Towards computational detection of metaphoric change in language evolution via word embeddings

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1. Introduction

One of the key communicative challenges that the hominin lineage was faced with in the course of the evolution of language was how to communicate about new referents in a changing, dynamic environment that continually introduced new potential referents and affordances of things to communicate about, while only possessing a limited inventory of signals. One of the solutions to this problem observable in the cultural evolution of languages is the process of meaning extension, whereby existing words acquire additional meanings, thereby becoming polysemous (e.g. Srinivasan & Rabagliati 2015). One of the primary driving factors of such semantic change is that of metaphor (Anderson 2017). For this reason, metaphor has also been assigned a central role in the evolution of language (e.g. Smith & Höfler 2015; Ellison & Reinöhl 2022).

Here, we propose a computational method to further investigate the processes of metaphoric extension central to language evolution. Computational methods have shown increasing promise in automatically detecting metaphoric change in language (e.g. Schlechtweg et al. 2017; Hamilton et al., 2016; Hills & Miani in press; Lau et al., 2012). However, one of the challenges of these approaches is that they generally require large corpus sizes. Using a less-resourced language, Polish, as a case study, we show how some of these challenges might potentially be addressed. Specifically, we explore the potential of using word embeddings in detecting metaphorical change in technology-related expressions in Polish.

2. Methods

This study analyses 60 words related to science and technology from the Korpus Barokowy (Kieraś et al., 2017; *KorBa*), a corpus of 17–18th century Polish and the corpus of 19th and early 20th century Polish (Łaziński et al., 2023, *F19*). Metaphors from these source domains emerged relatively recently, in contrast with figurative expressions related to natural phenomena (such as *fire* and *cold*), which opens a greater possibility for detecting the acquisition of metaphorical meanings in historical corpora.

In the first step of the analysis, we extracted all sentences containing the words from the list. The F19 dataset contained 1744 sentences, whereas the KorBa dataset included 1210. These sentences subsequently underwent binary annotation for whether the use of the target word in that sentence was metaphorical or not. Afterwards, we extracted sentence-level embeddings and word embeddings for the target word by fine-tuning the transformer-based large language model Polbert (Kłeczek et al., 2020), a Polish version of the BERT language mode (Devlin et al. 2019), to both of our datasets. We then computed the cosine distance between the word embedding and the sentence-level embedding, hypothesising that greater cosine distance entails a greater probability of that word being metaphorical (Liu et al., 2020).

For the classification task, both datasets were split so that 80% of the dataset was used as the training data and the remaining 20% was used for testing. We used a logistic regression classifier to evaluate our hypothesis. Our model achieved an F1-score of 60% for the KorBa corpus and an F1-score of 68% for the F19 corpus. We then extracted words that were classified as non-metaphorical in the KorBa corpus and compared this list with the list of metaphorical words from the F19 corpus.

One of the examples is the word *komórka* (*cell*), which occurs in contexts related to homes in KorBa (the word is a diminutive of *komora – chamber*), and acquires the metaphorical meaning of a biological cell in PL19. A similar case is attested for the word *ropa* (*puss*, but also *oil*), where the former meaning is attested in KorBa, but both meanings in PL19.

3. Conclusion

Given the proposed importance of metaphoric change for language evolution, it is important to investigate its dynamics in observable language change. Here we show that using fine-tuned state-of-the-art language models to historical corpora can support analyses of the acquisition of metaphorical meaning.

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