What makes metaphors more engaging? Insights from neuroimaging and physiological measures

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Metaphor processing: Overview

Metaphors help us understand and communicate abstract concepts such as anger in concrete terms, e.g., *'She blew her stack'* (Lakoff & Johnson, 1980). Conventional metaphors are immediately understood, while novel and creative metaphors require full activation of the literal meaning first, and pragmatic integration, e.g., '*He has a cloudy disposition'* (Glucksberg; Gibbs; Keysar et al., 2000, among others).

Metaphor processing recruits a bilateral, left-dominant fronto-temporal network:

- inferior frontal gyri (IFG) – **working memory, inhibition, problem solving**
- left superior temporal gyrus (STG) – **semantic processing and integration**
- medial prefrontal cortices – **theory of mind, conflict processing** (Bohrn et al., 2012; Reyes-Aguilar et al., 2018)
- **sensorimotor areas** associated with the concrete domain, e.g., motor cortex (Boulenger et al., 2012)

Emotional engagement: Our work

In addition to taste cortices, conventional metaphors such as **'*She looked at him sweetly*' elicited significantly stronger left amygdala activation than their almost identical literal counterparts**, i.e., **'*She looked at him kindly*',** matched in meaning and amount of emotional verbal content (Citron & Goldberg, 2014).

Since amygdala responds to evolutionary-relevant or contextually-salient (emotional) stimuli (Cunningham & Brosch, 2012), **metaphors evoke stronger emotional engagement in readers**.

This was **replicated** with other sensory domains (Citron et al., 2020), during more natural reading processes - reading of short stories (Citron et al., 2016); and **generalised** to idioms (Citron et al., 2019). **Converging evidence** comes from a meta-analysis of neuroimaging studies (Bohrn et al., 2012), behavioural (Bowes & Katz, 2015), and psychophysiological work (Rojo et al., 2014; Mon et al., *submitted*).

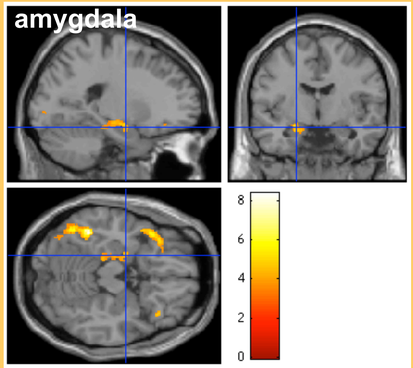

Figure 1: left amygdala activation in response to metaphors > literal counterparts (from Citron & Goldberg, 2014).

What makes metaphors more engaging?

Ⓐ **The fact that they appear as more pleasing or beautiful?**

Ⓑ **The richer meaning they convey?**

Ⓒ **The sensory information they carry?**

Study 1: Beauty *(Citron & Zervos, 2018)*

We collected beauty and familiarity ratings from the same participants who took part in the taste metaphor study (Citron & Goldberg, 2014) and correlated increasing beauty ratings with functional images.

- **Increasing beauty** – independent of familiarity – ***did not*** lead to significantly stronger amygdala activation (even with small-volume correction) ☛ **contra A**
- Instead, increasing beauty activated the **left post-central gyrus,** i.e., **somatosensory cortex**, suggesting that beauty perception activates sensory representations (in line with neuroaesthetic literature).

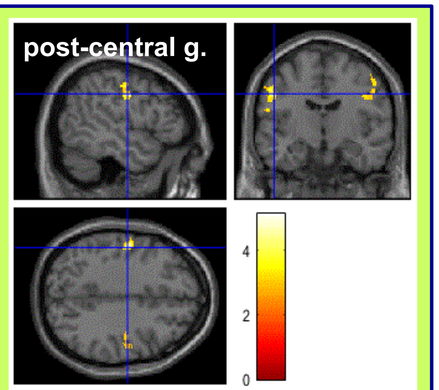

Figure 2: refer to main text.

Study 2: Emotional idioms *(Citron, Cacciari, Funcke, Hsu & Jacobs, 2019)*

A functional connectivity analysis between left IFG and amygdala during silent reading of emotive and neutral idioms showed a positive interaction, i.e., **the stronger the cognitive engagement** – activation of different possible meaning and selection of relevant one – **the stronger the emotive response**

- **Figurative expressions convey more meaning than literal language, and engage readers more strongly ☛ supporting B**

Examples of emotional vs neutral idioms: '*He's over the moon' vs. 'I'm all ears'*

Literal expressions: '*She laid in bed exhausted' vs. 'He explains what happened'*

Study 3: Pupil dilation *(Mon, Nencheva, Citron, Lew-Williams & Goldberg, submitted)*

Metaphors may be more engaging because of their metaphoricity as well as because of the sensory information they carry, which go hand in hand. To disentangle between the two, we created metaphorical key phrases embedded in sentences, e.g., ***sweet compliment***, abstract literal counterparts, i.e., ***kind compliment***, and concrete literal expressions, i.e., ***sweet candy***, which also contain sensory words like the metaphors. Conditions were matched for psycholinguistic properties incl. imageabilty, and emotive content.

We had participants listen to these sentences while their pupil dilation, a measure of physiological arousal (or emotional engagement) was recorded.

- Metaphorical key phrases evoked larger pupil dilation early on, compared to literal abstract renderings and literal concrete phrases. The effect was sustained over time.
- This suggests that **metaphoricity and not sensory information drives emotional engagement ☛ contra C**
- Follow up ratings suggest that **metaphorical phrases convey richer meaning** but not more information ☛ **supporting B**
- Thus conventional metaphors are more engaging in a way that cannot be reduced to concreteness, difficulty, frequency of use, amount of information, or downstream pragmatic inferences.

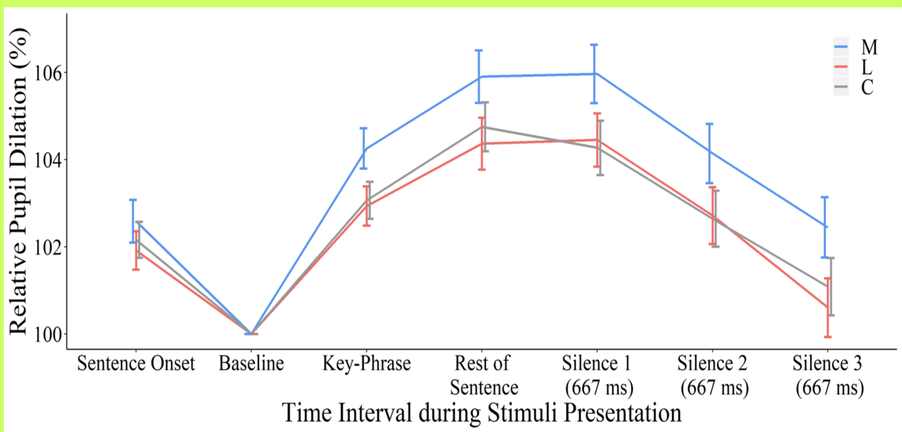

Figure 3: Time course of average relative pupil dilation compared to baseline for Metaphor (M), Literal (L), and Concrete (C) conditions during: sentence onset, baseline (first 100 ms of onset of key-phrase), key-phrase, rest of sentence, and 2 seconds of silence before additional jittered inter-stimulus intervals.

Conclusions

The neuroimaging and physiological data we have available seem to support the hypothesis that **the stronger emotional engagement evoked by highly common figurative expressions is due them conveying richer meanings than their literal counterparts (supporting B).** This is not reducible to the sensory information metaphors carry (contra C). Also, metaphors' perceived beauty does not seem to drive the emotional engagement in readers (contra A). Nevertheless, more research and further supporting evidence is needed.