



# Emotional context modulates embodied metaphor comprehension



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## ABSTRACT

Emotions are often expressed metaphorically, and both emotion and metaphor are ways through which abstract meaning can be grounded in language. Here we investigate specifically whether motion-related verbs when used metaphorically are differentially sensitive to a preceding emotional context, as compared to when they are used in a literal manner. Participants read stories that ended with ambiguous action/motion sentences (e.g., *he got it*), in which the action/motion could be interpreted metaphorically (*he understood the idea*) or literally (*he caught the ball*) depending on the preceding story. Orthogonal to the metaphorical manipulation, the stories were high or low in emotional content. The results showed that emotional context modulated the neural response in visual motion areas to the metaphorical interpretation of the sentences, but not to their literal interpretations. In addition, literal interpretations of the target sentences led to stronger activation in the visual motion areas as compared to metaphorical readings of the sentences. We interpret our results as suggesting that emotional context specifically modulates mental simulation during metaphor processing.

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## 1. Introduction

It has long been recognized that experiencing emotions is much more direct than talking about them. Indeed, despite the immediate and concrete experience of emotion, describing feelings in words tends to be via non-literal language (Edwards, 1999; Fainsilber and Ortony, 1987; Lubart and Getz, 1997). For instance, when people describe resentment, they prefer metaphorical expressions, such as ‘*a storm was brewing inside*’, over more literal depictions (Fainsilber and Ortony, 1987). Metaphors provide a way to describe what we find hard to express in words (such as emotions), by relating to concrete experiences in the world (Lakoff and Johnson, 2008). That is, concrete experiences in the world, such as pushing an object aside, are used in a metaphorical sense when someone says that he ‘*pushed his sorrows away*’.

Here we investigate specifically whether motion-related verbs when used metaphorically are differentially sensitive to a preceding emotional context, as compared to when they are used in a literal manner. We exploit the past findings that language that describes action or motion (‘*to throw*’, ‘*to write*’) activates parts of the brain also involved in actual action execution and motion perception (Hauk et al., 2004; Tettamanti et al., 2005; Willems and Casasanto, 2011; Willems et al., 2010a, 2010b). Such findings are

often taken as evidence for the embodiment of word meaning (Barsalou, 2008). While that interpretation is debated (Mahon and Caramazza, 2008; Willems and Casasanto, 2011; Willems and Francken, 2012; Wilson and Golonka, 2013), there is evidence that sensori-motor regions of the brain can be involved in coding word meaning.

Whether the metaphorical use of motion/action verbs similarly leads to activations of sensori-motor region has been investigated in several neuroimaging studies, with mixed results (Desai et al., 2013; Romero Lauro et al., 2013). In an elegant design, Saygin et al. (2009) compared activation in areas involved in motion detection in the inferior temporal cortex (human area MT, hMT), in response to literal motion sentences (*The deer jumped over the brook*), figurative/fictive motion sentences (*The bridge jumped over the brook*), and static control sentences (*The deer slept next to the brook*). Both fictive and literal motion sentences led to higher activation levels than the static control sentences in the hMT. This suggests that motion semantics is in use when we read about motion in a fictive manner (Boulenger et al., 2009; Desai et al., 2013). Contrary to this is the finding by Raposo et al. (2009), who measured the activation of motor and premotor cortices with three action verb conditions. Isolated action verbs (*kick*) and sentences with literal use of action verbs (*kick the ball*) activated the premotor cortex, while sentences with idiomatic use of action verbs (*kick the bucket*) did not (see also Aziz-Zadeh et al. (2006)). There is no consensus yet concerning the inconsistency in the abovementioned findings. Possible explaining factors include

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novelty (Cardillo et al., 2012; Lai et al., 2015) and context (Schuil et al., 2013). Cardillo et al. (2012) directed attention to novelty as a factor through investigating the shift from novel to conventionalized metaphors and how the brain is tuned to this process. Schuil et al. (2013) showed that sentential context modulates the degree to which motor regions are activated. Hence, the novelty of the figurative language and the context in which it is presented in can have an influence on the level of sensori-motor activations. Overall these studies inform us that early visual and motor regions *can be* involved in the processing of sentences that describe action in a metaphorical manner.

We hypothesize that the involvement of sensori-motor cortex will be increased when the metaphorical use of motion/action verbs is emotionally loaded. A couple of fMRI studies have examined the link between metaphor and emotion (Bohrn et al., 2012; Citron and Goldberg, 2014). One example is an fMRI study by Citron and Goldberg (2014) in which participants read sentences with metaphorical content (*'She looked at him sweetly'*) and carefully matched literal counterparts (*'She looked at him kindly'*). Based on an increased activation level to metaphorical as compared to literal sentences in the left amygdala, a structure known to be involved in the processing of emotions and emotional language, the authors concluded that metaphorical statements are more emotionally engaging than literal counterparts. The link between sensori-motor simulation and emotion in metaphorical language is suggestive. Some evidence that sensori-motor simulation could be increased specifically for emotional metaphors comes from a recent rating study. Citron et al. (2015) had participants rate German idioms on a number of psycholinguistic variables including concreteness, defined as the extent to which the figurative meaning could be experienced with one or more sensory modalities. They found a positive relationship between the emotional arousal of the idioms and the rated concreteness. That is, the more the figurative meaning of an idiom could be related to one of the senses, the higher it scored on emotional arousal. This is in line with previous work showing that abstract emotional words are rated higher on imageability compared to concrete emotional words (Altarriba and Bauer, 2004) and that response times to valence decisions are influenced by how much a word is related to a sensory modality (Jacobs et al., 2015).

The current study investigated the role of emotion in the literal and metaphorical interpretations of action/motion phrases. Participants read target sentences preceded by related short stories in four different versions/conditions while being scanned. The target sentences contained action/motion phrases that depending on the preceding stories could be interpreted as literal or metaphorical. Also depending on the preceding stories, the target sentences could be interpreted as high or low on emotion. Having the same target sentences across conditions ensured that any observed differences would be due to the experimental manipulation, and not due to differences in the materials between conditions. Focused region of interest analyses were carried out for regions previously implicated in comprehending motion- and action-related language (Willems and Casasanto, 2011): the primary motor

and premotor cortex and the bilateral human motion area hMT. Two separate localizer scans were collected in order to localize these regions.

Our main hypothesis was that sensori-motor activations in reaction to the metaphorical action language would be influenced by emotional context more than literal language. We expect an emotional 'boost' in the embodiment of metaphorical language, which would be expressed in an increased reliance on sensori-motor regions (Citron et al., 2015; Jacobs et al., 2015). Alternatively, there may be a main effect of emotional context, in the absence of an interaction effect. This would mean that emotional context 'boosts' sensori-motor simulation of action language overall, which is a viable alternative given the modulatory function of emotion on a range of cognitive processes, including language comprehension (Chwilla et al., 2011; Kaltwasser et al., 2013; Van Berkum et al., 2013).

## 2. Methods

### 2.1. Participants

25 healthy native Dutch speakers participated for course credit or payment. None of them had neurological problems by self-report; all had normal or corrected-to-normal vision and all were right-handed. Five subjects were removed from the final analysis because of excessive motion artifacts (4 participants) and the below chance score on the catch trials (1 participant). Data from the remaining 20 participants (4 male, mean age=21.89, range 18–27 years) were entered in the analysis. The local ethics committee approved the study (CMO Arnhem-Nijmegen, The Netherlands, protocol number 2001/095) and all participants gave informed consent in accordance with the declaration of Helsinki.

### 2.2. Stimuli

The final stimulus set after norming tests consisted of 120 quadruplets, that is, 120 target sentences preceded by 4 different short stories in Dutch (Table 1). Each target sentence contained the targeted action or motion verbs, such as verbs that imply physical action involving, or leading to movement (e.g., *to pick*) and those that denote motion (e.g., *to fall*). Pretests were carried out to ensure that each target sentence in isolation is not metaphorical or literal, and also not highly emotional or arousing (see Pretest 1 and 2 below).

Each story consisted of 3 sentences: The first sentence introduced the setting and the characters involved. The second and third sentences were manipulated according to two experimental factors: Figurativity (Literal, Metaphor) and Emotional Context (Low emotional, High emotional). The manipulation changes the interpretation of the fourth sentence, namely the target sentence, such that this sentence can be interpreted metaphorically with high emotional level, metaphorically with low emotional level, literally with high emotional level, and literally with low

**Table 1**

Example stimuli (originals in Dutch). Each target sentence is preceded by four stories/conditions that can render the interpretation of the target sentence literal or metaphorical (Figurativity), and low or high in emotions (Emotional Context). See text for pretest results.

Condition	Context	Target sentence
Literal and Low-Emotional Context	<i>Robert was lost in thought.</i> He had his textbook lying open for three hours. He did not want to look at it.	He pushed it away.
Literal and High-Emotional Context	<i>Robert was lost in thought.</i> He failed to understand the examination material. Angrily, he looked at the boring book.	
Figurative and Low-Emotional Context	<i>Robert was lost in thought.</i> He had to make a decision about his job. He did not think about it too much.	
Figurative and High-Emotional Context	<i>Robert was lost in thought.</i> He had to make a decision about his relationship. Thinking about it made him feel bad.	

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