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Verifying properties from different emotions produces switching costs: Evidence for coarse-grained language statistics and fine-grained perceptual simulation

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Abstract

We investigated whether emotions are activated during comprehension of emotion words. In the first part of the study, an experiment was conducted in which participants read sentence pairs each describing an emotional state and then engaged in a judgment task. Sentences were paired to either match or mismatch in emotion (happy, sad, or angry). We predicted that the sentences that mismatch in emotion produced longer reaction times than those where the emotion was the same, and that shifts between negative emotions had less of an impact. In the second part of the study, we calculated the frequency of first-order co-occurrences of nouns and adjectives related to happy, sad, and angry emotional states. This analysis demonstrated emotion words are more often accompanied by similar emotion words. Match and mismatch of emotion explained RTs as did statistical linguistic frequencies of the words. The combination of these two studies contributes to a growing body of research that supports the importance of both symbolic and perceptual processing of emotion.

Keywords: emotion; embodied cognition; symbolic cognition; statistical linguistic frequencies.

Introduction

Theories of embodied cognition claim that cognition is fundamentally based in perceptual experiences. That is, concepts only become meaningful through comprehenders mentally reenacting prior physical and perceptual experiences with the concept in the real world (Barsalou, 1999; Barsalou, Simmons, Barbey, & Wilson, 2003; Glenberg & Kaschak, 2002; Pecher & Zwaan, 2005; Havas, Glenberg, & Rinck, 2007; Semin & Smith, 2008). For instance, Glenberg and Kaschak (2002) proposed the action-sentence compatibility effect whereby language processing is facilitated when a congruent response motion is used to respond to sentences describing motion away from or towards the body. That is, sentences describing motion away from the body (e.g., close a drawer) were processed faster when response motions were also moving away from the body, and vice versa. These results and findings similar to these demonstrate that linguistic processing is facilitated through perceptual-motor information (see Leventhal, 1982 for an overview).

Similar to action related sentences, sentences with emotional content have also provided support for an embodied cognition account. Mouilso, Glenberg, Havas, and Lindeman (2007) found that reading 'angry' sentences resulted in faster movements away from the body and reading 'sad' sentences resulted in faster movements toward the body. In other words, when people read angry content, they processed the sentence faster with an aggressive action toward it, whereas 'sad' sentences evoke a withdrawal action, suggesting that emotional language can affect bodily responses.

Embodied responses have also been linked to cognition through the facial feedback hypothesis (Strack, Martin, & Stepper, 1988; Zajonc, Murphy, & Inglehart, 1989). The facial feedback hypothesis demonstrates that facial expressions might influence emotional assessments. For example, when participants were instructed to smile, cartoons were perceived as more humorous than when subjects were not smiling (Strack et al., 1988), showing that bodily states can affect both judgments and cognition.

Most literature supporting an embodied cognition account, however, demonstrates evidence without physical manipulation. For example, Pecher, Zeelenberg, & Barsalou

(2003) found that subjects read sentences describing features within the same modality faster than sentences describing features of differing modalities. When participants read a sentence like *apples can be tart* followed by the sentence *apples can be sweet* (describing the same gustatory modality) response times were faster for the second sentence when the second sentence did not describe a shift in modality, such as is the case when a visual modality was presented in *strawberries can be red* or *radios can be loud*. The modality of the target words impacted how those words were perceived. Processing costs incurred from the mismatched sentences resulted from a perceptual modality shift, suggesting that perceptual embodied features indeed impact language processing times.

Recently, the modality switching costs have been explained by language statistics (Louwerse & Connell, 2011). By computing the word frequencies of the co-occurrences of modality words from a large corpus of English, Louwerse and Connell were able to identify modality shifts similar to Pecher et al. (2003). This analysis was not only applicable to the adjectives (e.g., *tart* – *sweet* being more frequent than *tart* – *red* or *sweet* – *red*), but also to concept words (e.g., *apples* – *strawberries* being more frequent than *apples* – *radio* or *strawberries* – *radio*). Louwerse and Connell (2011) showed that these frequencies explained the response times that were attributed to an embodied cognition account. That is, faster response times were best explained by language statistics, slower response times were best explained by perceptual simulations. Louwerse and Connell's explanation was that the linguistic system offers a 'quick and dirty' shallow heuristic that can provide good enough performance in cognitive tasks without recourse to deeper conceptual processing in a perceptual simulation system. On the other hand, ultimately concepts are grounded and can be perceptually simulated. The explanation by Louwerse and Connell can be captured in the Symbol Interdependency Hypothesis, which proposed that conceptual processing can be explained by both symbol and embodied mechanisms (Louwerse, 2007; 2008; 2011). When we encounter a word, we garner a rough meaning from its linguistic (symbolic) neighbors using language statistics, but to fully ground the word, we perceptually simulate its physical and somatosensory features. Thus, words can rely on other words to establish a fuzzy sense of meaning without necessarily always being grounded themselves. In other words, perceptual information is encoded in language, such that mental representations are both perceptual and linguistic. Human beings can rely on such a linguistic short-cut when processing language in real time. However, if a deeper meaning or understanding is needed, grounding the world in perceptual experiences provides rich sensorimotor information about meaning. Importantly, language has encoded sensorimotor information, such that language users can utilize these cues in cognitive processes.

In short, the Symbol Interdependency Hypothesis proposes the following: 1) language encodes perceptual information; 2) language users rely both on language statistics and perceptual simulation in cognitive processes; 3) the relative dominance of language statistics and perceptual simulation factors is modified by stimulus type and task.

Although modality shifts have been shown to support the Symbol Interdependency Hypothesis (Louwerse & Connell, 2011), the question can be raised whether the finding for modality shifts can be extended to other semantic domains that have shown embodiment effects, such as emotions. In the current study we investigated whether (a) verifying properties from different emotions for concepts produces switching costs, similar to the modality shifts; (b) whether language has encoded the emotions of words, similar to the modality of words; (c) whether emotion shifts can be explained by a language statistics account.

To explore these questions we applied Pecher et al.'s (2003) modality shift paradigm to emotions. Emotional sentences shifted from happy to sad, sad to happy, happy to angry, angry to happy, sad to angry, and angry to sad. According to an embodied cognition account, switches between emotions should take longer to process than non-switches (happy-happy, sad-sad, angry-angry). Alternatively, according to a language statistics account, co-occurrence frequencies of word pairs should be able to equally account for subject RTs. We thereby made two hypotheses: (1) as with modality shifts, emotion shifts would take longer to process than non-shift sentence pairs, which would be in support of an embodied cognition account and (2) the same pattern of emotion shift cost would emerge from language such that emotion words that matched in valence would co-occur more frequently than the words that did not match in valence, which would be in support of a linguistic account.

Experiment 1: Emotion Shift

Method

Participants Thirty-three undergraduate students enrolled in an introductory psychology course participated for course credit.

Materials Sixty emotion sentences were created, following the method described in Pecher et al. (2003) with each sentence in the format *X can be Y*. There were 3 experimental types of emotions depicted in the sentences: angry, happy, and sad. For example, *birthdays can be happy* (happy emotion), and *insults can be devastating* (sad emotion).

The reason we selected angry, happy, and sad emotions was motivated by work from Isenhower et al. (2003) who found that people tend towards more positive states of emotion. That is, switching from positively valenced to negatively valenced emotions yields a greater disruption and requires additional cognitive processing. Further motivation came from a more recent study by Stein and Sterzer (2012). In this study, Stein and Sterzer demonstrated that people identify happy faces more quickly than angry faces. We therefore selected happy, sad, and angry words, and thus had one positively valenced emotion (happy) and two negatively valenced emotions (sad and anger).

Procedure Participants were seated at a computer in a standard computer lab. The instructions for the experiment were presented on the screen and read aloud by the experimenter. Five practice items preceded the experimental phase to ensure participants understood the task. Participants saw sentences one at a time in the center of the screen and then were asked to respond to the question *Is the characteristic true of the items it described?* Participants pressed designated *yes* or *no* keys on the keyboard. RT and accuracy were recorded.

Results

Incorrect responses were not included in the analyses. RT outliers were defined as 2.5 SD above the mean per subject per condition and were removed from the analysis. This removal affected less than 3.6% of the data.

A mixed-effect analysis was conducted on RTs with emotion shift as the fixed factor 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). Participants and items were treated as random factors in the analysis.

For the factor emotion shift no differences were found in RT, $F(1,114) = .431$, $p = .513$. This is somewhat surprising given that an emotion shift was predicted to increase RTs akin to the modality shifts. However, when individual emotion pairs were separated by transition (e.g., happy-sad, happy-angry), RT differences were obtained with an emotion shift from happy sentences to sad sentences, $F(1,421) = 30.41$, $p < .001$, with slower RTs for the shift than no-shift (i.e., a happy sentence followed by a happy sentence). Also, when shifting from happy sentences to angry sentences a significant difference was found between the two conditions, $F(1,380) = 20.82$, $p < .001$, there were slower RTs for the emotion shift sentences than no-shift. When the sad to angry sentences were compared, again a difference approaching significance was found between emotion shift and no-shift conditions, $F(1,455) = 5.88$, $p < .056$, where the shift between sentences yielded longer RTs than no-shift. In contrast, the comparison of sad to happy sentences yielded no significant differences between emotion shift and no-shift sentences, $F(1,395) = .02$, $p < .89$. When switching from angry to happy sentences, a significant effect was found, $F(1,485) = 20.69$, $p < .001$, again with faster RTs for the emotion shift sentences than no-shift. Finally, a significant effect was found when switching from angry to sad sentences, $F(1,430) = 5.05$, $p < .03$, however with faster RTs for the emotion shift sentences than the no-shift sentences.

In summary, a shift from happy to sad, happy to angry, sad to angry, and angry to happy yielded significant results, while the shift from sad to happy was not significant. Figure 1 shows the means and standard deviations for each emotion shift pair.

Even though no overall effect for emotion shift was found, patterns for specific emotion transitions did show shift effects, with specific emotion to emotion shifts resulting in longer RTs than non-shifts. More specifically, the shifts from happy to the two negative emotions, shows a significant increase in RT. The emotion shift from angry to happy was also significant, but showed a decrease in RT from angry followed by angry. This is in line with Stein and Sterzer (2012), who found that people are quicker to identify happy faces, rather than angry faces. We interpret this decrease in RT in terms of the nature of the shift. Angry followed by angry produces the longest RT, while happy followed by happy produces the shortest RT. As there is a tendency to prefer to shift toward a more positive state (Isenhower, Frank, Kay, & Carello, 2010), the reaction times for the non-shifts reflected this. Moreover, the shift from angry to happy decreases from its origin (angry followed by angry), because of the natural tendency to shift to the more positive state. This is supported by the significant differences when emotion shifts took place between angry and happy, angry and sad, and sad and angry.

However, we still are unable to determine whether an embodiment effect exists for emotion switching, as there was no overall effect for shifts as there were for Pecher et al. (2003), but only specific emotion to emotion effects.

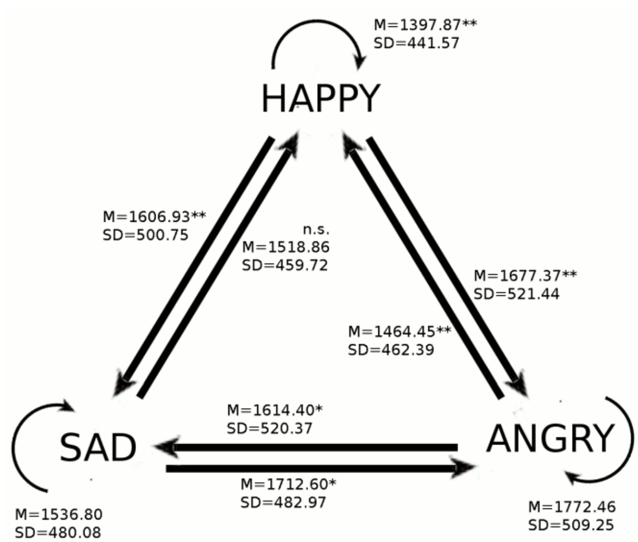

Figure 1. Emotion shifts, means, and standard deviations. ** $p < .01$, * $p < .05$, *n.s.* not significant. The means and standard deviations located at the emotion words indicate no emotion shift (e.g., a happy sentence followed by a happy sentence).

To determine whether or not overall shifts for emotions occurred, we ran a second experiment whereby the embodiment effect would be enhanced by an embodied facial feedback paradigm.

Experiment 2: Facial Feedback Hypothesis

In order to determine if emotion switching indeed supports an embodied cognition account, we examined the effects of the facial feedback hypothesis (Strack, et al., 1988; Zajonc, et al., 1989) by assessing the effects different conditions (frowning or smiling) had on RTs when judging emotion shift sentences. We hypothesized that neither frowning nor smiling would produce a significant effect between the negative emotions (sadness and anger), due to the trend towards positive (Isenhower et al., 2010). In addition, we hypothesized that the specific emotion to emotion shifts found in Experiment 1 would show similar patterns.

Method

Participants Twenty-six undergraduate students enrolled in an introductory psychology course participated for course credit.

Materials The same materials were used as in Experiment 1.

Procedure The procedure was the same as that used in Experiment 1, with one important addition. Participants were also randomly assigned to one of two facial feedback conditions (Strack et al., 1988). In the one condition, the participants held a pen in their lips (n = 15) to simulate frowning; in the other, the participants held a pen in their teeth (n = 11) to simulate smiling.

Results

As in Experiment 1, emotion shifts did not yield a significant difference in RT, $F(1, 117.27) = .16$, $p = .70$**.** Furthermore, there seemed to be no main effect of the facial feedback conditions, $F(2, 78.24) = .73$, $p = .49$. Next, we investigated the emotion transitions per facial feedback condition (smiling vs. frowning).

Frowning Facial Feedback When participants held the pen in their lips to simulate frowning, the shift from happy to sad was significant as it was in the previous experiment without the facial feedback task, $F(1,236) = 6.69$, $p = .01$, with higher RTs for the shift sentences than no-shift. The shift from happy to angry was also significant as found in the previous experiment, $F(1,202) = 8.36$, $p < .004$, with higher RTs for the shift sentences than no-shift. Also the shift from angry to happy was significant as previously found in Experiment 1, $F(1,248)$ 4.31, $p < .04$, with lower RT for the shift sentences than no-shift. Again, this is in line with Isenhower et al. (2010) and Stein and Sterzer (2012), in that the preference is to shift from a negative state to a positive state. This is especially true given the fact that participants were frowning due to the facial feedback task. The shifts from sad to angry and angry to sad were found to be non-significant, unlike the findings in Experiment 1. These results lend support to the facial feedback hypothesis, in that frowning (pen held in lips) is associated with both sadness and anger; it would stand to reason why there were no significant differences between these two conditions as they are both negative emotions and the motor system necessary for their simulation was already active, facilitating the effect. Figure 2 shows the means and standard deviations for each emotion shift pair, the shift direction, and the no shift means and standard deviations.

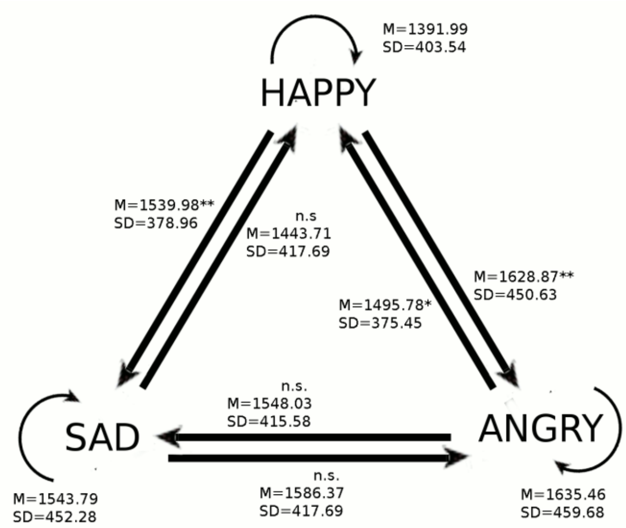

Figure 2. Emotion shifts, means, and standard deviations for frowning facial feedback condition. ** $p < .01$, * $p < .05$, *n.s.* not significant.

Smiling Facial Feedback When participants held the pen in their teeth to simulate smiling, the shift from happy to sad was significant, $F(1,168) = 8.98$, $p < .003$, with higher RT for the shift sentences than no-shift . The shift from happy to angry was significant, $F(1,164) = 15.48$, $p < .0001$, with higher RTs for the shift sentences than no-shift . The shift from sad to happy approached significance, $F(1,134) = 3.81$, $p < .053$, with lower RT for the shift sentences than no-shift. Finally, the shift from angry to happy was also significant, $F(1,179) = 17.84$, p < .001, with lower RT for the shift sentences than no-shift . Again, the decrease in RT for angry to happy is in accord with Stein and Sterzer (2012). The shifts from sad to angry and angry to sad were not found to be significant. Figure 3 shows the means and standard deviations for each emotion shift pair, the shift direction, and the no shift means and standard deviations. The main difference between the smiling condition and the previous frowning condition is the significant difference found in the sad to happy shift, which was not found in Experiment 1, or the frowning facial feedback condition. This difference supports the findings by Isenhower et al. (2010), in that since people have a tendency to tend towards a positive state, which they have in part done by smiling.

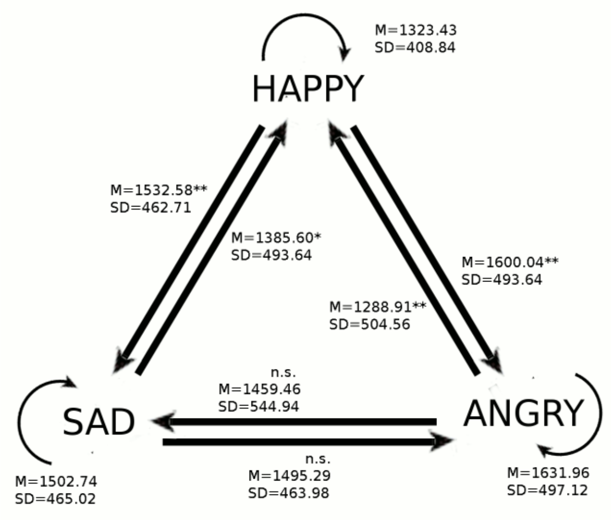

Figure 3. Emotion shifts, means, and standard deviations for smiling facial feedback condition. ** $p < .01$, * $p < .05$, *n.s.* not significant

Corpus Linguistic Study

So far, the results seem to suggest that emotional states can be based in embodied cognition, as some emotion to emotion shifts seem to indicate that emotion switching usually incurs some sort of processing cost. However, this is not the whole picture, as it does not take into consideration the linguistic nature of the words. We therefore investigated whether emotion shifts are encoded in language (Louwerse, 2008; Louwerse & Connell, 2011). To do this we calculated the frequency of first-order co-occurrences of all the possible combinations of the nouns and adjectives in the present study by utilizing the Web 1T 5-gram corpus (Brants & Franz, 2006). This corpus consists of 1 trillion word tokens (13,588,391 word types) from 95,119,665,584 sentences. The volume of the corpus allows for an extensive analysis of patterns in the English language. The frequency of co-occurrences of the word pairs was computed for bigrams, trigrams, 4-grams and 5-grams. For instance, the frequency of the phrase *birthdays can be happy* {happy, birthday} was determined by considering these words next to one another {happy birthday}, with one word in between {happy w1 birthday}, with two {happy w1 w2 birthday}, three intervening words {happy w1 w2 w3 birthday}, and so on.

A mixed effects analysis was conducted on the frequency of co-occurrences of the emotion adjectives and the noun referents. The independent variable was whether the emotion words were the same or different emotion, and the log frequency of the word pair was the dependent variable.

For all possible combinations of both nouns and adjectives, the log frequency of the co-occurrences were found to be significant, $F(1, 7078) = 212.76$, $p < .001$, with word pairs where there was no emotion shift ($M = 2.08$, $SE = .04$) being more frequent than word pairs where an emotion shift was present ($M = 1.11$, $SE = .054$). This pattern was also found for just the nouns $F(1, 3479) = 148.11$, $p < .001$, with word pairs where there was no emotion shift ($M = 4.29$, $SE = .08$) being more frequent than word pairs where an emotion shift was present ($M = 2.60$, $SE = .11$). Again, this pattern was found for adjectives, $F(1, 3598) = 279.17$, $p < .001$, with word pairs where there was no emotion shift ($M = 2.53$, $SE = .05$) being more frequent than word pairs where an emotion shift was present ($M = 1.00$, $SE = .07$).

In addition, we also compared the log frequencies of each of the word pairs to the experimental RT over the collapsed match and mismatch conditions (extracted from Experiments 1 and 2). Language statistics significantly predicted RTs, $F(1, 113.564) = 34.53$, $p < .001$. However, language statistics did not predict emotional transitions. Statistical linguistic frequencies explained RTs of general emotion shifts, but not RTs of specific emotion transitions.

General Discussion

Previous studies have found that two sentences that elicit a modality shift produce cognitive switching costs, compared to sentences that describe the same modality (Pecher et al., 2003). This finding has been reported as evidence for an embodied cognition account, because the increased RTs are an indication that comprehenders perceptually simulate the sentences. Others have shown that modality is encoded in language. Based on language statistics, concepts and their features can be categorized in visual, auditory, olfactory and gustatory modalities (Louwerse & Connell, 2011). Moreover, when the RTs for modality shifts were investigated with both language statistics and perceptual simulation as independent variables, fast RTs were best explained by language statistics and slower RTs were best explained by perceptual simulation. Louwerse and Connell (2011) concluded that language statistics serves as a coarse-grained system that serves as a shallow heuristic. Perceptual simulation, on the other hand, serves deeper conceptual processing. The idea that language encodes perceptual information and that these linguistic cues can be used by language users in shallow comprehension tasks is predicted by the Symbol Interdependency Hypothesis and supported by various studies (Louwerse, 2008; Louwerse & Hutchinson, 2012; Louwerse & Jeuniaux, 2008; 2010).

The current study investigated whether emotion shifts mimicked the patterns found for previous studies investigating modality shifts. Even though across three experiments no general effect was found for shifts, specific transitions between emotions did yield differences in RTs. Moreover, evidence was found that language encodes emotion shifts, and language statistics explained RTs for these general shifts.

The findings of the current study are supported by the Symbol Interdependency Hypothesis as well as by findings reported in other studies. Language statistics explained coarse-grained emotion shifts. However, language statistics did not explain fine-grained shifts. On the other hand, assuming that a perceptual simulation system is responsible for the other RT differences that were obtained in the two experiments, the perceptual system did not explain the coarse-grained differences in general emotion shifts, but did explain the fine-grained shifts between specific emotions.

These results provide further evidence for the theory that conceptual processing is both linguistic and embodied, whereby less precise linguistic processes account for general patterns in processing, whereas perceptual simulation provides the fine-tuning.

References

Baayen, R. H., 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. W. (1999). Perceptual symbol systems, *Behavioral and Brain Sciences, 22*, 577–660.

Barsalou, L. W., Simmons, W.K., Barbey, A.K., & Wilson, C.D. (2003). Grounding conceptual knowledge in modality-specific systems, *Trends in Cognitive Sciences*, *7*, 84–91.

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

Brysbaert, M. (2007). *The language-as-fixed-effect fallacy: Some simple SPSS solutions to a complex problem* (version 2.0). Royal Holloway, University of London. Technical report.

Ekman, P., & Rosenberg, E. L. (2004). *What the face reveals: basic and applied studies of spontaneous expression using the facial action coding system (FACS)*, New York: Oxford University Press.

Glenberg, A. M. (2007). Language and action: creating sensible combinations of ideas. In G. Gaskell (Ed.) *The Oxford handbook of psycholinguistics* (pp. 361-370). Oxford, UK: Oxford University Press.

Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin & Review*, *9*, 558-565.

Havas, D., Glenberg, A. M., & Rinck, M (2007). Emotion simulation during language comprehension. *Psychonomic Bulletin & Review*, *14*, 436-441.

Isenhower, R. W., Frank, T. D., Kay, B. A., & Carello, C. (2010). Capturing and quantifying the dynamics of valenced emotions. *Nonlinear Dynamics Psychology and Life Sciences, 16*(4), 397-427.

Leventhal, H. (1982). A perceptual motor theory of emotion. *Social Science Information, 21*, 819-845.

Littell, R. C., Stroup, W. W., & Freund, R. J. (2002). *SAS for Linear Models*, 4th Edition. Cary, NC: SAS Publishing.

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

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

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

Louwerse, M. M., and 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.

Louwerse, M. M. & Jeuniaux, P. (2008). Language comprehension is both embodied and symbolic. In M. de Vega, A. Glenberg, & A. C. Graesser (Eds.), *Symbols and Embodiment: Debates on Meaning and Cognition*. Oxford, England: Oxford University Press.

Mouilso, E., Glenberg, A. M., Havas, D. A., & Lindeman, L. M. (2007). Differences in action tendencies distinguish anger and sadness after comprehension of emotional sentences. *Proceedings of the 29th Annual Cognitive Science Society*, *14*, 1325-1330.

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

Pecher, D., Zeelenberg, R., & Barsalou, L.W. (2003). Verifying different-modality properties for concepts produces switching costs. *Psychological Science, 14*, 119-124.

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

Stein, T., & Sterzer, P. (2012). Not just another face in the crowd: Detecting emotional schematic faces during continuous flash suppression. *Emotion, 12*, 988-996.

Strack, F., Martin, L. & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology*, *54*, 768-777.

Zajonc, R. B., Murphy, S. T., & Inglehart, M. (1989). Feeling and facial efference: Implications for the vascular theory of emotion. *Psychological Review*, *96*(3), 395-416.