Engaging with figurative language: insights from neuroimaging

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We know from media, advertising and political discourse that language can be used as a powerful tool to influence people's attitudes and choices (Mio, 1997; McQuarrie & Mick, 1996). Figurative expressions in particular, such as metaphors and idioms, tend to be more persuasive (Sopory & Dillard, 2002). But why is that the case? Pioneering research by Fainsiber and Ortony (1987) showed that people use more metaphors when they describe *how they felt* during a personal past event compared to when they describe *what happened*, especially if the event was emotionally intense. This and more recent behavioral research (Bowes & Katz, 2015; Citron et al., 2016a; Citron, Lee & Michaelis, 2020a; Citron, Steele, Simmons & Cain, 2019a; Horton, 2007) suggests that figurative language may be better suited to convey emotion.

Over the last 20 years, neuroscientific research has clearly defined the neural network responsible for figurative language processing, which includes the left inferior frontal gyrus (IFG), associated with working memory, inhibition and problem-solving processes, and the left superior temporal gyrus (STG), indexing semantic processing and integration (Bohrn, Altmann & Jacobs, 2012; Reyes-Aguilar et al., 2018). Event-related potential (ERP) studies have also revealed larger N400 amplitudes – semantic processing - and a larger late positive component (LPC) – pragmatic integration (Bambini et al., 2016; Lai & Curran, 2013; Siyanova, Canal & Heredia, 2019). However, until about 5 years ago, little to no attention was paid to the role of figurative language in evoking emotive neural responses.

In a study of conventional taste metaphors, e.g., *She looked at him sweetly,* compared to *kindly* (literal counterpart), we found stronger activation of the left amygdala and anterior hippocampus in response to metaphorical formulations, along with other regions of the extended language network (Citron & Goldberg, 2014). Given the amygdala's role in responding to evolutionary relevant stimuli (Cunningham & Brosch, 2012), we interpreted our finding as indicating stronger emotional engagement for metaphors. Crucially, our stimuli were rated as highly similar in meaning and equal in emotive content, imageability and familiarity. Hence, it is not the emotive content *per se* that drives amygdala activation, but the metaphorical formulation. Our finding is consistent with a meta-analysis of 23 neuroimaging studies of figurative language that also showed consistently stronger activation of the left amygdala (Bohrn et al., 2012) and with converging evidence of stronger psychophysiological responses (heart rate) to metaphorical translations of English metaphors into Spanish compared to literal translations (Rojo et al., 2014). Furthermore, we replicated this finding using a range of different metaphors not restricted to taste, embedded in short stories to simulate more natural reading processes, and by avoiding explicit mention of emotions (Citron, Güsten, Michaelis & Goldberg, 2016b; Citron, Michaelis & Goldberg, 2020b; see also Forgács et al., 2012). We also extended this finding to idioms, e.g., *He was in seventh heaven; She spilled the beans* (Citron, Cacciari, Funcke, Hsu & Jacobs, 2019b). We also found no evidence for stronger engagement during metaphor comprehension in second language (L2) speakers, who typically show more emotional distance from their L2 (Pavlenko, 2012). Instead, L2 speakers showed greater activation for both literal and metaphorical sentences compared to native speakers in the extended language network and the 'language switching' network, typically active in multilinguals (Citron et al., 2020b).

What remains unclear is what makes figurative expressions more engaging. Preliminary evidence from secondary analyses of neuroimaging data undermines the idea that conventional metaphors are perceived to be more appealing or beautiful compared to literal language, insofar as increasing beauty ratings of phrases do not evoke amygdala activation (Citron & Zervos, 2018). Citron et al. (2019b) suggest a different possibility on the basis of a functional connectivity analysis in a study of idioms, which finds a positive interaction between the variation in activity in the amygdala and in the IFG (working memory, inhibition, executive control more generally; Citron et al., 2019b). This finding raises the possibility that greater cognitive engagement evokes greater emotional engagement (or *vice versa*). In fact, other physiological effects, such as increased pupil dilation, correlate with both cognitive load and affective response (e.g., Leknes et al. 2013, van der Wel, 2018). Greater cognitive engagement in turn may result from conventional metaphors' and idioms' additional activation of literal meanings (Cacciari, 2014) and source-domain based inferences. For instance, *She's over the hill* primes words related to the literal interpretation (e.g., *journey*); the metaphorical expression also implies that she was once active but is slowing down, inferences that are not made on the basis of a literal paraphrase such as, *She's old* (Gibbs et al., 1997; Lakoff & Johnson, 1980; Thibodeau, Hendricks, & Boroditsky, 2017).

The latest research from our lab aimed to disentangle the role of sensorimotor information from metaphoricity in engaging listeners by recording pupil dilation, a measure of physiological arousal. Metaphorical expressions embedded in sentences, *sweet compliment,* their abstract literal counterparts, *kind compliment,* and concrete literal expressions, *sweet candy,* which also contain sensory words, were compared. These were equal in psycholinguistic and

emotional dimensions. Metaphorical expressions showed larger pupil dilations than both literal expressions, suggesting that stronger physiological responses are elicited by richer meanings activated by metaphors, rather than their sensorimotor features (Mon, Nencheva, Citron, Lew-Williams, & Goldberg, *in preparation*).

More research into the time course of emotional engagement – is it early and automatic or does it involve later and more explicit processing stages? – is needed. But the time is right to take stock of what we know and what we still need to learn about emotive neural responses to metaphor.

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