Prospective and retrospective patterns obtained in SL2 group. Task 6.

Executor	Lag -5	Lag -4	Lag -3	Lag -2	Lag -1	Criterion Behavior	Lag +1	Lag +2	Lag +3	Lag +4	Lag +5
SL2 Group			Ayi (2.52)	Aym (2.28) UesC (2.92)	Ayi (5.95)	UesC	Ayi (2.29) Aym (2.42)	UesC (2.52)			
				UesCRg (3.38)	UesCRg (2.27)	UesCRg	UesCRg (2.62)	UesCRg (4.23)	UesCRg (2.26)	UesCRg (2.63)	UesCRg (2.38)
Adult					Aym (2.88)	Ayi	UesC (5.54)	Aym (3.18)			

FIGURE 8 | Prospective and retrospective patterns obtained in SL2 group. Post intervention task.

it stands out that prospectively, participants can perform all these skills autonomously, without adult help.

Therefore, as the intervention progresses and after its completion: (a) *Wrong use of strategy* (*UesEr*) is accompanied by a less adult intervention (some of these adult helps being gradually less explicit), until it can sometimes disappears in the post intervention task; (b) in addition, in this task, the participants themselves are able to self-detect their mistakes (*Ade*); aspect absent in tasks 1 and 6, and therefore implies progress in their planning skills; (c) the patterns are stabilizing, that is, there is not so much diversification of behaviors, as at the beginning of the intervention several patterns appear and in the post intervention task only one. This implies that *Wrong use of strategy* (*UesEr*) is decreasing, which also implies improvement, although it does not disappear. Therefore, there is still a possibility of progress in child behavior in this regard, although in turn we cannot forget the significant gain produced in terms of the self-detection of mistakes (*Ade*).

SL1 Group			SL2 Group		
Retrospective Patterns	Criterion Behavior	Prospective Patterns	Retrospective Patterns	Criterion Behavior	Prospective Patterns
AdpDs←Rep←UesEr←UesErRg**Ena**←Adp←	UesEr	→Adc→Adp →Adc→CesC →Adc→UesC		UesEr	→Adp→**CesC**
Rg←Ayi←RepUesEr**Nde**←Pr←Ayi← UesErRg←Ayi←RepUesEr**Nde**←Pr←Ayi← Rg←Ayi←RepUesEr**Nde**←Pr←Ord← UesErRg←Ayi←RepUesEr**Nde**←Pr←Ord←	UesErRg	→Adc →Adp →Ayi **Nde**		UesErRg	
	CesEr			CesEr	
	CesErNde			CesErNde	
	CesErAde			CesErAde	
	UesC	→Aym	Ord←	UesC	→Aym→ →**UesC**
	UesCRg		Adp← Ayi←	UesCRg	→Aym→Adp→**UesCRg**→Ayi→Adp →Aym→Adp→**UesCRg**→Ayi→**UesCRg** →Aym→**UesCRg**→ **UesCRg**→Ayi→Adp →Aym→**UesCRg**→**UesCRg**→Ayi→**UesCRg**
	CesC			CesC	
	CesCRg			CesCRg	
	Ade			Ade	
	Eva			Eva	
Rep← UesErRg**Ena**← UesErRg←	Adp	→UesErRg→Adc→CesC →UesErRg→Adc→UesC →UesC→Adc→CesC →UesC→Adc→UesC → UesErRg**Ena**→Adc→CesC → UesErRg**Ena**→Adc→UesC →UesEr→Adc→CesC →UesEr→Adc→UesC	AdpDs←**UesCRg**←NR← AdpDs←**UesCRg**←Rg← AdpDs←**UesCRg**←UesEr←	Adp	→**CesC** →Ord →**UesCRg**
Aym← UesEr←	Ayi	→CesC →Ds →UesErRg	**CesC**←Ayi←**UesC**←Aym← **UesCRg**←Ayi←**UesC**←Aym←	Ayi	→Rg→Aym→Ayi →Rg→Aym→AyiDs →**UesC**→Aym→Ayi →**UesC**→Aym→AyiDs →**UesCRg**→Aym→Ayi →**UesCRg**→Aym→AyiDs

Bold and underlined = Planning skills that progress during and after the intervention.

FIGURE 9 | Comparison of the patterns obtained in each group in task 1.

UesErRg (*Wrong use of strategy* co-occurring with *Regulation*): This criterion behavior generates patterns in tasks 1 and 6, but not in the post intervention task. In task 1 (**Figure 3**), *UesErRg* generates three prospective patterns and four retrospective patterns. However, prospective patterns are very brief (binary patterns) and are mainly made up of adult behaviors (*Error correction -Adc-*; *Direct help -Adp-*; *Indirect help -Ayi-*), without containing appropriate behavior of the participants (*No error detection -Nde-* is the only category appearing for participants). Therefore, these aids do not favor the emergence of appropriate child behaviors with greater force than those expected by chance. In retrospective patterns, adult intervention is also frequent, both to assist participants in understanding the task (*Command -Ord-* and *Repetition -Rep-*) and in its execution (*Indirect help -Ayi-*). Despite these aids, participants are not able to make correct answers, persisting in *Wrong use of strategy* (*UesEr*), sometimes accompanied by regulatory behaviors (*Rg*) but other times without detecting their error (*Nde*). In task 6 (**Figure 4**), *UesErRg* generates a single prospective and retrospective linear pattern. Prospectively, it is necessary adult *Direct help* (*Adp*) to participants change their strategy and give a correct answer (*CesC*) accompanied by regulatory behaviors (*Rg*). Retrospectively, participants use autonomously and correctly a strategy (*UesC*), also accompanied by regulatory behaviors (*Rg*). Therefore, there is a gain comparative to task 1, because the participants are able to execute correct behaviors (*UesC* and *CesC*), although sometimes they need adult help (*Adp*) to get it.

CesErNde (*Change to a wrong strategy* with *No error detection*): This criterion behavior only produces a pattern in task 6 (**Figure 4**). It is a single prospective pattern in which participants, thanks to *Direct help* from the adult (*Adp*), can change again their strategy and give a correct answer (*CesC*).

CesErAde (*Change to a wrong strategy* with *Error self-detection*) generates a pattern in the post intervention task (**Figure 5**), both prospectively and retrospectively. It is a linear pattern. The appearance of *Error self-detection* (*Ade*) (comparative to *No error detection -Nde-* that appears in task 6, and which has been described in the previous paragraph) implies progress. That is, although in both tasks the participants make mistakes, in task 6 they do not detect them and in the post intervention task they do. However, this *Error self-detection* does not entail an immediate correction of the error by the participants, as it is followed by adult help (*Repetition -Rep-* in lag +2) and *Wrong use of strategy* (*UesEr* in lag +3) until the participants execute correct actions (*CesC* in lag +5).

UesC (*Correct use of strategy*) generates patterns in all three tasks, being in all cases prospective patterns, never retrospective patterns. In task 1 (**Figure 3**) a binary pattern appears combined with an intervention of the adult (*Motivating help -Aym-*), although this adult behavior does not favor other child behavior. In task 6 (**Figure 4**) a binary pattern appears in which *Correct use of strategy* (*UesC*) leads to another *Correct use of strategy* (*UesC*). In the post intervention task (**Figure 5**) a pattern appears in which *Correct use of strategy* (*UesC*) implies that the adult performs *Motivating help* (*Aym*), then the participants

SL1 Group			SL2 Group		
Retrospective Patterns	Criterion Behavior	Prospective Patterns	Retrospective Patterns	Criterion Behavior	Prospective Patterns
	UesEr	→Ayi →Adc →Ayi →CesEr**Nde** →Ayi →CesC	UesC←CesEr← ←Nde←	UesEr	→**CesC**→**CesCRg**→**UesCRg**
UesCRg← ←	UesErRg	→Adp→CesCRg		UesErRg	
	CesEr			CesEr	→Rep→Nde→UesEr
	CesEr**Nde**	→Adp→CesC→Aym		CesErNde	
	CesErAde			CesErAde	
	UesC	→UesC	UesC←Adp←	UesC	→Aym→UesC
AyiUesCRg← ←AyiUesCRg←Ayi← CesC← ←AyiUesCRg←Ayi←	UesCRg	→**Eva**→AyiUesCRg→**Eva**→ →**Eva**	Ayi←CesC←Ord ←CesCRg←Rep← Ord←CesC←Ord←CesCRg←Rep← Ayi←CesC←UesCRg←CesCRg←Rep← Ord←CesC←UesCRg←CesCRg←Rep←	UesCRg	→Aym→ →UesCRg→Adp→CesCRg
UesEr←Adp←	CesC	→Aym→ →UesEr→UesC		CesC	→Aym→ →Ayi→UesCRg→Aym
	CesCRg			CesCRg	→Aym→UesCRg
	Ade			Ade	
UesCRg←Ayi←UesCRg←Ayi←UesCRg←	**Eva**			Eva	
UesC←UesEr← ←CesEr**Nde**← UesC←UesEr← ←Ord← UesC←UesEr← ←UesErRg←	Adp	→Adc→Aym→AyiUesCRg→Ayi →Adc→Aym→CesC→Ayi →CesC→Aym→AyiUesCRg→Ayi →CesC→Aym→CesC→Ayi →Ord→Aym→AyiUesCRg→Ayi →Ord→Aym→CesC→Ayi	UesCRg← ←Adp←Ord←	Adp	→CesCRg →UesCRg →Ord →Rg →UesC
AyiUesCRg←Adp←AyiUesCRg←Aym←AyiUesCRg← CesEr**Nde**←Adp←AyiUesCRg←Aym←AyiUesCRg← Ord←Adp←AyiUesCRg←Aym←AyiUesCRg← AyiUesCRg←Adp←CesC←Aym←AyiUesCRg← CesEr**Nde**←Adp←CesC←Aym←AyiUesCRg← Ord←Adp←CesC←Aym←AyiUesCRg← AyiUesCRg←Adp←AyiUesCRg←Aym←UesEr← CesEr**Nde**←Adp←AyiUesCRg←Aym←UesEr← Ord←Adp←AyiUesCRg←Aym←UesEr← AyiUesCRg←Adp←CesC←Aym←UesEr← CesEr**Nde**←Adp←CesC←Aym←UesEr← Ord←Adp←CesC←Aym←UesEr←	Ayi	→CesEr**Nde**→**Eva**→CesC→**Eva** →CesEr**Nde**→**Eva**→UesErRg→**Eva** →UesErRg→**Eva**→CesC→**Eva** →UesErRg→**Eva**→UesErRg→**Eva** →UesCRg→**Eva**→CesC→**Eva** →UesCRg→**Eva**→UesErRg→**Eva**	UesCRg←UesEr←CesC← ←Adc← Rg←UesEr←CesC← ←Adc← UesCRg←UesEr←CesC← ←CesC← Rg←UesEr←CesC← ←CesC← UesCRg←UesEr←CesC← ←UesCRg← Rg←UesEr←CesC← ←UesCRg←	Ayi	→CesC →UesEr

Bold and underlined = Planning skills that progress during and after the intervention.

FIGURE 10 | Comparison of the patterns obtained in each group in task 6.

SL1 Group			SL2 Group		
Retrospective Patterns	Criterion Behavior	Prospective Patterns	Retrospective Patterns	Criterion Behavior	Prospective Patterns
Ade←CesC←CesEr**Ade**← ←Rep←	UesEr	→**Ade**→CesC→CesEr**Ade**		UesEr	
	UesErRg			UesErRg	
	CesEr			CesEr	
	CesErNde			CesErNde	
UesEr←**Ade**←CesC←	CesEr**Ade**	→ →Rep→UesEr→ →CesC		CesErAde	
	CesCRg			CesCRg	
	UesC	→Aym→UesC	Ayi←Aym←Ayi← Ayi←UesC←Ayi←	UesC	→Ayi→UesC →Aym→UesC
UesCRg←Ayi←	UesCRg	→Aym→UesCRg	**UesCRg**←**UesCRg**←	**UesCRg**	→**UesCRg**→**UesCRg**→**UesCRg**→**UesCRg**→**UesCRg**
UesEr←**Ade**←	CesC	→CesEr**Ade**		CesC	
	CesCRg			CesCRg	
UesEr←	**Ade**	→CesC→CesEr**Ade**		Ade	
	Eva			Eva	
	Adp			Adp	
Aym←	Ayi	→UesC→Aym →UesCRg→Aym	Aym←	Ayi	→UesC→Aym

Bold and underlined = Planning skills that progress during and after the intervention.

FIGURE 11 | Comparison of the patterns obtained in each group in the post intervention task.

continue with *Correct use of strategy* (*UesC*). Therefore, there is progress between task 1 and task 6 because in task 1, despite the help of the adult, no response was obtained from the participants, while in task 6, *UesC* is followed by another *UesC* autonomously, without requiring adult participation. However, after a period of non-intervention (post intervention task) it is appreciated that these skills are not consolidated as participants need adult intervention to maintain *Correct use of strategy* (*UesC*).

UesCRg (*Correct use of strategy* co-occurring with *Regulation*): Its capacity to generate patterns increases as the intervention progresses, as it does not generate patterns in task 1 but does in task 6 (**Figure 4**). This capacity to generate patterns is maintained 1 month after the end of the intervention as *UesCRg* behavior also generates a pattern in the post intervention task (**Figure 5**). The patterns that are generated in task 6 (**Figure 4**) are 1 prospective and 2 retrospective ones. In the latter (retrospective patterns) *Indirect help* of the adult (*Ayi*) prevails while in the prospective one *Adjusted evaluation* (*Eva*) appears in several lag. Despite the important progress of this *Eva* behavior, its use does not seem to be consolidated since it does not appear in the post intervention task (**Figure 5**). In this task, retrospectively, *Indirect help* of the adult (*Ayi*) is still necessary to maintain *Correct use of strategy* (*UesC*) with *Regulation* (*Rg*). Prospectively, adult help (in this case *Motivating help -Aym-*) is also necessary for the execution of these behaviors. Therefore, in the post intervention task, participants need adult help, of one kind or another, to use their strategies correctly and with regulation.

CesC (*Change to a correct strategy*): It does not generate patterns in task 1 (**Figure 3**), but it does in the other two tasks. In both tasks, it generates a prospective and retrospective linear pattern that highlights the following comments. Retrospectively, in task 6 (**Figure 4**), participants are able to *Change to a correct strategy* (*CesC*) due to having received a direct adult help (*Adp*) to replace their previously erroneous strategies (*UesEr*). However, in the post intervention task (**Figure 5**), the adult help disappears. The children can autonomously *Change to a correct strategy* (*CesC*) since they are able to self-detect the errors (*Ade*) they have previously performed (*UesEr*); this implies progress in their planning skills.

Ade (*Error self-detection*): This criterion behavior only generates patterns in the post intervention task (**Figure 5**). It does it both alone and co-occurring with *CesEr* (this pattern had already been commented previously). In addition, it is the only task in which this category *Ade* also appears as part of the patterns generated by other criteria behaviors. Therefore, the appearance of *Error self-detection* (*Ade*) in the post intervention task represents a progress in the planning processes of SL1 group participants. Also, in most of the patterns in which *Ade* appears (either generating patterns or forming part of others) adult help no appears. Therefore, *Ade* favors a more autonomous activity in children.

Eva (*Adjusted evaluation*): It only generates one pattern in task 6 (**Figure 4**). It is a retrospective pattern. For children to perform a result and evaluate it correctly (*Eva*) they have previously used correct strategies in a regulated way (*UesCRg* in lag −1, lag −3 and lag −5). These correct behaviors have been favored by adult *Indirect help* (*Ayi* in lag −2 and lag −4). It is noteworthy that *Adjusted evaluation* (*Eva*) appears in task 6 not only generating patterns but also forming part of other patterns. In contrast, in task 1, it does not appear in any pattern. Therefore, the *Adjusted evaluation* (*Eva*) does not appear in the patterns corresponding to the start of the intervention but does in those referring to its completion (also generating a pattern by itself), representing progress in the skills of the participants. However, this progress is not consolidated as in the post intervention task (**Figure 5**) *Adjusted evaluation* (*Eva*) it does not generate a pattern nor is it part of other patterns.

In summary, the patterns of SL1 group indicate that these participants have advanced in their planning skills throughout the intervention and after it, given that: (a) less and less adult help is required to participants perform correct behaviors; (b) the patterns generated by *Wrong use of strategy* (*UesEr*) (both occurring alone and co-occurring with other behavior) are decreasing; and although they do not disappear, the behaviors referring to *No error detection* (*Nde*) that appeared in some patterns during the intervention are replaced by *Error self-detection* (*Ade*) 1 month after its completion; (c) in task 6 *Change to a wrong strategy* (*CesEr*) generates a pattern by co-occurring with *No error detection* (*Nde*) while in the post intervention task it is co-occurring with *Error self-detection* (*Ade*); (d) *Adjusted evaluation* (*Eva*) appears for the first time in task 6, both generating a pattern and forming part of other patterns; (e) in the post intervention task the participants are able to detect by themselves their errors (*Ade*) and replace them with correct strategies (*Change to a correct strategy -CesC-*), even without needing the help of the adult.

Regarding the patterns generated by adult behaviors in SL1 group (**Figures 3–5**), the following is observed. Only the criteria behaviors *Direct help* (*Adp*) and *Indirect Help* (*Ayi*) generate patterns.

Adp (*Direct help*) generates patterns in task 1 (**Figure 3**) and in task 6 (**Figure 4**), but not in the post intervention task (**Figure 5**). Therefore, in this last task, the category's capacity to generate patterns has decreased, which implies that 1 month after the intervention the participants are able to be more autonomous in their actions. However, their autonomy is not total due to other adult behaviors (*Indirect Help -Ayi-* and *Motivating help -Aym-*) appear even in this last task (post intervention task).

Ayi (*Indirect help*): This adult category generates patterns in the three tasks. In task 1 (**Figure 3**) and in task 6 (**Figure 4**), these patterns contain children's actions both adequate (*Change to a correct strategy -CesC-; Correct use of strategy* with *Regulation -UesCRg-; Adjusted evaluation -Eva-*) and/or inadequate (*Wrong use of strategy* with *Regulation -UesErRg-; Wrong use of strategy -UesEr-; Change to a wrong strategy* with *No error detection -CesErNde-*). Nevertheless, in the post intervention task (**Figure 5**), these patterns contain only adequate children's actions (*Correct use of strategy -UesC-; Correct use of strategy* with *Regulation -UesCRg-*). Hence, effectiveness of *Indirect help* (*Ayi*) is greater after the end of the intervention.

Figures 6–8 contain the patterns of SL2 group in tasks 1, 6 and post intervention task, respectively; as well as the patterns generated by adult behaviors with this group and in those tasks.

In SL2 group, the categories of participants considered as criterion behavior that have generated patterns occurring alone are: *Wrong use of strategy* (*UesEr*), *Change to a wrong strategy* (*CesEr*), *Correct use of strategy* (*UesC*), and *Change to a correct strategy* (*CesC*). In addition, the categories *Correct use of strategy* (*UesC*) and *Change to a correct strategy* (*CesC*) have generated patterns co-occurring with the category *Regulation* (*Rg*). The categories of participants considered as criterion behavior that have not generated patterns are: *No response* (*NR*), *Unrelated behavior* (*Ds*), *Checking break* (*Ic*), *No error detection* (*Nde*), *Error self-detection* (*Ade*), *Non adjusted evaluation* (*Ena*), and *Adjusted evaluation* (*Eva*).

UesEr (*Wrong use of strategy*): This criterion behavior is the least suitable for the resolution of tasks. It generates a pattern in tasks 1 and 6 but not in the post intervention task. In task 1 (**Figure 6**), it generates a linear prospective pattern in which, after *Direct help* of the adult (*Adp*), participants perform *Change to a correct strategy* (*CesC*). In task 6 (**Figure 7**), comparative to the execution in task 1, a progress is detected because: (1) correct behaviors (*CesC, UesC*) appear without adult intervention (adult help is not necessary for participants to replace their wrong strategies with correct ones); (2) furthermore, some of these participants' correct behaviors are regulated (*Rg*), which implies that participants are able to verify their actions. In the post intervention task (**Figure 8**), *Wrong* *use of strategy* (*UesEr*) does not generate patterns, indicating a significant gain in the skills of the participants.

CesEr (*Change to a wrong strategy*): This criterion behavior only generates a pattern in task 6 (**Figure 7**). It is a prospective pattern. Despite adult help (*Repetition - Rep-*) the participants do not detect their errors (*Nde*) and persist in them (*Wrong use of strategy -UesEr-*).

UesC (*Correct use of strategy*) generates prospective and retrospective patterns in the three tasks (**Figures 6–8**). Prospectively, *Motivating help* (*Aym*) is always necessary, and/or *Indirect help* (*Ayi*) in the case of the post intervention task, so that the participants continue performing *Correct use of strategy* (*UesC*). Retrospectively, adult intervention is also necessary for participants to perform *Correct use of strategy* (*UesC*), although these aids are more direct at the beginning and at the end of the intervention than a month later: in task 1 (**Figure 6**), *Command* (*Ord*) appears and in task 6 (**Figure 7**), *Direct help* (*Adp*) appears, while in the post intervention task (**Figure 8**) *Motivating help* (*Aym*) and *Indirect help* (*Ayi*) appear. Therefore, 1 month after the intervention, the participants show more autonomy than at the beginning and at the end of the intervention, although they still require adult help.

UesCRg (*Correct use of strategy* co-occurring with *Regulation*) generates prospective and retrospective patterns in all three tasks. In tasks 1 and 6 (**Figures 6** and **7**, respectively) the patterns are very similar as, both prospectively and retrospectively, adult interventions of various types appear (*Motivating help -Aym-*; *Direct help -Adp-*; *Indirect help -Ayi-*; *Repetition -Rep-*; *Command -Ord-*) that allow participants to take correct actions (*UesCRg*, *CesCReg*, *CesC*). However, in the post intervention task (**Figure 8**) adult intervention is no longer necessary for participants to perform correct actions (*UesCRg*), which implies greater autonomy.

CesC (*Change to a correct strategy*) only generates patterns in task 6 and this happens both alone and by co-occurring with *Regulation* (*Rg*). The pattern generated by occurring alone is a prospective pattern showing that although at the end of the intervention the participants are able to correctly change and use a different strategy from the one previously used (*CesC*), they need adult help at various times (*Motivating help -Aym-* in lag +1 and *Indirect help -Ayi-* in lag +3) to continue to perform more correct actions (*UesCRg*). It stands out that these correct actions are accompanied by behaviors of *Regulation* (*Rg*), that is, verification behaviors to check that their action is correct.

CesCRg (*Change to a correct strategy* co-occurring with *Regulation*): It generates a prospective pattern very similar to that originated by itself alone (*CesC*), which has just been explained. This pattern, as already indicated, also appears in task 6 (**Figure 7**). This pattern generated by *CesCRg* is shorter than that originated by *CesC*, as fewer adult aids are needed (*Motivating help -Aym-* in lag +1) for the participants to continue to carry out more correct actions (these also with regulation -*UesCRg*-). Therefore, the comparison of the two patterns shows that the regulation performed by the children while they are changing their strategy (*CesCRg*) entails a lower need for adult help.

In summary, the patterns of SL2 group indicate that these participants have improved their planning skills throughout the intervention and after its completion because: (a) the patterns generated by both *Wrong use of strategy* (*UesEr*) and by *Change to a wrong strategy* (*CesEr*) disappear after the intervention; (b) the adult help children need to perform *Correct use of strategy* (*UesC*) is less directive (although it does not disappear), which implies greater autonomy for the children; (c) sometimes, adult help even disappears in the post intervention task (it occurs in the patterns generated by *Correct use of strategy* co-occurring with *Regulation -UesCRg-*) and children can perform more correct actions alone. This gain corroborates their greater autonomy.

Concerning the patterns generated by adult behaviors in SL2 group (**Figures 6–8**), the following is observed. The criteria behaviors *Direct help* (*Adp*) and *Indirect help* (*Ayi*) generate patterns. However, the criteria behaviors *Error correction* (*Adc*) and *Motivating help* (*Aym*) do not generate patterns.

Adp (*Direct help*) generates a pattern in task 1 and task 6 (**Figures 6** and **7**), favoring participants to make correct answers (*CesC*, *UesCRg*, *CesCRg*, *UesC*). However, *Adp* does not generate a pattern in the post intervention task (**Figure 8**). Therefore, in this task the participants show more autonomy and do not require adult directive assistance; which indicates progress in their planning skills.

Ayi (*Indirect help*) generates patterns in all three tasks (**Figures 6–8**). Its effect on the action of the participants is similar to the other adult help (*Direct help -Adp-*) because it also allows them to perform correct actions (*UesC*, *UesCRg*, *CesC*). However, *Ayi* continues generating patterns in the post intervention task (**Figure 8**). Therefore, this result (generation of patterns by *Indirect help -Ayi-* in the three tasks) together with that previously explained (generation of patterns by *Direct help -Adp-* in task 1 and 6 but not in the post intervention task) allows for the following conclusion: although the participants show more autonomy in the post intervention task than in task 1 and 6, they are not yet totally autonomous in their behavior.

The category *Motivating help* (*Aym*), despite not generating patterns in any of the three tasks, does appear in all of them as part of other patterns (**Figures 6–8**). This corroborates our previous statement: the participants have gained autonomy but are not yet totally autonomous in their behavior.

Comparing the patterns obtained by SL1 and SL2 groups throughout the intervention and after its completion (**Figures 9–11**), the following is observed: (1) both groups have progressed; (2) however, this progress is qualitatively different as it affects distinct planning skills: (2a) SL1 group progresses in the use of evaluation skills (*Ena* and *Eva*) and *Error self-detection* (*Ade*) (marked in bold and underlined in **Figures 9–11**). In task 1 (**Figure 9**), this group performs evaluations, but incorrect ones (*Non adjusted evaluation -Ena-*). At the end of the intervention (task 6; **Figure 10**) these evaluations are correct (*Adjusted evaluation -Eva-*), and they appear generating a pattern, but also forming part of other patterns. These evaluations are not maintained 1 month after the end of the intervention (post intervention task; **Figure 11**). However, in this post, intervention task for the first time *Error self-detection* (*Ade*) appears, both generating patterns and being part of others. So, *No error detection* (*Nde*) that appears in task 1 and task 6 is replaced by *Error self-detection* (*Ade*) in the post intervention task (marked in bold and underlined in **Figures 9–11**). All this allows us to conclude that SL1 group progresses in complex planning skills. (2b) In contrast, SL2 group presents changes only in more basic planning skills: *Wrong use of strategy* (*UesEr*), *Change to a wrong strategy* (*CesEr*), *Correct use of strategy* (*UesC*) and *Change to a correct strategy* (*CesC*). Specifically, incorrect behaviors (both *Wrong use of strategy -UesEr-* and *Change to a wrong strategy -CesEr-*) disappear 1 month after the end of the intervention (post intervention task; **Figure 11**). Correct behaviors (*UesC* and *CesC*) are performed with less adult help. At the beginning of the intervention (**Figure 9**) the adult's continuous help is necessary for participants to carry out these correct behaviors (*UesC* and *CesC*) (aspect marked in bold and underlined in **Figure 9**). At the end of the intervention (**Figure 10**), in some cases, they can occur without adult help (aspect marked in bold and underlined in **Figure 10**). One month after the end of the intervention (**Figure 11**), *Correct use of strategy* co-occurring with *Regulation* (*UesCRg*) generates a long pattern without adult intervention (pattern marked in bold and underlined in **Figure 11**). Complex planning skills (*Non adjusted evaluation -Ena-*; *Adjusted evaluation -Eva-*; *Error self-detection -Ade-*) do not appear in this group in any of the three tasks.

DISCUSSION

There were two objectives of this study: (1) to show that the mixed methods approach can be useful in studying planning skills of children with ASD during and after an educational intervention; (2) to assess whether the planning skills of two groups of children with ASD (grouped according to their SL) improved during the intervention and if this progress was maintained 1 month after the end of the intervention.

Regarding objective 1, the mixed methods approach used in this work has allowed us to study in a rigorous and objective way the planning skills of children with ASD during and after the intervention. The first QUAL phase that constitutes the mixed methods approach have allowed us to address a pending challenge in the investigation of planning skills in ASD: create and implement an assessment instrument within an intervention capable of obtaining, in a natural and objective way, observational data on the functioning of the person. All that without altering the interactions that arise between children and adults in the dynamics of the intervention or adding extra evaluation elements that overload both (Gioia et al., 2010). In this sense, the constructed observation instrument (**Figure 1**) is a tool that can be of great help for future researchers and professionals in the evaluation of planning skills in children with ASD. Subsequently, the QUAN phase of the mixed methods approach followed. It implied to obtain the measurement parameters, to test the quality of the coded observational data and to carry out its analysis. Our initial observational dataset was qualitative but was transformed into quantitative data using lag sequential analysis (a quantitative analysis technique suitable for qualitative data). Since our initial dataset contained information not only about the primary parameter of frequency but also about other essential primary parameter, such as order (Bakeman, 1978; Anguera et al., 2001; Bakeman and Quera, 2011; Quera, 2018), quantification was robust. The consideration of the order parameter provided us with the means to know the different components of sequences of behavior as it occurred. Thereby, the order parameter was crucial for detecting hidden structures through the quantitative analysis of relations among different codes in our initial observational dataset. However, before carrying out this analysis, it was necessary to check the quality of the observational data. In this study, the quality of observational data was verified through intra- and inter-observer reliability. They were computed through Cohen's kappa coefficient. All results showed a very good agreement. So, we could conclude that the observational data obtained was excellent. Consequently, we could analyze them. As we have already indicated, data analysis was conducted using a particularly fitting technique for analyzing complex human behaviors in order to obtain detailed sequences of behaviors: lag sequential analysis. This technique offered patterns of behavior that inform the sequential structure of planning skills performed by children in interaction with the educational specialist. Thereby, the mixed methods approach has allowed to capture a large amount of invaluable information through other methodologies. In most of the research carried out with participants with ASD that try to analyze the effects of interventions on different areas of their development other methodologies (especially, selective methodology) are used. However, data obtained in these methodologies do not inform the changes and differences produced between the beginning and the end of the intervention (Kasari et al., 2014). In contrast, mixed methods approach used in this study allows to capture these changes and differences. Finally, we returned to QUAL phase of the mixed methods approach with the interpretation of the patterns behavior, permitting seamless integration. To do so, we considered the objectives of our study and prior researches. So, we could conclude that the two groups of children with ASD improved their planning skills during and after the intervention. (We explain this aspect more deeply later since it is closely linked to our objective 2).

In short, the mixed methods approach adopted has shown its enormous potential to help us to study the improvement of the planning skills of children with ASD, and consequently, to improve their quality of life; aspect that proves to be particularly deficient in children and adolescents with ASD compared to their typically developing peers (de Vries and Geurts, 2015). Therefore, and in accordance with other authors (Arias-Pujol et al., 2015; Rodríguez-Medina et al., 2016, 2018; Alcover et al., 2019), we advocate the use of mixed methods approach. The use of the mixed methods approach (and, more exactly, the observational methodology considered in itself as mixed methods), due it offers rigor and flexibility, is still more necessary and useful when it comes to the assessment of participants of a young age and special characteristics, as is the case of this study (Anguera, 2003).

Regarding objective 2, the results obtained indicate that the intervention involved gains for both groups of participants since the two groups improved their initial planning skills. Some of these gains were common for both groups and others specific to SL1 group. Both groups: (1) made fewer mistakes (*UesEr* and *CesEr*); (2) performed more correct executions (*UesC* and *CesC*). Both aspects (1 and 2) imply that the participants' behavior was adjusting to the demands of the task; (3) acquired greater autonomy in their actions: the application of scaffolds during the intervention are gradually less directive and once the intervention finished, participants became more proficient and autonomous. In addition to these gains, SL1 group was also able to: (a) self-detect their mistakes (*Ade*) and (b) evaluate properly their action (*Eva*); sometimes even being able to do it autonomously. Since both types of skills (*Ade* and *Eva*) constitute complex planning skills (Zelazo et al., 1997; Ward and Morris, 2005), it can be said that, after the intervention, SL1 group came to use complex planning skills autonomously. However, SL2 group never used complex planning skills (with or without the help of the adult), which entails negative consequences in the resolution of tasks, since effective planning implies a cyclical and continuous process in which the self-detection of errors and the evaluation of performance and results are required, in addition to other skills (Hill, 2004a; Olde Dubbelink and Geurts, 2017).

In summary, the results obtained allow us to conclude that this research has led to a breakthrough in terms of the numerous possibilities of practical application offered by the mixed methods approach as well as an advance in the very scarcely studied field of planning skills in ASD (Olde Dubbelink and Geurts, 2017).

The intervention has produced positive effects in both groups of participants. The literature review indicates that executive functions and in particular planning skills in children with ASD show an atypical development trajectory. Without intervention, their executive deficits persist throughout their life cycle, remaining below the performance of their standard developing peers (Pellicano, 2010). Hence the importance of carrying out research such as described here, to understand the improvement produced by different interventions on executive functions in children with ASD.

This is also precisely one of the positive aspects of this work: focus on one of the executive function deficits in children with ASD such as planning. The majority of studies, and even more of the interventions, are focused on the core deficits of ASD (especially, difficulties in social communication and interaction), forgetting other problems that affect these people and their quality of life (Bond et al., 2016).

Despite the progress shown by the two groups of participants after the intervention, the results obtained in this study indicate that both are susceptible to continue improving their planning skills. Therefore, it is recommended to incorporate some improvements into the intervention: (1) to prolong the intervention over time by increasing the number of tasks and activities in order to SL1 group continue progressing and strengthening their complex planning skills and SL2 group begin to use them; (2) to provide a more specific scaffolding adjusted to the level of development shown by the participants, especially those of SL2 group. This would imply modifying the support of the adult to guide the tasks, incorporating the systematic teaching of a series of strategies that cognitively enhance more complex behaviors in both groups of children (Meinchenbaum, 1974); (3) to increase the number of activities in the post intervention task; (4) to establish another subsequent post intervention measurement point to see if the effects of the intervention are maintained for a longer period. It could be 3 or 6 months later the post intervention task; (5) to design activities and tasks to try to extend the benefits of the intervention to other tasks similar to those training tasks used during the intervention (near transfer), as well as transfer to behavior on less similar non-trained tasks (far transfer) (Zelazo et al., 2017).

It should not be forgotten that the sample of this study is small. Therefore, the improvement observed in the two groups of participants should be taken with caution. In this sense, it would be necessary to have a larger sample in order to obtain a greater amount of data that support these findings. The small sample size was due to the inherent complexity involved in any intervention with this type of population, together with the difficulties of accessing a larger number of participants. In relation to this last aspect, it would be a challenge to promote models of collaboration between educational and research centers that foster practical research focused on innovative pedagogical strategies, as well as evidence-based interventions to improve the quality of educational practice in the field of autism (Locke et al., 2016; Stahmer et al., 2017).

Although, as we have already mentioned, this study shows the improvement of planning skills of each group both during and after the intervention, we consider it would be interesting to carry out an individual analysis of the records of each participant in the future. This would allow us to obtain a greater knowledge of the progress that each one of them was achieving, and therefore, adjust the intervention more to their needs.

Given the relevance of executive functions for integral development and adequate adaptation to daily life, and consequently, the great obstacle that their executive deficits involve to people with ASD, we believe that in the future other interventions should be designed to improve different executive components such as flexibility, inhibition, etc. This study and its suggestions for improvement indicated previously, could contribute in this area.

On the other hand, at the methodological level and more exactly in relation to data analysis, in the future, this study could be complemented by including other observational data analysis techniques different from the one used here (lag sequential analysis), such as *polar coordinate analysis* (Sackett, 1980; Anguera et al., 2018b) and *temporal pattern* (*T-patterns*) *detection* (Magnusson et al., 2016). We are unaware of works in which these data analysis techniques have been used for the evaluation of planning skills in children with ASD. Although the specifics of each of these three observational data analysis techniques (lag sequential analysis, polar coordinate analysis, and T-pattern detection) differ, all of them allow to analyze and increase understanding of the internal structure of observed behavior, as evidenced by the only two works we know that have applied these three techniques together for the analysis of child behavior, and also in school context (Santoyo et al., 2017; Escolano-Pérez et al., 2019). Consequently, the complementary use of these three powerful data analysis techniques would allow a more exhaustive evaluation of the planning skills of children with ASD.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

Research was evaluated and approved by the Education Doctoral Program Academic Commission of Zaragoza University. Research was also approved by the school management teams. In accordance with the Organic Law 15/1999 of December of Protection of Personal Data (1999, BOE n_ 298 of December 14) all the parents of the participants signed the informed consent authorizing the participation of their children in the study and being recorded while playing. In addition, and following the guidelines of the aforementioned law, the observers signed the confidentiality agreement. No ethics special approval was required for this research since the Spanish public education system and national regulations require no such approval. Each participant received a small reward (two chocolates) in gratitude for their participation.

AUTHOR CONTRIBUTIONS

EE-P involved in conceptual and methodological structure, literature review, systematic observation, drafting of the manuscript, results and discussion. MA-F involved in collecting data, systematic observation, literature review and drafting of the manuscript and also contributed to results and its discussion. MH-N involved in methodological structure, data analysis, results and discussion. All of the authors contributed to revising the manuscript and provided final approval of the version to be published.

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T-Pattern Detection and Analysis (TPA) With THEME^{TM}: A Mixed Methods Approach

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This work, which was started in the early 1970s, was inspired by social interaction analysis based on direct observation and careful coding of behaviors according to a list of behavioral (mostly ethological) categories, especially the ethological work of N. Tinbergen, K. Lorenz, and K. von Frisch, for which they shared a Nobel Prize in 1973 in Medicine or Physiology but also H. Montagner's ethological analyses of interactions in social insects and children. S. Duncan's psychological and linguistic research on turn-taking in human interactions provided great inspiration, and so did Chomsky's work on syntactic structure and Skinner's probabilistic real-time functional analysis and their consequent debate. A hypothesis concerning numerous kinds of temporal and spatial natural and especially biological structures, the T-pattern is a hierarchical self-similar fractal-like structure that recurs with significant translational symmetry on a single discrete dimension, initially real time. It also points to profound self-similarity across many levels of biological spatio-temporal organization, as it seems characteristic of molecular structures such as genes and a multitude of recurrent motives on DNA and its 3D generalization corresponding to (3D) folded proteins. Developed initially to facilitate empirical analysis, the T-pattern and its detection algorithms were first presented in AI (Magnusson, 1981) and Applied Statistics (Magnusson, 1983) through THEME (3 k Fortran IV) software using an evolution algorithm. It is now over 300 k lines of code, runs under Windows, and, more recently, uses parallel processing for increased speed. This has allowed abundant detection of hidden structure in numerous kinds of biological phenomena at highly varied scales, from human behavior at timescales of days (Hirschenhauser et al., 2002; Hirschenhauser and Frigerio, 2005) to interactions of many individual neurons simultaneously registered at a temporal resolution of 10^{-6} s in neuronal networks in rat brains to ongoing work on T-patterns in DNA molecules at a spatial nano-scale. T-pattern detection and analysis (TPA) thus mix qualitative and quantitative analyses, as T-patterns themselves are artificial categories composed of recurring coding categories with special real-scale statistical relations between their instances. After their detection, T-patterns are thus analyzed much as are other behavioral categories.

Keywords: behavior, interaction, T-pattern, ethology, pattern detection, fractal, software

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INTRODUCTION

As a Mixed Methods approach, T-pattern Analysis (TPA) passes repeatedly between qualitative and quantitative analyses, from data collection logging the occurrences of qualities (categories) and their real-time (quantitative) locations resulting in time-stamped data, here T-data, to the detection of T-patterns (qualities) defined below, typically followed by both qualitative and quantitative analyses of the detected patterns. TPA is primarily intended for structural exploration but has most often been combined with standard statistical methods for the detection of the effects of external (experimental) variables.

The initial inspiration for the development of this approach was the ethological work of Niko Tinbergen, for which he, in 1973, shared the Nobel Prize in Medicine or Physiology with Karl von Frisch and Konrad Lorenz. The present project, which began in the early 1970s and has led to TPA, was influenced more specifically from many other directions including ethological and human interaction research (for example, Tinbergen, 1963; Eibl-Eibesfeldt, 1970; Montagner, 1971, 2012; Dawkins, 1976; Duncan and Fiske, 1977), linguistics (for example, Chomsky, 1957), and also radical behaviorism (for example, Skinner, 1969), all focusing on recurrent hierarchical and syntactically constrained temporal sequences, patterns, or contingencies. All were concerned with non-random recurrent synchronic and/or sequential temporal patterns of behaviors that were often themselves such patterns. For example, in verbal behavior, common phrases are composed of common combinations of words, which are combinations of syllables that are themselves sequential patterns of phonemes, or letters in the case of written language. Some such word combinations occur as parts of recurring interactive verbal and/or non-verbal behavior patterns, where different individuals react to each other with characteristic (predictable) timing constraints. Constraints of order and relative timing include those characteristic of melodies and numerous verbal and/or non-verbal routines, ceremonies, and rituals of everyday life, including some widely recurring texts, some even called holy.

Exploration of statistical and AI computer methods indicated that new, more specifically tailored methods were needed for the discovery and analysis of hidden structure in behavior and possibly some other biological phenomena (Magnusson, 2004). The definition of a T-pattern below thus attempts to integrate aspects of known recurrent behavioral patterns in a formal pattern definition and algorithms for the computational detection of some otherwise hidden patterns.

This initially led to the definition and detection of "temporal configurations" as a kind of "artificial category", first presented in an AI and Applied Statistics (Magnusson, 1981, 1983, 1996, 2000) and now called T-patterns, which, with gradually added structural types, now forms the T-system for the structural analysis of behavior, interactions, and other mostly biological phenomena. The aim has been to obtain new objective, quantitative, and structural (qualitative) bio-mathematical insights into the structure of behavior through the formulation of hypothetical mathematical pattern types to be evaluated with corresponding detection algorithms in the dedicated software THEME™, which also provides specially developed diagrams for the visualization of T-data and T-patterns such as are found in this paper.

The parallel processing available on multicore PC processors now provides increased speed, facilitating TPA application and further development. Theme is now Windows software, including a free academic version, which can be downloaded from www.patternvision.com.

T-pattern detection and analysis has been applied in a number of research areas concerned with very different time scales, from 10^{-6} s in neuronal interactions (Nicol et al., 2005, 2015) to days and even years (Anolli et al., 2005; Magnusson, 2005, 2006, 2016, 2017, 2018; Casarrubea et al., 2015, 2018; Magnusson et al., 2016).

As the T-system concepts, algorithms, and applications have been widely published, this paper is concerned with other aspects such as the meaning of T-patterns and their (biological) relevance for the discovery and understanding of behavior and related biological phenomena such as T-patterned strings, called T-strings, the omnipresent texts in recent human mass societies.

METHODS

The following sections describe the type of data referred to by all T-system definitions, followed by an essential description of the T-pattern and its corresponding detection algorithm as implemented in the Theme software.

T-Data

All T-system definitions and TPA algorithms refer exclusively to a type of data, here called T-data (**Figure 1**) consisting of one or more sets of discrete (occurrence) point series, each set (here also called a sample) occurring within a continuous observation period. The collection of T-data itself uses a mixed method, as qualitative categories (here called event-types) with their real-time (quantitative) occurrence points are recorded. The data are stored in two-column.txt files; [time tab event-type], which are the required input to all Theme processing. Initially, each sample is stored in a separate file, but all can optionally be concatenated and analyzed together as a single multi-sample file. Patterns may thus be detected in each sample file separately or independently or across all samples in a single multi-sample file. The baseline probabilities used in pattern detection are calculated independently for each file, whether a single-sample file or a multi-sample file and will thus vary for some event-types. The setting of a search parameter, such as the minimum number of occurrences, must also take into account that while no pattern may occur that often in a single-sample file, it may occur much more often across all the samples in a multi-sample file. *Theme project* refers to all samples analyzed together, whether in a multi-sample file or separately (see the Theme manual for details).

Visualization of raw T-data is provided in Theme for overview of the data and to help identify coding errors.

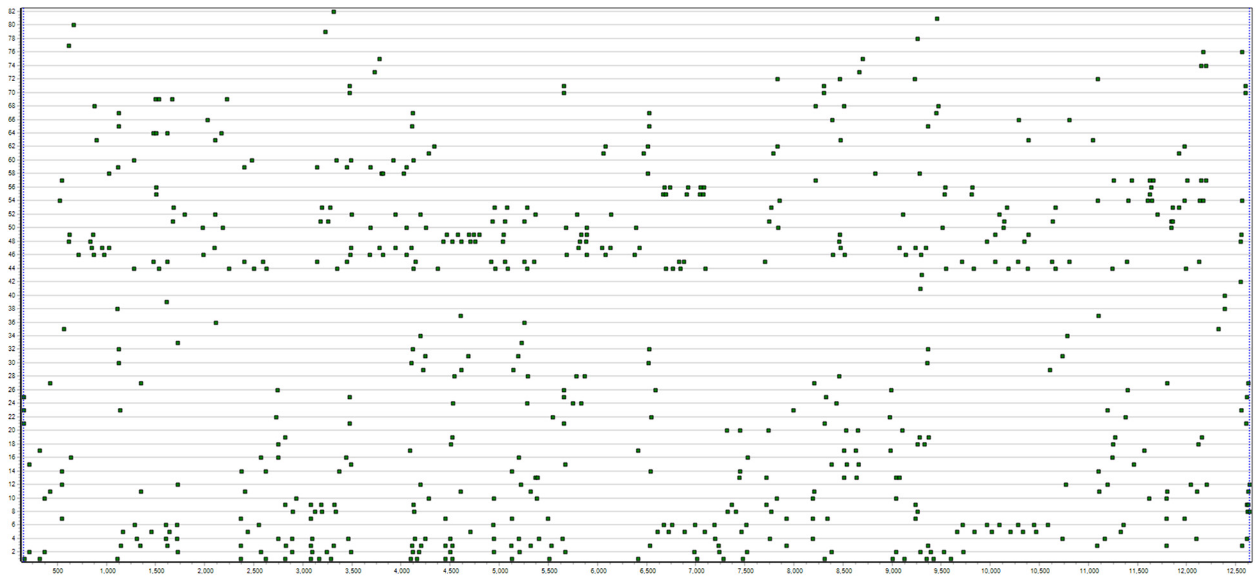

FIGURE 1 | This figure shows T-data of a 13.5 min children's free dyadic object play interaction where two 5-year-old girls take turns watching pictures in a picture-viewer. Each line of points represents the start or stop moments for a particular behavior for one or the other. In this image, the 82 series are sorted by actor (child) and frequency.

The T-Pattern

Here only an essential description is presented of the hierarchical, multiordinal, and self-similar T-pattern type and the essential corresponding detection algorithm implemented in Theme.

A T-pattern, Q, comprises m ordered components, $X_{1..m}$, recurring in a single discrete dimension, where each component is a T-data category (or pattern primitive, called event-type) or a T-pattern:

$$Q\text{: } X_1\ [d_1, d_2]_1\ X_2\ [d_1, d_2]_2 \ldots X_i\ [d_1, d_2]_i X_{i+1} \ldots$$
$$X_{m-1}\ [d_1, d_2]_{m-1}\ X_m \quad (m\ =\ \text{length})$$

where, over the n occurrences of the pattern within T-data, each of the distances X_i to X_{i+1} is significantly similar relative to a zero hypothesis of independent random distribution of each component. Each of these distances thus varies within a different one of the m-1 intervals, called critical intervals, $[d_1, d_2]_i$; $i = 1..(m-1)$; where $0 \leq d_1 \leq d_2$.

For special situations, this definition is restricted in various ways depending on the type of data and detection purposes. The current binary-tree bottom-up search algorithm of the Theme software relies on finding in T-data at least one pair of series related by a critical interval and then adding its occurrence series to the T-data and thus including it in the continued search for more pairs and possibly pairs of pairs etc. This binary tree approach has allowed detection of numerous and often quite complex T-patterns, but as will be exemplified below, this does not guarantee the detection of all possible T-patterns in the data, which might require using a trinary or higher tree.

T-patterns can be called recurrent hierarchical and multi-ordinal or, in more modern language, self-similar statistical pseudo fractal entities (objects) characterized by significant translation symmetry between their occurrences.

T-Pattern Detection Algorithm

Restricting the T-pattern definition above for detection purposes, any T-pattern Q: $X_1\ X_2..X_m$ can be split top-down recursively into a pair of shorter ones related by a corresponding critical interval, CI:

$$Q = Q_{Left}\ [d_1, d_2] Q_{Right}$$

Recursively, Q_{Left} and Q_{Right} can each be split until the full T-pattern is expressed as the 1..m terminals $X_1..X_m$ of a binary-tree of non-terminal critical interval relations.

Detection works in the opposite direction of the splitting above, that is, bottom-up, beginning with the series in T-Data and using special algorithms for critical interval detection, pattern construction, and pattern completeness competition (evolution algorithm), where redundant detections of the same underlying patterns are ignored. Theme then provides two types of statistical Monte Carlo validation.

Statistical Validation

When numerous significance tests are calculated, many may be positive even when the data is random, so it is necessary to evaluate to what extent this explains the detection of T-patterns in a dataset for given search parameter values. Two methods are provided in Theme, each using a different type of randomization, T-shuffling, or T-rotation. Under T-shuffling, each of the series in T-data is replaced with a series of random numbers within the observation interval, [1, T]. Under T-rotation, each series, t_i, is shifted by a new random value, dt, where $0 < dt < T$, so $t_i = [(t_i + dt) \bmod T]$. Each method repeatedly randomizes the data, searches for T-patterns, and stores the number of different patterns of each length found. Finally, the averages over all the randomizations are calculated and compared with the number detected in the original data. The differences found for each pattern length are usually far greater than required for significance (**Figure 2**).

Visualization

Visualization using a specially developed type of interactive diagram (**Figure 3**) primarily allows qualitative analysis but also provides some quantitative information. Each diagram shows all the occurrence (point) series in T-data that are involved in the pattern and all the bottom-up, level-by-level connections of points to form the full pattern. Theme software allows various interactive visualizations of T-patterns, other T-system structures, and their relations that cannot be presented in a paper but can be freely explored using the (free) academic version available at www.patternvision.com.

The following T-pattern diagram concerns the dyadic interaction for which the T-pattern model, algorithm, and software were first developed (**Figure 3**). Even though, over decades, the approximately 13.5 min interaction between two 5-year-old girls has been coded repeatedly and then searched for T-patterns, there is often something new to be noticed, as no single T-pattern captures all that is happening but still adds some new insight.

Restricted T-Patterns

Special T-pattern types are defined by specially restricted critical intervals such as the fast critical interval $[0, d_2]$ defining the univariate T-pattern type, called T-bursts, which are sudden increases in frequency in a single T-data occurrence (point) series. T-bursts may occur alone and/or as a branch of other T-bursts or T-patterns. A common characteristic of T-bursts is to sometimes greatly improve the prediction of other behaviors.

T-Patterns and Cyclicity

While the definition and detection of T-patterns are not based on cyclical occurrence, and just two occurrences of a T-pattern may allow detection, T-patterns often occur cyclically and may thus bring to light cyclical relations between T-data series where cyclicity is not present in any of the single series (Magnusson, 1989).

[1, 1] Restricted T-Patterns

Another restricted T-pattern type has the fixed critical interval [1, 1] and is used for some TPA of text or molecular sequences (DNA and proteins, in preparation) notably for the detection of recurrent continuous strings such as DNA codons or words within texts (see below).

The T-System

Starting with the T-pattern and its univariate version, T-burst, other structural aspects have been added to the T-System, including T-Markers, T-Predictors, T-Retrodictors (Magnusson, 2017), and T-packets with ±T-Associates as well as T-Composition have been described elsewhere (Magnusson, 2005, 2006, 2016, 2017).

QUALITATIVE AND QUANTITATIVE ANALYSIS OF DETECTED T-PATTERNS

After detection, a new set of analysis tools is used to extract qualitative and quantitative information of interest from the set of detected patterns. In addition to the detection and visualization of T-patterns and other T-system types, the Theme software provides pattern selection features and output of corresponding tables for quantitative analyses using standard statistical methods and tools.

Structural Qualitative Aspects

Most of the qualitative analyses concern the implication and structural positions of coded behaviors or T-patterns of special interest within more complex T-patterns as recurring context. Program features allow the selection of patterns, including any or all of specified behaviors and, optionally, in a specified order. A list of all coded behaviors occurring in selected patterns is also available, as well as at what hierarchical pattern levels each first appeared. As the coded behaviors usually specify the actor (agent, individual, group, etc.) of the behavior, detected multi-actor patterns suggesting interaction and/or synchronization can also be selected.

Figure 4 is an example of TPA used for qualitative structural exploration. It is of interest here as it captures, in a single T-pattern, the relations between a number of behaviors implicated in each of the four dyadic object transfers described above and underlines that a single T-pattern usually does not capture all the T-patterning found in a T-data set and combining information from two or more may provide better insight.

Figure 6 recently detected in data (**Figure 5**) from a previous project (Magnusson and Beaudichon, 1997) concerning children's dyadic problem-solving interactions, is the T-pattern in **Figure 6**. The puzzle had three stages, and this particular dyad was the slowest to reach completion and was therefore expected to be relatively unstructured. The T-burst within the T-pattern shown in **Figure 6** is different from those shown elsewhere (for example, Magnusson, 2016, 2017) in that each of its occurrences is of relatively long duration but still shows increased predictive power of a T-burst relative to single occurrences of its elements.

Quantitative Analyses

Quantitative analysis of a set of detected T-patterns usually concerns their number of occurrences, number of components, hierarchical levels, and number of actors and switches between them within the pattern. When subsets of the samples have been collected under different experimental conditions, such parameters have often allowed the discovery of effects of independent (external or background or experimental) variables.

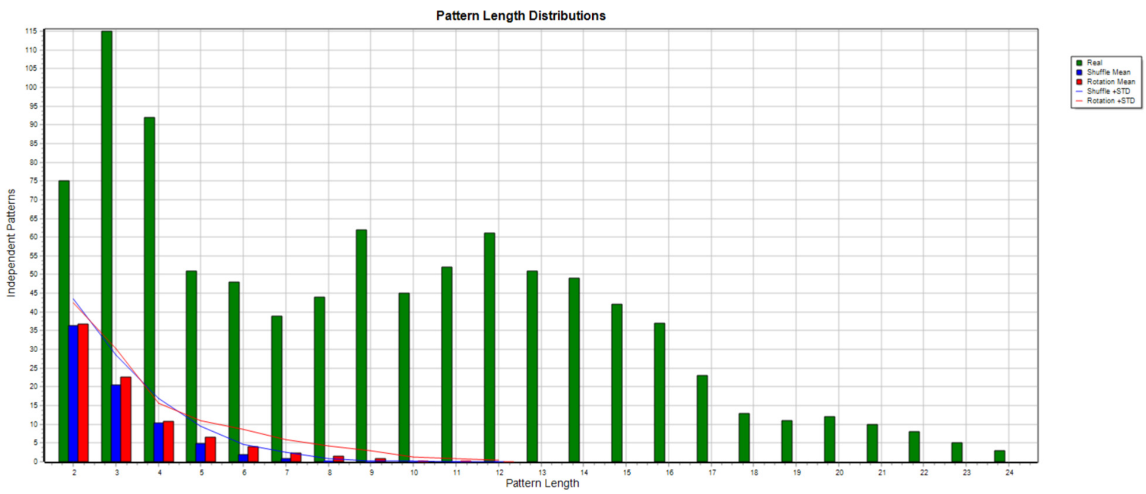

FIGURE 2 | This figure shows the result of a Monte Carlo (50 randomizations) comparison. The number of different T-patterns of each length detected in the initial data is shown in green, while the averages for shuffling and rotation are shown in blue and red, and the blue and red lines add one standard deviation to each.

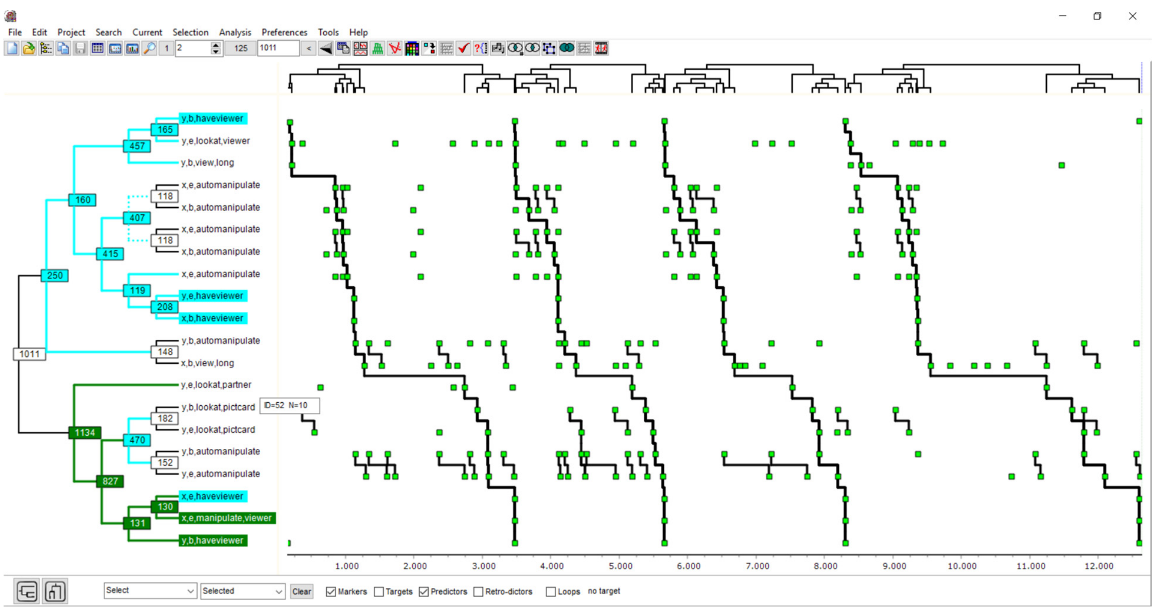

FIGURE 3 | This figure shows one T-pattern detected in the T-data shown in **Figure 1**. The clustering diagram on the left shows how points in the series on the right are connected level-by-level to form the four occurrences of the complete pattern. *x* and *y* in the labels represent the two girls, and b or e stand for beginnings or ends.

Numerous applications rely on this, as can be seen in a recent comprehensive review (Casarrubea et al., 2015).

SPATIAL T-PATTERNS AND SELF-SIMILARITY

The T-pattern and TPA were created primarily to help decipher the little known "languages" of non-verbal interactions among various organisms through the use of artificial means, here computational algorithms, to discover hidden or non-obvious patterns in real-time streams of behavior and, consequently, to try to understand their function or meaning and sometimes diagnostic value for distinguishing the behavioral profiles of individuals, groups, or (experimental) conditions.

It was in continuation of a number of bilateral collaborations regarding such interaction research that in 1995, seven European universities signed a collaboration convention around TPA entitled Methodology for the Analysis of Social Interaction. This growing network now includes 32 universities in Europe and the United States.

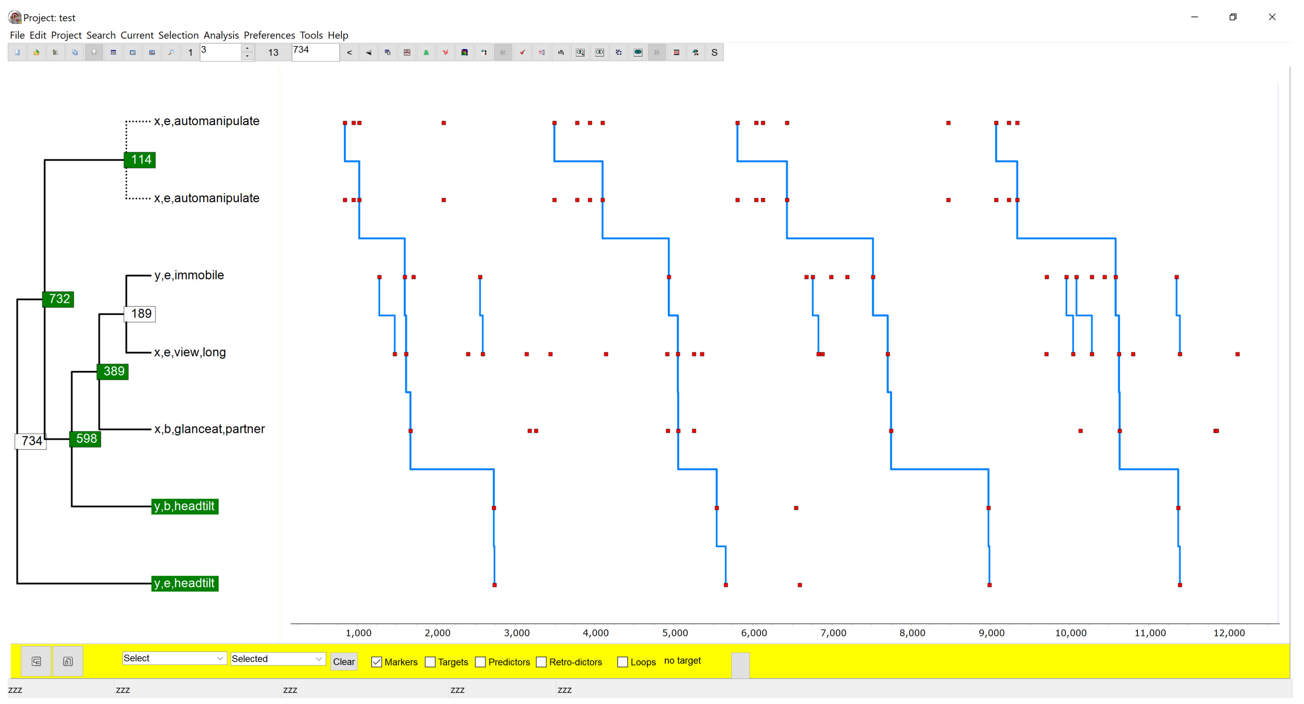

FIGURE 4 | This figure shows a T-pattern different from **Figure 3** but detected in the same T-data showing strong relations between the behaviors of each child related to the transfer of the toy. It is characteristic of girl x that when she is waiting to get the toy again, she repeatedly fiddles with something, easily perceived as a sign of impatience. Freezing (immobile) only occurs in y and only when she is waiting for the toy. Finally, the head tilt, often associated with begging, only occurs in y and then only when she is waiting.

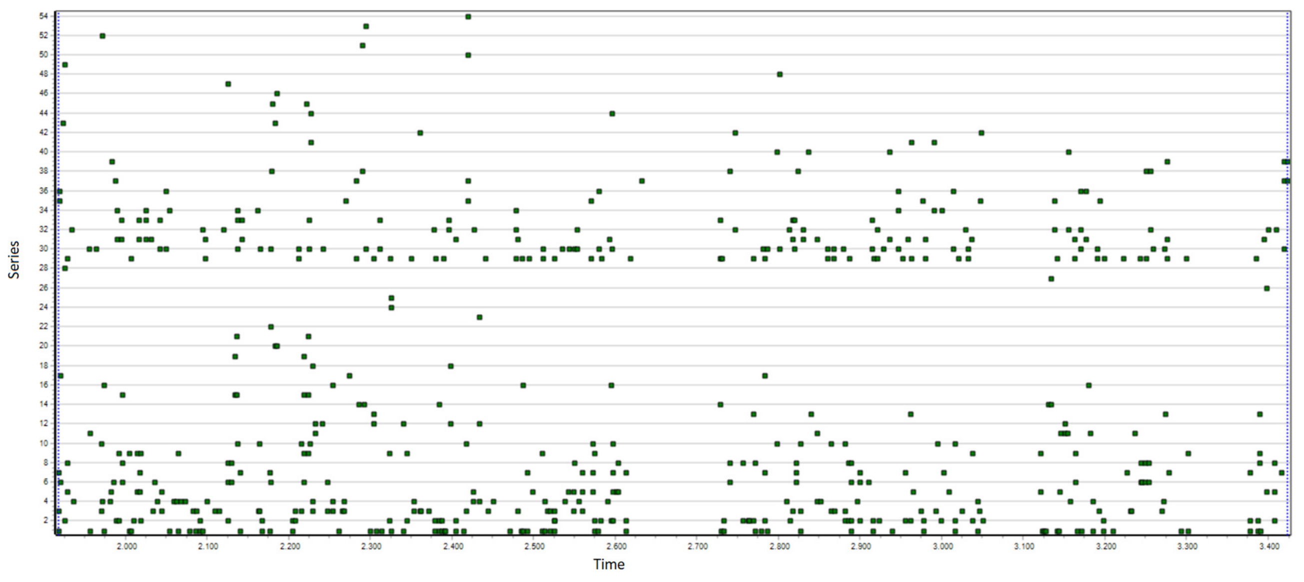

FIGURE 5 | This figure shows T-data of one problem solving dyad, where the two children (e and n) attempt to solve together a puzzle with three consecutive stages.

However, recent discoveries in cell biology, genetics, and proteomics have drawn attention to spatial T-patterns in physical strings and analogies between, on one hand, the purely informational physical strings (DNA) existing in all biological cells since billions of years ago, holding the blueprints for the numerous types of specialized citizens in the mass societies of proteins (now sometimes called "Cell Cities") and, on the other hand, texts, which have appeared in a biological eye-blink, with analogous blueprints for specialized individuals and now influencing practically all

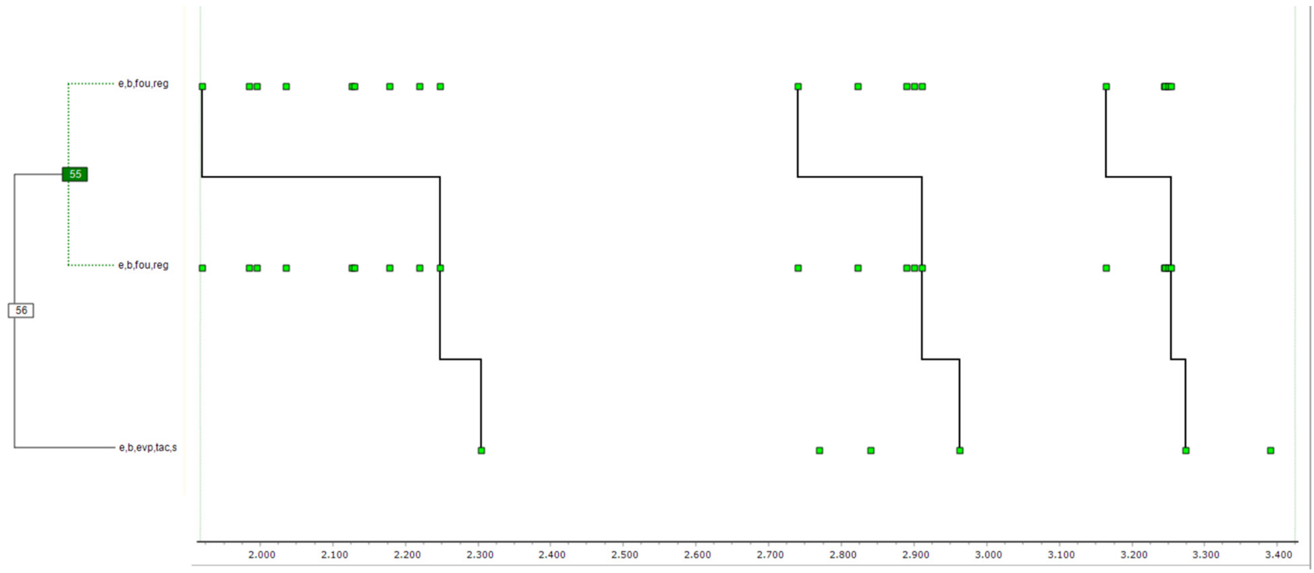

FIGURE 6 | This figure highlights bursts, here providing a rule (reg) for the solution at each stage, followed by a positive evaluation of progress (evp) by one of the two, talking to herself (s = soliloquy). Each of the behaviors in the burst clearly has little predictive behavior, but an occurrence of the burst each time predicts the positive evaluation.

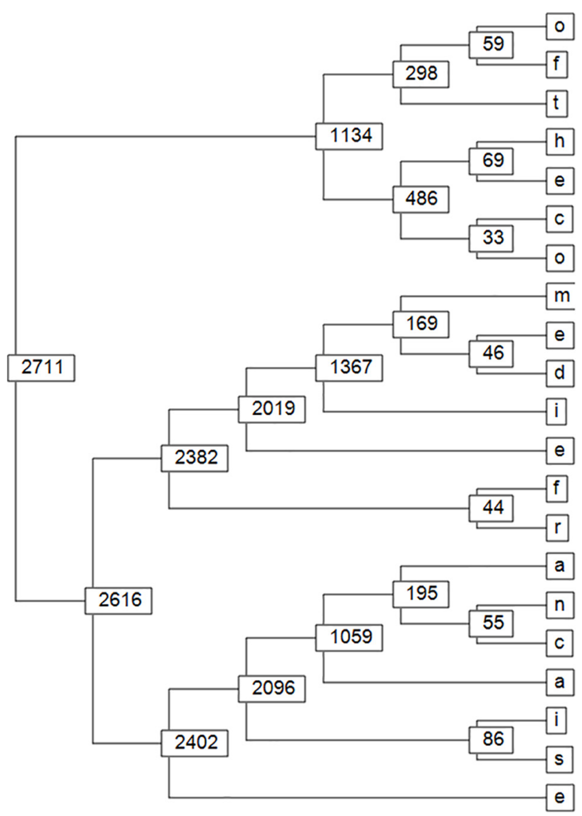

FIGURE 7 | This figure shows the gradual bottom-up detection, level-by-level, of a long recurrent T-pattern of letters: "ofthecomediefrancaise" even if occurring only twice in the short text where word separations (blanks) were removed.

human behavior, changing naked apes into string-enabled and string-controlled mass-social citizens. This view of the modern mass-social context of human interaction has only recently become possible thanks to new technology and discoveries in cell biology including genetics and proteomics, but such self-similarity across many orders of magnitude seems to underline the possible broad relevance of the T-pattern model and TPA at different levels of temporal and spatial biological organization. The latest addition to the T-system is thus physical strings containing spatial T-patterns, called T-strings, exemplified primarily by DNA and texts. In this light, some TPA of texts (and DNA) has therefore begun, with the first results now appearing.

Detecting Words in Text as T-Patterns and Their Meaning

For literate speakers of a language, its words and various word combinations are usually obvious in both speech and text and have a fairly clear meaning that is hidden to non-speakers. The same is true for many detected T-patterns in behavior and interactions, which, even after detection, may remain invisible to the naked eye or have no obvious "meaning."

A search for [1, 1] restricted T-patterns was made in a short text of 10103 letters (called "Zibeline" and randomly found and downloaded from the internet) but with word separators removed (i.e., blanks deleted) to see if TPA using the limiting binary tree approach (rather than trinary trees or higher) can detect recurrent words and possibly word combinations as T-patterns. Where all the words are known *a priori*, this can also help answer questions about limitations of the algorithm and the meaning of T-patterns (**Figures 7**, **8**).

FIGURE 8 | This figure shows some of the many recurrent letter T-patterns in a short text. It shows that some such patterns may not be easily given a particular meaning, as some common letter combinations often occur within words or as word endings, for example, "tion", while the common string "the" can occur alone or as a part of a longer word.

DISCUSSION

Important limitations of the current T-pattern should be mentioned here. While they need to be addressed, the current algorithm led to abundant detections of patterns where only minimal patterning had been found before using other methods, thus shifting the focus and limited programing resources to visualizing and analyzing the many detected patterns.

However, the following limitations exist and are being addressed.

First is the limitation caused by the exclusive use of binary-tree detection, which may overlook many T-patterns detectable with a higher-order tree. Recent searches for [1, 1] restricted T-patterns in text as occurrences of letters show that some words cannot be detected for this reason as, for example, some words include no significant pairs of letters, while, as a whole, they are highly significant T-patterns and would thus be detectable with higher-order trees.

Another major limitation is that the significance level is decided by the user rather than being detected by a special algorithm, long since among the top priorities in TPA development. A guideline for deciding on a significance level is briefly described elsewhere (Magnusson, 2000). This involves a kind of bootstrapping, that is, trying out different levels optimizing different aspects, depending on the main interest of the study, such as the maximum or average lengths or levels of detected patterns while giving good Monte Carlo results. An as yet unexplained observation is that significance levels near 0.005 are often found to be the best, which is why that value is the default value in Theme, to be modified as needed by the user.

A further limitation is the lack of consideration of substitutes or alternatives, such as when different components may occur at some position in a pattern, as each variant can only be detected as a different pattern and only if the variants occur the required number of times. This has become a more pressing concern because of a pilot study of [1, 1] restricted T-patterns in proteins testing whether some known patterns constitute significant T-patterns. All were found to be highly significant, but testing a large number (all) of such known patterns is in preparation. Most would not be detectable with the current algorithm, as their definitions typically include alternatives at some positions.

Algorithmic solutions for each of these limitations are in preparation and to be implemented in the next Theme version.

Some notes follow concerning the apparent biological interest and validity of the T-pattern and the derived T-string concept.

This work is rooted in Human Ethology, where a central theme is respecting the special characteristics of each species. But ethology, with its main focus initially on animal research, was not well prepared for the human kind of language and even less its written form, text, a recent and powerful kind of external memory appearing in a biological eye-blink but without which modern human behavior can hardly be understood. It was even less prepared for recent fractal mathematics highlighting self-similarity over numerous scales in the increasingly known universe (Rees, 1999; Baryshev and Teerikorpi, 2002; Kautz, 2011).

Highly structured mass societies of, for example, >10,000 individuals are very rare and in non-human animals are found only in insects. While external memory (texts) is essential in modern humans and in cells (DNA) for the specialization of their (human vs. protein) citizens, in insect societies, specialization is achieved very differently (Hölldobler and Wilson, 2008). Obviously, there is no direct or simple evolutionary path between the internal workings of biological cells and human mass societies, but, as underlined by Konrad Lorenz in his inaugural Nobel Lecture (Lorenz, 1974), analogy is a valuable source of knowledge in ethology, and here it provides a new perspective on the human situation where dramatic changes are taking place, not in genes, but in lifestyle.

While the discovery of the biological cell itself is so recent and that of DNA, the ribosome, and the RNA world even more so, "Cell City" now appears an attractive model for human behavior in modern human mass societies. Purely informational strings (DNA) suddenly became essential and omnipresent for the specialization, enabling, and control of the numerous and varied protein citizens. The RNA world became a DNA world of very complex cells, and bio-mathematical self-similarity was reached as the illiterate world became a purely informational text-based mass-social world. Both text and DNA seem to be T-strings to a large extent, suggesting spatio-temporal self-similarity over numerous levels of biological organization from nano to human scales (Magnusson, 2005, 2009, 2016), also indicating possible broader applicability of TPA.

DATA AVAILABILITY STATEMENT

The datasets analyzed in this manuscript are not publicly available. Requests to access the datasets should be directed to corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Selecting Training-Load Measures to Explain Variability in Football Training Games

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The purpose of this study was to investigate the structure of interrelationships among external (eT) and internal (iT) training intensity metrics and how these vary depending on game format in soccer. The variables were collected from 16 semi-professional players in seven types of small, medium, large-sided, and simulated games (SG). The eT variables were (per min): peak velocity (*V*max), total distance (DTmin), distance covered at velocities less than 60% (*D* < 60%min), between 60 and 80% (*D* > 60%min), and more than 80% (*D* > 80%min) of the maximal velocity, player load (PLmin), and distance covered accelerating at more than 2 m·s-2 (Daccmin) and decelerating at less than −2 m·s-2 (Ddecmin). The iT variables were: Edwards arbitrary units (EDWmin) and time spent at more than 80% of the maximal heart rate (*T* > 80% HRmin). All game formats were represented by three principal components (PC), explaining from 66.9 to 76.0% of the variance. The structure of the interrelationships among variables involved similar distributions in the PCs that are related to energetic production systems, such as the strength/neuromuscular dimension (PLmin and/or Daccmin and Ddecmin, complemented by DTmin and *D* < 60%min), the endurance/cardiovascular dimension (EDWmin), and the velocity/locomotion dimension (*V*max, *D* > 60%min, or *D* > 80%min). A particular combination of external and internal intensity measures is required to describe the training load of game formats.

Keywords: team sport, time motion, heart rate, small-sided game, principal component analysis

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INTRODUCTION

Research using a mixed-methods approach presents us with the challenge of combining and integrating quantitative and qualitative data in the same study (Anguera et al., 2018). Although this approach is not new, it continues to attract increasing attention. Recently, it has been applied in sports contexts in order to explain the behavior of football players (Maneiro and Amatria, 2018; Maneiro et al., 2019) or teams (Diana et al., 2017).

Football players are subject to different types and amounts of load during training sessions, with the aim of optimizing their performance (Graham et al., 2018) in competition and reducing, as far as possible, the risk of injury (Gabbett, 2016). For this reason, monitoring the training load in a systematic way is a key aspect in being able to plan and intervene on the quantity, quality, and appropriate order of the training process, with the aim of maximizing its efficiency (Impellizzeri et al., 2005). The evaluation of the training load in general, and specifically that of the underlying training tasks, is indispensable both in terms of optimizing the players'conditional performances (avoiding under- or over-training through conditions that are very different from those of matches) and in preventing overtraining and injuries (Sangnier et al., 2018).

Reduced games are sport motor situations (Parlebas, 2001) that include most of the factors that arise in the "real" game in an adaptable way (Renshaw et al., 2009). An important part of the content of football training is related to the tasks performed, e.g., small- (SSG), medium- (MSG), and large-sided games (LSG) (Little, 2009). The pitch dimensions of interaction in the task proposals affect the quality and quantity of the driving behavior of players, in which significant differences have been detected in the game. The individual space of interaction (ISI) is an important variable to consider in the design of tasks for training in soccer. There is extensive literature supporting the hypothesis that different game formats demand particular patterns of movement, provoking a specific response in players and having acute and chronic effects on physical condition (Hill-Haas et al., 2011; Aguiar et al., 2013; Sgrò et al., 2018). Nevertheless, due to the multiple conditional demands of SSGs, there is no consensus as to what variables better represent those demands.

Recent research studies (Weaving et al., 2017a,b, 2018) support the idea that a single training load variable is not sufficient to capture a significant proportion of the variety provided by multiple load variables. For this reason, it is usually decided to use a multitude of variables, e.g., global load indicators or intensity variables, to describe the demands and the response provoked in the players during training and/or competition (Akenhead and Nassis, 2016). However, managing a multitude of variables is not very efficient (provoking, in some cases, redundancy in the information reported), making it difficult for the physical practitioner to carry out a thorough follow-up and control of the stimulus provoked to the players, which makes it necessary to use strategies that allow the management of the minimum amount of variables necessary to have the essential information (Williams et al., 2016).

With the aim of reducing redundancy (Casamichana et al., 2019), one of the strategies recently proposed in rugby (Weaving et al., 2017a) for workload monitoring of different training modes, or in basketball (Casamichana and Castellano, 2015) for comparing the differences among players' positions, is related to with the implementation of principal component analysis (PCA). The use of this analytical technique allows it to be determined whether we are using redundant information, e.g., variables that provide the same information about the load or the intensity implied by the practice of the tasks performed (Casamichana and Castellano, 2015).

Principal component analysis is based on a systematic process that allows a reduction in the number of variables to attend to, minimizing the loss of information associated with that process. Currently, more information is required in order to determine how physical and physiological variables are related in different game formats and in simulated games (SG) so as to allow a fine-tuning of the selection of variables necessary to provide all the information needed by preparers to design and control the stimuli demanded from the players.

In this way, the purpose of the current study was to investigate the structure of interrelationships between the external and internal training intensity variables and determine how they vary between different types of SSG-, MSG-, and LSG (e.g., from 3 vs. 3 to 10 vs. 10). Considering hypothetical results, if different training tasks involve no similar physical demands, it could help coaches to design tasks where players can replicate the demands that will probably be required during games.

MATERIALS AND METHODS

Participants

A total of 23 semi-professional male football players from group IV of the third division in the Spanish League took part in the study. Due to the number of devices available, information related to 16 of them was used (age = 25.1 ± 3.7 years; height = 178.3 ± 5.0 cm; weight = 74.6 ± 7.9 kg; percentage of body fat obtained with the Möhr formula = 10.8 ± 2.2%). The players completed, on average, 3–4 weekly training sessions and played one official match every weekend. Before taking part in the study, all the players involved signed an informed consent form. Participants and the team's technical staff were informed about the procedure and possible risks and benefits of the study. Furthermore, the procedures used in this project were in accordance with the Declaration of Helsinki and the Ethics Committee of the University of the Basque Country (UPV/EHU), which also gave its institutional approval of the study.

External Intensity Variables

The following external variables were studied: peak velocity (*V*max), total distance (DTmin), distance covered at less than 60% (D < 60%min), between 60 and 80% (D > 60%min) and more than 80% (D > 80%min) of the maximal velocity of each player, player load (PLmin), and distance covered accelerating at more than 2 m·s-2 (*D*acc > 2min) and decelerating at less than −2 m·s-2 (*D*dec < −2min). Except for the variable *V*max, the rest of the measures were relativized and expressed in minutes of practice. All of these external variables are related to the locomotor (distance and velocity) and neuromuscular (acceleration/deceleration) dimensions.

Internal Intensity Variables

In all training sessions, HR was recorded with a short-range telemetry system (Polar Team2 Pro System, Polar Electro Oy, Kempele, Finland). The Edwards method was used (EDWmin) to quantify the internal load from the HR (Edwards, 1993). This method distributes the magnitude of the HR in five different zones. Each zone has a value associated with it (50–60% HRmax = 1, 60–70% HRmax = 2, 70–80% HRmax = 3, 80–90% HRmax = 4, and 90–100% HRmax = 5), and these are later added together. The second variable was time spent at more than 80% of the maximal HR (T > 80%HRmin), similar to that proposed by Henderson et al. (2015).

To calculate the maximum HR for each player, a maximal progressive test was carried out on a treadmill with a HR monitor, beginning at a velocity of 8 km·h^{-1} and increased at a rate of 1 km·h^{-1} every minute until the point of physical exhaustion was reached (Graff, 2002). All HR-based measures are related to the endurance dimension.

Assessment of Small-Sided, Medium-Sided, Large-Sided, and Simulated Games

Eight game formats were used in this study, involving different numbers of players per team, always with a goalkeeper and official football eleven-a-side goals. The players did not have any technical or tactical limitations during the performance of the SSG. Considering the duration of the tasks, number of bouts, and dimensions of the field, the eight game formats were grouped into four types of training tasks: 3 vs. 3 as SSG, 4 vs. 4, 5 vs. 5, and 6 vs. 6 as MSG, 7 vs. 7, 8 vs. 8, and 9 vs. 9 as LSG, and 10 vs. 10 as SG, with the constraints that appear in **Table 1**.

Procedures

This observational study was carried out during seven consecutive microcycles (from 30 to 37) of a competitive period (from February to April) of the 2016–2017 season. The specific observational design (Anguera et al., 2011) employed was: point (without intersessional follow-up), multidimensional (analysis of internal and external load), and nomothetic (focus on several players).

Heart rate sensors and GPS devices monitored all training sessions. Before beginning the study, the players underwent a maximal progressive resistance test on a treadmill (in a laboratory) to calculate the maximum heart rate (HR) of each player and a 40-meter velocity test on the training ground provided whilst wearing the GPS devices to measure the individual *V*max (Roe et al., 2017). In total, 698 recordings were collected in 16 training sessions (43.6 ± 12.1 per player). The quality of the signal of the GPS devices was assessed: the mean (± sd) number of satellites during data collection was 12.5 (± 0.6) (Castellano et al., 2011).

Physical demands were measured using a portable GPS device operating at a sampling frequency of 10 Hz, which contains a 100 Hz triaxial accelerometer (Minimax v.4.0, Catapult Innovations Victoria, Australia). The device was attached to the upper back of each player using a special harness. The GPS devices were activated 15 min before the start of each session or match, in accordance with the manufacturer's instructions. Collected data from the Minimax S4 and PolarTeam2 devices were downloaded to a PC to be analyzed using the Sprint v5.1.4 software package (Catapult Innovations, Victoria, Australia, 2010).

The validity and reliability of this technology have been previously demonstrated, indicating that it is a valid way of monitoring different speed ranges (Johnston et al., 2014). The internal response was assessed based on HR (Alexandre et al., 2012), which was recorded every 5 s using a telemetric device (Polar Team Sport System, Polar Electro Oy, Finland). All the players were familiarized with the use of both GPS and HR monitors before starting the study.

Statistical Analysis

Descriptive statistics data from the training games are reported as the mean and standard deviation (± sd). Additionally, magnitude-based inferences were used to analyze the data based on the recommendations of Batterham and Hopkins (Batterham and Hopkins, 2006). Differences between SSG, MSG, LSG, and SG were assessed via standardized mean differences (Cohen's d with a 90% confidence limits). The interpretation thresholds for standardized effect size (ES) were as follows (Batterham and Hopkins, 2006): <0.2 (trivial), 0.2–0.6 (small), 0.6–1.2 (moderate), 1.2–2.0 (large), and >2.0 (very large).

Before carrying out PCA, the Pearson correlation matrix with ten external and internal training intensity variables was constructed in order to perform a visual inspection of data factorability (Tabachnick and Fidell, 2007). This method aims to extract the most important components and/or variables from data without reducing the volume of information. The Kaiser-Meyer-Olkin (KMO) method was used to verify whether the 10 external load variables were suitable for PCA, i.e., KMO > 0.5 (Kaiser, 1960). The KMO values for the four game formats were 0.54, 0.516, 0.514, and 0.522 for SSG, MSG, LSG, and SG, respectively, showing that the dataset is suitable for PCA. Bartlett's sphericity test was significant for each training mode ($p < 0.001$). The principal axis method was used to extract the components. Components with eigenvalues of less than 1 were not retained for extraction (Kaiser, 1960).

The PCA was applied with a VariMax rotation to identify components that are not highly correlated. Subsequently, the rotation was performed with the goal of making the 9 × 1 component loadings more easily interpretable. The stages involved in the calculation for PCA were the same as those used previously (Weaving et al., 2014). Following the methods of Weaving and colleagues (Weaving et al., 2014) for each extracted PC, only the original variables that possessed a PC loading greater than 0.7 were retained for interpretation.

Finally, the correlation between external and internal load variables was measured for each game format. Following Hopkins, the following qualitative correlation descriptors were used: trivial (0–0.09), small (0.1–0.29), moderate (0.3–0.49), large (0.5–0.69), very large (0.7–0.89), nearly perfect (0.9–0.99), and perfect (1) (Hopkins, 2000). The Statistical Package for the Social Sciences (SPSS, Version 24.0 for Windows; SPSS Inc., Chicago, IL, United States) and JASP version 0.7.5 (Love et al., 2015) were used to conduct the analysis.

RESULTS

The means and standard deviations of each physical measure and HR derived variable recorded in the eight types of format games are shown in **Table 2**. There were significant differences among game formats, specifically: larger game formats had higher velocity demands (maximal and average), while smaller formats demanded more acceleration and deceleration. The demands derived from HR were higher in the SSG and MSG compared to the LSG and SG.

Figure 1 represents ES for the SG format compared with the other three game formats. At the bottom of the figure, it can be observed that SG and LSG do not differ substantially in any of the compared variables. All of the variables analyzed showed small magnitude differences between SG and LSG, but the differences

TABLE 1 | Description of the features of the four groups of training tasks: small-sided games (SSG), medium-sided games (MSG), large-sided games (LSG), and simulated games (SG).

Format	Players per team (*n*)	Records (*n*)	Pitch size (m^2 per player)	Number of bouts (*n*)	Duration of bouts (min:sec)
SSG	3	25	≈ 84	4	≈ 3:30
MSG	4	216	≈ 132	3	≈ 3:00
	5	238	≈ 105	4	≈ 5:00
	6	28	≈ 130	4	≈ 6:30
LSG	7	26	≈ 247	2	≈ 17:00
	8	60	≈ 272	3	≈ 13:00
	9	44	≈ 235	2	≈ 15:00
SG	10	61	≈ 300	2	≈ 19:00

TABLE 2 | Means and standard deviations (± sd) of internal and external training intensity measures according to the groups of game formats.

Load measures	Variables (units)	SSG	MSG	LSG	SG
External (eTL)	V_{max} (km·h^{-1})	17.9 ± 2.8	18.9 ± 2.7	24.0 ± 2.7	25.1 ± 2.2
	D < 60%min (m·min^{-1})	94.2 ± 16.9	96.6 ± 14.4	99.0 ± 14.8	100.3 ± 13.8
	D > 60%min (m·min^{-1})	1.6 ± 2.5	3.2 ± 3.7	5.0 ± 2.8	6.2 ± 2.5
	D > 80%min (m·min^{-1})	0.0 ± 0.0	0.1 ± 1.0	0.6 ± 1.0	1.2 ± 1.3
	DTmin (m·min^{-1})	95.8 ± 18.0	100.1 ± 15.5	104.7 ± 16.0	107.6 ± 14.4
	PLmin (AU·min^{-1})	11.9 ± 2.9	11.2 ± 2.4	9.8 ± 2.0	10.0 ± 1.9
	*D*acc > 2min (m·min^{-1})	4.6 ± 1.3	4.4 ± 1.6	3.6 ± 1.0	3.4 ± 0.9
	*D*dec < −2min (m·min^{-1})	3.1 ± 1.3	3.1 ± 1.3	2.8 ± 0.9	2.6 ± 0.8
Internal (iTL)	EDWmin (AU·min^{-1})	3.3 ± 1.5	3.6 ± 1.0	3.1 ± 1.0	3.2 ± 0.7
	T > 80%HRmin (min·min^{-1})	0.3 ± 0.4	0.7 ± 1.2	0.3 ± 0.5	0.2 ± 0.4

SSG is 3 vs. 3 (three players per team), MSG involves 4 vs. 4, 5 vs. 5, and 6 vs. 6 game formats, LSG includes 7 vs. 7, 8 vs. 8, and 9 vs. 9 game formats, and SG is a simulated game (10 vs. 10). Vmax is peak velocity, DTmin is total distance covered, D < 60%min is distance covered at less than 60% of the maximal velocity of each player, D > 60%min is distance covered at between 60 and 80% of the maximal velocity of each player, D > 80%min is distance covered at more than 80% of the maximal velocity of each player, Mmin is distance covered per minute, EDWmin is Edwards arbitrary units per min, T > 80%HRmin is time spent at more than 80% of the maximal heart rate, PLmin is player load per minute, Dacc > 2min is distance covered accelerating at more than 2 m·s^{-2}, and Ddec < −2min is distance covered decelerating at less than −2 m·s^{-2}.

become higher and lower (depending on the assessed variable) when compared to SSG or MSG. Variables involving a velocity dimension (e.g., Vmax, D > 60%min, D > 80%min and DTmin) were higher in SG with a moderate to very large effect, while variables regarding strength (e.g., PLmin, *D*acc > 2min and *D*dec < −2min) were higher in SSG and MSG with a small to moderate effect.

Regarding PCA (**Figure 2**), the eigenvalues for each principal component were 3.79, 1.82, and 1.05 for the first (PC1), second (PC2), and third (PC3) principal components, respectively. The total explained variances by each principal component were: 37.90, 18.24, and 10.53 for PC1, PC2, and PC3, respectively. **Figure 3** shows the representativeness of the 10 iTL and eTL intensity variables (rotated component).

Finally, **Figure 3** shows the position of each game format in the rotated component plot. Only two main factors were plotted so as to visually represent the differences between game formats.

DISCUSSION

The aim of this research was to study the identification of a structure with three principal components summarizing eight external and two internal intensity variables for all of the types of game formats studied. This is the first piece of work that focuses on assessing the demands and responses of the same team in eight different game tasks grouped into four types of game format (SSG, MSG, LSG, and SG). The main value of this study is the opportunity to compare players of the same team in different game formats that are usually practiced in football training sessions, understanding the characteristics associated with each of the formats. The main results of the study can be summarized as follows: (1) through PCA analysis, determine the minimum amount of variables necessary to obtain the essential information and (2) thus obviate redundant information in workload analysis and help to save effort on the part of physical trainers and increase the quality of their analyses.

The application of this procedure to determine the minimum amount of variables can be applied to load adjustment for each of the variables. This method (PCA) aims to extract the most important components and/or variables from data without reducing the information. Although the initial number of factors was the same as the number of variables used in the factor analysis, only the first three (1, 2, and 3) PC were retained in the present study. The total percentage of variance explained by the sum of the three rows (factors) used was 66.7%. C1 involved five eTLs, namely D < 60%, PL, DT, *D*acc > 2, and *D*dec < −2, C2 was represented by three variables, namely Vmax, D > 60%, and D > 80%, and, finally, only one iTL had a score above 0.70 (all values were relative to minutes of practice). Considering

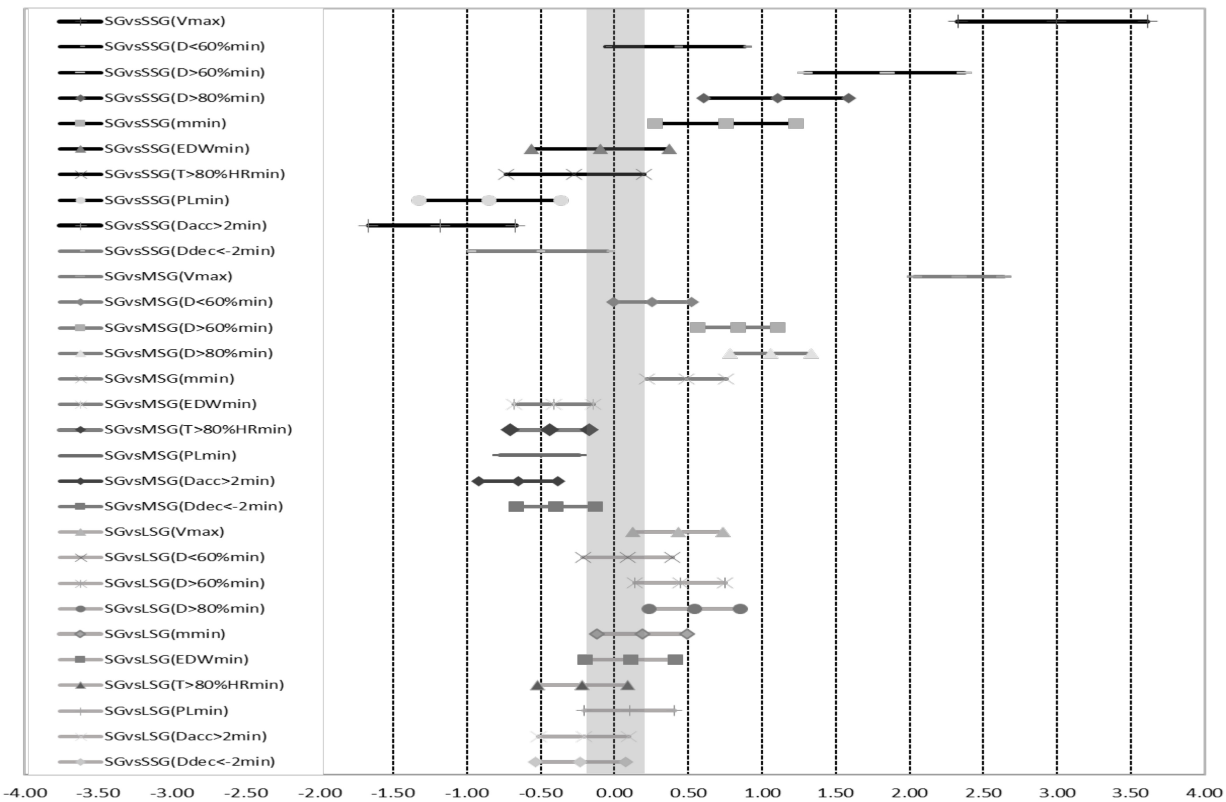

FIGURE 1 | Effect sizes for the simulated games (SG) format compared with the other three, small-sided (SSG), medium-sided (MSG), and large-sided (LSG) games. V_{max} is peak velocity, DTmin is total distance covered, $D < 60\%$min is distance covered at less than 60% of the maximal velocity of each player, $D > 60\%$min is distance covered at between 60 and 80% of the maximal velocity of each player, $D > 80\%$min is distance covered at more than 80% of the maximal velocity of each player, EDWmin is Edwards arbitrary units per min, $T > 80\%$HRmin is time spent at more than 80% of the maximal heart rate, PLmin is player load per minute, Dacc > 2min is distance covered accelerating at more than 2 m·s^{-2}, and Ddec < -2min is distance covered decelerating at less than –2 m·s^{-2}.

this, we can conclude that these factors (depending on game format) adequately represent the demands and responses in the original data.

Firstly, from a comparative point of view, the demands and responses associated with the different groups of game formats when compared to simulated games (SG) follow the same profile found by previous studies. Larger field dimensions and a higher number of players per team translates into higher demands in terms of Vmax and $D > 80\%$min (Casamichana and Castellano, 2010; Hodgson et al., 2014). Conversely, when both variables (dimensions and players) are lower, more demand is placed on acceleration and deceleration variables (Castellano and Casamichana, 2013; Castellano et al., 2015).

In almost all of the variables (except for $D < 60\%$min, $T > 80\%$min, and EDWmin), the differences between the extreme formats, e.g., SSG versus SG, are from moderate to large. However, between more similar training game formats, e.g., MSG versus SSG, these differences become small or trivial. As has been suggested previously (Casamichana et al., 2019), the lack of similarity between the demands of the four groups of training formats could suggest the need to use the whole range of training game formats (e.g., from 1 vs. 1 to 10 vs. 10) when coaches want to overstimulate or replicate the demands of competition (SG in the current study), having as a reference the particular needs of each playing position (Delaney et al., 2018; Lacome et al., 2018).

The first principal component explained the greatest proportion of variance (38%), involving five of the ten variables studied. Three out of the five external training load variables involved in this component (PL, ACC, and DEC) have a close relation to the neuromuscular or strength dimension. Furthermore, DTmini and distance covered above 60% of the individual velocity are also representative of this component. Previously, it has been shown that there is a high correlation between PL and DT in both training sessions (Casamichana et al., 2013) and training tasks (Casamichana and Castellano, 2015). According to the academic literature (Castellano and Casamichana, 2013; Hodgson et al., 2014), SSG and MSG request more intermittent activity in players, with less time in recovery periods ($D < 60\%$min) and more PLmin.

In relation to the second component, Vmax and DT $> 80\%$min had the most representativeness. These two variables are related to the locomotor or velocity dimension. As can be seen in **Figure 3**, game formats with higher dimensions, numbers of players per team, and durations of the activity are the ones that plot closer to this component. Once again,

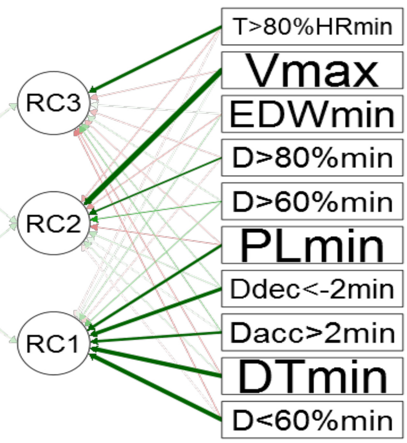

FIGURE 2 | Results of the PCA, showing the rotated training load component loadings for each PC extracted (values above 0.7 are highlighted: in PC1, $D < 60\%\text{min} = 0.83$, PLmin = 0.74, DTmin = 0.86, $D\text{acc} > 2\text{min} = 0.79$, and $D\text{dec} < -2\text{min} = 0.84$, in PC2, $V\text{max} = 0.82$ and $D > 80\%\text{min} = 0.72$, and in PC3, $T > 80\%\text{HRmin} = 0.79$).

this is in line with the previous proposals (Casamichana et al., 2019) in relation to the type of training formats that replicate football-eleven velocity demands. The higher the dimensions of the field, the greater the demands related to high running velocity (e.g., peak velocity and/or distance accumulated running at high speed) (Casamichana and Castellano, 2010; Casamichana et al., 2019).

Finally, the third component was represented by the variables related to HR measures, which involved an endurance dimension. Even if EDWmin (as the global internal indicator) did not have any weight in this dimension, $T > 80\%$HRmin was the iTL variable that best represented it. The training formats closer to this variable were SSG and MSG, which means that with a reduced number of players per team, they become more directly involved in the game. These results are consistent with those reported by other studies of SSGs in soccer (Brandes et al., 2011), being an effective means of improving endurance in soccer players (Dellal et al., 2008).

With respect to the identification of a structure, we conclude that all game formats could be represented by three dimensions (e.g., cardiovascular, locomotor, and neuromuscular), all of which are necessary to categorize the spectrum of demands on and responses of players in the range of side games in football. Analyzing the three dimensions and determining the variables needed for one correct and high-quality analysis of the workload would be sufficient.

A lack of inclusion of additional variables of the game formats studied in the analysis (e.g., number of bouts, duration and type of rest periods, etc.) is one of the limitations of the present study. It is possible that these variables could affect the results obtained. Different distributions of the activity durations and recovery periods of the game formats could have made specific demands. The second limitation involves the differentiation between playing positions (Casamichana et al., 2019) or even between players (Weaving et al., 2017a). In those cases, other factors and correlations between variables could emerge. Consequently, further research is required to establish the demands and

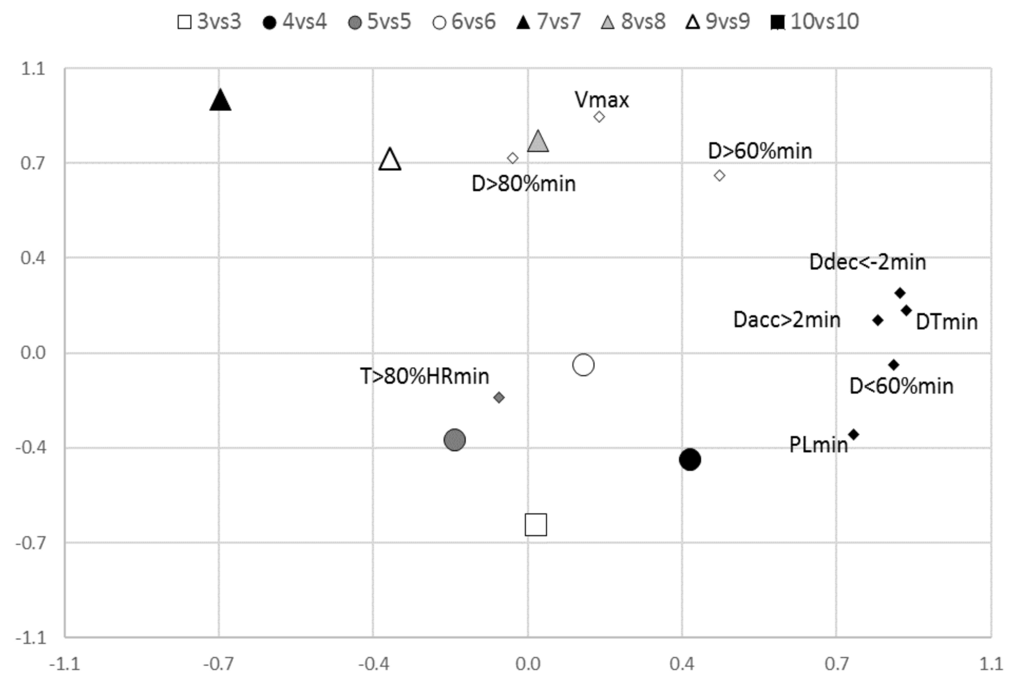

FIGURE 3 | Game format distribution as the average position of each training task through the two principal components (first and second). The game formats are from 3 vs. 3, the small-sided game with three players per team, to 10 vs. 10 or simulated games.

responses associated with different game formats in relation to specific playing positions and/or individual players.

The results obtained in the present study provide very interesting findings. Firstly, they show that a combination of external and internal intensity variables explains a high proportion of the variance observed in the training game formats performed by a semi-professional football team (e.g., from 3 vs. 3 to 10 vs. 10 plus goalkeeper). Secondly, they indicate that when the same players participate in different game formats, the demands of the training tasks are not equal. For this reason, it could be interesting to consider different types of game format depending on the conditional objective of the session in order to replicate, overload, or underload the game demands (Casamichana et al., 2019). In any case, it seems interesting to include variables from different dimensions in the load management process, with the objective of assessing with accuracy the demands and responses invoked by the training formats used. As presented throughout the paper, each game format represents/involves specific demands and responses but with a similar structure of dimension demanded (e.g., the same dimension but with a different weight for each variable).

Practical Applications

The findings of this study focus on the demands of different training game formats and how a reduced number of variables can be selected while keeping the maximum amount of information, providing coaches with information with which to enhance the effectiveness of the design and assessment of training sessions and weekly periodization. A combination of internal and external intensity variables allows a deep description of the current demands of and responses to game formats that are usually applied by coaches in daily training sessions. Using all of those game formats integrates the majority of requirements that are placed on players when competing. Once coaches consider the different demands of and responses to all the variety of game formats in football (e.g., from 1 vs. 1 to 10 vs. 10), optimal training loads can be proposed, overloading or under-loading depending on the necessity of the moment in the session, week, or in a larger periodization.

CONCLUSION

The conclusion of the study was that a combination of different game formats explained all the variables that have been analyzed in the present study. The authors agree with the suggestion of previous research studies (Casamichana et al., 2019) that confirm the idea that different types of stimulus are necessary to optimize the conditional demands on players. The different training game formats used showed that the acceleration and deceleration component was the most stimulated in SSG, the cardiovascular demands were highest in MSG, and peak and average velocity were most demanded in LSG and SG. Future research should focus on the study of this type of different game format analysis with regards to player positions and/or individual profiles.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by M10/2015/303/CASTELLANO PAULIS. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

UZ and JC: conceptualization, investigation, and resources. UZ, IE, IG, and JC: methodology and writing – original draft preparation. UZ: data extraction. JC: analysis and supervision. UZ, JC, and DC: data management. IE, IG, and DC: writing – review and editing.

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ORIGINAL RESEARCH
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Teaching Reading: A Case Study Through Mixed Methods

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The present study analyzes the relationship between teachers' beliefs about learning to read, teaching practices, and discourse. To carry out this study, we benefited from the collaboration of six teachers in kindergarten and the first levels of primary education. First, an attribution questionnaire was used to analyze beliefs about learning to read (Jiménez et al., 2015). Secondly, to study teaching practices, an observation tool was used (Suárez et al., 2018). Thirdly, in order to know the opinion of teachers about how to teach reading, we adapted the instrument to assess teaching perspectives elaborated by Clark and Yinger (1979). Finally, all the information was triangulated and analyzed using mixed methods. The results indicated that the relationship between beliefs, practices, and discourse is not always consistent. In all teachers, a relationship was found between some of their beliefs, practices, and discourse. At the level of beliefs, all teachers presented one predominant attributional profile, although to a lesser extent, their beliefs were also attributable to other learning theories. The results indicated that all the teachers carried out teaching practices associated with the different learning theories. Similarly to their discourse, all teachers showed diverse opinions about the learning processes involved in reading. These results indicate that teachers maintain eclectic approaches, both when they carry out activities in the classroom and when they think about learning to read.

Keywords: beliefs, teaching practices, reading, teacher discourse, triangulation, mixed methods

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INTRODUCTION

For almost three decades, research has documented the influence of teachers' beliefs on educational practice (Berthelsen and Brownlee, 2007; Kuzborska, 2011; Barrot, 2015). Teacher's beliefs are thoughts, perceptions, and values about their roles as educators, education, and how students learn (Vartuli, 2005). It has even been shown that if teachers are aware of their own beliefs, the repertoire of teaching skills can be increased (Tracey and Mandel, 2012), leading to a change in classroom decision making, and teaching strategies and evaluation. If we want to achieve improvements in teaching, it is necessary to examine the teachers' beliefs and modify them (McAlpine and Weston, 2002). A great deal of research in this direction has shown that instructional events can be catalysts for changing beliefs (Stevens, 2002; Theurer, 2002; Fazio, 2003), since beliefs are permeable mental structures susceptible to change (Thompson, 1992), although there appears to be no consensus on this (Block and Hazelin, 1995; Richardson, 1996).

More recent studies have provided us with more detailed information on how beliefs and implicit knowledge influence teachers' instructional practices (Cunningham and Zibulsky, 2009), actions, and strategies that they implement to teach reading in the classroom. The research carried out in this regard has focused on differentiating three traits appearing in the teaching and learning of reading. Thus, Tolchinsky and Ríos (2009) analyzed the relationship between what teachers say and do (2.250), teaching practice ($N = 2$), and students' knowledge ($N = 814$). To do this, they used a self-report questionnaire of 30 questions, with high reliability ($\alpha = 0.81$) and a Likert scale (0–6). Through a cluster analysis, they detected three differentiated profiles: *instructional* practices focused on teaching the names of letters, letter–sound relationships, as well as the importance of learning products; a *situational* approach to activities arising from classroom situations, where students look for the means to understand texts that they do not know; and *multidimensional* activities such as letter knowledge, recognition, and letter–sound association, as well as reading and writing work from situations that arise in the classroom. The results showed the following distribution: instructional (33.87%), situational (37.06%), and multidimensional (29.06%). Also, they found that 30% of the children were able to recognize unknown words and did not seem to have difficulty in mastering the code, and that teachers used explicit, early, and systematic teaching practices.

Also, in Spain, Barragán and Medina (2008), analyzed the practices teachers use through questionnaires. They found significant differences depending on the profile and educational level. Thus, nursery/kindergarten teachers showed a higher profile of situational practices (50%), compared to elementary school teachers who showed a profile of instructional practices (70%). Subsequently, they analyzed the profile of practices according to geographical area, finding that the teachers who carried out the greatest number of situational practices were those of the Basque country, followed by teachers from Almería, Cantabria, Catalonia, and the Community of Madrid (more than 50%). Catalonia and Cantabria showed a lower frequency of instructional practices (less than 20%); however, the teachers from León and Asturias used these practices more frequently (more than 55%). The same authors also observed six Early Childhood Education classrooms in Almeria. The results showed a relationship between the declared belief profile and its practices in the classroom. In another study, Ríos et al. (2010) demonstrated the relationship between the knowledge learned and the practices in teaching reading of two Infant Education teachers. They found that the contents worked on by the teacher with a situational profile were reading and writing functions, identification of words in reading, and letter names and sound values.

The teacher with an instructional profile used word identification and word reading. In the study carried out by Baccus (2004), a direct relationship was found between the teachers' beliefs and the instructional time dedicated to the teaching of reading. In addition, Rapoport et al. (2016) focused on analyzing the beliefs that teachers maintain ($N = 144$) regarding the contribution of executive functions in reading performance and their teaching practice. Their results showed a positive relationship between these two variables ($r = 0.512$, $p < 0.01$).

Ethnicity has been another feature highlighted in studies assessing the dyad of beliefs and practices in teaching. The Center for the Improvement of Early Reading Achievement [CIERA] (2001) examined the beliefs and practices of 250 early childhood teachers. Their results showed a relationship between beliefs (based on the importance of the development of alphabetic knowledge, word recognition, stories, and oral language) and practices. Differences in relation to beliefs were found based on the ethnicity of teachers. African American teachers tended to believe that it was more important for the child to learn to read through teaching the alphabet (e.g., naming letters, saying their sounds), while white teachers thought it was more important for children to learn to read from teaching oral language activities (e.g., answering questions about a story or telling a story from a drawing). On the other hand, they found significant differences depending on the academic training received, so teachers with a higher academic level believed that teaching of oral language was more important, while teachers with lower academic levels did not share this belief.

Also, the report presented by the Teaching and Learning International Survey (TALIS) (OCDE, 2009) provides detailed information on the development of variables involved in the teaching and learning process. This report analyzed the beliefs of secondary school teachers in several countries. Their results indicated that most countries (Northeastern Europe, Scandinavia, Australia, and Korea) showed constructivist positions ($p < 0.05$). Humanities teachers presented more structured beliefs and were little oriented toward students ($p < 0.05$), also with differences depending on teaching experience, so the teachers with more years of experience thought and performed more structured practices ($p < 0.05$). The analyses also revealed a positive correlation between constructivist beliefs and practices in teachers from different countries ($p < 0.05$), except in Korea, where a weak relationship was found between beliefs and practices with a direct style. Finally, they found that positioning depended largely on the quality of the learning environment and job satisfaction ($p < 0.05$). In subsequent reports (OCDE, 2013), an average 95% of OECD teachers stated that they agree with constructivist practices.

Other lines of research have not found a bidirectional relationship between the teachers' thinking and their action in the classroom. An example is the study carried out by Miglis et al. (2014) with 90 Norwegian teachers. They used a 130-item questionnaire to measure beliefs (e.g., their role as teachers, the role of teachers in teaching reading, consistency with current research about the importance of early literacy) and teaching practices (e.g., books, book contents, alphabetic knowledge, phonological awareness, and reading and writing). They found that teachers reported moderately positive beliefs about their role as a teacher in their students' reading success, and they "agreed" with the idea that research has found that early literacy is necessary. These beliefs were not related to their practices, since the time devoted to this type of instruction was minimal. However, they discovered that the most widely used practice was "shared reading and reading aloud for 10 min a day" (29.3%). There are numerous studies that have not found a relationship between these two variables (Wilcox-Herzog, 2001). Thus, for example, through two teachers' collaboration, Pérez-Peitx (2013) was able to observe classroom practices and analyze interviews. Their results also indicated that there was no relationship between these two variables. Along the same lines, another recent study (Utami et al., 2019) based on socio-cognitive theory studied teacher beliefs and practices in reading comprehension tasks. They found that the practices were not always consistent with their beliefs.

To our knowledge, there is no research assessing the profile of the teacher and teaching practices, in relation to all the theoretical principles that govern the teaching and learning processes of reading (i.e., innatist, maturationist, corrective, repetition, sociocultural, constructivist, psycholinguistic approaches).

The objective of this study is to find out whether or not there is a relationship between the beliefs, practices, and discourse used in teaching reading in the classroom, in order to propose more effective teaching strategies.

MATERIALS AND METHODS

The study was carried out from a mixed methods perspective, integrating qualitative and quantitative sources of information through "merge" (Creswell and Plano-Clark, 2007). The proposed design was triangulation (Morse, 2003; Creswell and Plano-Clark, 2007; Tashakkori and Teddlie, 2010; Anguera et al., 2012, 2018; Creswell, 2014), which was found suitable for the aims. A direct observation of teaching reading practices was carried out. The observational study was configured based on three criteria: study's units, temporality, and dimensionality (Anguera et al., 2011). The observational design can be classified as Nomothetic/Follow-up/Multidimensional (N/F/M) (Sánchez-Algarra and Anguera, 2013; Portell et al., 2015). Frequency was analyzed. In order to analyze the relationship between teacher's beliefs, practices, and discourse, a Pearson's correlation was carried out.

Participants

Six teachers with an age between 25 and 50 years participated. The teachers' years of experience ranged from 10 to 35 years. They belonged to different Infant and Primary Education units on the island of Tenerife (Canary Islands, Spain). The selection criteria were based mainly on the fact that the staff member taught the subject Spanish Language and Literature, devoting an average time period of 1 h a day to the teaching of reading.

Materials

To carry out this study, three fundamental tools were used: a questionnaire to know the teachers' beliefs, an observation tool to analyze their practices, and a semi-structured interview to analyze the teachers' speech about teaching and learning to read.

– *Questionnaire on Beliefs about Learning and Teaching Reading*, composed of 60 items (see Suárez et al., 2013; Jiménez et al., 2014, 2015) corresponding to the basic postulates of each learning theory: innatist, maturationist, sociocultural, constructivist, corrective, repetition, and psycholinguistic (see for review Tracey and Mandel, 2012). Teachers had to respond according to their degree of agreement or disagreement using a Likert scale of 0–10, where 0 means strongly disagree, and 10, strongly agree. Cronbach's Alpha was 0.88.

Observation Tool on Reading Teaching Practices. This tool used here was developed by Suárez et al. (2018) and combines a field format and systems of categories. This consists of 14 criteria—alphabetic knowledge, phonological awareness, use of teaching resources, prior knowledge of children, reinforcement, feedback, modeling, direct instruction, guided oral instruction, extracurricular tasks, reading and writing, psychomotor skills, functional reading skills, and vocabulary—and 77 categories on practices in teaching reading. For the measurement plan, the results showed that the absolute and relative generalizability measures were acceptable (at 0.970 and 0.989) at 30 sessions and that 40 sessions were needed to reach 0.977 and 0.992, respectively. For the generalizability indexes to measure inter- and intraobserver reliability, a four-faceted SRC/O (Session, Criterion, Category/Observer) design was used, and analysis showed the greatest percentage of variability to be related to the Criterion facet (33%), while the Observer facet showed no variability at all. The absolute generalizability coefficient was 0.999, and the relative coefficient was also 0.999. With respect to the intra-rater reliability, using a four-faceted SRC/M (Session, Criterion, Category/Moment) design, analysis showed that 32% of variability corresponded to the Session facet and 33% corresponded to Criterion, while Moment showed no variability. The absolute and relative generalizability coefficients obtained for Observer 1 were both 0.999. The absolute and relative coefficients for Observer 2 were both 0.997, facet showed no variability at all. The absolute generalizability validity using a two-faceted model [Observation (2) and Criterion (74)] showed a value of 0.000 (absolute and relative validity).

– Four digital video cameras and Match Vision 3.0 software (Perea et al., 2006) were used for the sessions to record teaching practices. Data quality was analyzed using the Generalizability Study (GT) version 2.0.E program (Ysewijn, 1996) and the SAS 9.1 statistical package. Teacher discourse was analyzed using Atlas.ti 6.0 (Friese, 2011).
– *Structured Teacher Interview on Teaching Practices*. We adapted the interview on teaching perspectives elaborated by Clark and Yinger (1979), composed of 28 questions on aspects related to teaching and learning: general questions about teaching, daily classes, teaching and learning, curriculum, time, and teachers' "philosophy." Changes were included in the nomenclature of the subjects of the curriculum and in the section on teacher philosophy (F), where the questions were guided toward the field of reading (see **Table 1**).
– For the interviews, a video camera and two Panasonic recorders, model RR-US455 (with 66 h of recording capacity), were used to ensure safe information storage.

TABLE 1 | Interview adapted from Clark and Yinger (1979).

General teaching issues

1. When did you start teaching? What levels have you taught? How many years in each level?

2. How would you describe the current situation of your teaching? How long have you been teaching at this level?

3. How is your class organized today? Is there another form of organization?

4. How big is your school? Number of students? Teachers? Classrooms?

5. How is the teaching in this school? How is it similar to other places where you have previously taught?

6. What are the school's surroundings like? Are parents and the community involved in the school?

7. Does the director impose your way of teaching? And inspections? (If yes, indicate how.)

Everyday class

1. What media do you consider important as a teacher? For example, equipment, space,. Do you have them in the classroom?

2. How many students do you currently have? How would you describe them as a group? How different are they from other years? What would an ideal group be like? How would you teach that group?

3. How were students assigned to your class? Did you have anything to do with that decision?

4. Do you have other people such as teaching assistants, helpers, parent volunteers, or subject specialists who help you in your class? When and for what type of activities?

Teaching and learning

1. How would you describe your teaching style? To what extent would you change if you had 10 students less? What if you had 10 more students?

2. In which subjects do you feel more prepared or trained? Which cause you the biggest problems? Are these the ones you enjoy more or less? To give instruction in reading, what level or year would you prefer? Why?

3. When you think about what you are going to teach and how you are going to teach it, what characteristics of your students do you have in mind? How do you notice that your performance has been improving, or getting worse? How do you think your students really learn? Do you think it is important to remedy bad learning? What could be done? If yes, how? If no, why? Do you think students with low ability should be taught in the same class?

4. How do you know that your teaching has been successful?

5. Teachers often tell me that they have enjoyed their day. Could you tell me what a good day is for you? When does it happen?

6. What has been your greatest reward in teaching your current group? Your greatest frustration?

7. I know that it is not easy to clarify it, but could you try to explain to me what you are trying to achieve most earnestly as a teacher? What do you try to achieve above all? Interview adapted from Clark and Yinger (1979).

Curriculum

1. What three things do you think are the most important in elementary or preschool education? What do you do to achieve them? Who decides on the content you have to teach? How do you decide your choice? What influence do you have on what you have to teach in your class? If there are strict guidelines, to what extent do you feel free to deviate from syllabus/curriculum guidelines?

2. What kinds of curriculum materials are available in the school? And in the area? What texts do you usually use? (Author/s and publisher.) Do you consider it satisfactory? If so, for what reasons? Do you group students together to learn? What criteria do you use to group them? (Tests, information from other teachers, tests, other interactions, etc.) Can you group them from more to less skilled? What kind of evaluation do you usually use? What information do you provide? When you finish the year, do you expect more or less distance between the students in your class?

Time

1. If you were paid five more hours a week (to devote to your work), which of the following activities would you choose to cover that extra time?

   Pedagogical Renewal Collective

   Personal preparation

   Public relations

   Teaching in class

   Talking to parents

   Tutorials

   ________________________ (specify others if appropriate)

2. Of the following subjects (areas), which do you give the most emphasis to? Language, Mathematics, Natural Sciences, Social Sciences, Crafts.

3. If you had two more hours a week to devote to teaching, how would you distribute them taking into account the following subjects?

4. Do you have a fixed weekly schedule that you try to follow?

5. Could you describe a typical day?

Teacher philosophy

1. Which do you think have been most crucial in your training as a teacher and have influenced your opinions about the teaching of reading (public examinations, teachers, books, other colleagues, the experience of teaching)?

2. Reviewing the development of your notions about reading, do you think that your notions have changed from the time you were a student until now? (If so, could you specify the time and experiences that have produced these changes?)

3. Could you briefly outline your concepts of what a primary/elementary/nursery school teacher should be?

- To transcribe information, the program Naturally Dragon Speaking (Baker, 1975), version 12 was employed, and Atlas.ti, version 6, for information analysis (Friese, 2011).

Procedure

Before the recordings were made, authorization was obtained from both the teachers and the pupils' parents. All participants provided written informed consent prior to their participation. Likewise, a schedule was agreed on for when the study would be carried out. On the day indicated, the belief questionnaire was applied to the participating teachers, their doubts in this regard were clarified, and approximately an hour was spent to complete it. Seven recording sessions per teacher (twice a week for 1 h each day) led to total of 42 h of recording (see Suárez et al., 2018). The interviews were held with the participating teachers and recorded in classrooms devoid of noise. Cameras were located in front of each teacher, and the furniture was arranged in an interview layout. The interviews of the six teachers were recorded, each lasting approximately 1 h. The audio was later transferred to the computer for the literal transcription of the interviews. Subsequently, the available information was collated and all the material subject to data processing organized. To conclude this phase, each interview was reviewed to gain an overall impression of the information provided by each teacher.

In the next phase, the document was segmented and coded through the Atlas.ti 6.0 program. The data were processed using the thematic analysis technique, according to the proposal of Braun and Clarke (2006). Initially, the hermeneutic units were defined according to the interview questions, taking into account the theories about learning to read. Subsequently, the primary documents were worked on and information segmented. In this case, we focused on words as well as phrases/sentences and texts. The relevant information was then selected, and these units were encoded. Later, we established code families composed of the different variables affecting teaching and its context. Teachers' opinions about learning to read were categorized. The code families structured the relationship between the previously identified categories and theories on the learning of reading (e.g., innatist, maturationist, sociocultural, constructivist, corrective, repetitive, and psycholinguistic).

TABLE 2 | Teachers' profiles in each theory in percentiles.

	Teacher	F.	M.	C.	M.C.	S.	I.
Theory	Sociocultural	30	70	75	5	75	5
	Maturationist	5	75	5	10	70	5
	Corrective	75	15	5	65	75	25
	Repetition	15	60	5	10	25	25
	Innatist	75	20	20	25	75	75
	Constructivism	35	30	25	25	65	45
	Psycholinguistic	35	50	55	75	40	15

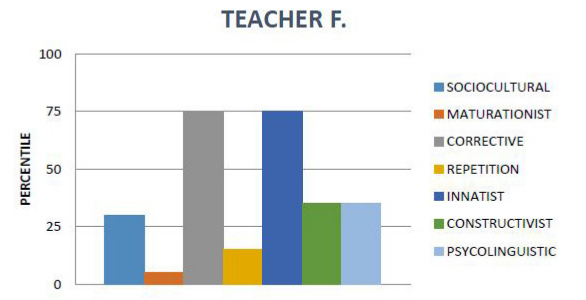

FIGURE 1 | Example teacher F. profile.

TABLE 3 | Summary of teachers' profiles.

Theoretical profile	Teacher
Corrective–innatist	F.
Maturationist–sociocultural	M.
Repetition	
Psycholinguistic	
Sociocultural	C.
Psycholinguistic	
Psycholinguistic	M.C.
Corrective	
Corrective/innatist/sociocultural	S.
Maturationist	
Constructivism	
Innatist	I.
Constructivism	

RESULTS

In order to classify each teacher according to his/her attributional profile, factor scores for each theoretical approach defined the teachers' beliefs according to the percentiles (see **Table 2**).

To determine which theory should be attributed most to each teacher, the score was set around the percentile ≥75, and to determine which theories fitted less, around percentile ≥50 (see **Figure 1**).

Although all teachers were characterized by a predominant attributional profile that defined their particular beliefs, we found that their reading teaching behavior could also be attributed to any of the other theories to a lesser extent (see **Table 3**).

Regarding teaching reading practices, it was found that the most used was feedback (praising or correcting the student), followed by the use of teaching resources (e.g., stories, songs, or poetry), direct instruction (e.g., individual–group reading, aloud or silent, with or without intonation, and fluency) and functional knowledge of reading (e.g., summary, questions, comprehension exercises). To a lesser extent, they used literacy activities, reinforcement through praise (e.g., tangible or verbal), reading and writing, and work on alphabetic knowledge.

The latter strategy indicated that teachers mostly referred to constructivist theory, except teacher M.C., who chose to position herself in psycholinguistic theory. Similarly, teacher F. emphasized that students should build their learning and that teachers should function as a guide. To a lesser extent, she commented on aspects of the maturation and behaviorist theory (see **Figure 2**). Teacher M. also focused on the foundations of

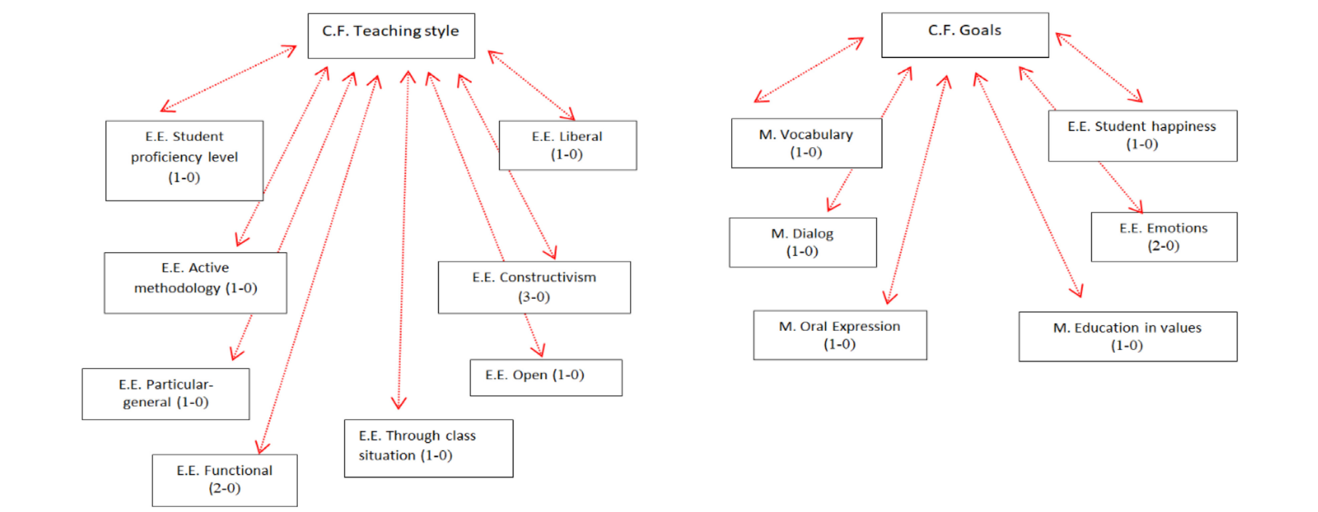

FIGURE 2 | Teacher F. Network summarizing key concepts associated with the teaching process.

constructivism (e.g., prior knowledge, children discover their learning). She also talked about the importance of psychomotor skills, correctness in reading, as well as the involvement of parents. Teacher C. commented that students learn through construction and must discover reading autonomously through the support offered by the teacher. She also emphasized the role that parents play in reading, the importance of resources, oral language work, phonological awareness, as well as maturity in the development of reading. Teacher M.C. placed greater emphasis on the development of phonological awareness and oral language to teach reading. However, teacher S. focused more on student autonomy in the learning process and to a lesser extent on oral language, use of resources, and correction during reading (feedback). Teacher I. focused mostly on the construction of learning and less so on the role of oral language and the use of resources (library).

Subsequently, the information was triangulated after analyzing the beliefs, practices, and discourse of the teachers. For this, several researchers who are experts in the learning and teaching of reading skills agreed on the following relationship, in accordance with the basic postulates of each of the theories considered (see **Table 4**).

Then the teachers' scores were compared in relation to their beliefs, teaching practices (in terms of frequency), as well as teacher discourse, previously analyzed through its categorization into teaching–learning processes and their context (see **Table 5**). Finally, the results were interpreted according to Pearson's correlation analysis. The results showed a high correlation ($r = 0.72$, $p < 0.05$) in teacher F. and in teacher I. ($r = 0.71$, $p < 0.05$) and a negative and high correlation in teacher M. ($r = -0.81$, $p < 0.05$) between beliefs and practices. Moreover, they showed a moderate correlation in teacher C. ($r = 0.52$) and in teacher M. ($r = 0.45$) between beliefs and discourse. Finally, the results showed a negative and high correlation in teacher I. ($r = -0.74$, $p < 0.05$) and in teacher M.C. ($r = -0.76$, $p < 0.05$) between practices and discourse.

Teacher F. showed links between his theoretical profile and his practices. A relationship between corrective beliefs (27.8%) and practices (29.2%) was found. On the other hand, we observed that in his practices, he used activities associated with other theories: repetition (23.5%), constructivism (19.9%), and psycholinguistic (16%). This also happened when he thought about how children learn to read, since he considered that the construction of learning (77.8%), maturation (11.1%), and providing feedback (11.1%) were fundamental. Other discourse makers, teacher M. did not show a link between her sociocultural (22%) and maturationist (23.4%) theoretical profile and her practices (5.7% and 0.6%). However, the results indicated that her maturationist (23.4%), sociocultural (22%) beliefs were related only to her discourse. So, she thought that the use of psychomotor skills (21.4%), teaching resources such as stories, stories, poems, and texts (14.3%), and teaching previous knowledge (50%) were important. However, practices based on other currents were observed: corrective reading (32.6%) and repeated reading (25.2%), as well as constructivism (19.1%), such as working previous knowledge or reading and writing and psycholinguistic skills (16.6%) [e.g., alphabetic knowledge: teaching letter names and sounds, rules with support rhymes, etc.; phonological awareness: stimulating children to become aware of letter sounds, saying words that begin with a certain sound, separating words into syllables, playing the game *veo-veo* (I spy.); vocabulary: teaching the meaning of words]. During the interview, opinions related to other theories were also found (i.e., corrective).

As for teacher C., there was a bidirectional relationship between her sociocultural theoretical profile (39.6%) (e.g., use of teaching resources such as stories, songs, writings from different sources, etc.) and her discourse (33.3%). Also, it was found that her psycholinguistic profile (28.9%) was related to her discourse (11.1%) (e.g., oral language or phonological awareness). However, the results indicated that this teacher carried out other practices not related to her theoretical beliefs, such as: feedback (50.8%)

TABLE 4 | Triangulation between theoretical profile, teaching practices, and teacher discourse.

Theory	Teaching practices	Speech		
		Teaching	**Learning**	**Context**
Sociocultural	Teaching resources		Sociocultural	Neighborhood Available resources
	Homework			School requirements
				Parents/teacher support
Maturationist	Psychomotor skills		Maturationist	*Not contemplated*
Corrective	Feedback			*Not contemplated*
Repetitive	Reinforcement	Evaluation through observation	Repetitive	*Not contemplated*
	Modeling			
	Direct instruction			
	Guided oral Instruction			
Innatist	Practices were not observed	Programming	Innatist	*Not contemplated*
		Individual/group/pair organization		
Constructivism	Teaching resources	Modeling	Constructivist	*Not contemplated*
	Previous knowledge	Self-appraisal		
	Reading and writing	Construction knowledge		
		Previous knowledge		
		Situations that arise in the classroom		
		Autonomy		
		Liberal		
		Phonological		
Psycholinguistic	Phonemic awareness	Syllabic	Psycholinguistic	*Not contemplated*
	Alphabetic knowledge	General–specific		
	Vocabulary	Specific–general		
	Fluency	Oral expression		

TABLE 5 | Percentages of teachers' beliefs, reading practices, and discourse.

	Teachers' beliefs %						Reading practices %						Teachers' discourse %					
Theory	**F.**	**M.**	**C.**	**M.C.**	**S.**	**I.**	**F.**	**M.**	**C.**	**M.C.**	**S.**	**I.**	**F.**	**M.**	**C.**	**M.C.**	**S.**	**I.**
Sociocultural	11.1	22	39.6	2.4	17.6	2.6	5.3	5.7	4.4	4.4	4.4	10.6	**	14.3	33.3	3.7	21.7	10
Maturationist	1.8	23.4	2.6	4.6	16.6	2.6	2.2	0.6	0.6	0.3	1.4	0.2	11.1	21.4	22.3	**	4.3	**
Corrective	27.8	4.8	2.6	30.2	17.6	12.8	29.2	32.6	50.8	37.6	35.1	23	11.1	14.3	**	14.8	13	**
Repetition	5.6	18.7	2.6	4.7	5.9	12.8	23.5	25.2	16.9	19.6	36	25.3	**	**	**	7.4	**	**
Innatist	27.7	6.2	10.6	11.6	17.6	38.5	*	*	*	*	*	*	**	**	**	**	**	**
Constructivism	13	9.4	13.1	11.6	15.3	23	19.9	19.1	10.9	13	9.6	19.3	77.8	50	33.3	14.8	47.9	70
Psycholinguistic	13	15.6	28.9	34.9	9.4	7.7	16	16.6	12	4.1	8.5	3.7	**	**	11.1	59.3	13	20

**Practices not observed. **Opinion about different theories not contemplated in teachers' discourse.*

and repetition (16.9%). The same occurred with her discourse; she thought that maturation was also important (22.3%).

Regarding teacher M.C., a negative relationship was found between her psycholinguistic discourse (59.3%) and her teaching practices (4.1%). The same happened with her corrective practices (37.6%) and her discourse (14.8%) (e.g., correct when the child is wrong, point out, provide examples, deny). However, when we analyzed her practices, we found activities justified by other theories, such as functional knowledge of reading or use of teaching resources (13%) or repetition (19.6%) and constructivism (13%) (e.g., previous reading and writing, and likewise when we asked her opinion about how children learn to read (e.g., constructivism).

Regarding teacher S., she showed a corrective (17.6%), innatist (17.6%), sociocultural (17.6%), maturationist (16.6%), and constructivism (15.3%) profile. Then, she carried out corrective (35.1%) practices (e.g., feedback, direct instruction). During her discourse, opinions were also found that were constructivist (47.9%) and psycholinguistic (20%). Nevertheless, repetition practices (36%) were observed that had nothing to do with her expressed beliefs.

A relationship was found between the constructivism profile (23%) of teacher I. and her practices (19.3%). Then the result showed a relationship between corrective (12.6%) and repetitive (12.6%) beliefs and practices. Furthermore, this teacher used other practices unrelated to any of her attributed beliefs, such as:

sociocultural (10.6%). No relationship between corrective (23%) and repetition (25.3%) practices and discourse were found. In the same way, she referred to the implication of other (e.g., sociocultural and psycholinguistic) theories in infant readers' learning. The innatist profile of teacher I. was not related to her practices or discourse.

DISCUSSION

The results of the present study are congruent with previous study results that showed that teachers hold eclectic positions (Clemente, 2008; Jiménez and O'Shanahan, 2008; Clemente et al., 2010; Rodríguez and Clemente, 2013). Other research has shown quite different results, from studies finding a relationship between beliefs and teaching practices in reading learning (Cunningham and Zibulsky, 2009; Tolchinsky and Ríos, 2009; Rapoport et al., 2016) to studies which indicated a moderate correlation (Baumann et al., 1998). On the opposite side, other authors found no such relationship (Pérez-Peitx, 2013; Miglis et al., 2014; Enyew and Melesse, 2018; Utami et al., 2019).

The data extracted from the belief questionnaires have been complemented with the analysis of teaching practices and each teacher's interviews, which allowed us to provide additional information (Castañer et al., 2013). In our case, the interview helped us complete the teacher's profile. We found that the teaching and learning processes are mediated by multiple contextual variables that were not identified by the questionnaire or recorded observations.

Analysis of the practices allowed us to identify not only what activities the teachers performed in their real teaching context but also how their sequence of instruction was oriented in all cases toward the use of their own multiple resources, applying other theories. The relationship found between some beliefs and practices in this study suggests that if teachers are aware of their own beliefs, the repertoire of teaching practices can be increased (Tracey and Mandel, 2012), causing changes in decision making in the classroom and in teaching and evaluation strategies. In addition, as all teachers used many activities characteristic of other theories they did not explicitly hold, we focused on the opposite process, modifying their practices to cause a change in their beliefs (Fazio, 2003), since these are permeable mental structures that can be modified (Thompson, 1992). But how can we achieve this? Some studies confirm that people form their implicit theories through the knowledge they acquire (Suárez and Jiménez, 2014).

The first step is to achieve the teacher's predisposition to change, always through invitation (Baena, 2000), by encouraging reflection. To do this, they should become aware how their own beliefs are involved in their teaching practice and how they influence student performance. In addition, the false myths about learning to read and teaching practices should be recognized, as prescribed by the National Reading Panel [NRP] (2000). The question remains whether teachers have received training based on the latest advances in scientific research on the teaching of reading, in order to provide young students (who may or may not have difficulties) with the tools necessary for their learning to proceed optimally.

Online training offers teachers the opportunity to recycle their knowledge (Costi et al., 2005; Jiménez, 2015; Jiménez et al., 2015; Jiménez and O'Shanahan, 2016), which generates an important pillar supporting success, integration, and sustainability in education (Haydon and Barton, 2007; Somekh, 2008). It is also an alternative solution to the lack of time and difficulties in reconciling work and family life. It has been found that experience with these resources plays a fundamental role, since it favors a positive attitude of teachers and also confidence in the use of these tools for education (BECTA, 2009). Joshi et al. (2009) found that the training teachers receive is inadequate because textbooks and courses in education reflect superstitions, anecdotes, and beliefs that are not based on scientific evidence. Research has also found that teachers do not properly use the practices that are based on scientific evidence (Moats, 2009). If the learning environment is effective, it can even happen that only a small percentage of students present difficulties in learning to read (Cunningham and Zibulsky, 2009).

The updating of knowledge according to research conclusions is proposed as an alternative for teachers who specialize in teaching reading, since teaching quality is one of the main factors determining the academic success of students (European Council, 2008). For teachers to learn good practices, it is important that they have the following knowledge at their disposal: (1) fundamental research and theories about the development of language and reading; (2) strategies for use in the classroom to teach word recognition, vocabulary, text comprehension, and fluency; (3) tools to work on reading and writing at the same time; (4) the best strategies to teach reading and the materials to use; (5) different techniques for student evaluation; (6) how to maintain a good balance between theory, practice, and information technologies; (7) knowledge of dyslexia and other learning disorders (IRA, 2007); and (8) how to interpret and administer assessment tests to plan teaching (IDA, 2010). In addition, they must learn to ask more complex questions to help students make inferences and more elaborate reflections, as well as work with students' prior knowledge (RAND, 2002). However, the teacher alone should not be responsible for this process, because we have confirmed that in the teaching environment, there are other strong factors such as society or culture (Quintana, 2001). The challenge now consists of achieving a change in the ways of thinking of those responsible for educational administration. The necessary means should also be provided to facilitate refresher courses and ongoing e-learning for teachers, with training programs that include content based on scientific evidence. One limitation is that the study consisted of six teachers and is not generalizable to a greater audience.

CONCLUSION

In general terms, we can conclude that the relationship between beliefs, practices, and discourse varies according to certain nuances. Thus, of the two beliefs attributed to teacher F., only one (corrective) was related to his form of instruction and his opinion. Among the four beliefs attributed to teacher M. (sociocultural, maturationist, repetition, and psycholinguistic), a relationship was found only between her maturationist and sociocultural profile and her discourse. Both beliefs attributed to teacher C. (sociocultural and psycholinguistic) were related to the discourse content. Of the two beliefs attributed to teacher M.C. (corrective and psycholinguistic), neither of them was related to her actions and reflections. Among the five beliefs attributed to teacher S. (sociocultural, innatist, corrective, maturationist, and constructivist) only two (corrective and sociocultural) were related to her active practices and discourse comments. Finally, of the two beliefs of teacher I. (innatist and constructivist), only constructivism was related to her practices or her opinion.

Although it is true that a relationship was found in all the teachers between some of their beliefs, practices, and discourse, as revealed in their discursive talks, all the teachers thought that learning to read depended on factors underlying other theories not related to their attributional profile. Therefore, despite attributing to them certain beliefs when they teach children to read and when they think of learning to read, it can be concluded that all teachers maintain an eclectic approach.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/supplementary material.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

NS: this author's grant was used to run the project Integrando creencias y prácticas de enseñanza de la lectura (Integrating beliefs and practices about teaching reading), ref: PSI2009-11662. She participated actively in the research, analyzed the teaching practices and discourse, and was responsible for the literature review and drafting of this manuscript. JJ: supervised the project and the preparation of the study, offered theoretical guidance, and was responsible for reviewing the manuscript. CS: supervised the design and preparation of the study, offered guidance on methodology, and helped review the manuscript. All authors approved the final version of this article.

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KEY CONCEPTS

Concepts	Principal postulate
Repetition theory	The importance of repetition, reinforcement, modeling direct instruction, and guided oral Instruction to teaching to read.
Corrective theory	The teacher gives feedback (e.g., correct reading, line jump, incorrect pronunciation, report errors, make questions) to the students to read well.
Constructivist theory	The students are the builders of their own learning, meaningful learning prevails, and the teacher acts as support.
Maturationist theory	For reading, children need to develop space–time orientation. Not all of them learn at the same time; it depends on their stage and rate of development.
Innatist theory	Children can read at early ages.
Sociocultural theory	The role of the family, school, instruction and characteristics of the teacher, society, regulatory laws, and the curriculum of each autonomous region (state etc.) play a crucial role in reader learning.
Psycholinguistic theory	The importance of phonological awareness in the teaching of reading, as well as other cognitive processes: lexical, syntactic, semantic.

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Mixed-Methods Analysis of Emotional Quality in Sports Organizations: Facial Expressions of Child Users of Sports Services as Data

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Proper quality management of sports services requires knowledge of the needs, perceptions, expectations, and emotions of users. Facial expressions provide relevant information about the immediate perception of stimuli. The objective of this study was therefore to analyze how a group of child users of sports services expressed their satisfaction with the programs in which they participated through facial expressions during an in-depth interview tailored to their age. Nineteen child users of a sports organization (aged from 5 to 12 years) were interviewed, involving both qualitative and quantitative analyses. The analysis of facial expressions was performed using Face Reader v.6.1.10, which automatically analyzes eight categories of facial expressions (six basic emotions, one neutral, and one unidentified). The data collection and transformation procedures fully satisfied the requirement for flexibility and provide new perspectives for incorporating data into the study of biopsychosocial factors in everyday contexts using a Mixed-Methods approach. In addition, the generalizability analysis itself, carried out to determine the levels of reliability, generalizability and precision of the sample (with relative and absolute G indexes of between 0.86 and 0.93 for the three analyses performed), was also a Mixed-Methods procedure.

Keywords: Mixed Methods, emotional quality, sports organizations, facial expressions, children

INTRODUCTION

Users of a sports service focus not only on how useful it is to them; an especially important issue is how it is associated with the experience of an emotion (Fernando-García et al., 2020). Hence the importance of evaluating the elements related to the pleasure experienced by the user, a factor that is becoming increasingly important in assessing the quality of a service (Pérez-López et al., 2015). In this sense, emotions play a very important role in sports practice and are emerging as a key facet of user satisfaction in sports centers (Silla-Merchán et al., 2014; Pedragosa et al., 2015).

There are studies suggesting that in the practice of directed sports activities emotional experience is a factor that can contribute to satisfaction with the activity practiced and is more likely to promote future practice intentions (Lee et al., 2016). Satisfaction with the performance of a sporting activity, therefore, is not only a cognitive phenomenon but also includes other determinants, such as affective states (Wirtz and Bateson, 1999; Wirtz et al., 2000; Martínez-Tur et al., 2001). Ries and Sevillano (2011) state that positive emotions will encourage the intention to practice sport and create a greater willingness to increase the frequency and duration of that activity, whereas the opposite occurs with negative emotions. Therefore, in the context of a sports organization, knowing how emotional experiences influence users and how they relate to satisfaction and the perceived quality of services is a vital issue that has already been highlighted by several authors (Bigné and Andreu, 2004; Jiang and Wang, 2006; Ladhari, 2009; Ozgen and Duman Kurt, 2012).

It is especially important to include the study of emotions in the user satisfaction process, because most services are based on the experience of the users of a given service (Liljander and Strandvik, 1997; Foxall and Greenley, 1999; Benkenstein et al., 2003; Lewinski et al., 2016). For this reason, in conceptualizing and measuring the quality of the service provided it is considered important to differentiate between a hedonistic and a utilitarian type of service. In the evaluation of a utilitarian service, rational factors will have the greatest weight, while in the other type, satisfaction with the service will be determined largely by emotional responses (Jiang and Wang, 2006). From the hedonistic perspective, the perception of quality will be associated with the presence of pleasant or agreeable properties intrinsic to the service being evaluated (Mano and Oliver, 1993). Following this line of argument, an increasing number of authors have raised the need to take account of the more emotional factors in concepts of quality of service (Price et al., 1995; Gwinner et al., 1998; Peiró et al., 2005; Potocnik et al., 2010).

To improve the emotional experience of users in organizations, several issues need to be considered. For example, interaction between workers and users will be of vital importance, and good communication between them should be encouraged if the experience of positive emotions is to be increased (Ozgen and Duman Kurt, 2012; Romani et al., 2012). Similarly, Molina-García et al. (2016) argue that it is essential to create attractive activities and pleasant environments to foster a more positive emotional experience and contribute to increasing user satisfaction in sports organizations.

In this study we used the Three-Dimensional Model of Service Quality (Sánchez-Hernández et al., 2009). This model posits three facets of quality. (1) Functional quality of service refers to the efficiency with which the core service is provided. This dimension includes factors such as reliability, safety, and responsiveness. (2) Relational or emotional service quality focuses on the emotional factors (extras, genuine understanding, and empathy) related to interaction during the service that go beyond the core service and demonstrate affection and esteem toward the user. Finally, (3) tangible factors refer to opinions of the more physical or material elements that accompany the service, such as the facilities or equipment used.

It is possible to ascertain the emotions of users by analyzing their facial expressions, a subject that has been studied for more than a century (Darwin, 1872/1998). This type of analysis has been a fundamental guiding principle for the main theories of emotion (Tomkins, 1962; Izard, 1977; Izard et al., 1990; Ekman, 1992). Emotions can be caused by many things, such as an unexpected situation, remembering or talking about a past experience, or seeing the emotional reactions of another person (Yu and Ko, 2017). Of all the emotions reflected in facial expressions, six have been considered innate. These are known as the basic emotions: joy, sadness, fear, disgust, surprise, and anger (Ekman, 1993, 2003).

The work of Cameron et al. (2018), though conducted with robots, discusses the influence of facial expressions according to gender and its role in social relations. The importance of gender in facial expressions has also been confirmed by Bachmann et al. (2019), using FaceReader and a psychiatric population. Terzis et al. (2013), estimating that FaceReader is capable of measuring emotions with an effectiveness greater than 87% during a CBA (Cognitive Behavioral Assessment), point out that analysis by gender highlights the differences between the spontaneous emotions of each gender.

There are various systems for measuring facial expressions, but the most widespread and commonly used is the Facial Action Coding System (FACS) (Ekman and Friesen, 1976). This system assigns a number to each facial configuration, produced by movements of a set of muscles, and these numbered individual configurations are called action units (AU) (Ekman, 2003). It also uses EMFACS, an acronym for "Emotion FACS," based on using the FACS to detect emotions through facial expression. Both systems use hand coding.

This procedure certainly attributes an important role to facial expression in emotional response, as reflected in the facial feedback hypothesis (Tomkins, 1979), which postulates that the activity of the facial muscles is mainly responsible for emotional experience through a muscular sensory feedback process, according to which facial expressions can evoke emotional reactions in the person making them. This was a starting point for the systematic study of facial expression, giving functional value to the different facial muscles that could be used as units of action to classify different emotions (Ekman, 2003).

Significant progress has been made in automated analysis of facial expression. Over the past few decades, tools have been developed that overcome the limitations of FACS coding. The rapid development of information technology has enabled these analyses to be carried out automatically, while achieving greater validity, speed, and accessibility (Cootes et al., 2001; Viola and Jones, 2001; Beumer et al., 2006; Valstar et al., 2011; Swinton and El Kaliouby, 2012; Lewinski et al., 2014).

FaceReader is one of the tools used for the analysis of facial expression of emotions (van Kuilenburg et al., 2005; Lewinski et al., 2014), although there are others, such as AFFDEX and FACET from iMotions (Stöckli et al., 2018). Recent studies have indicated that this software is an effective tool for analyzing emotions, with 90% accuracy (Loijens and Krips, 2013). A similar degree of accuracy is achieved in the work of Terzis et al. (2013) and Lewinski et al. (2014). FaceReader is an instrument that allows automated direct observation of facial expressions. This process can, in itself, be considered a Mixed Method (Anguera and Hernández-Mendo, 2016). This study also uses a CONNECT strategy of integrating qualitative and quantitative elements.

Mixed Methods have been defined by classical authors as "the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, and inference techniques) for the broad purposes of breadth and depth of understanding and corroboration" (Johnson et al., 2007, p. 123). Mixed Methods are used extensively in educational, psychological, sports, health, and social contexts. They do not constitute a unitary whole; the approaches are plural, but they converge in the essential point: the term describes "a study that mixes or combines quantitative and qualitative methods, techniques, concepts, or language into a single study or series of linked studies," as Fakis et al. (2014, p. 139) define it. This core, however, is remarkably broad, which is consistent with the extensive and intensive deployment of the discipline (Anguera and Hernández-Mendo, 2015). The complementarity that Mixed Methods propose can be implemented from a range of positions, guided by the designs included in the scientific literature of recent years (Johnson and Onwuegbuzie, 2004; Teddlie and Tashakkori, 2006, 2009; Creswell and Plano Clark, 2007; Greene, 2007; Leech and Onwuegbuzie, 2009; Morse and Niehaus, 2009; López-Fernández and Molina-Azorín, 2011; Anguera et al., 2012, 2014; Guest, 2012) that have made it possible to establish three strategies for integrating qualitative and quantitative elements: MERGE, CONNECT, and EMBED.

The objective of this study was to evaluate the satisfaction of a group of children with the sports programs in which they participate by analyzing their facial expressions during an interview conducted for this purpose.

MATERIALS AND METHODS

Design

We designed a systematic direct observational study (Anguera et al., 2017) to analyze in-depth interviews with children in a sports context. The Mixed-Methods approach involves the collection, analysis, and interpretation of qualitative and quantitative data for the same purpose and within the same study. Systematic observation of child users in a sports organization was carried out as a system integrating quantitative and qualitative analysis and satisfying both the rigorous standards of scientific research and the flexibility required to study the unstructured ecological context of a sports organization (Plano Clark et al., 2015; Portell et al., 2015; Anguera and Hernández-Mendo, 2016). Integrating quantitative and qualitative data can dramatically increase the value of research with Mixed Methods (Fetters et al., 2013).

In this case, the methodological approach must be extremely rigorous, since these are situations in which the substantive areas merge with the multiple realities of everyday life. Considering the nature and requirements of the study, they justified the use of a Nomothetic/Isolated/One-dimensional observational design, corresponding to quadrant III of the designs in observational methodology (Anguera et al., 2001, 2011; Sánchez-Algarra and Anguera, 2013). The design was (a) *nomothetic*, because a plurality of children were observed, acting individually; (b) *isolated*, because data were collected during a session for each child, but each session was recorded in its entirety, without interruption (intra-sessional monitoring); and (c) *one-dimensional*, because the instrument of observation had only one dimension (the eight categories established by FaceReader).

Participants

A sample of 19 (n = 19) participants was obtained, of whom 8 were boys (42.10%) and 11 were girls (57.89%), aged between 5 and 12. They all participated in sports activities in Alcalá la Real (Jaén, Spain): swimming, hockey, football, acrobatic gymnastics, tennis, basketball, and rhythmic gymnastics. The sampling was intentional, seeking to achieve stratification with proportional allocation.

Parents were informed in advance of the recording of the interviews and asked for their signed consent, in accordance with the Helsinki Declaration (World Medical Association, 2013). Approval was also obtained from the Ethics Committee of the University of Málaga (No. 243; CEUMA Registry: 18-2015-H).

Instruments

The individual interviews were conducted with questions about the sports activities, the instructor, the equipment, the sports facility/space, and the organization. The questions were formulated following the Three-Dimensional Model of Service Quality (Price et al., 1995; Sánchez-Hernández et al., 2009).

The individual interviews were recorded with a Sony HDR-CX505VE digital camera. Facial recognition of emotions was performed using FaceReader software (Noldus, 2015), version 6.1.10. FaceReader is a program for analyzing facial expression. It can detect emotional expressions of the face, identifying eight configurations, six related to basic emotions (happy, sad, angry, surprised, scared, and disgust), a neutral and one that does not identify the six emotions indicated above (unidentified). It also detects movements of the face (right and left, opening and closing the eyes, opening and closing the mouth, raising and lowering the eyebrows). It recognizes a face and then models it in three dimensions and finally analyzes it to classify the emotions that the person expresses.

The software used, in addition to FaceReader, was the SDIS-GSQ program (Bakeman and Quera, 2011) for sequential analysis, the Hoisan coding and analysis program (Hernández-Mendo et al., 2012) to carry out the analysis of polar coordinates, the SAS statistical program v.9.1 (Schlotzhauer and Littell, 1997; SAS Institute Incorporated, 1999) to analyze variance components, the SAGT program (Hernández-Mendo et al., 2016) to perform generalizability analyses, and the Theme program (Pattern Vision Ltd and Noldus Information Technology, 2004) for calculating T- patterns.

Procedure

Individual interviews were conducted with each of the children separately. To capture the face properly, the video camera was placed on the tripod, so that it could focus on the children's faces. Natural lighting was used and in no case was there any additional lighting.

The duration of each individual interview was adjusted to each child's attention span and ability to concentrate, allowing for a detailed description of their experiences as a participant in sports activities.

Once the facial expressions had been coded using FaceReader software, the data were transformed into code matrices containing purely qualitative information (Anguera et al., in press). This transformation is achieved by organizing the dominant emotion into a single column ready for quantitative analysis.

RESULTS

First, a variance components analysis was performed for estimation of normality. We decided to perform a least-squares variance analysis (VARCOM Type I) and a maximum likelihood (GLM) components analysis and check whether the error variance was the same in the two procedures. A three-faceted model [y = s| p| e] was used, where s = sex, p = person, and e = emotion. The error variance with the two procedures proved to be equal (GLM error = 34159.14021/VARCOMP error = 34159 for the model without interactions, and zero for the model with interactions). With these estimated results showing the equality of error variance in both a least-squares and a maximum-likelihood procedure, it can be assumed that the sample is linear, normal, and homoscedastic (Hemmerle and Hartley, 1973; Searle et al., 1992).

Subsequently, a generalizability analysis with a crossed design was performed on the [s][e]/[p] model and it was shown that the relative *G* index (reliability) = 0.95 and the absolute *G* index (generalizability) = 0.94 (see **Table 1**) (Blanco-Villaseñor et al., 2014).

Another generalizability analysis with a crossed design was then performed, first by gender, with model [e]/[p], where e = emotion and p = participants. For girls, the relative G (reliability) = 0.92 and absolute G (generalizability) = 0.90. In boys, values of relative G coefficient (reliability) = 0.87 and absolute G (generalizability) = 0.85 were obtained (see **Table 1**) (Blanco-Villaseñor et al., 2014).

TABLE 1 | Models used in generalizability analysis.

Name of the values	Model [s] [e]/[p]	Model [e]/[p] for girls	Model [e]/[p] for boys
s	(2; INF)		
p	(19; INF)	(11; INF)	(8; INF)
e	(8; INF)	(8; INF)	(8; INF)
Total number of observations	304	88	64
Relative *G* coefficient	0.957	0.929	0.876
Absolute *G* coefficient	0.946	0.908	0.855
Relative error	6.151	18.031	39.711
Absolute error	7.737	23.815	47.718
Standard deviation of relative error	2.480	4.246	6.302
Standard deviation of absolute error	2.781	4.880	6.908

Subsequently, two types of analysis were performed based on the FaceReader results, T-patterns, and polar coordinate analysis.

T-Pattern Analysis

T-pattern analysis is an analytic technique in the field of observational methodology that makes it possible to detect T-patterns (regular behavioral structures) using THEME software, which analyzes observational data in search of critical interval relationships in an upward direction, from a simple T-pattern (two events that are related at a first level) to complex T-patterns (comprising a number of events related at various levels) (Magnusson, 1996, 2000, 2018).

The assumption underlying the T-pattern detection method is that complex human behaviors have a temporal structure that cannot be fully detected through traditional observational methods or mere quantitative statistical logic (Magnusson, 1996, 2000, 2018). By detecting T-patterns, or time patterns, this method can detect structural analogies across many different levels of organization and allow a major shift to be made from quantitative to structural analysis.

T-pattern detection studies have been carried out in many different scientific fields and also in the field of sport (Borrie et al., 2002; Chaverri et al., 2010; Gutiérrez-Santiago et al., 2013; Lapresa et al., 2013a,b, 2015; Zurloni et al., 2014; Tarragó et al., 2015; Aragón et al., 2016). Furthermore, T-pattern detection has wide applicability in many fields, such as the study of emotions (Merten and Schwab, 2005) and education (Castañer et al., 2013; Suárez et al., 2018), etc.

Since human behavior observation records have a temporal and sequential structure, an analytic tool that can describe this structure can only enhance understanding of the target behavior(s). For instance, the discovery of hidden T-patterns could help coaches to better predict the behavior of competitors through an integrated system allowing greater depth of analysis.

The calculations of the methods used in this study were made with the THEME v.6 Edu (T-pattern detection) program (Magnusson, 1996, 2000, 2018), which is available free of charge.

Analysis of Polar Coordinates

Polar coordinate analysis was proposed by Sackett (1980) and optimized through the "genuine retrospectivity" technique of Anguera (1997), which improves on Sackett's original approach. This technique makes it possible to achieve a drastic reduction of data and a vectorial representation of behavior in the interrelations between the different categories that make up the proposed taxonomic system (Hernández-Mendo and Anguera, 1999; Gorospe and Anguera, 2000).

The technique is based on a sequential analysis of the prospective (Sackett, 1980) and retrospective delays in the successive behaviors that occur, using the genuine technique (Anguera, 1997). The values derived from the calculation of the conditioned probability will make it possible to obtain the Zsum parameter:

$$\mathrm{Zsum} = \frac{\Sigma \mathrm{z}}{\sqrt{\mathrm{n}}}; \quad \bar{\mathrm{x}} = 0;\ sx = 1$$

where n is the number of delays (Cochran, 1954). The distribution of this Zsum parameter has a mean equal to zero and a standard deviation equal to one. By obtaining these values, we establish the interrelational behavior map or polar coordinate map (Gorospe and Anguera, 2000). In order to produce the behavioral maps, the value of the vectors needs to be determined (they must be equal to or greater than 1.96 to be considered significant). The modulus or length of the radius is obtained from the square root of the sum of the square of the Zsum of the X (forward) and the square of the Zsum of the Y (backward):

$$Radius = \sqrt{x^2 + y^2}$$

The angle of the vector (φ) (which will depend on the quadrant in which it is found) marks the nature of the relationship (Castellano and Hernández-Mendo, 2003). This angle (φ) is calculated as:

$$\phi = \frac{\text{Arc sine of } Y}{\text{Radius}}$$

Polar coordinate analysis also has wide applicability in several fields of knowledge, such as clinical psychology (Arias-Pujol and Anguera, 2017; Rodríguez-Medina et al., 2018), sports (López-López et al., 2015; Morillo-Baro et al., 2015; Morillo et al., 2017; Menescardi et al., 2019), environmental psychology (Pérez-Tejera et al., 2018), etc.

Girls

The girls' records were analyzed using the THEME program to detect T-patterns that show the structure of emotional transitions. The T-pattern 1 obtained (**Figure 1**) has the following structure: {happy [(surprised neutral)(unknown happy)]}.

There is a clear recurrence between *surprised* and *neutral*, as well as between *unknown* and *happy*.

In order to have evidence of both recurrences, polar coordinate analysis was applied, carried out on a transitory basis from the two existing possibilities.

Surprised/neutral relationship

On the one hand, *surprised* was considered as a focal behavior and *neutral* as conditioned, making them activate each other, since the *neutral* vector is in Quadrant I. And on the other hand, *neutral* was considered as a focal behavior and *surprised* as conditioned, also leading to their mutual activation, since the *surprised* vector is in Quadrant I (**Table 2**).

Unknown/happy relationship

On the one hand, *unknown* was considered as a focal behavior and *happy* as conditioned, making them activate each other, since the *happy* vector is in Quadrant I. And on the other hand, *happy* was considered as a focal behavior and *unknown* as a conditioned behavior, also causing them to activate each other, since the *unknown* vector is in Quadrant I (**Table 3**).

As indicated above, the vectors of Quadrant I show the existence of reciprocal activation relationships between the focal behavior and the corresponding conditioned behavior.

Boys

The boys' records were analyzed with the THEME program to detect T-patterns that show the structure of emotional transitions. The T1 pattern obtained (**Figure 2**) has the following structure: [(happy unknown)(happy neutral)].

There is a clear recurrence between *happy* and *unknown* expressions, as well as between *neutral* and *happy*.

In order to have evidence of both recurrences, polar coordinate analysis was applied on a transitory basis from the two existing possibilities.

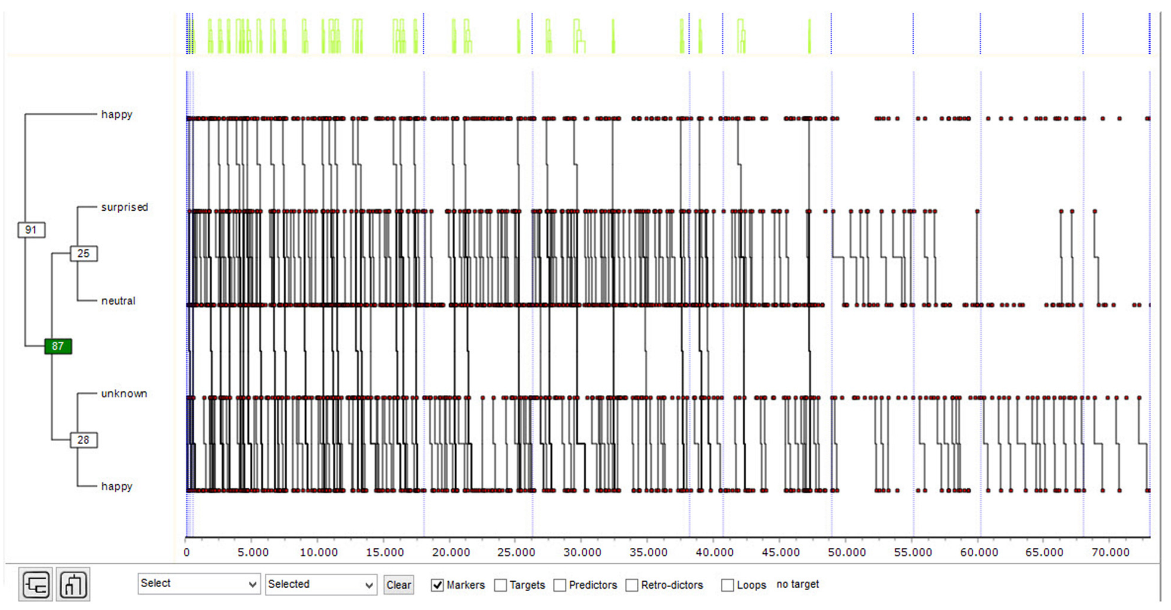


FIGURE 1 | T-pattern 1 for girls (significance level = 0.005; minimum number of occurrences = 30).

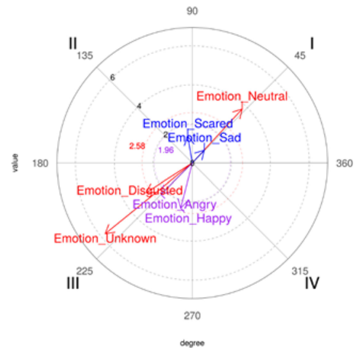
TABLE 2 | Polar coordinate analysis focusing on *surprised/neutral* and *neutral/surprised* relationships, corresponding to the girls' records.

Search for relationships between *surprised* and *neutral*

Parameters (focal behavior: *surprised*)

Category	Quadrant	Prospective	Retrospective	Length	Angle
Emotion_unknown	III	−4, 47	−3, 62	5, 75 (*)	218, 99
Emotion_neutral	I	2, 55	2, 76	3, 76 (*)	47, 22
Emotion_happy	III	−0, 6	−2, 31	2, 38 (*)	255, 5
Emotion_sad	I	0, 61	0, 65	0, 89	46, 75
Emotion_disgusted	III	−2, 37	−1, 52	2, 81 (*)	212, 65
Emotion_scared	II	−0, 24	1, 36	1, 38	99, 89
Emotion_angry	III	−1, 61	−1, 61	2, 27 (*)	224, 95

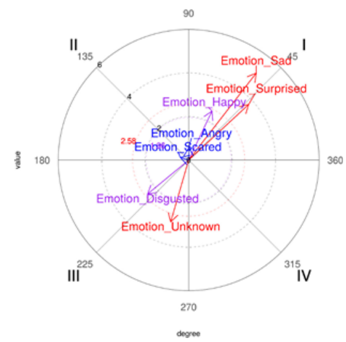
Vector



Search for relationships between *neutral* and *surprised*

Parameters (focal behavior: *neutral*)

Category	Quadrant	Prospective	Retrospective	Length	Angle
Emotion_unknown	III	−0, 83	−2, 84	2, 96 (*)	253, 76
Emotion_surprised	I	2, 76	2, 55	3, 76 (*)	42, 78
Emotion_happy	I	1, 07	2, 24	2, 49 (*)	64, 51
Emotion_sad	I	3, 11	3, 99	5, 06 (*)	52, 12
Emotion_disgusted	III	−1, 89	−1, 56	2, 45 (*)	219, 53
Emotion_scared	II	−0, 38	0, 12	0, 4	162, 57
Emotion_angry	I	0, 01	0, 57	0, 57	89, 01



*The meaning of * is a significant vector ($z \geq 1.96$, $p \leq 0.05$).*

Happy/unknown relationship

On the one hand, *happy* was considered as focal behavior and *unknown* as conditioned, making them activate each other, since the *unknown* vector is in Quadrant I. And on the other hand, *unknown* was considered as focal behavior and *happy* as conditioned behavior, again leading them to activate each other, since the *happy* vector is in Quadrant I (**Table 4**).

Neutral/happy relationship

On the one hand, *neutral* was considered as focal behavior and *happy* as conditioned, making them activate each other, since the *happy* vector is in Quadrant I. And on the other hand, *happy* was considered as focal behavior and *neutral* as conditioned behavior, also leading them to activate each other, since the *neutral* vector is in Quadrant I (**Table 5**).

DISCUSSION

The aim of this study was to assess satisfaction with sports programs in which a group of children participated. For this purpose, interviews were recorded and facial expressions were analyzed. This is in line with previous work that has highlighted the importance, from a hedonistic perspective, of analyzing emotional factors in order to assess the quality of the services provided to users and their satisfaction with them (Peiró et al., 2005; Jiang and Wang, 2006; Potocnik et al., 2010).

The study integrates the data from interviews focusing on facial expressions, recorded sequentially using FaceReader, with quantitative data analysis techniques, such as T-pattern detection and polar coordinate analysis and is thus recognizable as a Mixed-Methods approach. Generalizability analyses were also performed to establish the reliability and generalizability of the data collected. The results obtained were satisfactory and indicate not only that the sample is adequate in terms of reliability, but also that the results can be generalized, in relation both to the total sample and to the sample by gender.

In general terms, this study has detected recurrences that serve as a basis for checking the relationships between the respective codes of emotional states by polar coordinate analysis, with the dual intention of assessing the relationship between the two analytic techniques and establishing the differential profiles of boy and girl users. The results are relevant for several reasons.

First, there is an important correspondence between the results of the T-pattern analysis and those of the polar coordinate analysis. The data show considerable congruence between the dyadic relationships detected in the T-pattern

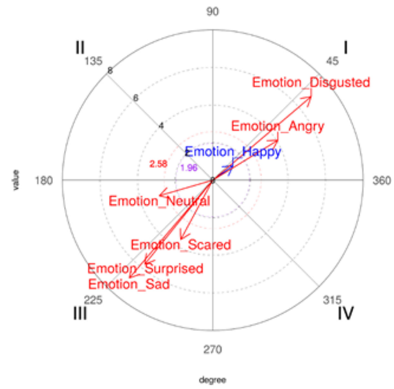
TABLE 3 | Polar coordinate analysis centered on *unknown/happy* and *happy/unknown*, corresponding to the girls' records.

Search for relationships between *unknown* and *happy*

Parameters (focal behavior: *unknown*)

Category	Quadrant	Prospective	Retrospective	Length	Angle
Emotion_neutral	III	−2, 84	−0, 83	2, 96 (*)	196, 24
Emotion_surprised	III	−3, 62	−4, 47	5, 75 (*)	231, 01
Emotion_happy	I	1, 08	0, 77	1, 32	35, 5
Emotion_sad	III	−4, 44	−5, 21	6, 84 (*)	229, 56
Emotion_disgusted	I	5, 23	4, 45	6, 87 (*)	40, 35
Emotion_scared	III	−1, 7	−3, 16	3, 59 (*)	241, 67
Emotion_angry	I	3, 46	2, 12	4, 06 (*)	31, 53

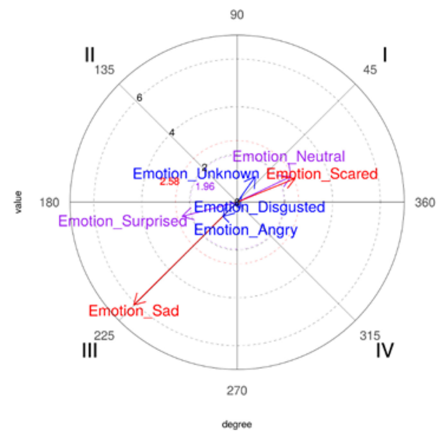
Vector



Search for relationships between *happy* and *unknown*

Parameters (focal behavior: *happy*)

Category	Quadrant	Prospective	Retrospective	Length	Angle
Emotion_unknown	I	0, 77	1, 08	1, 32	54, 5
Emotion_neutral	I	2, 24	1, 07	2, 49 (*)	25, 49
Emotion_surprised	III	−2, 31	0, 6	2, 38 (*)	194, 5
Emotion_sad	III	−4, 33	−4, 29	6, 1 (*)	224, 75
Emotion_disgusted	IV	0, 12	−0, 27	0, 3	293, 06
Emotion_scared	I	2, 43	0, 99	2, 62 (*)	22, 2
Emotion_angry	III	−0, 59	−0, 59	0, 84	225, 28



*The meaning of * is a significant vector (z ≥ 1.96, p ≤ 0.05).*

analysis and the analysis of polar coordinates, as suggested by the results of previous studies (Castañer et al., 2017; Santoyo et al., 2017; Tarragó et al., 2017; Escolano-Pérez et al., 2019; Portell et al., 2019).

Second, the profiles found in boys and girls have some convergent features and others that suggest gender differences. In the T-pattern for girls, a clear relationship can be observed between the emotional state of *surprise* and *neutrality*. The analysis of the respective polar coordinates was performed taking the first element of each dyad (*surprised* and *unknown*) as focal and the second element (*neutral* and *happy*) as conditioned behavior in Quadrant I, which involves mutual activation. There is also a clear relationship between *unknown* and *happy* emotional states. The relevant polar coordinate analysis was performed considering the first element of each dyad (*unknown* and *happy*) as focal and the second (*unknown* and *happy*) as conditioned behavior in Quadrant I, again involving mutual activation (Codina et al., 2016).

The T-pattern for boys shows a clear relationship between *happy* and *unknown* emotional states. The relevant polar coordinate analysis was performed taking the first element of each dyad (*happy and unknown*) as focal and the second element (*unknown* and *happy*) as conditioned behavior in Quadrant I, which involves mutual activation. There is also a clear relationship between *neutral* and *happy* emotional states. The relevant polar coordinate analysis was performed considering the first element of each dyad (*neutral* and *happy*) as focal and the second element (*happy* and *neutral*) as conditioned behavior in Quadrant I, again involving mutual activation.

As can be seen, the emotional states prioritized by girls and boys partially coincide. However, they do show some peculiarities that characterize each gender and suggest differentiated emotional experiences. This phenomenon has already been highlighted in previous studies, which is consistent with the results obtained in this research (Terzis et al., 2013; Bachmann et al., 2019). The close relationship between the *happy* and *unknown* emotions is significant in both groups, and we

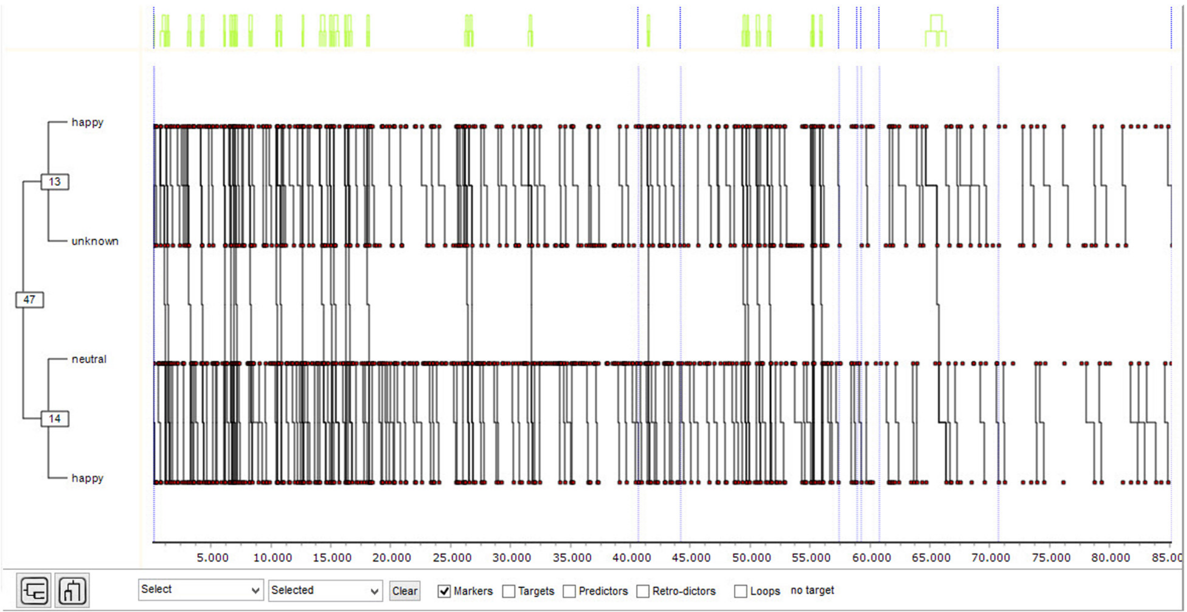


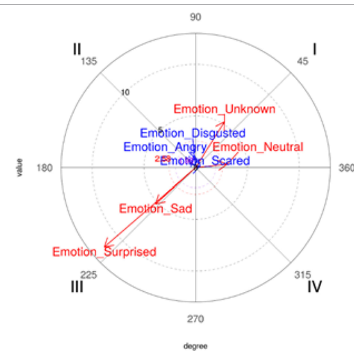
FIGURE 2 | T-pattern 1 for boys (significance level = 0.005; minimum number of occurrences = 30).

TABLE 4 | Polar coordinate analysis centered on happy/unknown and unknown/happy, corresponding to the boys' records.

Search for relationships between *happy* and *unknown*

Parameters (focal behavior: *happy*) — **Vector**

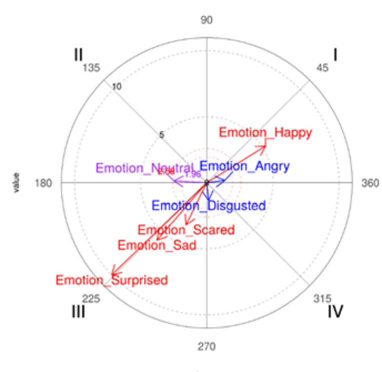
Category	Quadrant	Prospective	Retrospective	Length	Angle
Emotion_unknown	I	2, 78	4, 44	5, 24(∗)	57, 94
Emotion_neutral	I	3, 02	0, 31	3, 03 (*)	5, 83
Emotion_surprised	III	−8, 83	−7, 76	11, 7 (*)	220, 99
Emotion_sad	III	−3, 87	−3, 5	5, 22(∗)	222, 18
Emotion_disgusted	II	−0, 16	1, 18	1, 19	97, 76
Emotion_scared	I	0, 41	0, 13	0, 43	17, 18
Emotion_angry	II	−0, 12	0, 96	0, 96	97, 27



Search for relationships between *strange* and *happy*

Parameters (focal behavior: *unknown*)

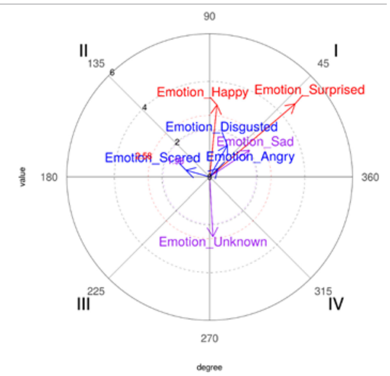
Category	Quadrant	Prospective	Retrospective	Length	Angle
Emotion_neutral	II	−2, 5	0, 14	2, 5 (*)	176, 8
Emotion_surprised	III	−7, 19	−6, 97	10, 02 (*)	224, 11
Emotion_happy	I	4, 44	2, 78	5, 24 (*)	32, 06
Emotion_sad	III	−3, 77	−4, 33	5, 75 (*)	228, 96
Emotion_disgusted	IV	0, 14	−1, 33	1, 34	276, 12
Emotion_scared	III	−1, 57	−3, 17	3, 54 (*)	243, 64
Emotion_angry	I	1, 37	0, 18	1, 38	7, 43



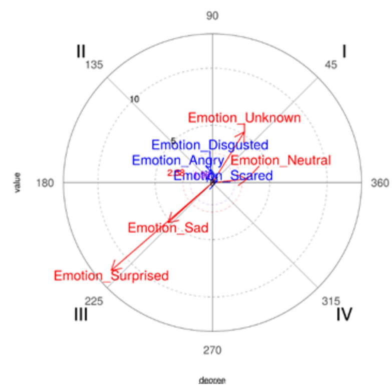
*The meaning of * is a significant vector (z ≥ 1.96, p ≤ 0.05).*

TABLE 5 | Polar coordinate analysis centered on *neutral/happy* and on *happy/neutral*, corresponding to the boys' records.

Search for relationships between *neutral* and *happy*						
Parameters (focal behavior: *neutral*)						**Vector**
Category	**Quadrant**	**Prospective**	**Retrospective**	**Length**	**Angle**	
Emotion_unknown	IV	0, 14	2, 5	−2, 5 (*)	273, 2	
Emotion_surprised	I	3, 59	3, 06	4, 72 (*)	40, 46	
Emotion_happy	I	0, 31	3, 02	3, 03 (*)	84, 17	
Emotion_sad	I	1, 67	1, 11	2, 01 (*)	33, 58	
Emotion_disgusted	I	0, 74	1, 32	1, 52	60, 62	
Emotion_scared	II	−0, 99	0, 28	1, 03	164, 19	
Emotion_angry	I	0, 35	0, 35	0, 49	44, 85	



Search for happy/neutral relationships					
Parameters (focal behavior: *happy*)					
Emotion_unknown	I	2, 78	4, 44	5, 24 (*)	57, 94
Emotion_neutral	I	3, 02	0, 31	3, 03 (*)	5, 83
Emotion_surprised	III	−8, 83	−7, 76	11, 7 (*)	220, 99
Emotion_sad	III	−3, 87	−3, 5	5, 22 (*)	222, 18
Emotion_disgusted	II	−0, 16	1, 18	1, 19	97, 76
Emotion_scared	I	0, 41	0, 13	0, 43	17, 18
Emotion_angry	II	−0, 12	0, 96	0, 96	97, 27



*The meaning of * is a significant vector (z ≥ 1.96, p ≤ 0.05).*

consider that the contextual situation in the in-depth interview could explain the specific nature of the emotions related to sports practice.

One of the recurring expressions throughout the analysis is "happy," in both girls and boys. This fact is consistent with the research conducted in relation to the Three-Dimensional Model of Service Quality (Sánchez-Hernández et al., 2009), which is concerned with emotional service quality focused on interaction during service and which shows affection and esteem for the user.

The limitations of this study lie in the sampling. It would be valuable to sample over different cities and to increase the age range. In relation to Mixed-Methods strategies, the use of a MERGE strategy in addition to a CONNECT strategy, with content analysis, would give the study greater power and flexibility.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by 18-2015-H (Ethics Committee of the University of Malaga). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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