The Upbeat of Language: Linguistic Context and Embodiment Predict Processing Valence Words

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Abstract

Previous studies have demonstrated that comprehension of conceptual metaphors elicits embodied representations. This finding is non-trivial, but begets the question whether alternative explanations are to be dismissed. The current paper shows how a statistical linguistic approach of word co-occurrences can also reliably predict metaphor comprehension. In two experiments participants saw word pairs with positive (e.g. *happy*) and negative (e.g. *sad*) connotations. The pairs were presented in either a vertical configuration (Experiment 1) or a horizontal configuration (Experiment 2). Results showed that response times could be explained by both the statistical linguistic approach and the embodied approach. However, embodied information was most salient in the vertical configuration and statistical linguistic information was most salient in the horizontal configuration. Individual differences modulated these findings, with female participants being most sensitive to the statistical linguistic approach, and male participants being most sensitive to the embodiment approach. These findings suggest that comprehension of conceptual metaphors can be explained by both linguistic and embodiment factors, but that their relative salience is modulated by cognitive task and individual differences.

Keywords: embodied cognition; symbolic cognition; linguistic context; valence words; gender differences; symbol interdependency

Introduction

When we are happy, we are in high spirits; when we are sad, we are down in the dumps. Our mood is lifted when we are cheerful, but our enthusiasm drops when we are depressed. We have our high times and our low times. We reach for the sky, but sometimes our plans run into the ground. These are some examples suggesting that conceptual metaphors highlight associations between abstract concepts (e.g., happy, sad) and spatial properties (e.g., high, low). Lakoff and Johnson (1981; 1999) suggest that metaphors like these help automatically ground abstract concepts in bodily experiences. In this sense, metaphors inform the language user of the perceptual and biomechanical processes underlying the representation of those concepts. Such theories of embodied cognition have received an impetus in the last decade (Barsalou, 1999; Glenberg, 1997; Prinz, 2004; Zwaan, 2004) with considerable empirical support showing that cognitive processes are undoubtedly influenced by perceptual and spatial information (De Vega, Glenberg, & Graesser, 2008; Pecher & Zwaan, 2005; Semin & Smith, 2008 for overviews). These findings allow for the conclusion that linguistic symbols are grounded in modality specific perceptual and motor systems.

If conceptual metaphors highlight associations between abstract concepts and physical or spatial properties, it is predicted that words with positive connotations are processed faster when presented higher in space, and words with negative connotations are processed faster when presented lower in space. This is indeed what a number of studies have shown, with participants being apt to process and remember matches between location and words (i.e., *joy* presented on the top of the screen) better than mismatches (i.e., *hate* presented on the top of the screen) (Meier & Robinson, 2004; Meier, Hauser, Robinson, Friesen, & Schjeldahl, 2007; Pecher, van Dantzig, Boot, Zanzolie, & Huber, 2010; Schnall & Clore, 2004; Schubert, 2005). More recently, Santana and de Vega (2011) found that matches facilitate comprehension of figurative language more so than that of literal language, suggesting that positive and negative metaphors are also processed through embodied mechanisms. Similarly, when pictures are presented in their expected spatial positions (i.e., an image of a positive concept presented on the top of screen) comprehension of such affectively salient pictures is facilitated (Crawford, Margolies, Drake, & Murphy, 2006; Meier et al., 2007). Furthermore, when participants are in a positive mood, they are more likely to exhibit upwards biases during line bisection tasks, with the opposite pattern holding true for negative moods (Wapner & Werner, 1957). Subjects even feel more successful (a positive feeling) when standing erect (a high vertical position) and less successful (a negative feeling) when slumped over (a low vertical position) (Stepper & Strack, 1993). In a review of the literature, Meier and Robinson (2008) summarized that affect is indeed understood through embodied relations, including vertical spatial representations.

However, such strong evidence supporting embodied representations diverts our attention away from other explanations for these findings. Paivio (1986) has extensively shown that both verbal and non-verbal representations play important roles in cognition. Barsalou, Santos, Simmons, and Wilson (2008) and Louwerse (2007; 2008; 2011) have similarly argued that both statistical

relationships between symbols and embodied representations work together to represent conceptual knowledge. Louwerse (2007; 2011) proposed the Symbol Interdependency Hypothesis, arguing that language encodes embodied representations. That is, embodied cues are encoded linguistically, so that language users can rely on the linguistic system as a shortcut to the perceptual system. Consequently, comprehension can be explained both by a statistical linguistic approach and an embodied approach, a conclusion supported by an increasing amount of empirical evidence (Louwerse, 2011).

Louwerse and Jeuniaux (2010) further argued that language processing relies on both linguistic and embodiment factors variably depending on the cognitive task. They showed that linguistic factors best explained response times (RTs) when participants made semantic judgments about word pairs, but perceptual factors best explained RTs when participants made iconicity judgments about pictures. Importantly, both linguistic and perceptual factors explained RTs in both semantic judgments and iconicity judgments, for both linguistic stimuli and pictorial stimuli, but their relative importance changed as a function of the task and stimulus.

In addition, Louwerse and Connell (2011) have shown that findings initially entirely attributed to embodied representations, such as the increased processing times for modality shifts, can in fact be attributed to statistical linguistic frequencies. Interestingly, faster processing can be best explained by the linguistic system, and slower processing can best be explained by the perceptual system.

In addition to cognitive tasks modifying statistical linguistic and embodiment effects on comprehension, individual differences might also play a role in how we represent information. Preexisting strategies or habits may impact an individual's propensity for processing information in different ways. For example, because embodied representations ground language through bodily experiences we could predict that those individuals with superior spatial ability are more likely to utilize such simulations. Similarly, those with enhanced language skill may show an inclination to process information in a linguistic fashion. This possibility is easily explored through gender differences, with males showing greater general spatial ability (Kimura, 2000; Linn & Peterson, 1985) and females showing greater general language ability (Kimura, 2000; Kramer, Delis, Kaplan, & O'Donnell, 1997). Based on such tendencies, we hypothesized that because males may have a greater affinity to encode information in an imagistic format, embodiment factors should better predict RTs for males. Likewise, females might be more likely to encode information in a symbolic manner, thus linguistic factors were hypothesized to better predict female RTs.

The current study had three goals. First, we aimed to investigate the extent to which a statistical linguistic approach and an embodied approach explained processing of valence words. As in Louwerse and Jeuniaux (2010) we identified embodied and linguistic factors and determined how well each factor could explain RTs. Second, we aimed to investigate whether the effect of a statistical linguistic approach and an embodied approach is modified as a function of the cognitive task. As demonstrated by the aforementioned studies, presenting positive-negative word pairs in a vertical orientation seems to encourage subjects to perceptually simulate the words they are reading. However, we also know that positive words usually occur before negative words in texts (e.g., *plus and minus*, *good and bad, positive and negative*), thus if we present words horizontally (as we read them), we might expect subjects to instead rely upon statistical linguistic features. We therefore hypothesized that embodiment factors would be more salient when words were presented vertically whereas linguistic factors would be more salient when words were presented horizontally. Thirdly, we aimed to investigate whether the effect of a statistical linguistic approach and an embodied approach is modified as a function of individual differences, and more specifically as a function of participant gender. We answered these questions in two experiments whereby male and female participants responded to positive and negative valence word pairs. In Experiment 1 word pairs were presented in a vertical configuration (e.g., *happy* above *sad*) to encourage subjects to rely upon embodied features; in Experiment 2 word pairs were presented in a horizontal configuration (e.g., *happy* preceding *sad*) to encourage subjects to rely upon statistical linguistic information.

Experiment 1

Participants

Thirty-four undergraduate native English speakers at the University of Memphis (24 females) participated for extra credit in a Psychology course.

Materials

The experiment consisted of 50 pairs of words that were opposites on a valence dimension (e.g., positive-negative) (see Table 1). One hundred filler items consisted of word pairs without a positive-negative relation, with half of the pairs having a high semantic association and half having a low semantic association as determined by latent semantic analysis (LSA), a computational linguistic technique that measures the similarity in meaning between word pairs, but ignores an order relation (Landauer, McNamara, Dennis, & Kintsch, 2007) (high semantic association: cos =.44; low semantic relation: cos = .18).

Procedure

Participants were asked to judge the semantic relatedness of word pairs presented on an 800x600 computer screen running E-Prime software (Psychology Software Tools Inc., Pittsburgh, PA). Words were presented one above another, in a vertical orientation. Upon presentation of a word pair, participants indicated whether the pair was related in meaning by pressing designated yes or no keys. All word

pairs were randomly ordered for each participant to negate any order effects. Each participant saw all word pairs, but whether a participant saw a word pair in an iconic or a reverse iconic order was counterbalanced between two groups, such that all participants saw iconic and reverse-iconic word pairs, but no participant saw a word pair both in an iconic and a reverse-iconic order. To ensure participants understood the task, participants completed five practice trials before beginning the experimental task.

Table 1: Positive-Negative Critical Word Pairs

achievement – failure	add – subtract
angel – devil	angels – demons
appear – disappear	beautiful – ugly
bright – dim	birth – death
clean – dirty	confident – arrogant
day – night	dead – alive
dream – nightmare	excitement – boredom
fast – slow	freedom – slavery
friend – enemy	fun – boring
gain – loss	good – bad
grow – shrink	handsome – ugly
happy – sad	healthy – sick
heaven – hell	hero – villain
laugh – scream	life – death
love – hate	more – less
on – off	optimist – pessimist
pass – fail	plus – minus
positive – negative	pretty – ugly
progress – stagnation	protagonist – antagonist
regular – irregular	right – wrong
safe – danger	smile – frown
strong – weak	sunshine – rain
true – false	unite – split
victory – defeat	wealthy – poor
winner – loser	yes – no

Results and Discussion

Subjects whose RTs fell more than 2.5 SD from the mean per condition, per subject were removed from the analysis, affecting 3.7% of the data.

Linguistic and Embodiment Factors

We distinguished between a linguistic and an embodiment factor in order to determine whether a statistical linguistic approach or an embodiment approach would better explain the processing of valence words.

Linguistic factor The statistical linguistic factor was operationalized as the log frequency of a-b (e.g., *happy-sad*) or b-a (e.g., *sad-happy*) order of word pairs. The order frequency of all word pairs within 3-5 word grams was obtained using the large *Web 1T 5-gram* corpus (Brants & Franz, 2006).

Embodiment factor If conceptual metaphors are understood through embodied representations and processes (Lakoff & Johnson, 1981; 1999), then a concept must be perceptually simulated in order to determine if it is positive or negative. Therefore, we operationalized embodiment factor as a rating of how positive or negative a concept was, following previous studies (Louwerse, 2008; Louwerse & Jeuniaux, 2010). Thirty-eight participants at the University of Memphis were asked to what extent they agreed with the statement: *x is more positive than y* (e.g., *happy* is more positive than *sad* or *sad* is more positive than *happy*). Ratings were made for all word pairs (in both orders) on a scale of 1-6, with 1 being strongly disagree and 6 being strongly agree.

Response Time Analyses

A mixed-effect regression model analysis was conducted on RTs with linguistic and embodiment factors as the fixed factors and participants and items as random factors (Baayen, Davidson, & Bates, 2008). The model was fitted using the restricted maximum likelihood estimation (REML) for the continuous variable (RT). F-test denominator degrees of freedom were estimated using the Kenward-Roger's degrees of freedom adjustment to reduce the chances of Type I error (Littell, Stroup, & Freund, 2002).

The embodiment factor was significantly related to the RTs, F (1, 86.93) = 10.40, $p < .002$, with higher ratings yielding lower RTs. This finding supports an embodied cognition account: the more a word pair marked a positive-negative relation, the stronger the effect on the RTs. However, the linguistic factor also explained the RTs, F (1, 85.511) = 70.96, $p < .001$, with higher frequencies yielding lower RTs. These findings show that the vertical configuration of conceptual metaphors can be explained by both the linguistic system and the embodied system, confirming previous findings and the claim that language processing is both linguistic and embodied.

Gender Effects

Next, we investigated whether the linguistic and embodiment factors were modulated by individual differences. To test whether embodiment factors better predicted RTs for males, and linguistic factors better predicted RTs for females, we conducted a mixed effects analysis on RTs using the interaction between gender x linguistic factor and gender x embodiment factor as fixed factors and subject and item as random factors. The two interactions on RTs were significant, for both gender x linguistic factor, F (2, 113.86) = 38.68, $p < .001$, and gender and embodiment factor, F(2, 210.99) = 8.23, $p < .001$. Interestingly, and as predicted, the effect size was largest for females x linguistic factor, and males x embodiment factor, as shown in Figure 1.

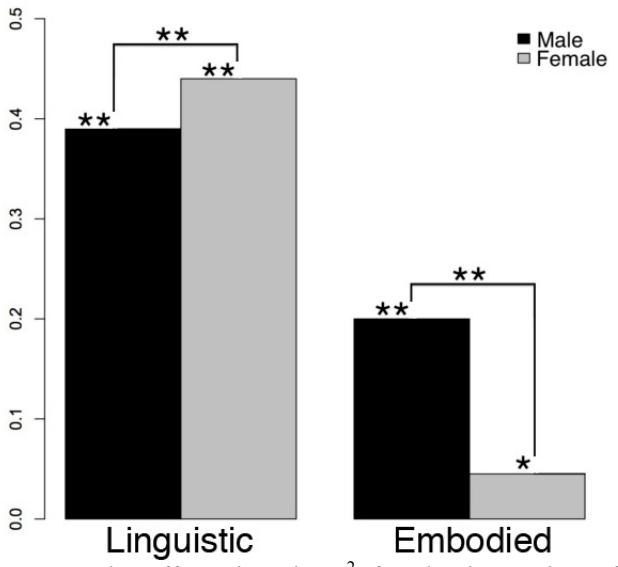

Figure 1. The effect sizes in R^2 for the interaction of participant gender x linguistic factor and the interaction of participant gender x embodiment factor on RT in vertical configuration of valence word pairs.

The results of Experiment 1 show that both linguistic and embodiment factors explain processing of valence words. The effects of either factor are modulated by individual differences. Although both male and female participants depended more upon the linguistic factor, females relied more on the linguistic factor than males, and males relied more on the embodiment factor than females.

Experiment 2

Participants

Forty undergraduate native English speakers at the University of Memphis (29 females) participated for extra credit in a Psychology course.

Materials

Materials were identical to those used in Experiment 1.

Procedure

The procedure was identical to Experiment 1 except that items were now presented next to each other (horizontal configuration) rather than above each other (vertical configuration).

Results and Discussion

Linguistic and Embodiment Factors

As in Experiment 1 a mixed effects regression model was conducted with RT as the outcome variable, with the linguistic and the embodiment factors as fixed predictor factors, and with both participants and items as random factors. Again, the embodiment factor was significantly related to the RTs, F (1, 84.93) = 7.01, p = .01, with higher embodiment ratings yielding lower RTs. The linguistic factor also explained RTs, F (1, 86.01) = 94.60, p < .001, with higher frequencies yielding lower RTs. These findings are similar to those obtained in Experiment 1, and support the conclusion that language processing is both linguistic and embodied.

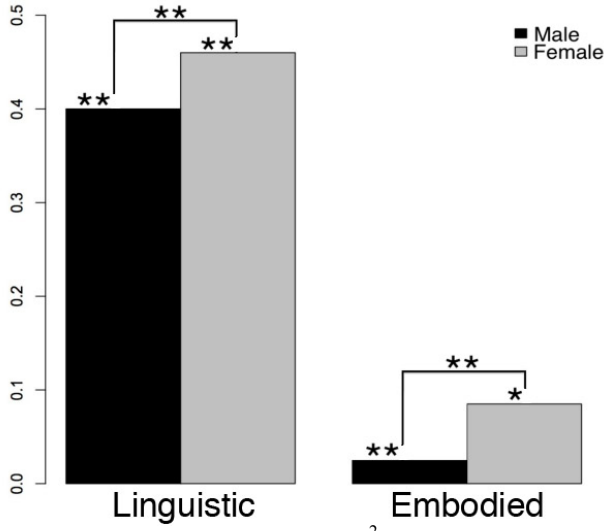

Figure 2. The effect sizes in R^2 for the interaction of participant gender and the linguistic factor and the embodiment factor on RT in horizontal configuration of valence word pairs.

Gender Effects

As before, to determine interactions between gender x linguistic factor and gender x embodiment factor, we conducted a mixed effects model using the two interactions as fixed factors and subjects and items as random factors. Both interactions reached significance, for gender x linguistic factor, F(2, 142.89) = 48.12, p < .001, as well as gender x embodiment factor F(2, 207.74) = 4.19, p = .02. The effect size was again largest for female participants and the linguistic factor (Figure 2). However, effect size was now also larger for females and the embodiment factor. A possible explanation for this finding is that the embodiment factor may have played a lesser role in the horizontal configuration than in the vertical configuration, an explanation that fits the idea that cognitive task modulates the relative importance of linguistic and embodiment factors. This issue was investigated next.

Next, we were concerned with the relationship between the prominence of a linguistic factor and a embodiment factor during processing. To answer this question we conducted an analysis using both the linguistic and embodiment factor, comparing their relative importance in the vertical (Experiment 1) versus horizontal (Experiment 2) configurations. Again, both participants and items were used as random factors in the mixed effects regression, and the interaction of the linguistic factor x orientation (vertical versus horizontal), and the interaction of the embodiment factor x orientation were of interest. The interaction for both orientation x linguistic factor and orientation x embodiment

factor was significant, F (2, 133.13) = 53.75, $p < .001$ and F (2, 163.86) = 6.32, $p < .01$ respectively. Furthermore, an interaction between orientation x linguistic factor x embodiment factor reached significance, F (2, 165.28) = 4.90, $p < .01$. Although the linguistic factor played a more important role in both configurations, the linguistic factor was more salient in the horizontal configuration than in the vertical configuration, whereas the embodiment factor was more salient in the vertical configuration than in the horizontal condition (Figure 3). These results suggest that the relative importance of linguistic and embodiment factors is modulated by the cognitive task.

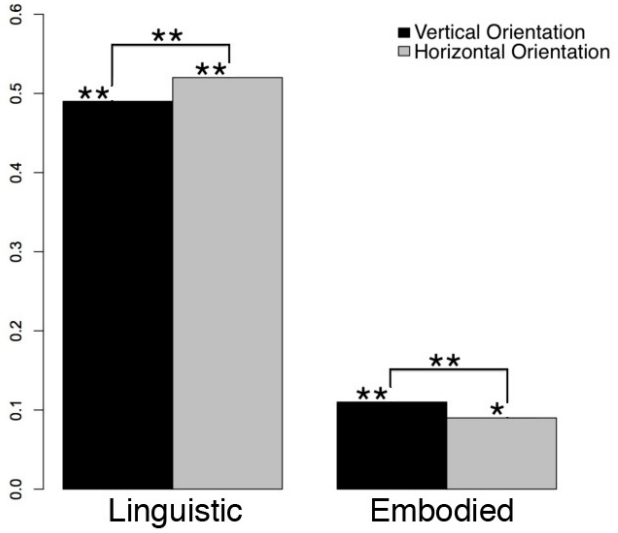

Figure 3. The effect sizes in R^2 for both the linguistic factor and the embodiment factor in vertical orientation of valence word pairs (Experiment 1) and horizontal orientation of valence word pairs (Experiment 2).

Discussion

Previous studies have shown that when comprehenders process conceptual metaphors, they activate perceptual simulations (Lakoff & Johnson, 1981; 1999). The notion that metaphor comprehension is embodied is non-trivial. However, it begets the question whether alternative explanations are to be dismissed. The two experiments reported here show that both linguistic and embodiment factors explain the processing of valence words. Furthermore, the dominance of one factor relative to the other was modified differentially based on the experimental task, such that linguistic factors better explained RTs for horizontal presentations, with embodied features better explaining RTs for vertical presentations. Moreover, we found evidence suggesting that male participants typically rely more on embodied representations, whereas female participants typically rely more on statistical linguistic patterns.

The findings reported in this paper are important for theories of cognition. Although there is much evidence supporting embodied accounts of mental representations (Barsalou, 1999; Glenberg, 1997; Pecher & Zwaan, 2005; Semin & Smith, 2008; Zwaan, 2004), there is also an increasing amount of evidence suggesting that other factors can play an important role (Hutchinson, Johnson, & Louwerse, 2011; Louwerse, 2008; Louwerse & Jeuniaux, 2010; Barsalou, Santos, Simmons, & Wilson, 2008). It is important that researchers consider alternatives contributing to metaphoric conceptual processing rather than fixating on one explanation without leaving any room for alternative explanations. Our findings do not dispute the necessity of employing embodied representations but rather we call into question their dominance during cognition. Comprehension of conceptual metaphors can be explained by both linguistic and embodiment factors, but their salience as predictors of cognitive processing is modified by cognitive task and by individual differences.

References

Baayen, R., Davidson, D., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390-412.

Barsalou, L. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*, 577-660.

Barsalou, L. W., Santos, A., Simmons, W. K., & Wilson, C. D. (2008). Language and simulation in conceptual processing. In M. de Vega, A. M. Glenberg, & A. C. Graesser (Eds.), *Symbols and embodiment: Debates on meaning and cognition* (pp. 245-283). Oxford, UK: Oxford University Press.

Brants, T., & Franz, A. (2006). Web 1T 5-gram version 1. Philadelphia: Linguistic Data Consortium.

Crawford, E., Margolies, S., Drake, J., & Murphy, M. (2006). Affect biases memory of location: Evidence for the spatial representation of affect. *Cognition & Emotion*, *20*, 1153-1169.

de Vega, M., Glenberg, A. M., & Graesser, A. C. (Eds.). (2008). *Symbols and embodiment: Debates on meaning and cognition*. Oxford, UK: Oxford University Press.

Glenberg, A. M. (1997). What memory is for: Creating meaning in the service of action. *Behavioral and Brain Sciences*, *20*, 1-55.

Hutchinson, S., Johnson, S., & Louwerse, M. M. (2011). A linguistic remark on SNARC: Language and perceptual processes in Spatial-Numerical Association. In L. Carlson, C. Hoelscher, & T. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society* (pp. 1313-1318). Austin, TX: Cognitive Science Society.

Kimura, D. (2000). *Sex and cognition*. Cambridge, MA: The MIT Press.

Kramer, J. H., Delis, D. C., Kaplan, E., & O'Donnell, L. (1997). Developmental sex differences in verbal learning. *Neuropsychology*, *11*, 577-584.

Lakoff, G., & Johnson, M. (1981). *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh*: *The embodied mind and its challenge to western thought*.

New York, NY: Basic Books.

Landauer, T., McNamara, D., Dennis, S., & Kintsch, W. (Eds.). (2007). *Handbook of latent semantic analysis*. Mahwah, NJ: Erlbaum.

Linn, M. C., & Peterson, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development*, *56*, 1479-1498.

Littell, R. C., Stroup, W., & Freund, R. J. (2002). *SAS system for linear models*. Cary, NC: SAS Publishing.

Louwerse, M. M. (2007). Symbolic or embodied representations: A case for symbol interdependency. In T. Landauer, D. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of latent semantic analysis* (pp. 107-120). Mahwah, NJ: Erlbaum.

Louwerse, M. M. (2008). Embodied relations are encoded in language. *Psychonomic Bulletin and Review*, *15*, 838-844.

Louwerse, M. M. (2011). Symbol interdependency in symbolic and embodied cognition. *TopiCS in Cognitive Science, 3,* 273-302.

Louwerse, M. M., & Connell, L. (2011). A taste of words: Linguistic context and perceptual simulation predict the modality of words. *Cognitive Science, 35,* 381-398.

Louwerse, M. M., & Jeuniaux, P. (2010). The linguistic and embodied nature of conceptual processing. *Cognition*, *114*, 96-104.

Meier, B., Hauser, D., Robinson, M., Friesen, C., & Schjeldahl, K. (2007). What's "up" with god? Vertical space as a representation of the divine. *Journal of Personality and Social Psychology*, *93*, 699-710.

Meier, B. P., & Robinson, M. D. (2004). Why the sunny side is up. *Psychological Science*, *15*, 243-247.

Meier, B. P., & Robinson, M. D. (2008). The metaphorical representation of affect. *Metaphor and Symbol*, *20*, 239-257.

Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, UK: Oxford University Press.

Pecher, D., van Dantzig, S., Boot, I., Zanzolie, K., & Huber, D. E. (2010). Congruency between word position and meaning is caused by task Induced spatial attention. *Frontiers in Psychology*, *1*, 1-8.

Pecher, D., & Zwaan, R. A., (Eds.). (2005). *Grounding cognition: The role of perception and action in memory, language, and thinking*. Cambridge, UK: Cambridge University Press.

Prinz, J. (2004). *Furnishing the mind: Concepts and their perceptual basis*. Cambridge, MA: MIT Press.

Santana, E., & de Vega, M. (2011). Metaphors are embodied, and so are their literal counterparts. *Frontiers in Psychology, 2,* 1-12.

Schnall, S., & Clore, G. (2004). Emergent meaning in affective space: Conceptual and spatial congruence produces positive evaluations. In K. Forbus, D. Gentner, & T. Regier (Eds.), *Proceedings of the 26th annual meeting of the cognitive science society* (pp. 1209-1214). Mahwah, NJ: Erlbam.

Schubert, T. W. (2005). Your highness: Vertical positions as perceptual symbols of power. *Journal of Personality and Social Psychology*, *89*, 1-21.

Semin, G., & Smith, E., (Eds.). (2008). *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches*. New York, NY: Cambridge University Press.

Stepper, S., & Strack, F. (1993). Proprioceptive determinants of emotional and nonemotional feelings. *Journal of Personality and Social Psychology*, *64*, 211-220.

Wapner, S., & Werner, H. (1957). The effect of success and failure on space localization. *Journal of Personality*, *25*, 752-756.

Zwaan, R. A. (2004). The immersed experiencer: Toward an embodied theory of language comprehension. *Psychology of Learning and Motivation*, *44*, 35-62.