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# Constraining Theories of Embodied Cognition

Arthur B. Markman

University of Texas

C. Miguel Brendl

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Address all correspondence to

Arthur B. Markman
Department of Psychology
University of Texas
1 University Station, A8000
Austin, TX 78712
Phone: (512)232-4645
FAX: (512)471-5935

markman@psy.utexas.edu

Abstract

Influences of perceptual and motor activity on evaluation have led to theories of embodied cognition suggesting that putatively complex judgments can be carried out using only perceptual and motor representations. We present an experiment that revisits a movement compatibility effect in which people are faster to respond to positive words by pulling a lever than by pushing and negative words by pushing than by pulling. We demonstrate that the compatibility effect depends on people's representation of their self in space rather than on their physical location. These data suggest that accounting for embodied phenomena requires understanding the complex interplay between perceptual and motor representations and people's representations of their self in space.

In both cognitive and social psychology, there has been significant interest in the relationship between thought and perception and action systems (Barsalou, 1999; Barsalou, Niedenthal, Barbey, & Ruppert, 2003; Glenberg, 1997; Wilson, 2002). Many studies within this *embodied cognition* approach demonstrate that performing actions associated with a particular valence leads to compatibility effects in subsequent judgments. For example, Strack, Martin, and Stepper (1988) had people hold a pen in their mouths with the tip facing outward with their lips (which leads to a frowning posture of the lips) or with their teeth (which leads to a smiling posture). While doing this, people evaluated a series of cartoons. Smile-posture participants rated the cartoons as funnier than frown-posture participants.

We are interested in the influence of evaluation on speed of motor movements. We examine this relationship in order to explore the tenets of the embodied cognition approach in detail. Wilson (2002) suggests that existing data make clear that the representations used by the perception and action system are *necessary* for understanding higher-level cognitive processes. Some theorists speculate that perceptual and motor representations are *sufficient* for understanding cognition, so that cognitive processes can be explained by appealing only to representations that are tied to perceptual and motor modalities (Barsalou et al., 2003; Glenberg, 1997, Prinz, 2002).

## Arm movements and evaluations

Many studies have found that movements of the arm are related to people's evaluations. On this view, pulling movements of the arm are associated with approaching desired objects and that pushing movements of the arm are associated with the avoidance of undesired objects (Cacioppo, Priester, & Bernston, 1993; Chen & Bargh, 1999; Solarz, 1960). For example, Chen and Bargh (1999) showed people words on a computer screen and asked them either to pull or push a lever to signal the onset of a word on the screen. They found that pulling movements were faster for positive words than for negative words. In contrast, pushing movements were faster for negative words than for positive words. Some theorists have suggested that there are automatic connections between perceptions and motor movements (e.g., Dijksterhuis & Bargh, 2001) and indeed, interactions of this type are consistent with such a view.

However, the results of studies using body movements are not completely consistent about the relationship between direction of movement and evaluation. For example, Wentura, Rothermund, and Bak (2000) instructed participants to either push a button (an approach response) or to withdraw their hand from a button (an avoidance response). They found that pressing the button was faster for positive stimuli than for negative ones, but withdrawing their hand from the button was faster for negative stimuli than for positive ones. Given the way participants were seated, pressing the button required a movement away from the body, while withdrawing required a movement toward the body. This reversal of previous findings is inconsistent with an account positing a direct connection between body movements and evaluation, but is consistent with an early study by Münsterberg (1892).

Many theories of embodied cognition do not assume direct connections between perception and motor action (Barsalou et al., 2003; Glenberg, 1997, Prinz, 2002), but rather that all cognitive representations are tied to perceptual or motor modalities. This richer embodied view is silent on what perceptual or motor representations would cause the observed reversal. Thus, data bearing on this issue would favor richer theories of embodied cognition over the direct motor-evaluation view and thus would constrain these richer theories.

To explore this issue, we begin by observing that evaluative movements involve moving objects toward or away from the "self," which is assumed to be located in the body of the participant. While this assumption is reasonable, it is important to ask whether these two confounded concepts—the representation of the location of the self in space and the representation of the participant's body in space—can be deconfounded. A natural starting point for embodied theories is that people represent the self as located in the body, and so data suggesting that people can represent the self as being separate from the body would require extensions of these theories.

We constructed a variant of the Chen and Bargh task in which participants' representations of themselves are separated from that of their bodies. This setup is illustrated in Figure 1 (top panel). Participants sat at a computer screen depicting a corridor receding in depth. A participant's name (representing the self) was presented in the center of the corridor, and words to be evaluated were shown either far away in the corridor (Figures 1a and 1c) or near in the corridor (Figures 1b and 1d). In some blocks of trials, participants were instructed to move the joystick in the direction from the word toward their name if it was positive and away from their name if it was negative (Figures 1a and 1b). In other blocks, participants moved the joystick in the direction from the word away from their name if it was positive and toward their name if it was negative (Figures 1c and 1d).

When the word is far away in the corridor, then both the participants' representation of self and their bodies are in the same relative position to the stimulus word. In this case, we expect people to be faster to pull positive words toward their name than to push them away, and to be faster to push negative words away from their name than to pull them toward it. This finding would replicate Chen and Bargh's (1999) previous findings.

The critical trials are those on which the stimulus word appears near to the participant in the corridor. In this case, pushing a positive word toward the name involves pushing it toward a non-physical representation of self and away from the body.[1]

Pulling a negative word away from the name involves pulling it away from a non-physical representation of self and toward the body. There are two possible outcomes in this condition. If evaluations are connected to movement representations directly, then people should be faster to pull positive words toward their bodies and to push negative words away from their bodies regardless of the position of their names. In contrast, if body movements are made relative to a person's representation of self, then positive words should be moved most quickly toward the name and negative words should be moved most quickly away from the name.

## Method

Participants were 108 German-speaking students at the University of Konstanz. Of these, 2 were excluded for dyslexia, 7 because they were not native speakers of German, and 8 because they needed but did not have corrective eyewear. The data from 91 participants were analyzed.

The primary independent variables in this study were Valence (Positive vs. Negative words), Movement Direction (Push vs. Pull) and Instruction Set (Positive Toward/Negative Away vs. Positive Away/Negative Toward). Valence and Movement direction were run within subjects, Instruction Set was run between subjects. The dependent variable was response time to initiate the movement of the lever.

Stimuli were a 23 positive and 23 negative German words drawn from those used by Fazio, Sanbonmatsu, Powell, and Kardes (1986) published in Bargh, Chaiken, Govender, and Pratto (1992). Valence of the words was verified for the German sample by thermometer scale ratings of how cold and warm the words were (Brendl, Markman, and Messner, 2004, Study 1).

Participants sat at a computer and grasped an arm lever with their dominant hand. They were told that their first name would appear in the middle of a corridor and that another (valenced) word would appear shortly after either in front of it or behind it. Participants were randomly assigned to either the *Positive Toward/Negative Away condition* (where they were instructed to move the lever toward their name for positive words and away from their name for negative words; Figures 1a and 1b) or the *Positive Away/Negative Toward condition* (where they were instructed to move the lever away from their name for positive words and toward their name for negative words; Figures 1c and 1d). Before the experimental trials, participants were given the opportunity to practice, first, by having the words bad and good appear, and then, by having various valenced words appear. Feedback was given during these practice trials. There were 100 actual trials divided into 4 blocks separated by pauses. Pauses were followed by 2 warm-up trials.

Response times (ms) were calculated from the moment of onset of the stimulus to the point where the lever was moved 0.208 mm.

# Results

Response times from correct trials in the lever movement task were log-transformed. Values more than 2 standard deviations from the mean were eliminated. Means for this exclusion were calculated separately for each Instruction Set condition. The data were then submitted to a 2 (Valence) x 2 (Movement Direction) x 2 (Instruction Set) Repeated Measures ANOVA.

In this analysis, if the speed of people's movements is driven by their representation of their selves rather than their bodies, there should be a main effect of Instruction Set. Moving positive words toward their name should be faster than moving them away from their name. Moving negative words away from their name should be faster than moving them toward their name. Consistent with this prediction, people were significantly faster to respond to words in the Positive Toward / Negative Away condition (*M*=717 ms) than in the Positive Away/Negative Toward condition (*M*=1006 ms), $F(1,89)=61.60$, $p<.001$, partial $\eta^2=.41$. The effect held both for negative and positive words and for pushing and pulling movements, all p's < .001, see Table 1.

If the speed of people's movements is driven by their representation of their bodies rather than their selves, they should be faster to pull positive words than to push them and to push negative words than to pull them. This pattern would result in an interaction between Movement Direction and Valence. Surprisingly, there is a significant interaction between Movement Direction and Valence, $\underline{F}(1,267)=7.80$, $\underline{p}<.05$, partial $\eta^2=.05$, but it reflects an effect that goes in the opposite direction from that obtained by Chen and Bargh (1999). As shown in Table 2, people are slightly faster ($t < 1$) to pull the negative words toward their bodies than to push them away from their bodies. In contrast, they are significantly faster to push the positive words away from their bodies and than to pull them toward their bodies, $t(89) = 3.61$, $p < .001$. This pattern is consistent with the results of Wentura et al. (2000) and Münsterberg (1892).

Finally, there was a significant interaction between Instruction Set and Valence, $\underline{F}(1,267)=20.92$, $\underline{p}<.001$, partial $\eta^2=.19$. As shown in Table 1, this interaction reflects that people are faster to make responses that involve moving the joystick away from their name ($M$=834 ms) than to make responses that involve moving the joystick toward their name ($M$=889 ms). The source of this effect is not clear, but it does not alter the interpretation of the primary results of this study (see Brendl, Markman, & Messner, 2004, for more discussion about effects of this type).

## Discussion

Accounts of embodied phenomena, such as those of Barsalou et al. (2003) and Glenberg (1997) focus primarily on the connection between perceptual and action systems. These accounts do not distinguish between a person's representation of their (non-physical) selves and their bodies.

These results constrain theories of embodied cognition by suggesting that the ease of a particular movement depends crucially on people's representations of the task that go beyond simple learned motor actions. We deconfounded people's bodies from their non-physical representation of themselves within the task by placing people's name in a visual scene of a corridor receding in depth. People were faster to move positive words toward their name (i.e., toward their representation of themselves) regardless of whether this response required a pushing movement (which would push the word away from their physical body) or a pulling movement (which would pull the word toward their physical body). Neumann and Strack (2000) reached a similar conclusion based on the observation that motor and perceptual information prime approach or avoidance states.

The importance of people's representation of the task is consistent with previous research on the Simon effect (e.g., Simon, 1990). In this effect, people are faster to respond with the hand that is on the same side as a directional cue provided by the stimulus, even if that directional cue is not relevant to the judgment being made. For example, people might respond with the left-hand to a high tone and with the right hand to a low tone. In this task, people are faster to respond to tones played on their left with their left hand and to tones played on their right with their right hand even though the spatial location of the tone is not relevant to the pitch judgment.

The Simon task confounds the physical movement made by participants with the physical location of the stimulus. That is, responses made with the left hand are also made to the participant's left. Studies have deconfounded these possibilities by performing this task and having participants respond with their arms crossed so that their right hand is pressing a button on their left side. When the task is done this way, the Simon effect occurs based on the spatial compatibility of the stimulus and the button rather than based on the spatial compatibility of the stimulus and the side of the body, so that responses to stimuli on the left are faster for buttons on the left than on the right and vice versa (see Brendl, 2001; Wascher, Schatz, Kuder, & Verleger, 2001). Our results are similar, because they suggest that people's representation of self is also distinct from their low-level representation of particular aspects of their body.

Movement compatibility effects demonstrate that evaluations and judgments that have been explained in terms of higher order processes arise from the important coupling of perceptual and motor systems. On the information-processing view of cognition, these effects and their implications were often ignored. Embodied accounts correct this oversight by emphasizing the importance of perceptual and motor representations in cognition. The present results suggest that perceptual and motor representations alone may not be sufficient to account for cognitive processing, because phenomena that at face value seem prime examples of lower order perceptual and motor processing may nonetheless involve higher-order symbolic processing. At a minimum, embodied accounts must specify how symbolic information about the self is tied to perceptual and motor representations.

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# Footnotes

[1] The word on the screen did not actually move.  We use the phrases “move the word toward/away from the name” as a shorthand for “moved the joystick in the direction toward/away from the name.”  In later studies with a slightly different methodology, the word moved toward or away from the name following the response.  This manipulation does not influence the strength of the effect reported in this paper.

Table 1. Mean response times (ms) as a function of Instruction Set, Movement Direction, and Valence (standard errors in parentheses). Pulling versus pushing motions refer to moving the arm toward versus away from the body, respectively. Toward versus away refers to moving the arm toward versus away from the first name depicted in the corridor (cf. Figure 1).

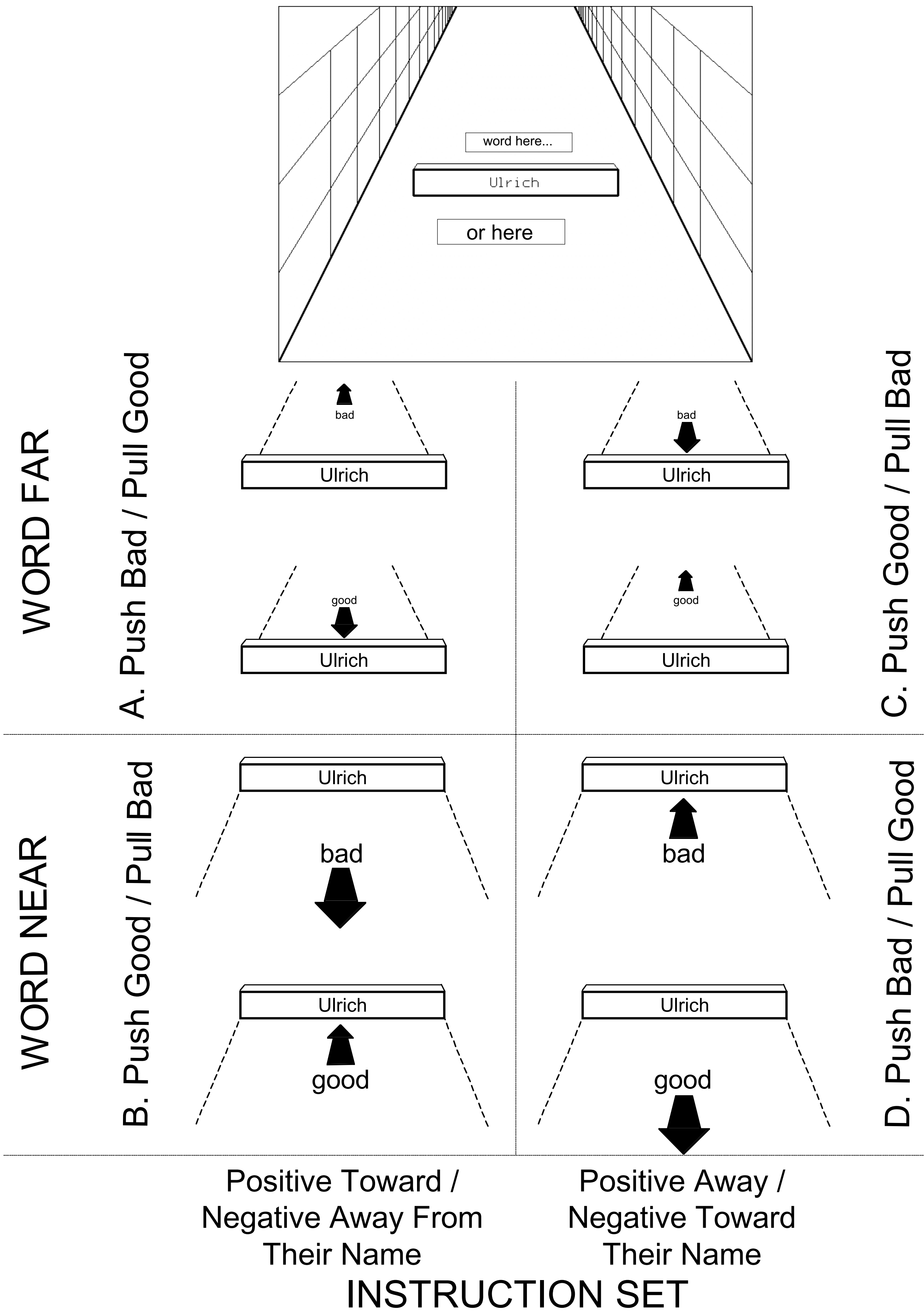
| | Positive Words | Negative Words | Mean |
|---|---|---|---|
| Pulling Motion | | | |
| Positive Toward/Negative Away | 769 (23.70) | 678 (19.11) | 724 (15.91) |
| Positive Away/Negative Toward | 994 (36.43) | 1033 (31.63) | 1014 (24.08) |
| Pushing Motion | | | |
| Positive Toward/Negative Away | 723 (23.83) | 697 (21.10) | 710 (15.88) |
| Positive Away/Negative Toward | 966 (30.72) | 1031 (36.88) | 999 (24.11) |

Table 2. Mean response times (ms) as a function of Valence and Movement Direction (standard errors in parentheses)

| | Pulling Movement | Pushing Movement |
|---|---|---|
| Positive Words | 885 (24.90) | 848 (23.33) |
| Negative Words | 861 (26.43) | 870 (27.75) |

Figure Caption

*Figure 1.* Illustration of the experimental setup. The top panel shows the corridor displayed on the computer monitor. A participant's name is presented in the center of the "corridor." One word to be evaluated was placed either far (Figures 1a and 1c) or near (Figures 1b and 1d) in the corridor. When the word is presented near in the corridor, the participants' representations of their selves and of their bodies are deconfounded. Arrows symbolize instructions to move the word, but respondents did not see these arrows.


word here...
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