Verb Metaphoric Extension during Sentence Processing

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How does one understand a sentence like *the lantern limped*? Metaphoric uses of verbs are frequent in everyday language (Krennmayr, 2011). Yet the vast majority of research on metaphor processing has focused on noun-noun metaphors (e.g., *my job is a jail*, *my lawyer is a shark*) (Glucksberg et al., 1997). Comparatively little experimental work has focused on verb metaphors (but see Cardillo et al., 2012; Stamenković et al., 2019; Torreano et al., 2005). This dearth of research on verb metaphor is problematic, as verb metaphor may in fact be more common than noun metaphor (Krennmayr, 2011; Jamrozik et al., 2013).

The objective of this research is to characterize the processes underlying verb metaphoric extension in sentence processing. We base our work on prior findings of a *verb mutability effect* in sentence processing (Gentner, 1981; Gentner & France, 1988; Kersten & Earles, 2004, Reyna, 1980), which reported that verbs have a greater propensity to alter their meaning in semantically strained contexts than do nouns. For example, Gentner and France (1988) found that, when asked to paraphrase strained (nonliteral) sentences like *the lantern limped*, people tend to alter the verb's meaning rather than the noun's, producing (for example) *the light flickered.* Here, we test two possible process accounts of verb mutability: online adjustment vs sense selection. The *online adjustment* account is that verb mutability is due to online adaptation processes that alter the verb's meaning to fit the noun's. The *sense selection* account is that verb mutability is a matter of selecting an appropriate meaning from the verb's existing senses. Past work on verb mutability (e.g., Gentner and France, 1988; Kersten & Earles, 2004) used verbs that were significantly more polysemous than the nouns, leaving open the possibility that sense selection can explain these findings.

In Study 1, we compared the sense selection account with the online adjustment account. As in Gentner & France's (1988) paradigm, participants paraphrased a mix of unstrained (literal) sentences (e.g., *the professor complained*) and strained (nonliteral) sentences (e.g., *the box complained*). Sentences were generated by combining 6 nouns and 6 verbs factorially for a total of 36 intransitive sentences, constructed such that half the nouns and verbs used were low-polysemy and half were high-polysemy. We asked new participants to paraphrase these and assessed the degree of noun and verb meaning change in the paraphrases using word2vec (Mikolov et al., 2013). The results supported the online adjustment account: both low- and high-polysemy verbs changed meaning in response to strain to an equal extent, while both low- and high-polysemy noun meanings remained equally stable (see Figure 1).

In Study 2, we tested the *minimal subtraction hypothesis* (Gentner and France, 1988), which states that verbs extend metaphorically in a graded manner, with domain-specific aspects being altered before more abstract relational structure. Using the same paraphrase paradigm, we selected 18 new nouns (6 human, 6 artifact, and 6 abstract) and 54 new verbs from 3 different classes (manner of motion, communication, and bodily process). Strain was increased systematically by varying the noun subject type (e.g., *the woman limped, the wagon limped, the fantasy limped*). The results replicated Study 1 and were consistent with minimal subtraction: word2vec scores indicated that verb (but not noun) meaning change increased in a graded manner as a function of strain. Regardless of type (human, artifact, or abstract), noun meanings remained stable across strain.

In our current research (Study 3), we directly investigate which aspects of the verb's meaning are altered as strain increases. The paraphrases from Study 2 were given to a new group of participants, who judged which components of the original verb's meaning were retained in each paraphrase. The results so far are consistent with minimal subtraction: (1) verb meanings changed in a graded manner; (2) domain-specific aspects of the verb's meaning changed before more domain-general aspects (see Figure 2).

Figures
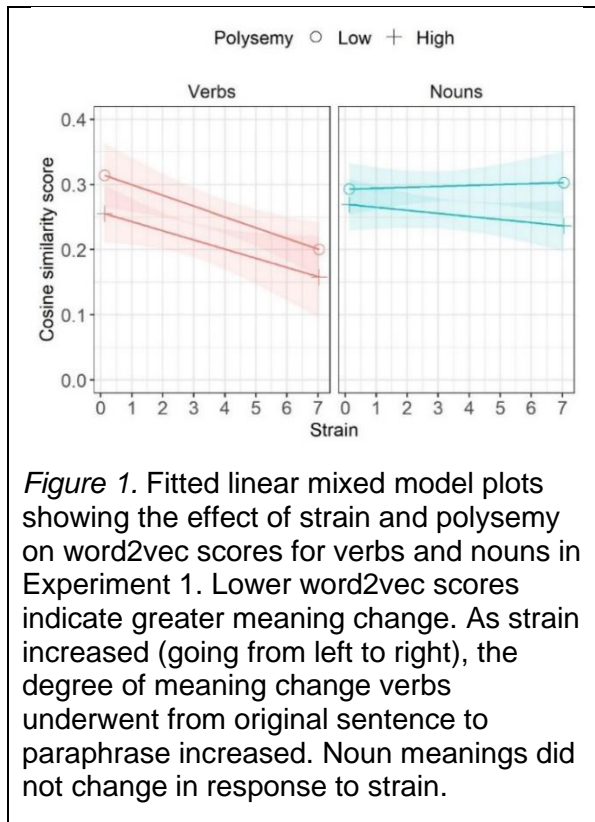
Noun Type	Physical Motion Involving Legs	Physical motion not involving legs	Metaphoric motion	No physical or metaphoric motion	Unsure
Human	75	8	5	7	14
Artifact	6	79	6	14	6
Abstract	2	2	54	44	13

Figure 1. Fitted linear mixed model plots showing the effect of strain and polysemy on word2vec scores for verbs and nouns in Experiment 1. Lower word2vec scores indicate greater meaning change. As strain increased (going from left to right), the degree of meaning change verbs underwent from original sentence to paraphrase increased. Noun meanings did not change in response to strain.

Figure 2. Current results of Experiment 3 (ongoing) for manner of motion verbs. Numbers represent response frequencies for verb meaning components retained across paraphrases. Rows correspond to the semantic strain of the stimuli sentences, increasing from top to bottom. Columns represent the dependent measure: level of verb abstraction for a given sentence. Yellow cells indicate responses consistent with minimal subtraction. For example, *the wagon limped* was paraphrased as *the damaged cart creaked along*, resulting in a code of *physical motion not involving legs. the fantasy limped* was paraphrased as *the story moved along* slowly, and was coded as *metaphoric motion*.

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