

## Why is “tree skin” better than “human bark”: Semantic centrality predicts asymmetries in metaphorical extensions

**Background.** People have a remarkable ability to draw analogies between different domains, an ability often showcased by metaphors. For instance, we frequently interpret the concept of life through the lens of a journey, where life is viewed as a path we travel on, starting at birth and encountering various challenges along the way. However, such mappings often exhibit an asymmetry – for example, we rarely if ever use life to understand journeys. A common explanation for this asymmetry is that metaphors typically map from more concrete to more abstract domains, rather than the other way around. Conceptual metaphor theorists (Kovecses, 2010; Lakoff & Johnson, 1980) proposed that our physical experience provides a natural basis for understanding more abstract ideas, and concreteness explains why in most everyday metaphors the (more concrete) source and the (more abstract) target are not reversible. Concreteness is also proposed to explain the metaphorical extension of meaning. For example, terms denoting sensory experiences are regularly used to communicate more abstract concepts like rationality, as in the phrase “You are blinded by love” to mean that one is not acting rationally. The opposite mapping is rather more difficult to conceive.

However, concreteness falls short of explaining asymmetries when mappings between two relatively concrete domains. For example, English and Russian use “balls” and “eggs” respectively to refer to testicles. Opposite mappings are rarely if ever attested. English speakers find it relatively easy to understand a novel mapping such as the use of “skin” to refer to bark (as in “tree skin”) as done in Mandarin Chinese among other languages. The reverse (equally unfamiliar) mapping—using “human bark” to refer to “skin” seems rather more strained. Researchers have attempted to explain these asymmetries in several ways. For example, Bottini and Casasanto (2013) argued that the source domain may be relatively more familiar, perceptually available, imageable, memorable. Dancygier and Sweetser (2014) further suggest that the source domain's higher intersubjective accessibility – its ease of being accessed and shared among multiple speakers – makes metaphors a valuable tool in communication for aligning understanding of less accessible domains. Aligning with the accessibility account, Winter and Srinivasan (2022) proposed that word frequency is a good explanation for asymmetry in cross-domain mapping, as more frequent words are easier to access, more familiar, and more memorable, making them ideal sources of metaphorical meaning extension. Consistently, they found frequency as a robust predictor of asymmetry in the metaphorical extension of meaning across languages.

However, a reliance on word frequency as an explanation begs the question of why words from the source domain are more frequent in the first place. In a series of studies, Liu et al. (2023) found that—controlling for multiple confounds—word frequency was predicted by measures of semantic centrality: the number of connections the word and its surrounding words have (as measured by, e.g., Laplacian centrality), and the ability of the word to connect less interconnected words (as measured by, e.g., Burt's constraint). These network properties not only predicted synchronic word frequency, but centrality measures taken at one point predicted which words decreased and which words increased in frequency later, suggesting a potential causality link between network centrality and word frequency. Here, we extend this approach to examine whether network centralities can help explain the asymmetry in metaphorical extensions.

**Method.** We used data from Urban (2011) that contains 71 concept pairs that have cross-linguistic asymmetries in their semantic extensions (e.g., skin ~ bark, ball ~ testicle). We matched the translation equivalents of concept pairs in English from Urban (2011) with concreteness data (Brysbaert et al., 2014) and word frequency (Google Ngram). We also use two network centralities: Burt's constraint and Laplacian centrality as computed from English word associations (De Deyne et al., 2019) as proxies for semantic centrality. For concepts with multiple English equivalents (e.g., 'road/street/way'), we calculated the average frequency, concreteness, and centrality values across these terms. We then applied a mixed logistic regression model, predicting whether a concept is the source domain of that concept pair from the fixed effects: log frequency, concreteness, Burt's Constraint, and Laplacian Centrality (all standardized as

z-scores) of that concept. The model also included random intercepts and random effects for frequency, concreteness, and centrality measures by concept pair. This regression model was estimated using the *brms* package in R (Bürkner, 2017), with a weakly informative prior (normal distribution with mean 0 and standard deviation 1).

## Results and discussion.

Winter and Srinivasan (2022) found word frequency was a robust predictor of asymmetry in the semantic extension of meaning across multiple languages, and the concreteness of a word doesn't predict whether it's more likely to be the source of extension. Our re-analysis shows that semantic centralities are better predictors (*Burt's constraint*:  $\beta = -1.4$ ,  $SE = 0.68$ , 95% credible interval  $[-0.12, 2.78]$ , odds: 4 to 1; Laplacian Centrality:  $\beta = 1.04$ ,  $SE = 0.53$ , 95% credible interval  $[0.14, 2.18]$ , odds: 3 to 1]. The results suggest that the less a word is

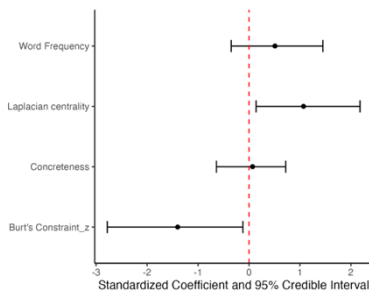


Figure 1 Standard Coefficients in predicting asymmetry of semantic changes. Error bars indicate 95% Credible Interval.

“constrained” by its neighbors (by bridging neighbors that are not interconnected among themselves), and the more connections a word and its neighbors have, the more likely the word will become the source of metaphorical semantic change. Importantly, when we include semantic centralities as predictors, word frequency ceases to be a significant predictor ( $\beta = 0.51$ ,  $SE = 0.46$ , 95% CI  $[-0.35, 1.45]$ ). Concreteness, hypothesized by conceptual metaphor theories to explain the asymmetry is also not in fact predictive of it ( $\beta = .07$ ,  $SE = 0.34$ , 95% CI  $[-0.64, 0.72]$ ).

This finding highlights the significant role of a word's semantic centrality in understanding the dynamics of semantic extension and metaphorical asymmetry. Traditional metrics like concreteness fall short of explaining why concepts of similar

concreteness are used metaphorically to represent each other. The accessibility hypothesis instead posits that more accessible words are likelier to become sources in metaphorical extensions. We posit a linking hypothesis that connects centrality, accessibility, and frequency by arguing that words with a central position in the network are more frequently activated during speech comprehension and production. This higher activation level is due to the increased input these words receive from their neighboring connections, enhancing their accessibility and, consequently, the likelihood of their use and extension to new meanings. Furthermore, words that serve as bridges in less connected network segments tend to have higher contextual diversity and wider semantic ranges, making them better candidates for metaphorical extension in contrast to words situated in densely interconnected clusters, which often have narrower and more redundant semantic contexts. The current analysis does not definitively establish a causal link between network centrality and asymmetry in semantic change. However, future longitudinal studies could provide deeper insights by e.g., analyzing how words with similar levels of metaphorical usage but differing network positions influence the likelihood of metaphorical extension at a later time.

Additionally, it's also possible to experimentally manipulate a word's position within a participant's semantic network to see if it causes changes in the propensity of that word to be metaphorically extended.

## References.

- Bottini, R., & Casasanto, D. (2013). Space and time in the child's mind: Metaphoric or ATOMIC? |Brysbaert, M., Warriner, A. B., & Kuperman, V. (2014). Concreteness ratings for 40 thousand generally known English word lemmas. |Bürkner, P.-C. (2017). *brms*: An R Package for Bayesian Multilevel Models Using Stan. |Dancygier, B., & Sweetser, E. (2014). *Figurative Language*. |De Deyne, S., Navarro, D. J., Perfors, A., Brysbaert, M., & Storms, G. (2019). The “Small World of Words” English word association norms for over 12,000 cue words. |Kovecses, Z. (2010). *Metaphor: A Practical Introduction*. |Lakoff, G., & Johnson, M. (1980). *Conceptual Metaphor in Everyday Language*. |Liu, Q., De Deyne, S., Jiang, X., & Lupyan, G. (2023). Understanding the Frequency of a Word by its Associates: A Network Perspective. |Urban, M. (2011). Asymmetries in overt marking and directionality in semantic change. |Winter, B., & Srinivasan, M. (2022). Why is Semantic Change Asymmetric? The Role of Concreteness and Word Frequency and Metaphor and Metonymy.