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Looking inside the *black box*— semantic investigations on a frequently used expression beyond AI

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Talking about Artificial Intelligence (AI) as a *black box* is a current phenomenon in scientific communication as well as in journalistic reporting on this topic. Yet, for several years we can observe an increasing use of the expression *black box* in further contexts like economics or politics not related to AI. This leads to the question of which aspects of meaning are associated with the expression and how the respective context of use might influence the constitution of the specific semantic features. Furthermore, it raises the question, which evaluative features accompany the expression as this might have an impact on the perception of the entity referred to as a *black box*. In our paper, we investigate these questions based on 288 contemporary articles from German speaking journalistic publications. Our method combines a qualitative content analysis with approaches from semantic theory of use and discourse semantics. The results indicate that the expression *black box* has developed a wide range of supplementary semantic features as lack of knowledge, uncertainty or (lack of) traceability through the use in varied contexts such as economics, politics or biochemical processes. This shapes the conceptualization of the term *black box* in contemporary language use, which also affects the conceptualization of AI in return whenever it is referred to as a *black box*.

KEYWORDS

black box, artificial intelligence, conceptualization, discourse linguistics, journalistic coverage, metaphor, semantic features

1 Introduction

Artificial Intelligence (AI) is becoming an increasingly important technology in modern life. It is notable that when talking about AI, we frequently use the expression *black box* to conceptualize it as some examples from the scientific discourse on AI may illustrate: Castelvechi (2016) asks if we can “open the *black box of AI*,” Bleicher (2017) speaks of “demystifying the *black box that is AI*” and Vorras and Mitrou (2021) talk about “unboxing the *black box of Artificial Intelligence*.”

This metaphor dates back to the early days of Cybernetics (von Hilgers, 2010; Card, 2017) and stems from the fact that in many cases we do not have direct access to the operating processes of AI systems. What we can observe is the data input which is fed into the systems and the output that emerges from the operating processes. Sometimes, we do not even have access to the input (von Eschenbach, 2021, p. 613). From the point of view of computer sciences this working routine of AI systems is not necessarily problematic (Kishiyeve, 2022; Card, 2017).

However, it is no longer just computer scientists who are discussing AI. Due to the developments in AI technologies in the last few years, we have seen increased journalistic reporting

on AI. The expression *black box* is also booming in public discourse as the Digital Dictionary of German Language (DWDS) attests (“[Black-Box, 2024](#)”, date of access 01/26/2025). An example from a comment published in the Swiss newspaper *Neue Zürcher Zeitung* illustrates this:

- (1) By the time Artificial Intelligence begins to interact and collaborate independently, processes that should actually be accessible to humans will have disappeared in a black box. Enlightenment becomes opaque; the age of faith returns (Neue Zürcher Zeitung, “KI schafft eine neue Dunkelheit in einer hypermodernen Welt,” 8/2/2021).¹

The author depicts a dark vision of a future in which processes run by AI would no longer be understandable for human beings. In this context he uses the keyword *black box* which refers to a well-sealed and non-transparent container that does not permit any access from the outside. By constructing a discrepancy between a desirable state (processes should be accessible to humans) and an anticipated state (processes will have disappeared in a *black box*), he suggests a negative interpretation of the expression *black box*. Although the conceptualization of *black box* is not completely different to the above mentioned cybernetic one, it problematizes the consequences resulting from the fact that the functioning processes can neither be observed nor fully understood. Hence, this use of the expression *black box* opens a different perspective on the object it refers to.

Yet, the expression *black box* is not only used in connection with AI, but increasingly in relation to other entities as well. This raises the question of the extent to which the metaphorical meaning of *black box* as an unobservable, closed system has changed through its use in other contexts. We assume that using the expression in various contexts of everyday life led to an adjustment and extension of its meaning due to the contexts in question. This adjustment of meaning might also impact the conceptualization of objects called a *black box* like AI often is.

We address this question by presenting the results of a linguistic corpus analysis of 288 German-language journalistic texts from the period 2020 to 2022. We chose this period because we assumed that during the Covid 19-pandemic that spread globally in 2020 the expression *black box* might have been used more frequently in journalistic coverage to refer to unknown developments. The end of our research period is marked by the release of the Open AI text generator ChatGPT which was the first AI tool that had been made available for use by a wider public. Because of its use of AI, we expected an increase in the use of the expression *black box* in the journalistic reporting on it.

Nevertheless, the expression was also frequently used in everyday language before this specific period of time. This choice of investigation period is a pragmatic decision intended to make our qualitative analysis more manageable.

The main objective of this study is to show how the usage of the expression *black box* has shifted over time from being used in a purely technical context toward a more metaphorical usage within contemporary German language, specifically in a journalistic context. To illustrate this shift, (i) we will first establish the origins of the

expression *black box*. Following this, (ii) we explore in which contexts the expression is frequently used and which aspects of meaning it reveals. This leads to the question how the respective contexts of use affect the development of semantic and evaluative features of the expression *black box*. Using content analytical and (discourse) semantic methods we intend to outline the concepts behind the expression *black box* holistically by looking at keywords connected to the respective use of the term *black box* and which associations to the *black box* they reveal. Finally, (iii) with our results we hope to show that the expression *black box* is used in one of four usage cases: as a technical term, as something that is not understandable, as something that is used to intentionally obscure content, and finally as the obfuscation of content with malicious intent (for a detailed description, see chapter 4.1.1). To illustrate this, we will draw upon our learnings from the associations connected to the *black box* depending on the context the expression is used in.

These investigations aim at acquiring a better understanding of concepts tied to the expression *black box* and are intended to close a research gap. As Geitz et al. (2020, p. 7) state, the expression itself “can be understood as a black box. It is a term that is used ubiquitously, that works well and therefore seems to have a meaning. At the same time, the expression is vague and is used inconsistently.”² There are only few studies that investigate the question of the semantic and especially metaphorical character of the black box expression. Those studies mostly focus on the domain of Artificial Intelligence by examining the potential of shaping the conceptualization of AI through this expression (Christin, 2020; Watson, 2024), by discussing this metaphor in comparison to other metaphors depicting AI (Möck, 2022; Longo, 2025) or by considering the impact of metaphors like black box on practices of AI governance (Maas, 2023). However, there are no studies that investigate the use of the expression in more general contexts that leads to the formation of new semantic features throughout these use practices. Our analysis is based on an examination of the expression’s actual use to identify dominant contemporary semantic aspects that may have developed during its history of use or that pre-existed but have not been dominant so far. To this end, we considered the thematic contexts in which the expression *black box* is used as the context (Chapter 4.1), associations to the expression *black box* provided by the specific context of use (Chapter 4.2) and connotations that emerge from context and associations (Chapter 4.3). We assume that those collateral context features have an influence on the development of new semantic aspects.

2 Theoretical framework

2.1 Semantic theory of use and discourse semantics

Our theoretical footing thus follows approaches of use theory of meaning that can be traced back to considerations of Ludwig Wittgenstein, who claimed that the meaning of a word arises from the way the word is used conversationally. Based on this premise, it is not expedient to reduce an expression to a general meaning

¹ As all our corpus examples are in German, we translated them for better understanding into English. A full record of the cited journalistic articles can be found in [Appendix 1](#).

² Citations in German have been tacitly translated into English.

which generates a variety of uses, but to consider that each expression includes a certain spectrum of uses from which its meanings arise (Fritz, 1998, p. 9 f.). Those uses may be connected in a systematic way, that can be ascribed to aspects of the expression's conceptual history or to communicative patterns of word usage like metaphoric, euphemistic or ironic use of an expression. Hence, the construction of meaning can be understood as a communicative act in which both the sender and the recipient participate (Bechmann, 2016, p. 184). In this process, the communication partners are assumed to have a certain amount of shared knowledge, which makes pragmatic and semantic innovation possible (Fritz, 1998, p. 102). This shared knowledge includes, among other things, knowledge of the rules governing the use of words. Some of those rules of word use are related to the properties of a specific object as semantic aspects. This may help to decide in which situations the expression *black box* might be used in a literal or metaphorical way (Bechmann, 2016, p. 190). Other rules are based on social conventions, for instance conversational maxims, like the maxim of relation that demands that every utterance should be relevant to the aim of a conversation (Grice, 1989, p. 27). Furthermore, shared knowledge also includes the fundamental certainty that utterances serve the purpose of communication. Although this may seem trivial, it is a fundamental communicative condition that allows us to draw conclusions about the intention of what has been uttered, even in the case of obvious violations of the rules (Grice, 1989, p. 26). For instance, it allows the recipient to recognize an ironic use of an utterance, although it contradicts the conversational maxim of truth, according to which utterances should be truthful to ensure a successful conversation (Grice, 1989, p. 27). The recipient assumes that the sender would not lie to them and therefore concludes that the obvious untruthfulness of an utterance must have a different intention. In this way, the rules of word and meaning usage are open to a certain extent that enable processes of meaning transformation (Bechmann, 2016, p. 186).

At the same time, these changes in word usage lead to changes in the knowledge connected to the respective expression. New epistemic aspects accumulate around the word, while older ones are lost in oblivion and vanish. In this way, not only the shared use of an expression, but also the shared transformation of use contributes to a joint production of knowledge that manifests itself in public discourses. Participants in these discourses generate, modify and solidify knowledge through negotiation processes using linguistic devices (Spieß, 2018, p. 144; Berger and Luckmann, 2004, p. 47). According to Busse (2020, p. 196), those discourses can be seen as “the effect of the social in the world of epistemes” because of this joint production of knowledge. Thus, the pragma-semantic analysis of the usage and meaning of an expression like *black box* can give further insights into this joint knowledge production surrounding the expression. Discourse semantics especially aim to identify and describe those semantic elements of an expression that are related to knowledge relevant for comprehension. Our approach ties in with this as we collect the understandings associated with the expression *black box* based on context-oriented analyses of how the word is used. Subsequently, we categorize these understandings and set out the underlying epistemic premises that may have shaped them (Busse, 2020, p. 197). In this way, we aim to reveal the epistemic structures that underlie the expression *black box* and hence contribute to reflect discursive practices that arise from the use of the expression.

2.2 Concepts and conceptualizations of *black box*

To identify the diverse semantic components of the expression, it seems useful to shed light on its conceptual history.

As mentioned above, the expression *black box* has experienced a significant rise in use in public discourse in the last years. Nevertheless, conceptual aspects that accompany this expression seem to be an underserved scientific issue (Geitz et al., 2020, p. 3). There are only a few studies (von Hilgers, 2010; Passig, 2017; Geitz et al., 2020; Petrick, 2020; Kishiyeve, 2022) that deal with its conceptualizations, its history and its linguistic usage. Hence, it seems necessary to take a closer look at the concepts behind the expression and its conceptual history to get deeper insights into how it is used in contemporary contexts.

Starting from a literal understanding of *black box* as an artifact, it can be described by its specific features: A *black box* is a container which is usually locked. The color adjective *black* as the determinative part of the composition *black box* hints at its ascribed quality of opaqueness, which means that it is not possible to look inside it.

This literal understanding can be tied to the history of the expression's origin, which has been reconstructed by von Hilgers (2010, p. 145): The first use of this expression seems to date back to the time of the Second World War, when British physicists transferred a newly developed magnetron from Great Britain via Canada to the United States. This new magnetron technology allowed them to build high-performing radar devices. As they would have a deep impact on further developments during the war, it was important to keep this transfer secret. Hence, the magnetron was hidden in a sealed black metal box, which might be seen as a prototype of a *black box*.

This potential narrative of origin provides central aspects that bring forth not only a literal understanding of *black box* but a metaphorical concept as well: it emphasizes the aspect of inaccessibility, sealing and opacity as specific properties of the expression.

Oftentimes, we state examples in which it is not easy to decide if the expression is used in a literal or metaphorical sense. This is especially the case if an artifact has features of a locked and inaccessible container but is not necessarily black. A common example is a flight recorder which is called *black box*, though it might be of a different color. The central point in calling this device a *black box* is the fact that it is an encased instrument which must not be opened to guarantee its smooth functioning—the recording of flight data, which can provide clarification in the event of an accident.

A range of technical devices are constructed as encased instruments hiding their technical interior from unauthorized access which might manipulate or even ruin their functioning. From a user's perspective, encasing can also be a strategy to conceal the technical complexity and draw attention to a structured user interface. In these cases, technical artifacts can be seen as *black boxes* which reduce complexity for the user's sake by enclosing it in an inaccessible container (Weber, 2019, p. 121).

Furthermore, *black box* can be used in a metaphorical way as an epistemic dispositive which allows to generate knowledge. In this context, the principle of complexity reduction is crucial (Petrick, 2020, p. 576). For instance, *black box* models which are used in computer sciences focus on input–output–relations, while everything related to

data processing is left out—or more precisely enclosed into a metaphorical *black box*:

“A programmer who utilizes a function in a program needs to know what the function does (such as calculate a square root or convert a temperature from degrees Fahrenheit to degrees Celsius) but should not need to know how the function accomplishes its task. This is often referred to as treating the function as a black box” (Kishiyev, 2022).

Kishiyev emphasizes that this kind of conceptualizing the expression can be understood as a procedural abstraction to differentiate between relevant and non-relevant aspects during the act of programming. This concept of procedural abstraction is pushed to the extreme in the context of machine learning, which applies forms of autonomous decision-making. Algorithms operate in an autonomous way providing specific outputs but deny an introspection into their data procession (Diakopoulos, 2017, p. 3). Nevertheless, those outputs as well as the input data are two access points to the question of what is happening inside the *black box* of algorithmic operations (Diakopoulos, 2017, p. 17).

Next, to computer sciences other disciplines also functionalize the metaphorical concept of the *black box* for epistemic purposes. One of the best-known approaches is the theory of behaviorism that focuses on the relation between stimulus and reaction and fades out cognitive or psychological factors that may have an impact to the reaction observed. The main interest is in influencing behavior by constantly modifying the relations between stimulus and response. Hence, the observable components of input and output move to the center, while inner processes are neglected. This allows one to regard individuals or groups of people as *black boxes* (Maschewski and Nosthoff, 2020, p. 120).

Beyond this, the *black box* concept may offer helpful access to domains like the human mind that seem to be inaccessible from the outside as it sheds attention on what is observable. At the same time, it requires “that the relationship between knowledge and ignorance be continuously and operationally redefined: With every piece of knowledge that can be elicited from the black box, a hitherto unknown realm of non-knowledge is revealed” (von Hilgers, 2010, p. 152).

Hence, from the perspective of the concept’s history and development, we can state neutral or even positive connotated conceptualizations of the expression *black box* as it may help to generate knowledge by focusing on output phenomena, prevent data manipulation by its sealed enclosure or simplify the usage of technical devices by providing a well-structured user interface. This raises the question of how the expression is used in contemporary journalistic texts. Our findings demonstrate that the term *black box* is employed in contexts that extend beyond its conceptual development in the technical and scientific domain. Specifically, the metaphor is also applied to political, financial or legal topics.

3 Materials and methods

3.1 Research corpus

For our purpose of developing a deeper understanding of the concepts behind the expression, a corpus of journalistic articles containing the keywords *blackbox**, *black box** or *black-box** was built up via the

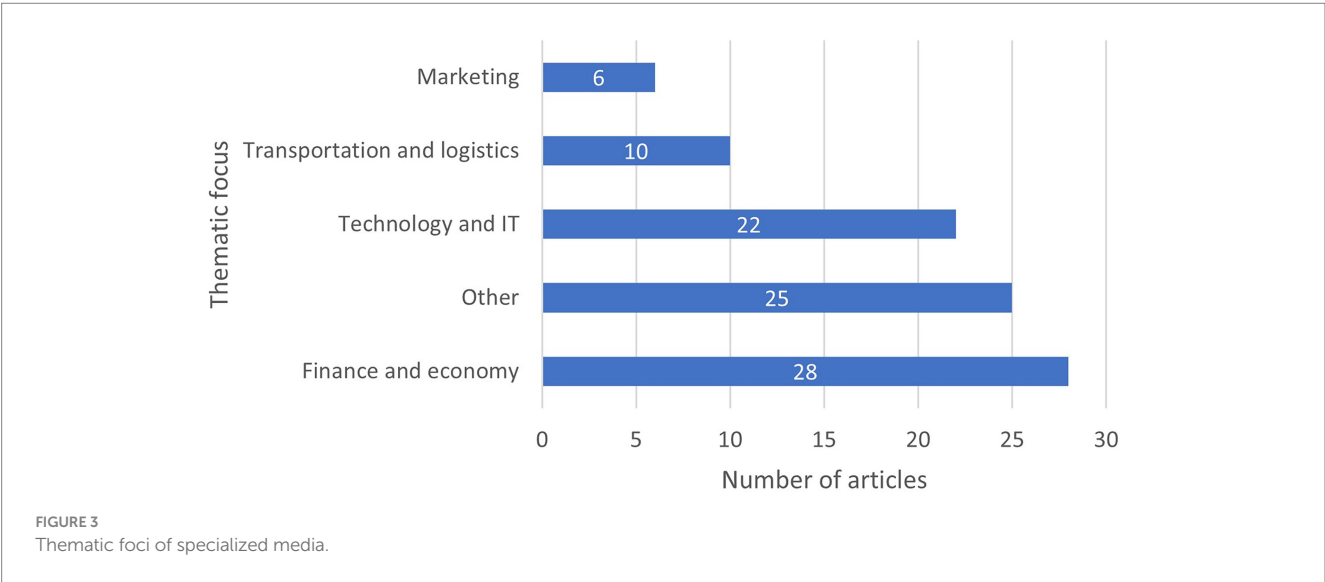
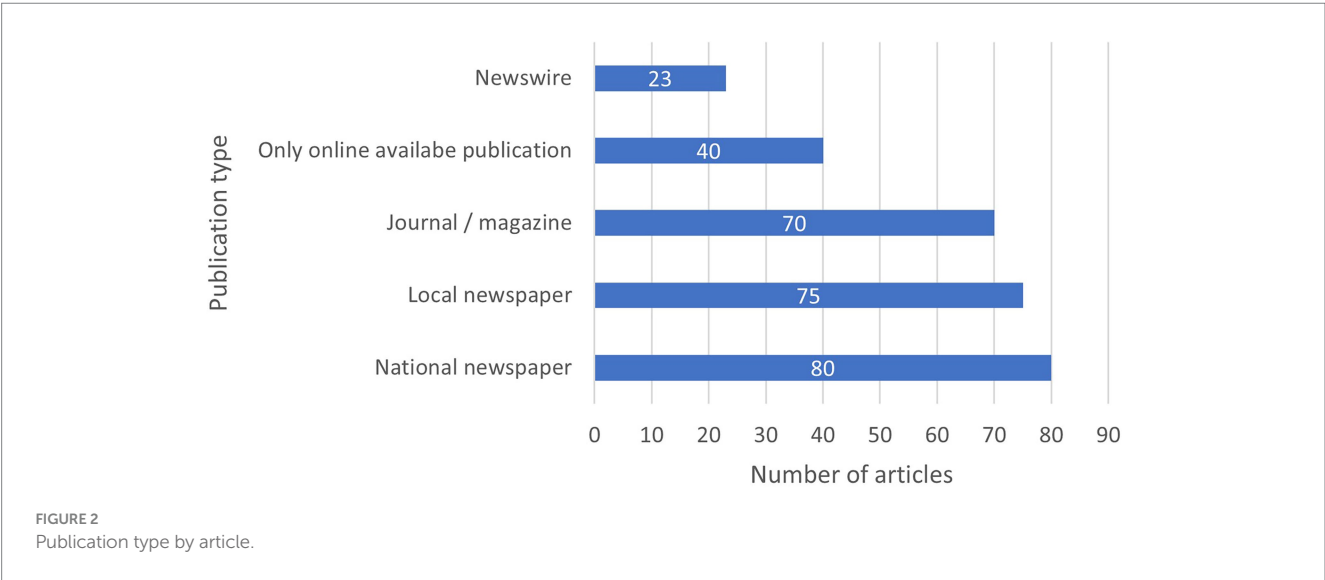
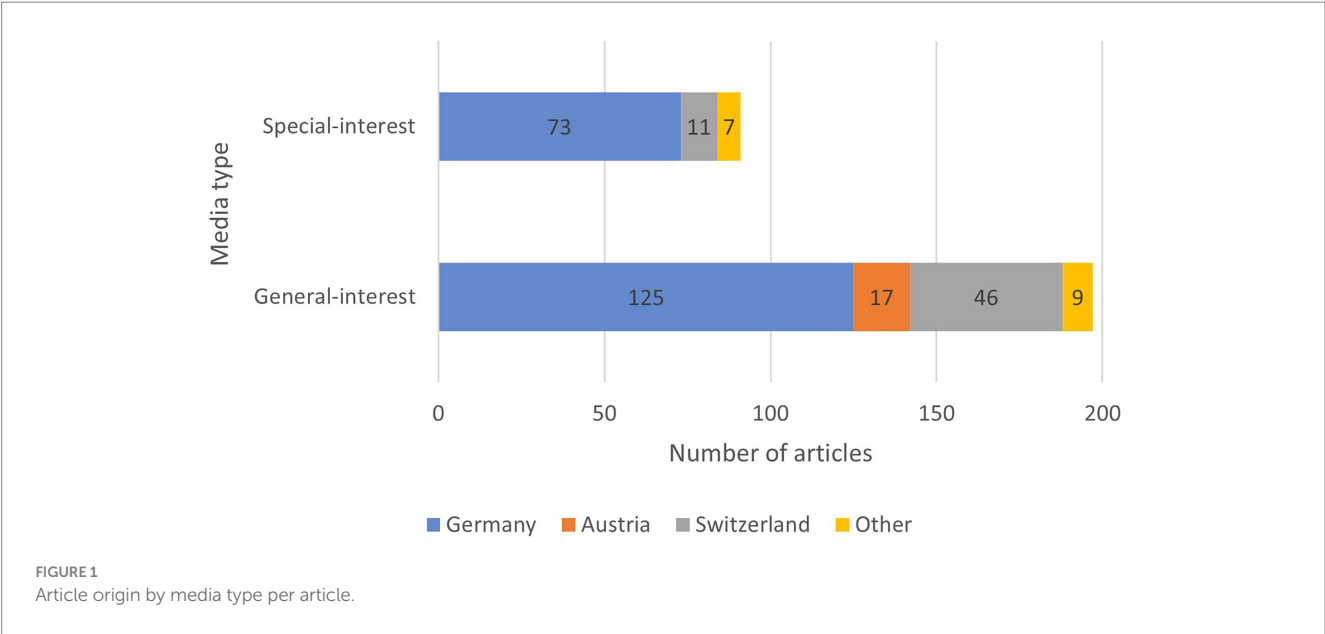
database LexisNexis. We chose a research period from 01/01/2020 to 12/31/2022 as it includes the spread of the Covid 19-pandemic in 2020 and the release of ChatGPT at the end of 2022. Both events had significant influence on the public discourse and were characterized by features of uncertainty and a lack of knowledge, suggesting a more frequent use of the expression *black box*. Furthermore, this period was chosen because it only dates back a short time and a period of 2 years provides a scope manageable for qualitative analysis, which allows insights into current uses of the expression.

Due to a very high number of results³ which could not be handled in a non-automated qualitative analysis, we decided to randomly select eight articles for each month of our research period. Thus, our corpus was reduced to 288 German speaking articles which originate from 126 various publication media mainly from Germany, Austria or Switzerland (the research corpus is recorded in App. C). As Figure 1 indicates the corpus consists of 197 articles from general-interest media, e.g., newspapers and journals and 91 from specialized media (e.g., manager magazin, Lebensmittelzeitung). Most articles originate from local newspapers (75 articles from 45 sources) and national newspapers (80 articles from 20 sources). Another substantial part is represented by journals and magazines (see Figure 2). Additionally, there are media outlets that operate exclusively online (40 articles), as well as a small number of articles from newswires (23 articles, e.g., from dpa). Regarding the specialized media, we gathered articles from the fields of finance and economy (28 articles), technology and IT (22 articles), transportation sector (10 articles), marketing (6 articles) and several other fields like agriculture, healthcare or real estate business which sum up to 12 media providing a total of 25 articles to the corpus (see Figure 3).

3.2 Semantic codings and qualitative content analysis

For our study we combined a qualitative content analysis with an approach deriving from the domains of semantic theory of use and discourse semantics as described in Chapter 2.1. Thus, we coded the articles of our corpus using the software MaxQDA. Our codings followed the aforementioned considerations that the meaning of any expression arises from the way it is used in context. This means, we considered as much contextual information as possible to guarantee a semantic description as accurate as possible. Thus, it is crucial to our approach to describe the respective understanding of the expression *black box*, which in many cases is integrated into the text metaphorically. The integration of an expression into a specific context can lead to a disambiguation of a potentially polysemic expression like *black box* (Busse, 2015, p. 128). The basic idea of a context-based description consists of the consideration that the context, in which the expression is used, serves as a mechanism of selection. This mechanism evokes a certain variant of the expression’s meaning that suits the respective context (Oheim, 2007, p. 57). In our case, we define as context the text surrounding the expression (co-text or intralingual context). This means, we use a relatively narrow understanding of context which allows us to focus on information, that originates from the accompanying co-text. Yet, it is necessary to

³ In total 5,264 German speaking journalistic articles.



emphasize that even a context-based description has limits as some expressions “remain even in clearly defined contexts indeterminate, vague or unclear in some areas of meaning” (Oheim, 2007, p. 65).

Being aware of this limitation, we coded our corpus according to the following semantic-related aspects: First, we recorded context-based which understandings or concepts are evoked by the expression *black box* (e.g., *black box* as a non-visible, closed entity or *black box* as a recording device). In addition, we considered in which thematic contexts the expression is used (e.g., in the transportation sector or economics). Another important semantic information we coded is whether positive or negative connotations occur with the expression and which associations arise when using it (e.g., *black box* as a means of enlightenment). We define associations as context-based semantic aspects that occur with the expression *black box*.

After a rough review of some of the material, we inductively created categories. The advantage of an inductive approach lies in the fact that it “strives for a depiction of the material that is as naturalistic as possible, close to the object without distortions due to the presuppositions of the researcher, a grasp of the object in the language of the material” (Mayring, 2015, p. 86). The resulting categories went through different iterations before being finalized. Similar to Freeman and Aoki (2023, p. 29) “we did not conduct an inter-coder reliability test as it is typically used in quantitative studies, instead relying on consensus and continuous communication between the experienced coders to ensure consistency and accuracy in the coding process.”

Methodologically, we defined our categories according to Mayring (2015) suggestions for qualitative content analysis. The core of the structuring content analysis is the precise description of the categories through definitions, anchoring examples and coding rules, which are summarized in a coding guide (Mayring, 2015, p. 111).

The definition summarizes the most important characteristics of the respective category. Text passages from the journalistic articles, so-called anchoring examples, illustrate the definition. In addition, “if there are any problems of demarcation between categories, rules are formulated to enable clear assignments” (Mayring, 2015, p. 97). In the case of associations, concept-evoking keywords, i.e., lexemes that reveal the corresponding association through their meaning, were also recorded.

3.3 Description of the categories

3.3.1 Contexts of use

Ten categories were formed for the contexts of use, which are briefly summarized below. The complete coding guide can be found in Appendix A.

Artificial Intelligence (AI) includes contexts in which AI itself or AI-associated terms such as neural network, (self-)learning system or algorithm are referred to as a *black box*.

Science and Technology (ST) includes on the one hand (talking about) scientific models on the theoretical level, and on the other hand the application-oriented level, e.g., regarding batteries or apps.

Person/Group of People (Ppl) includes the behavior and actions of individuals or groups.

Biochemical and Cognitive Processes (BCP) include any gradually developing processes (“Prozess, 2025”) that take place based on physical, chemical, or biological processes within or in interaction with an organism, as well as cognitive processes that affect perception and cognition.

Covid-19 pandemic (C-19) includes contexts that describe follow-up reactions to or events triggered by the pandemic.

Financial issues/Economy (FIE) refers to contexts that describe financial or business-related topics such as companies, employers, services and contracts, or related institutions such as the German organization “SCHUFA”.⁴

Politics (Pol) includes the actions of parties or governments, as well as their representatives. Entire nations, holders of state power and foreign or security policy institutions also fall under the context of Pol.

Law/Jurisprudence (LJ) includes contexts in which the issue referred to as *black boxes* are in the field of Law, including linked institutions such as courts or prisons.

The Transportation Sector (TS) combines contexts that deal with the transport of goods and passengers or with institutions that are in turn interlinked with transportation.

3.3.2 Associations

Nine categories were formed for the associations, which are briefly summarized below. The complete coding guide can be found in Appendix B.

The category Disclosure contains text passages which suggest that the *black box* serves as a means of clarification, e.g., of an accident.

Opacity is coded if the context suggests that facts are perceived as non-transparent. If the object referred to as a *black box* seems to deprive a person/group of people of the possibility of influencing it and its behavior or actions, this is interpreted as Loss of Control (LoC).

Lack of Knowledge (LoK) summarizes situations in which there is an actual or perceived knowledge gap with regard to the situation referred to as *black box*.

The association of Surveillance may arise if the context speaks of using a *black box* to observe people or record data.

In some contexts, the expression *black box* may evoke a perception of Uncertainty, often combined with mistrust/skepticism, usually due to ambiguity.

The category of Incomprehensibility refers to any situations that seem to be unfathomable or incomprehensible and cannot be grasped intellectually or emotionally.

Inaccessibility summarizes passages in which a situation is divided into an inside and an outside, whereby access to the inside is not possible or at least is perceived as impossible.

Finally, text passages where it becomes clear that investigating decisions or processes is the focus, or where traceability in this area is explicitly demanded are coded as Traceability.

4 Results

4.1 Evaluation of the contexts of use of the expression *black box* in German language articles

As mentioned in chapter 3, we assessed the articles for 10 categories regarding the use of the expression *black box* and in which contextual use

⁴ A private-sector German credit agency which collects account data from creditors and provides them on request to third parties.

it was embedded. These “Contexts of Use” (CoU) were a major focus in our investigation, since we wanted to understand in which contexts (additional to the AI *black box* and the data recorder *black box*) the expression had started to take root as a metaphor, and which additional meanings might have latched onto the description—or even replaced former meanings (see chapter 2).

4.1.1 Findings regarding the contexts of use

Based on content specific aspects of the contexts in which the expression *black box* is used, we were able to detect common issues in the use of the expression. Thus, we state that the expression *black box* is used in the following situations:

- a. *Black box as a technical term*: This specifically applies to the data recorders in planes, cars and ships. The use of *black box* in the AI context can in some cases also be classified as a technical term, where it serves as a descriptor for the data processing in AI systems.
 - (2) The data saved in the Event Data Recorder, the so-called *black box*, is supposed to help with accident investigations (Neue Zürcher Zeitung, “Neue Automodelle bekommen Tempobremse und Blackbox,” 02/17/2022).
 - (3.) Modern Methods of Artificial Intelligence are usually *black boxes*: how the AI arrives at decisions and predictions remains hidden (Elektronik Praxis, “Black-Box öffnen: Schwachstellen im Stromnetz finden,” 10/20/2021).
- b. *Black box as something that is not understandable*: Since *black box* in the AI context is used to describe when something is not (easily) understandable, the *black box* metaphor is used to describe either missing or obscured information or how certain processes work.
 - (4) Exactly this explainability and comprehensibility of AI-based decisions is something that many experts still deem a *black box* (cio.de, “Künstliche Intelligenz: Wie Banken und Finanzdienstleister KI nutzen,” 01/07/2021).
 - (5) The surveillance of an AI is problematic, because its output is not explainable. It is thus described as a *black box*. The result is known, but it is objectively impossible to comprehend how it came to be (Der PLATOW Brief, “Künstliche Intelligenz—Haftungsfälle für Manager?,” 02/03/2020).
- c. *Black box as something that is intendedly obscuring content*: Leaning onto the second meaning, the *black box* conceals obfuscated contents based on specific (e.g., socio-economic) calculations regarding institutions, corporations, groups of people or even individuals. Common with all these actors is the intent behind creating and maintaining the *black box*, making the existence of the *black box* in this context very intentional, whereas the *black box* under 2 does not necessarily have to be intentionally obscured. This may include political, social or economic calculations from actors.
 - (6) The idea of an IT on autopilot is naturally very tempting. This way many problems get solved in one swoop: the costs are sinking, the complexity of the interplay is basically hidden in a *black box*, and the employees can finally take care of the conceptional questions, instead of permanently looking for

sources of error and ways to optimize (IT-Business, “Storage-Automatisierung: Medizin mit Nebenwirkungen,” 04/19/2021).

4. *Black box as something that is intendedly obscuring content with malicious intent*: The intent to obscure content such as information, specifically in combination with an actor, can suggest malicious intent from said actor (a single person, group or institution)—e.g. in a political, social or economic context, when an actor intends to make a profit or trying to dominate another actor involved.
 - (7) For 6 days the clerical rulers cut the internet and turned their nation into a *black box*. Almost nothing leaked out of the raging brutality, with which the thugs of the regime went against the mostly young adversaries of the system (Stuttgarter Zeitung, “Eine Wahl ohne Auswahl,” 02/19/2020).

This categorization of our results at a higher level of abstraction enabled us to specify semantic aspects that emerged from the contexts of use. Hence, the concepts behind the expression took shape. As one can observe from our findings as well as the short demonstration in the introduction, the usage of the expression *black box* slowly evolved from being a technical term describing a tangible, often physical *black box* into a metaphor describing something that is *like a black box*. During the investigation, we observed how the expression *black box* was used in technical contexts, in our case specifically the *Transportation Sector CoU*, in comparison to other CoUs, e.g., *Financial Issues/Economy* or *Politics*, where the majority of *black box* uses delved into metaphorical territory.

4.1.2 Examples for contexts of use and their distribution in the corpus

To illustrate how we came to these conclusions, we will now go into detail on how the coding process worked and how we decided which (and in some cases, how many) CoUs were fitting for the respective usages of the expression *black box*.

In order for us to get results as precise as possible, we aimed at coding only one Context of Use per *black box* occurrence, meaning that if multiple aspects (e.g., the voltage of a battery in a car, making *Science and Technology* and *Transportation* possible CoUs) factored into how a *black box* idiom was used, we would only code the main CoU (in the aforementioned example this was *Science and Technology*, since the article’s emphasis was put on the voltage of the battery, a physical phenomenon, over the battery’s use in a car). If these aspects were equally meaning-determining for the use of the *black box* (as an example, see the *black box* “Cofag” in chapter 4.1.2.3), we would code each of the CoUs detected. For us, the advantage of this approach is that it made it easier for us to locate the intersection between topics and whether they are typical in German language use.

4.1.2.1 Single codings

German-language reference guides, specifically the DWDS⁵ record only two distinct contexts of use for the expression *black box*: The first

5 DWDS stands for Digital Dictionary of the German Language (Digitales Wörterbuch der Deutschen Sprache), see chapter 1. The DWDS names three possible meanings for the expression *black box*; as a part of a cybernetic

one is the *Transportation Sector* with a technical *black box* that can be defined as a data recorder, as this type of *black box* has been used in planes for quite some time, as well as being implemented more and more into modern cars or even ships. The other clearly definable context of use for us was that of *Artificial Intelligence*. The *black box* metaphor has been used in Cybernetics and AI research as well as in communication about AI research for decades, with the *black box* being not only associated with AI, but also a common metaphor for those familiar with the subject (see chapter 2.2). Consequently, there is a high number of single codings both for *Artificial Intelligence* (40 out of 43 of codings) and the CoU *Transportation Sector* (45 out of 58 codings).

Yet, we realized, that the expression is also used in various other contexts like *Biochemical and Cognitive Processes (BCP)* or *Financial Issues/Economy (FIE)* as Table 1 indicates. For the BCP CoU, this meant that biological phenomena, e.g., regarding the human body, or cognitive processes were plainly stated to be a *black box*.

- (8) Puberty is a *black box* (Stuttgarter Zeitung, “So finden Sie die richtige Schule für Ihr Kind,” 11/28/2022).

For the *FIE* CoU, economic processes or institutions, e.g., logistics or organizations like SCHUFA, were titled *black box*.

- (9) The cost calculation of the corporate groups continues to be a *black box*, that the companies naturally keep closed (Allgemeine Zeitung, “Blackbox/Kommentar von Ralf Heidenreich zum Tankrabatt,” 06/29/2022).

Regarding the CoU *Transportation Sector* however, we realized that not every *black box* mentioned in the corpus was a technical data recorder. In a few instances, metaphorical *black boxes* were used, for example to describe happenstances connected to the transportation sector, like in this article where train delays were described as a *black box*:

- (10) Train delays happen to one based on fate and are a total *black box*. Except for a few codes like ‘damage to the catenary’ no one hears anything of the logistical and communicative catastrophes behind the scenes (ZEIT online, “Zugverspätungen sind ein Geschenk,” 05/28/2022).

The metaphorical transportation *black box*, however, often made it necessary to code an additional CoU, since additional context was referenced in these phrases. The benefit of double codings to our research questions is that we can consider more contextual information that influences the concept behind the expression *black box*.

4.1.2.2 Multiple Codings

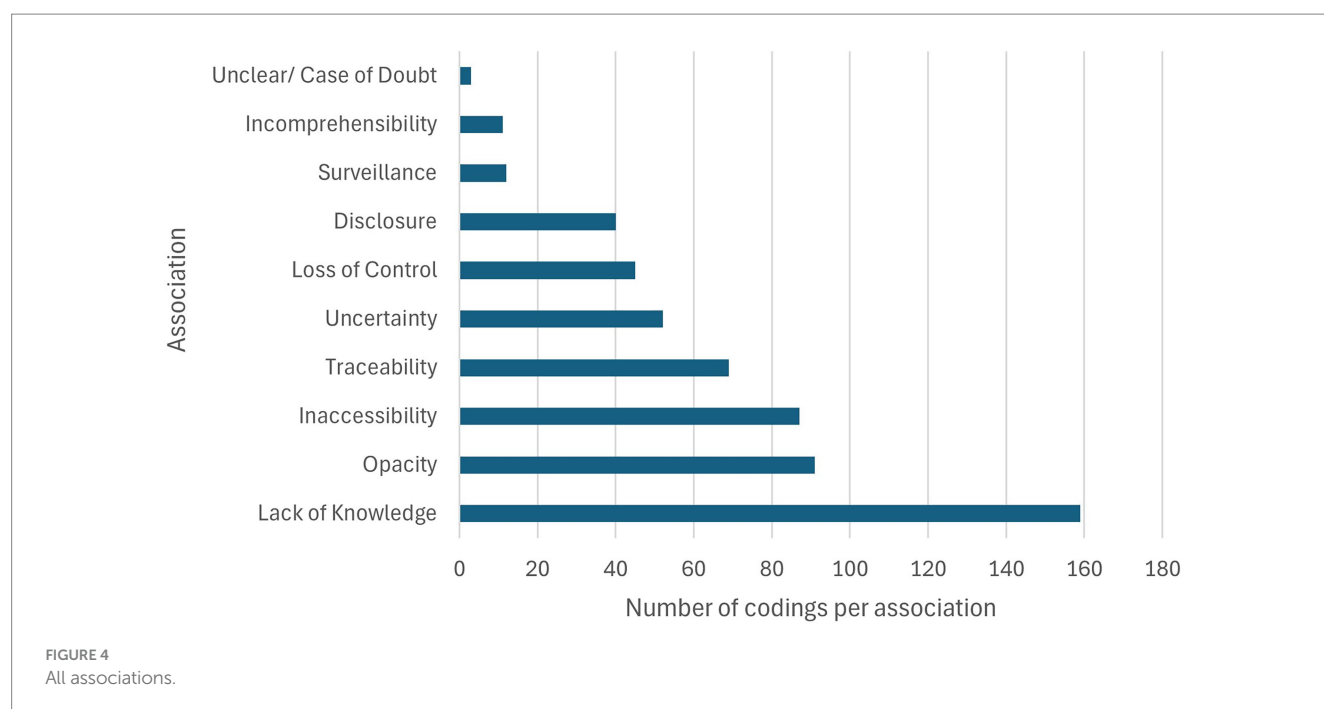
As it was not always possible to clearly distinguish a single context of use as the texts provide indications to several contexts which can be relevant to the respective understanding of the *black box* expression, we decided to mark those contexts with multiple codings.

system, as a (flight) data recorder and a darkly designed theater room. We decided to use the Cybernetic *black box* and the flight data recorder but not the theater stage, since there was little reference to them in our corpus texts.

TABLE 1 Distribution of single and multiple codings of Contexts of Use.

Context of use	Distribution		Total
	Single CoUs	Double CoUs	
Artificial Intelligence (AI)	93%	LJ 4.7% FIE 2.3%	43
Science and Technology (ST)	57,7%	TS 23.1% C-19 7.7% FIE 7.7% Pol 3.9%	26
Biochemical and Cognitive Processes (BCP)	70,6%	C-19 17.7% TS 5.9%	17
Covid-19 pandemic (C-19)	33,3%	Ppl 16.7% Pol 13.3% BCP 10% FIE 10% ST 6.7%	30
Financial Issues/ Economy (FIE)	75,6%	Pol 7.8% LJ 5.6% C-19 3.3% Ppl 3.3% ST 2.2% AI 1.1%	90
Politics (Pol)	35,6%	Ppl 11.1% C-19 8.9% FIE 8.9% TS 6.7% LJ 2.2% ST 2.2%	45
Law/ Jurisprudence (LJ)	47,1%	FIE 29.4% AI 11.8% Ppl 5.9% Pol 5.9%	17
Transportation Sector (TS)	77,6%	ST 10.3% Pol 6.9% AI 1.7% BCP 1.7% U 1.7%	58
Person/ Group of People (Ppl)	42,9%	C-19 17.9% Pol 17.9% FIE 10.7% LJ 3.6%	28
Unclear/ Case of Doubt (U)	-	TS 100%	1

The CoU *Financial Issues/Economy* illustrates this intricate coding process: It appears, that oftentimes institutions and people are classified as *black boxes*—leaning more heavily into the meaning derived from the AI context, where the *black box* is used to describe a divide, an opaqueness between a person seeking answers and an obstacle blocking its view. This meaning also carries over into the *Person/Group of People* CoUs, where oftentimes people are described as *black boxes*.



- (11) Even then the numbers are not guaranteed, Waskow says, since the individual disposal behavior cannot be exactly determined. “The Household is a *black box*, you cannot say with certainty, how much is wasted” (Welt, “Noch immer verfallen die Deutschen der MHD-Panik,” 10/05/2020).

In this example, a household, or to be more precise, the people of a household are described as a *black box*. This means that a *Person/ Group of People* as a whole and thus all their actions, motivations and minds gain semantic features as being closed off or not understandable for outsiders.

Regarding the double codings in our corpus, it is our estimation that both the *AI* and the *Transportation Sector* CoUs, meaning the technical data recorder *black box* as well as the opaque *AI black box*, inform all the other *black boxes* in their new Contexts of Uses. This is evident in phrases such as this one:

- (12) For Mrs. and Mr. Schweizer, the highest court is a *black box*, comparable to algorithms in Social Media—whose logic even programmers do not oversee completely anymore (Blick, “Blackbox Bundesgericht,” 12/18/2022).

In this case, the semantic association to the opaque *AI black box* is specifically mentioned, therefore the connection is easy to follow for readers.

In a few cases, we even opted for a triple “context of use” coding of certain *black box* phrases, in case the use of the phrase *black box* could not be adequately captured by one or even two CoU codings. The decision on which codings were applicable in which context was based on relevant keywords or phrases, that corresponded to a specific CoU (for a detailed list, see chapter 3.3.1). To demonstrate this, we picked an example where we found three applicable CoUs for one usage of the expression *black box*,

wherein the designated *black box* was the Austrian Covid-19 financial relief agency ‘COFAG’:

- (13) He has the SPÖ in one instance on his side: The *black box* Cofag does not help the businesses. Billions of taxpayer money go inside, and barely anything comes out the other side for the companies taxed by the pandemic, ranted the SPÖ economic spokesman Christoph Matznetter these days⁶ (Der Standard, “Zum Haare raufen: Manche Friseurse sehen sich am Rande der Existenz,” 01/02/2022).

This passage has been coded with the CoUs *Politics*, *Financial Issues / Economy* and *Covid-19 pandemic*. The *black box* in this phrase is the “Covid-19 Finanzierungsagentur des Bundes” (eng. “federal Covid-19 financing agency,” in short “COFAG”) in Austria. By nature, as a federal financing agency the COFAG combines a monetary aspect with politics, thus calling for the *Politics* and *Financial Issues/Economy* CoUs to be coded as a base layer. In addition, the COFAG was founded as a Covid-19 relief for the Austrian economy, thus making a *Covid-19 pandemic* CoU coding here necessary to capture the complicated nature of this *black box*.

4.2 Evaluation of associations

The contexts in which the expression *black box* is used reveal several associations tied to the expression like *Lack of Knowledge* or *Inaccessibility* (see Figure 4). Those associations shed light on the semantic aspects

⁶ SPÖ is an abbreviation for the Austrian Social Democratic Party. Cofag describes the federal Covid-19 financing agency that was funded to financially support businesses during the pandemic.

TABLE 2 Co-codings of occurred associations.

Associations	Surv.	Disc.	Inacc.	L. o. contr.	Uncert.	L. o. know.	Incom.	Opacity
Surveillance								
Disclosure	5							
Inaccessibility	1	2						
Loss of Control	2	1	13					
Uncertainty	0	0	7	7				
Lack of Knowledge	1	0	51	18	36			
Incomprehensibility	0	0	3	2	1	7		
Opacity	0	1	39	16	11	52	3	
Traceability	1	0	19	9	10	39	1	28

Bold numbers in the table mark co-coded associations that occur particularly frequently.

accompanying the expression *black box*. Yet, it also indicates quantitative differences in the occurrence of the respective associations within our corpus. As Table 2 indicates, the association of a *Lack of Knowledge* (159 codings) can be frequently found while associations like *Surveillance* (12 codings) or *Incomprehensibility* (11 codings) have been coded relatively seldom. We also realized a strong connection between the Context of Use and the occurrence of a respective association.

4.2.1 Findings regarding associations

Our findings on associations illustrate the flexibility of the *black box* metaphor, which adapts to various domains while retaining semantic core aspects of *Inaccessibility*, *Lack of Knowledge*, and *Opacity*. However, its specific implications are shaped by the context, whether it pertains to institutions, judicial systems, or individual actors.

The associations are linked to keywords, reflecting specific meanings or contextual features. Thus, capturing the associations also allows for a more precise determination of the context-dependent *black box* concept. For instance, the association *Disclosure* is almost exclusively tied to the context of *Transportation Sector*, as the *black box* here functions as a recording device, such as in cars or airplanes:

- (14) The search continued for the second *black box*, the flight recorder, which could provide technical information and other crucial data on the cause of the crash. [...] ‘With the currently available information, it is impossible to draw a clear conclusion about the cause of the accident,’ Zhu Tao, Director of the Aviation Safety Office, said at a press conference on Tuesday (dpa Infoline Politik und Wirtschaft, “Blackbox von Unglücksflieger im Süden Chinas entdeckt,” 03/23/2022).

Key phrases such as “providing information” or “clear conclusion” frequently appear, emphasizing the device’s role in clarifying events, particularly accidents.

The distinctive role of the *revealing black box* is also indicated by the few co-codings between *Disclosure* and other associations, as shown in Table 2. When multiple keywords indicating different associations were identified within a single text passage, all associations were included to reflect the various appearances of the *black box* concept. Table 2 presents the co-occurrence of different associations, with cases exceeding 20 overlaps highlighted.

The most frequently coded category is *Lack of Knowledge* (LoK). This category overlaps with all others, except for *Disclosure*. When the expression *black box* is used metaphorically, it may suggest an absence of knowledge or understanding or hidden information, thereby evoking the association *LoK*. Many of the other associations are directly derived from this knowledge gap. This association is triggered by keywords like “unknown,” “puzzling,” and “unclear,” which inherently diverge from aspects of meaning linked to *Disclosure*. These expressions underline the conceptualization of the *black box* as something inherently enigmatic. Co-codings frequently link *LoK* with *Opacity* and *Inaccessibility*. For example, in journalistic accounts, *Lack of Knowledge* often combines with *Inaccessibility* when data or processes are described as “hidden” or “sealed off.”

The category *Traceability* developed from the association *Incomprehensibility*. The analysis revealed two distinct types of comprehension problems related to the concept of *black box*: either individuals are described as a *black box* due to the inability to understand their inner emotional or cognitive processes, or the expression refers to algorithms or artificial intelligence systems whose functioning is intentionally designed to be opaque and not readily comprehensible. As a result, we found that *Traceability* occurs significantly more frequently in combination with the expression *black box* compared to *Incomprehensibility*. Examples of *Traceability* demands often invoke expressions like “explainability,” especially in discussions about AI systems.

The association *Disclosure* is almost exclusively used in the CoU *Transportation Sector*, reflecting the literal function of *black boxes* as data recorders. Exceptions include its application in economic forecasting and software tracing within the CoU *Science and Technology*. In the latter case, the *black box* is explicitly compared to a flight recorder, emphasizing its function as a data recording device. Keywords such as “data” and “informing” are central, and key phrases like “revealing the cause” emphasize the positive connotation of *black boxes* in this sector.

The association with *Surveillance* is also linked to transportation but extends to *AI*. In both cases, *black box* typically refers to a specific device or application. There is a single overlap with the CoU *Politics*, in which an intelligence agency proposed for abolition is referred to as a *black box*. Except for this political example, *Surveillance* and *Disclosure* are always tied to a specific kind of *black box*, either an algorithm or a recording device.

4.2.2 Associations by Context of use

Since the CoUs in our corpus are not evenly distributed, the remaining associations are described for each CoU. Analyzing the distribution of usage contexts for each association would risk skewing the results toward the more frequently occurring CoU. *Disclosure* and *Surveillance* were analyzed separately above, since their distribution was more distinct compared to the other associations. Associations pertaining to *black boxes* in the context of *AI* will be discussed in chapter 4.4, dedicated to these special *black boxes*.

4.2.2.1 Science, biochemical processes, COVID-19

In the CoU *Science and Technology*, several overlaps highlight the metaphorical use of the expression *black box*. Beyond *Lack of Knowledge*, the expression also evokes associations with *Inaccessibility*, often described through keywords such as “insight into the interior,” “not publicly known,” and “difficult to comprehend.” These keywords emphasize the restricted and obscure nature of processes or systems. Additionally, *Opacity* is frequently associated with *black box*, highlighted by the key phrase “demand for transparency,” which reflects a call for greater clarity and openness in scientific and technological contexts. Lastly, the expression is linked to *Uncertainty*, with keywords such as “danger” and “trust” underscoring the perceived risks and the fragile reliance on systems that lack transparency. A recurring example is the characterization of a battery as a *black box*, whose properties, such as battery capacity, depend on numerous factors that are challenging to quantify.

- (15) ‘For many engineers the battery is like a *black box*: they often do not know how it works and where its limits lie’, the physicist explains (tab, “Batterieforschung und ihre Grenzen,” 04/2021).

The complexity reduction enabled by the *black box* allows these factors to be ignored during regular operation; however, it also renders accurate assessments of the battery’s condition, if needed, nearly impossible. Keywords such as “unclear state” emphasize challenges in assessing their functionality.

When an app or technical application is referred to as a *black box*, *Traceability* often becomes an additional factor, reminiscent of descriptions of *black boxes* in the *AI* context (see chapter 4.4):

- (16) However, the security researcher from TU Darmstadt warns that the function where she discovered the vulnerability is a *black box*. Critical information [...] is not publicly available and must first be laboriously traced using the so-called reverse engineering process (Spiegel Online, “Sicherheitslücke im Samsung Galaxy S8 ermöglicht gezielte Überwachung,” 05/01/2020).

In this example, understanding the *black box* requires effort but is feasible, much like initiatives in the field of explainable AI suggest.

In the context of *Biochemical and Cognitive Processes*, most overlaps occur with *Lack of Knowledge*, reflected in keywords such as “why” and “how.” This suggests a neutral perspective on the *black box* concept in this domain, as illustrated by the following example:

- (17) She reports on successes and investigates their origins but still sees herself facing a *black box*. Some effects appear to

stem from hormone-like messengers released by active muscles—myokines—while others are linked to stress hormones. ‘There is still much to learn about the how, but experience shows that physical exercise is safe for patients and contributes to their physical and psychosocial health’ (Die Presse, “Mit Biologie gegen Krebs?,” 06/21/2020).

This example demonstrates how a *black box* can represent an area of inquiry that, while not fully understood, drives exploration and understanding. Other associations, such as *Incomprehensibility* (“enigmatic”) or *Loss of Control* (“out of control”), do not align with the description of these objective scientific processes. Instead, they are more commonly observed when abstract concepts such as “thoughts” or “puberty” are described as a *black box*. These cases are limited to three to four codings per association. The distinction between *black box* as a constructive unknown and more negative conceptualizations of a *black box* indicates the diverse application of the metaphor across different scientific and cognitive domains. It reflects both the potential of unexplored processes to advance knowledge and the challenges posed by abstract phenomena that resist comprehension or control.

In connection with the Covid-19 pandemic, all associations were coded at least sporadically, reflecting the diverse ways the topic was addressed. The most frequent association was *Lack of Knowledge (LoK)*, triggered by phrases like “we do not know,” which is unsurprising given the emergence of a novel virus. However, it is interesting that associations such as *Uncertainty* and *Loss of Control (LoC)* appeared more frequently than *Opacity*, which emphasizes deliberate concealment. Instead, the dominant theme was a general state of uncertainty, during which virtually anything and anyone could be described as a *black box*. The following example shows how *LoC* was triggered, because authorities cannot access the soccer players in the changing rooms to check distancing rules:

- (18) Changing rooms are a *black box* for the authorities. There is no independent supervisory authority (Frankfurter Rundschau, “Flackerndes Lagerfeuer,” 05/07/2020).

Expressions like “isolate” and “uncertainty” highlight broader societal impacts in this context, including the inability to monitor or control behaviors effectively.

4.2.2.2 Finance, politics, law

In the domain of *Financial Issues/Economy*, associations are distributed in distinct patterns. As in most cases, *Lack of Knowledge* is the most frequently coded association, reflecting its fundamental role in the *black box* concept. Keywords such as “unknown,” “lack of clarity,” and “unverified information” reflect the persistent challenges in fully grasping financial processes or systems. However, this domain stands out as the only context where *Opacity* emerges as the second most common association, represented by keywords such as “increasing transparency,” “shedding light on the *black box*” and “opaque.” This reflects a widespread recognition of the need for greater visibility and clarity within financial systems, underscoring the risks and inefficiencies posed by their lack of openness. *Inaccessibility* follows closely as the third most significant association, with keywords like “secret” and “restricted access” highlighting the deliberate or systemic barriers to obtaining critical financial information. Economic

black boxes appear particularly closed off to external observers, often denying access and insight:

- (19) For KPMG, however, Wirecard's partner business remains a *black box*. The auditors cannot verify the revenue figures for the years 2016 to 2018. They cannot access the documents necessary for this (manager magazin, "Gezinkte Karten," 6/26/2020).

Other notable associations include *Uncertainty*, *Traceability*, and *Loss of Control*. These are often linked to calculations of financial contributions or returns, which are challenging to trace and carry potential consequences for future decisions. This highlights the multifaceted ways in which *black boxes* manifest in economic contexts, often intertwining inaccessibility with broader implications of risk and control.

In the political context, *Lack of Knowledge* remains the dominant association, though the gaps between *LoK* and other associations are less pronounced compared to other domains. Similar to the economic context, *Inaccessibility* ("hide," "isolate," "restrict access," "keep secret") and *Opacity* are closely aligned, with a slight emphasis on *Inaccessibility*. This seems to reflect political processes, which may be partially visible to the public yet remain obscured in significant ways. *Uncertainty* ("trust") and *Loss of Control* ("security," "evading control") also play significant roles, highlighting the uncertainty and unpredictability inherent in political contexts. The following example shows how *black boxes* in political contexts intertwine inaccessibility and opacity, fostering uncertainty by complicating efforts to predict political actions:

- (20) Myanmar's military is already an exceptionally opaque institution, shrouded in rumors and stories—a *black box* that even experts struggle to interpret. Even now, there is speculation about why the military reclaimed power. One thing is clear: the generals have always been erratic and unpredictable (Zeit Online, "Die Blackbox," 2/11/2021).

The thematic proximity between the contexts of *Law/Jurisprudence* and *Politics* is also reflected in a similar distribution of the most frequent associations *Lack of Knowledge* ("speculate," "unknown"), *Inaccessibility* ("secretive," "isolated"), and *Opacity* ("transparency obligations"). Many examples relate to institutions, such as prisons, which are inherently inaccessible or lack transparency due to their operational logic. However, a notable shift emerges in the distribution: *Traceability* and *Loss of Control* were found with roughly equal frequency in the context of *Law/Jurisprudence*. *Traceability* often pertains to the complexity of laws. In one instance, the judiciary system itself is directly compared to *black box* algorithms:

- (21) For Mrs. and Mr. Schweizer, the highest court is a *black box*, comparable to algorithms in social media—whose logic even the programmers themselves can no longer fully grasp (Blick, "Blackbox Bundesgericht," 12/18/2022).

This comparison is particularly noteworthy as it equates the Swiss population with programmers, who, despite being closest to their algorithms, still fail to maintain an overview. Similar to algorithmic *black boxes*, no pathway is offered for understanding judicial processes, reinforcing the impression of opacity.

When individuals or groups of people are described as *black boxes*, *Uncertainty* ("fear," "trust") emerges as the most frequent association after *Lack of Knowledge*. As the following example demonstrates, *Uncertainty* is often tied to themes of trust or mistrust:

- (22) The *black box* Putin, who uses language to lie, deceive, or conceal as needed. [...] Putin destroys the reference to reality and the truthfulness of language, undermining the fundamental trust we must have in speech acts to communicate with one another (Die Zeit, "Auf dem Balkon des Zweifels," 05/12/2022).

Trust or mistrust is more easily addressed toward specific individuals or groups than toward abstract concepts in biochemistry or law, explaining the high prevalence of this association in this context. *Opacity* and *Inaccessibility* also follow closely and seem to dominate across many contexts.

4.3 Connotations of the expression *black box*

Our findings suggest that the expression *black box* oftentimes is accompanied by further evaluative features that emerge both from the context of use and the associations generated by the respective context.

Hence, we also examined which evaluative features emerge from the extended textual context around the issues, which are referred to as *black boxes*, and the revealed associations. This was intended to provide a fairly general assessment of the basic mood and to get a better understanding of how a *black box* (or something that is perceived as a *black box*) is evaluated.

Overall, a negative assessment predominates (see Figure 5). In most contexts, *Lack of Knowledge* was evoked and, especially in combination with further associations like *Opacity* or *Loss of Control*, negatively rated.

These combinations are often found in the almost consistently negatively connotated area of financial issues (156 negative codings, vs. 10 positive and 42 neutral ones), which is due in particular to the fact that there are for example "incalculable risks" ("The tariff system is a *black box* with incalculable risks for every heat consumer," St. Galler Tagblatt, "Wärmeverbund nicht ausbauen," 01/27/2022) and similar imponderables. Overall, a feeling of ignorance, of uncertainty, but also of lack of transparency, e.g., with regard to the SCHUFA-organization, seems to prevail.

In the transportation sector, on the other hand, neutral denotations (67) outweigh negative (46) and positive (42) connotations. It becomes clear that the *black box* as a technical device in an aircraft is almost always viewed as neutral to positive, as it is seen as an important instrument:

- (23) It is good that the *black box* has been found and we can hear the last conversations of the pilots and crew (dpa-AFX, "Flugschreiber der verunglückten Militärmaschine geborgen," 07/06/2021).

Relative to the frequency of coded instances, *Disclosure* is associated with the most neutral and positive connotations emerging from this context. Further positive evaluations were only occasionally found among the other associations. The category *Uncertainty* emerged most often in negative contexts, with no positive assessments recorded.

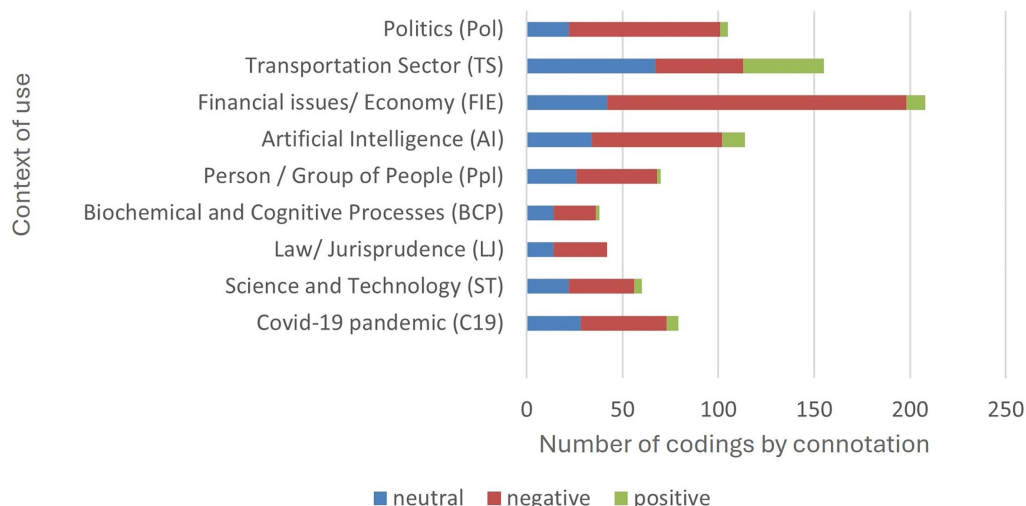


FIGURE 5
Code-relation: context of use and connotation.

Although the *black box* in the car serves a similar purpose as in planes and might be linked to positive connotated associations like *Disclosure*, negative connotations are increasingly added here, as it is experienced as coercion, seen as a means of surveillance, or data protection reasons play a central role:

- (24) From next summer, new car models will have to have an accident data recorder installed, and in 2024 this will be mandatory for all newly produced cars (Basler Zeitung, “Für die Datenauswertung gibt es diverse Hürden,” 01/06/2022).

We could observe that the *black boxes* in the *Transportation Sector* occasionally displayed a double use of the expression—on the one hand the *black box* as a data recorder, while simultaneously being a metaphorical *black box*. This is especially evident in the case of the article “From July 2022, Big Brother will ride in the car” (About fleet, “Ab Juli 2022 fährt Big Brother im Auto mit,” 04/2022). This article describes how data recorders will become mandatory in Swiss cars starting July 2022. By linking *black box* to the Orwellian term “Big Brother” and thus drawing on its connotative meaning, *black box* becomes a metaphor for *Surveillance*. The users know the data input and who might use the data, yet they do not know what the data will be used for—or what the potential outcome might be.

The evaluation of the issue, which is referred to as a *black box*, and the circumstances in which the expression is used, therefore depends heavily on whether it is a technical term or a metaphor—or both. The *black box* as Big Brother example shows the semantic change the expression is going through.

4.4 The special case of the artificial intelligence *black box*

When looking at AI as a *black box*, it is evident that in a lot of cases, the thing described as a *black box* is either AI itself or something very closely related to it. In our corpus alone, a good part of the items described as a *black box* are AIs, AI-based systems, AI-based decisions, neural

networks, software or algorithms, specifically in the CoUs of *Artificial Intelligence* and *Technology/IT*. In the other cases, the use of the AI *black box* varies from being used as a descriptor (“like a *black box* AI,” “works as a *black box*”), to AI being a part of a larger structure, which then in turn transforms the structure (or the AI-related part of the structure) into a *black box*.

One of the most common themes throughout is the harkening back on data collection, data processing or data analysis within the corpus. However often AI itself is described as a *black box*, the processes within AI (systems) appear to be just as opaque, with many journalists referencing specifically the way AI-based systems handle data.

This also correlates with the view journalists have on the *black box* AI, which is overwhelmingly negative—out of 43 AI-*black boxes*, we could detect a negative connotation in 33 cases, 16 neutral denotations and five positive connotations—out of these 43 cases, 11 *black boxes* had a double coding, where the *black box* was attributed with either both neutral and negative or negative and positive connotations. For positive connotations, this includes the *black box* being linked to chances. For negative connotations, phrases like “enigmatize,” “raising problems,” or that steps should be taken so that something “would not turn into a *black box*” indicated, that something being a *black box* is a circumstance that is not desirable and should, if possible, be remedied—hence these *black boxes* were identified to have a negative connotation.

Quite a few of these negative connotations can in turn be traced back to people not knowing what is going on within a *black box* and that the processes within are hard to follow:

- (25) Specifically the explainability and comprehensibility of AI-based decisions still appears to be a *black box* to a lot of experts (Rheinische Post, “Leichtteile und Black Box im Meer gefunden,” 01/10/2021).

This goes so far, that the *black box*, specifically in the AI context, is repeatedly framed as something to be avoided:

- (26) This last scenario is supposed to prevent the so-called *black box*-effect of AI-systems, that themselves can exceed the

understanding of their own developers (Euractiv, “EU-Kommission schlägt Ausweitung der Produkthaftungsvorschriften vor,” 09/28/2022).

This also correlates with the associations placed on the AI *black box* in our corpus: *Traceability*, the most frequent association in this context, is often cited as a reason why a *black box* cannot or should not be used. Keywords such as “explainability” and “transparency” highlight ongoing concerns about algorithmic opacity. In such cases, *Traceability* is presented as a property in direct opposition to the concept of a *black box*:

- (27) AI is increasingly being used in safety-critical areas such as medical technology, vehicles, or industrial systems. In these fields, an AI system must not be a *black box*. It must be transparent how the decisions or results of an AI application come about (silicon.de, “Interview: Wie es um die Compliance bei KI steht,” 03/14/2022).

At the same time, the implementation of AI that does not operate as a *black box* is not excluded. Approaches such as Explainable AI are proposed as solutions to overcome the *black box* concept:

- (28) With the right tools, a neural network does not have to remain a *black box* (Maschinenmarkt, “Meine App sagt mir, wer du bist,” 02/11/2021).

As the examples show, associations like the second most frequent *Lack of Knowledge* and *Opacity* appear to play an equally important role in the context of AI, followed by associations of *Inaccessibility*. These categories align with properties typically attributed to *black box* algorithms, such as their lack of traceability. This is particularly evident for *Opacity*, where examples often involve demands for greater transparency or critiques of existing opacity. While *Inaccessibility* is typically described in broader terms, such as decision-making processes being “not openly visible,” the associations of *Lack of Knowledge* and *Opacity* are evoked through more specific expressions like “unknown” or “transparent.” There are fewer overlaps with categories such as *Loss of Control* and *Uncertainty*, underscoring a technical meaning.

In summary, *black boxes* in the context AI are predominantly evaluated negatively, showing concerns about traceability or transparency and addressing the question of the trustworthiness of AI technologies.

5 Conclusion

In conclusion, we would like to take up again the questions we posed in the introduction and provide answers based on our findings.

First, we established in chapter 2.2 the expression *black box* to have an origin in Cybernetics (Card, 2017) and therefore a connection to the field of Artificial Intelligence. Furthermore, von Hilgers (2010) pointed out the possible origins of another *black box* as a container used to conceal military technology, thus giving the *black box* not only a metaphorical but also a physical meaning. Another use of a *black box* mechanism that we pointed out is its function to limit access to a mechanism, making it inaccessible. However, that inaccessibility might also guarantee its smooth functioning without outsider interference, e. g. in the case of a data recorder. It might also make a mechanism more accessible, by hiding the parts that might not be understandable to laypeople behind a more user-friendly interface (Weber, 2019). The expression *black box* therefore

already covers a variety of meanings, which all inform the various interpretations linked to the concept of the *black box*.

Regarding the question in which contexts the expression *black box* is used in contemporary German language, we stated nine distinct categories of contexts in which it was frequently used in our corpus. Most often we coded the category of *Financial Issues/Economy* (90 codings). This category was followed by the categories *Transportation sector* (58 codings), *Politics* (45 codings) and *Artificial Intelligence* (43 codings). The category of *Covid-19 pandemic*, which we assumed to be a fruitful context for the use of *black box* metaphors was only coded 30 times. Further Contexts of Use with even fewer codings were *Person/Group of People* (28 codings), *Science and Technology* (26 codings), *Law/Jurisprudence* (17 codings) and *Biochemical and Cognitive Processes* (17 codings). Although this selection of CoUs is not representative, it indicates nevertheless a shift from the use in rather technical contexts (*black box* as a device of data recording as well as *black box* as an encased technical instrument) to contexts beyond which also implies a shift to a metaphorical meaning of *black box*. For instance, this is apparent in the case of financial or political contexts that refer to institutions or financial processes as *black boxes* due to semantic features like non-transparency or inaccessibility that are projected to the new referees.

This leads to the question of how the meaning of the expression may have changed due to this flexible use in different contexts. Which aspects of meaning have become more relevant by using the expression in specific contexts? Are there any new semantic features that arose from new practices of use?

As we were able to show, the CoU has a significant role in how the expression *black box* is understood and influences which aspects of its meaning emerge.

On the one hand, we can conceptualize *black box* as a descriptor for data recording and processing which reveals a technical understanding and therefore is oftentimes found in technical contexts, including the AI context. Depending on the context, this conceptualization can evoke associations like *Disclosure* (mainly in the context of transportation) but also associations like *Opacity* or *Lack of Knowledge*, if it refers to the fact that the data processing is not observable.

A more metaphorical meaning may emerge when features of opacity, seclusion and inaccessibility become more relevant. *Black box* then can be conceptualized as something that is not fully understandable. Nevertheless, the context may clarify whether these features attributed to the object referred to as a *black box* are accidental or intentional. In the first case, it is not by purpose that something appears to be a *black box*, as for instance in biochemical processes like puberty. In most contexts this conceptualization is associated with a *Lack of Knowledge*.

In the latter case, something is intendedly obscured and therefore the association of *Lack of Knowledge* is frequently accompanied by associations like *Uncertainty* but also with *Traceability*. These semantic features oftentimes occur in political or economic contexts, as there may be processes which for some reason must not be fully transparent to the public.

Finally, a *black box* can be conceptualized as an intentional obfuscation with malicious intent. This also appears frequently in political or economic contexts as well as concerning people and their actions, to name only a few. This conceptualization goes hand in hand with associations like *Loss of Control* or *Uncertainty*.

Thus, our investigations into the use of the expression *black box* revealed its adaptability across various domains, as it evokes diverse associations through context-specific keywords. Despite this

variability, several core themes—such as *Lack of Knowledge*, *Opacity*, and *Inaccessibility*—consistently underpin the metaphor, reflecting its conceptual foundation.

As we were able to observe, the *black box* metaphor predominantly evokes associations of *Lack of Knowledge* across all domains, represented by keywords such as *unknown*, *speculate*, and *unclear*. The prevalence of *Lack of Knowledge* is amplified by frequent co-coding with *Opacity* and *Inaccessibility*, suggesting that gaps in understanding are often exacerbated by restricted transparency or access. Hence, a lack of knowledge can be seen as a core association to the *black box* concept.

In contexts such as finance and politics, the association of *Opacity* is closely tied to demands for transparency and clarity, as reflected in keywords like *shedding light* and *opaque*. Systems characterized by opacity foster uncertainty, mistrust, and speculation, particularly when associated with concealed processes or inaccessible information. Thus, the association of *Opacity* may refer to a call for transparency.

The *black box* metaphor frequently symbolizes inaccessibility, particularly in institutional and political contexts, where systemic restrictions are represented by keywords such as *secret*, *hidden*, and *sealed off*. *Inaccessibility* reinforces the perception of exclusion and loss of control, highlighting the deliberate or structural nature of restricted access to critical information.

Associations with *Uncertainty* and *Loss of Control* often emerge in contexts involving individuals or institutions, where unpredictability and reliance on obscured systems lead to diminished trust. These associations, while less frequent, emphasize the fragility of confidence in *black box* systems, particularly when their functioning cannot be easily predicted or understood. Therefore, *Uncertainty* and *Loss of Control* reflect precariousness and the delicate status of trust.

The association of *Traceability* underscores a growing focus on understanding and explaining *black boxes*, particularly in the context of AI and algorithms. Keywords like *explainability* and *transparency* indicate that demands for clarity challenge traditional notions of opacity and inaccessibility, suggesting the development of new semantic features of the metaphor. The association of *Traceability* thus highlights the demand for explanation.

The association of *Disclosure* is predominantly linked to the *Transportation Sector*, where *black boxes* serve as constructive tools for clarifying events, such as accidents. Keywords like *data*, *informing*, and *revealing causes* demonstrate the positive connotations of *black boxes* in this context, contrasting with more abstract or metaphorical uses in other domains.

We can state that the context in which the expression *black box* appears also impacts its evaluation as accompanying words and emerging associations can influence the perception of the expression. Throughout our corpus, we encountered predominantly negative connotations of *black box*, which is easily understandable from the above-mentioned conceptualizations of the expression. Only in the case of *black box* as a data recorder we stated a higher proportion of positive connotations as the device is used to clarify accidents. Nevertheless, even in this context, negative connotations occur increasingly as the legal requirement of having a *black box* in modern cars opens the expression up for negative associations like *Surveillance*.

In sum, to answer our main objective for this study, we can state that the use of the expression *black box* has become more flexible in the last years. It can be inserted in a manifold of contexts through a metaphorical use which is mainly based on semantic features like opacity, seclusion and inaccessibility. As they reveal in most cases associations of lacking

knowledge, uncertainty, precariousness and/or loss of control, it is not astonishing that the expression predominantly has negative connotations.

Yet, there are some limitations regarding the validity of our results. The use of the database LexisNexis to obtain a research corpus had the disadvantage that it provided a relatively high number of professional interest publications from the field of economics (15 media with 28 articles). This led to a slight bias toward economic subjects in coverage and might explain the dominance of the CoU *Financial Issues/Economics* regarding the occurrences of *black box*. Nevertheless, this gave us the opportunity to thoroughly examine this specific Context of Use and its implications for the conceptualization of the expression.

Another limitation is our relatively small corpus of only 288 texts. As semantic analyses need a very intense introspection into the texts to detect the specific uses of an expression, we decided to limit ourselves to a modest corpus which allowed the in-depth-analysis required. Therefore, our results reflect trends that could be investigated in more detail in follow-up studies.

Finally, the question arises as to how the expression will develop in the future. In a few cases within our corpus, we found a very unspecified use of the expression with a loose resemblance to the semantic features mentioned above. Our final example illustrates this use:

(29) I did not have a record player either, everything was played on the radio—at 16, I was still like an empty *black box* (ÖÖ Nachrichten, “Der Österreicher tut sich ja immer selber leid“, 11/25/2022).

This example alludes to *black box* as a container and projects it to the individual development of a person: during life this container will be filled by experiences, knowledge etc., but for the very moment it is empty. Semantic aspects of seclusion or inaccessibility, lack of knowledge concerning the contents of this *black box* seem to not play a role in this conceptualization. Hence, the use of the expression *black box* appears to be very vivid and opens it up to further developments of new aspects of meaning.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

PA: Conceptualization, Data curation, Formal analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. FB: Conceptualization, Data curation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Validation. AK: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Validation. MH: Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Validation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcomm.2025.1569313/full#supplementary-material>

Appendix 1: Cited journalistic articles

- Aachener Nachrichten: *Flut: Opposition droht mit Klage*, 01/20/22.
- Aachener Zeitung: *Die Katastrophe in der politischen Krise*, 01/09/20.
- About fleet: „Ab Juli 2022 fährt Big Brother im Auto mit“, 04/2022.
- Allgemeine Zeitung: *Blackbox*, 06/29/22.
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- bank und markt + technik: „Die Digitalisierung ist ein fortlaufender Prozess“ – Interview mit Ulf Meyer, Michael Moschner und Matthias Brandes, 03/16/20.
- Basler Zeitung: *Für die Datenauswertung gibt es diverse Hürden*, 01/06/22.
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