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Editorial: Integrating trans-disciplinary methods between physics and linguistics

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Editorial on the Research Topic
Integrating trans-disciplinary methods between physics and linguistics

This Research Topic aims to motivate scientists to explore deep interactions between physics and linguistics through discussions on the significance and applicability of methodologies based on physics.

Hayata's article presents a novel quantitative framework combining rank–frequency statistics with time-reversal asymmetry (TRA) to assess translation quality, tested on English → Japanese and back-translations. The core idea is that natural texts exhibit long-tailed rank–frequency distributions and broken symmetry under time reversal; high-quality translations should preserve these statistical signatures. This interdisciplinary perspective demonstrates, in particular, how linguistic structure can be quantified beyond standard automatic metrics such as BLEU (Bilingual Evaluation Understudy), a long-standing automatic metric for machine-translation quality [1].

The author applies nonlinear regression and Durbin–Watson analyses to sequences of Japanese syllables (45-symbol inventory), comparing long-tail and short-tail fits, and examining forward versus reverse reading to detect asymmetries. The methodology is carefully validated using control cases (e.g., ranking of Japanese boy names, passages from a Japanese novel) before being deployed on sixteen human translations of American writer Edgar Allan Poe (1809–1849) and five backtranslations of works by Japanese Nobel laureate Kenzaburō Ōe (大江 健三郎, Ōe Kenzaburō; 1935–2023). The results show that human translations consistently reflect stronger long-tail dominance (see Figure 1 cited from Supplementary material) and more significant TRA than older machine outputs. But in a diachronic analysis, newer AI translations (as of October 2024) begin approaching human translators on these metrics. The perturbation experiment (injecting repetitive conjunctives) further demonstrates that disrupting long-range correlations degrades these statistical markers and presumably translation "quality."

Overall, the paper makes a compelling contribution to the interdisciplinary space between physics/statistics and translation studies. Its strengths lie in methodological rigor, clear motivation, and illustrative case studies. One limitation is that the approach is tested on a narrow pair of languages (English ↔ Japanese) and with one syllabic coding scheme; further generalization would strengthen its applicability. With recent rapid advances in neural machine-translation and

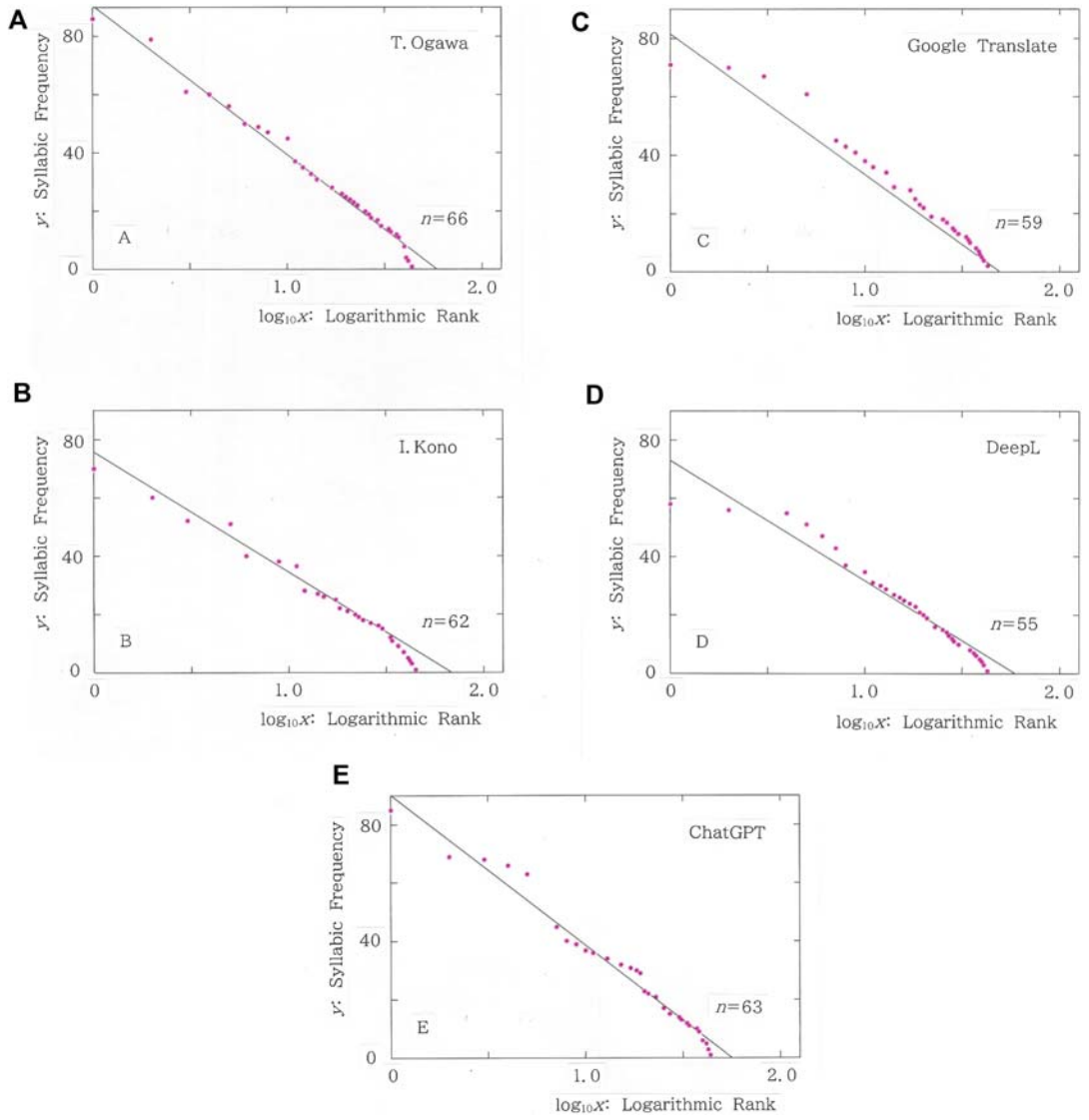

FIGURE 1
Cross-sectional view of the rank-frequency relation for the entire first paragraph of *The Fall of the House of Usher* by Edgar Allan Poe. **(A)** Translation by T. Ogawa. **(B)** Translation by I. Kono. **(C)** Google Translate. **(D)** DeepL. **(E)** ChatGPT.

newer evaluation metrics (e.g., COMET) [2, 3], Hayata's approach offers an alternative perspective on benchmarking and encourages a fruitful cross-fertilization between physics and linguistics by suggesting a new way to evaluate translation fidelity and style.

Lee and Choi investigate the roles of manual and nonmanual features in Korean Sign Language (KSL) prosody, focusing on how they mark prominence and prosodic boundaries. In addition to the conventional speech and written languages, visual aspects of language have become an interesting Research Topic in connection with gesture studies, multimodality, and iconicity [4]. Using Bayesian mixed-effects modeling, Lee and Choi analyzed both articulations across prominence conditions and boundary positions. To date the latter features such as raised eyebrows, widened eyes, head movements, and directed gaze have been identified as key markers of informational focus in many sign languages. The authors found that in contrast to previous findings in Israeli Sign Language [5], where eyebrow movements primarily marked boundaries, KSL signers predominantly used both eyebrow and eye movements as prominence markers. Their finding suggests that prosodic cues are subject to the cross-linguistic as well as cross-modal variation.

In addition to the abovementioned two languages, there are many articles relevant to American, British, Dutch, Italian, and Japanese sign languages. In the future, along with an effort to develop powerful physical modellings, comparative studies among the different sign languages will be needed to reveal an unknown feature in the languages.

In the context of the physics-informed neural networks, Wu et al. developed a method of embedded physical neural networks to construct a framework suitable for modeling the dynamics of public opinion propagation that is based on a set of parabolic-type nonlinear partial differential equations. The prototype of the

equations had been presented for explaining propagating plagues [6] by adding a diffusion term to the Kermack-McKendrick model. The approach of Wu et al. combines the automatic differentiation mechanism of neural networks with the equations through the design of a loss function, making possible an efficient fitting to real data.

Incidentally, similar attempts have been presented in an effort to solve Navier-Stokes equations as well as Maxwell equations. Along with the conventional methodology using the nonlinear finite elements, Crank-Nicolson's scheme, time-domain finite differences, and path integrals being improved with the aid of the fast Fourier transform, the method developed by Wu et al. can be expected to become a powerful tool for dealing with the equations.

As the authors mention explicitly, at present their method includes a few limitations. That is, in the design of the loss function of the neural network, the weights need to be determined empirically by humans. Furthermore, certain noise results in the so-called overfitting problem. There is further work ahead.

Zhou and Cheng's article introduces a computational stylometric framework to study the style of translations. Specifically, they compare English renderings of Chinese science fiction by two sources: the acclaimed human translator Ken (Kenneth) Liu (刘宇昆, Liú Yǔkūn; born 1976), a Chinese-American writer, and ChatGPT-4o. Their method relies on Multi-Dimensional (MD) analysis. The central idea is straightforward: a translator's style can be quantified across linguistic scales, such as involvement and density. The authors hypothesize that human translators may exhibit greater stylistic flexibility compared to large language model (LLM) outputs. This work revives classic corpus stylistics traditions [7, 8] and applies them directly to the challenge of evaluating AI-based translation, moving beyond standard quality metrics like BLEU [1] or COMET [2].

To conduct the research, Zhou and Cheng built a parallel corpus from thirteen science-fiction works translated by Ken Liu and then retranslated by GPT in five runs each to test the model's consistency. Using the MAT (Multidimensional Analysis Tagger) tool [9], they segmented the texts, aligned the segments, and calculated normalized frequencies for 67 linguistic features to generate MD scores. Statistical tests (e.g., Kruskal–Wallis, χ^2) then compare within-translator variation (across works) and between-translator variation (Ken Liu versus GPT). The findings indicate that Ken Liu shows substantially more stylistic adaptation across works, whereas GPT maintains a more uniform style; this mainly concerns Dimension 1 (involvement) and less so on Dimension 2 (information density). Functional analysis suggests Liu's minimalist style enhances resonance in science-fiction themes, while GPT's more narrative clarity may smooth over thematic depth.

The study contributes to comparative stylistics in the age of AI by offering a method to isolate translator style and contrast it with algorithmic consistency. Naturally, the work has limitations: it focuses exclusively on one narrow genre (science fiction), the MD analysis might not capture highly sophisticated rhetorical or semantic artistry, and there is currently no reader reception data to link these stylistic differences to actual reader impact. As translation AI and its evaluation advance, the authors suggest integrating semantic, pragmatic, and reception dimensions into future research.

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