Difference in Action Tendencies Distinguish Anger and Sadness after Comprehension of Emotional Sentences

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Abstract

We investigate the complex relations among language, emotion, and action. Emotions function to ready the body to take effective action (Davidson, 1994; Frijda, 2005), but how specific are these action tendencies, do they correspond to actual physical impulses, or are they merely abstract? Work in the neuroscience of language suggests that language comprehension utilizes the neural substrates of perception, action, and emotion (Gallese, Keysers & Rizzolatti, 2004; Rizzolatti & Arbib, 1998). Therefore, we hypothesize that comprehending emotional language will prime particular actions. To test this hypothesis we measured the amount of time it takes participants to move a lever either toward or away from the body while reading angry, sad or emotionally neutral sentences. Reading angry (versus sad) sentences results in faster movements away from the body, while reading sad (versus angry) sentences result in faster movements towards the body. The results suggest that emotional action tendencies may result from emotional language understanding, and that these tendencies may be quite specific.

Keywords: Emotion; embodiment; language comprehension; action tendencies; sadness; anger.

The present study is designed to investigate the complex interplay of language, emotion, and action. Emotion and action have been related in studies of the functions of emotion. Some theorists propose that emotions function to direct an organism towards a certain set of behaviors (Frijda, 2005) or to allocate the necessary metabolic support for emotion specific actions (Davidson, 1994). In each case, situations that activate anger, for example, will motivate an organism to engage in a certain set of anger behaviors (fist clenching, threat display, and physical or verbal attack). The organism can then execute the behavior that is most adaptive in the situation. These theories suggest that the autonomic nervous system activates the appropriate physiological processes to allow the organism to carry out the chosen behavior. Thus, for example, the experience of anger should facilitate a different set of behaviors than the experience of sadness (Davidson, 1993). If emotions function to facilitate action, measurable changes in behavior ought to exist between different emotional states.

Intriguingly, emotion has been implicated as a moderating variable in many psychological processes that have behavioral consequences such as perception, attention, cognition, learning, recognition, and motivation; however, research on the behavioral effects of emotion is scant (Zajonc & McIntosh, 1992). In contrast, the powerful link between emotion and language has been well documented (Velten, 1968), and recent studies have shown that language is ultimately grounded in bodily activity (Glenberg, & Kaschak, 2002; Glenberg, Sato, Cattaneo, Riggio, Palumbo, & Buccino, in press; Lakoff, 1987). That is, when asked to comprehend language, people often make use of the same neural systems that are used to produce action, perceive the world, and experience emotion. These systems are used to simulate the meaning of the language (e.g., Havas, Glenberg & Rinck, in press). Nonetheless, other scientists suggest that language consists of abstract symbols, some of which may remain ungrounded (e.g. Kintsch, in press). Hence it becomes important to test if language about emotional situations is grounded in emotion and action.

The embodiment position suggests that understanding sentences about actions utilizes the same neural components as producing literal action and that simulation of these systems prepares the body to take the kind of literal action described in the sentence. For example, Glenberg and Kaschak (2002) investigated the relation between action and language comprehension using a behavioral method. Participants judged whether a sentence was sensible or nonsense by, in one condition, moving to a response button far from them, and in another condition moving to a

Figure 1. The response lever in the Away condition. The apparatus is rotated 180 degrees for the Toward condition.

response button close to them. Results indicated that responding was faster when the action implied in a sentence was compatible with the action participants used to respond, than when the two were incompatible. Further support for the neural link between action and language comprehension comes from neural imaging studies. For example, Hauk, Johnsrude, and Pulvermüller (2004) used fMRI to demonstrate that silently reading action verbs such as "kick," "pick," and "lick" was accompanied by activation in traditional language areas as well as activation in areas of motor and premotor cortex. Activation in motor areas for a particular word corresponded to the effector that would be used in making the action. Thus, "kick" activated areas of the motor and premotor cortex that control the leg, whereas understanding the word "pick" activated in areas that control the hand, and so on.

The present study builds on theories about the behavioral functions of emotion (Davidson, 1994 and Frijda, 2005) as well as work on the link between language comprehension and activation of the neural substrates of action and emotion (Gallese, et al., 1996; Gallese, Keysers & Rizzolatti, 2004; and Rizzolatti, et al., 1996). Little behavioral evidence exists regarding the changes in action that result from the experience of different emotions. Nonetheless, the measurement of such changes could provide a useful technique in answering questions not only about the function of emotion itself but also about the existence of autonomic specificity in general. The present study will help determine if comprehending sentences about emotional situations can be used to investigate these relations.

Participants read angry, sad or neutral sentences to decide if the sentences made sense. Sense judgments are made by moving a lever (see Figure 1) so that the time taken to move the lever can be used as a behavioral measure of the level of bodily activation associated with the emotion produced by the sentence. Participants responded that a sentence was nonsense by pushing a button located on top of the lever without moving the lever itself.

Simply finding that reading angry sentences results in faster lever movement times could be interpreted as the result of a generally greater level of bodily arousal produced by anger than sadness. Thus, the present study includes two different lever motion conditions: some participants make sense judgments by moving the lever towards their bodies and others by moving the lever away from their bodies. It was predicted that reading angry sentences would facilitate movement away from the body whereas reading sad sentences would facilitate movement towards the body.

Much work has been done proposing an asymmetry in prefrontal cortex (PFC) processing such that the left PFC is used in the processing of approach-related positive affect while the right PFC is used in processing withdrawal-related negative affect (Davidson, 1984). In this initial conceptualization of the theory, anger and sadness as negative emotions were both expected to be processed in the right PFC; however, findings suggest that in fact the left PFC process anger (Harmon- Jones, 2004).

As a result, Harmon-Jones (2004) proposed that the positive-negative dimension be dropped from the model so that approach-withdrawal exclusively defines the frontal asymmetry of emotion. Recently, support for the inclusion of anger as an approach emotion was found when increased left PFC activation was demonstrated in response to personally relevant anger-provoking stimuli when participants had an approach-related action expectation (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006). Similarly, significant reductions in the processing of anger were observed after rTMS was used to deactivate the left PFC (Van Honk, & Schutter, 2006). In the case of the present study, pushing a lever away from the body can be seen as a type of approach action and also as a component process of the prototypical response of aggression. Therefore, reading angry sentences is hypothesized to be associated with faster movement times when participants are pushing the lever away from their bodies.

The predicted effect of sadness is, perhaps, somewhat counterintuitive. One might expect, based on research showing that depression is associated with slower motor movements (Parker & Brotchie, 1992), or energy conservation, that participants would move the lever more slowly regardless of direction. However, there is a body of research that suggests that some types of sadness, specifically grief and sorrow, are associated with actions designed to find and reunite with a lost figure or reacquire a lost possession (Averill & Nunley, 1988; Bowlby, 1980). Based on this work, some types of sadness would be predicted to facilitate movements intended draw an object or person closer to the body rather than to withdraw from a situation and conserve energy. In the present study, many of the sad sentences involve social loss or isolation so that it is predicted that participants will be faster to pull the lever towards their bodies.

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Method

Participants

One hundred and eight undergraduates (72 females and 36 males) from the University of Wisconsin-Madison enrolled in an introductory psychology class participated in the experiment for course credit. Four subjects were excluded from the analysis due to missing data or failure to follow instructions. In addition, data from the last two participants were excluded in order to achieve balanced cells for the analysis.

Design

The experiment used 3 (Sentence Valance) X 2 (Lever Direction) design. The Independent variable of Sentence Valance was manipulated within subjects and had three levels: Sad, Angry and Neutral, while Lever Direction was a between subjects variable with two conditions: Towards the body and Away from the body. The dependent variable was the amount of time that participants took to move the lever from a start location to a stop location

Materials

The experiment used a lever that required some force to move it away from the starting point and to move it back. Analog signals of the lever's position were sent to a Logitech Attack 3 joystick for translation into digital computer input. The program USB Overdive (2005) was installed on the computer and used to read data from the lever/joystick via a USB port on the computer. The time it took the participant to move the lever from its starting position (either close to or far from the body depending on condition) to the end position where it made contact with a stopping device, was calculated as the time at which the lever first left the starting position (thus releasing a button) until it made contact with the stopping device (thus depressing a second button). Nonsense responses were recorded from a thumb button attached to the top of the lever handle.

 Each block of sentences contained two sentences of each valance randomly selected from the entire list of sentences along with six nonsense sentences selected in the same manner. The order in which sentences were presented within blocks was also random. Each participant saw each of the sentences only once. The 14 Neutral, 14 Angry and 14 Sad sentences were selected from a larger set of previously-normed sentences with high ratings on the intended emotion as well as relatively low ratings on the unintended emotion. On a 0 (Not at all) to 2 (Very much) scale, Angry sentences were rated low on sadness (M = 0.26, SD = 0.18) and high on anger (M = 1.61, SD = 0.15), while Sad sentences were rated low on anger (M = 0.77, SD = 0.41) and high on

Table 1: Examples of sentences

Type of Sentence	Example
Angry Sensible	The workload from your pompous professor was unreasonable; this course evaluation will make the jerk pay.
	Reeling from the fight with that stubborn bigot, you slam the car door.
Sad Sensible	Because of your awkward appearance, you will never win your love's affection.
	Your parent just told you the news; your grandparent had a stroke and is in critical condition at the hospital.
Neutral Sensible	You talk with your cousin the telemarketer while passing the salt during dinner.
	Looking around your Madison apartment, you decide you will go sit in your favorite chair.
Nonsense	While in a rush to make your meeting on the 24th floor, the empty box elevators to a sudden stop.
	You are unable to go home for Winter break because the exam makes the shaving company.

sadness (M = 1.75, SD = 0.13). Neutral sentences were designed to be roughly equivalent to the emotional sentences in terms of key words and syntax, and those selected were rated both low on anger (M = 0.04, SD = 0.05) and sadness (M = 0.07, SD = 0.05). Sentences across all emotional conditions were generally similar in number of words (Mean = 17.58, SD = 3.82), complexity of words and sentence topic (See Table 1).

Procedure

The experimental room consisted of a small cubicle containing a computer, a desk, a chair and a lever. After obtaining informed consent, each participant was led individually into the experimental booth by the experimenter and told that the task would involve reading a series of sentences on the computer screen and deciding if the sentences made sense or not. Participants were then instructed in the correct use of the lever and asked to respond as quickly as possible.

 During the trials, each sentence appeared on the computer screen until the lever was moved or the button was pressed. To make a "sense " response, participants pushed the lever either away from the body until it contacted a metal stop (Away condition) or towards the body until it contacted a metal stop (Towards condition). Participants then returned the lever to its original resting position in preparation for the

next trial. To respond "nonsense", participants pressed the button on the top of the lever handle with the thumb. The dependent variable of greatest interest is the time taken to move the lever from the start location to the stop location.

At the end of each block of sentences there was a rest period, participants could decide when they wanted to continue by clicking the "Next" button. At the end of the final block of sentences, participants completed an exit questionnaire. Each of the participants was thanked for participating and given an oral debriefing by the experimenter that outlined the purpose of the experiment, and the predicted results.

Results

Based on our prediction that different emotions are associated with different action tendencies, we predicted that the amount of time participants would take to move the lever would vary depending on the emotional valance of the preceding sentence as well as the direction of lever motion. Specifically, we predicted an interaction between Lever Direction and Sentence Valence such that when pushing lever Away, participants would be faster after reading an Angry sentence than after a Sad sentence and when pulling the lever Toward themselves, participants would be faster after a Sad sentence than after an Angry sentence.

A 2 X 3 between subjects ANOVA was conducted on correct sensible trials. The data was trimmed to remove all trials with reading times or lever-movement times greater than two and a half standard deviations from their respective overall means. In addition, we excluded lever movement times that were 2.5 standard deviations from each participant's condition mean. The trimming procedure removed approximately five percent of analyzable trials.

A sentence-emotion-by-lever-direction interaction in the lever movement times was found in both subject, $F1(2, 100)=4.41$, $MSe=2864$, $p < .02$, and item analyses, $F2(2,26)=6.39$, $MSe=746.9$, $p < .01$). No other significant effects were found. Results of a Tukey's HSD revealed a simple effect in sad sentences across lever condition in the item analysis, $t(39)=4.42$, $p<.05$. Specifically, lever movement times after reading sad sentences were significantly faster in the toward condition than in the away condition (See Table 2).

The significant interaction between sentence emotion and lever direction was also followed by several dependent-sample t-tests designed to test our specific predictions. When the lever was pushed in the Away direction, the Angry sentences were responded to more quickly than the Sad sentences, $t(50) = 2.019$, $p=.05$. The effect was most prevalent for the male participants (mean difference = 54 msec), $t(14) = 2.42$, and was not statistically significant for the female participants (mean difference = 13 msec), $t(35) < 1$. The reverse was found when the lever was pulled in the Toward condition. That is, the Sad sentences were responded to more quickly than the Angry sentences mainly

Table 2: Subject analysis mean lever movement times and standard deviations by condition

		Sad	Neutral	Angry
Toward	Mean	779	799	791
	SE	34.4	37.9	36.7
Away	Mean	815	795	789
	SE	24.3	22.8	23.2

for the women (mean difference = 20 msec), $t(32) = 2.510$, $p=.02$, but not for the men (mean difference = -2 msec), $t(17) < 1$. Thus, the results are substantially in line with our predictions, albeit with an interesting twist due to gender.

Discussion

The present study measured the effect of comprehending sentences of different emotional content on the speed that participants pushed the lever away or pulled the lever toward their bodies. We predicted that participants who pushed the lever away from their body would move the lever faster after reading angry sentences than after reading sad sentences, whereas participants who moved the lever toward their body would be faster to move the lever after reading sad sentences than angry sentences. This prediction was largely confirmed by a significant and corresponding interaction pattern in both subject and item analyses. Post-hoc analyses confirmed a significant and predicted difference between toward and away conditions for sad sentences only. The null result for angry sentences might be due to difficulty as reflected in higher error rates for angry sentences (discussed below). In addition, men responded to the Angry sentences more quickly than the Sad sentences in the Away condition, whereas the women responded to the Sad sentence more quickly than the Angry sentences in the Toward condition. These gender-specific effects are consistent with other (unpublished) results collected in our laboratory and suggest interesting theoretical directions that we explore elsewhere.

Overall, these data demonstrate several behavior differences that arise from reading and understanding emotional language. As such, the data are consistent with the claim that language comprehension utilizes the same neural substrates as action and emotional experience themselves. These data represent a clear behavioral difference resulting from reading and understanding emotional language and as such is consistent with the theory that language comprehension utilizes the same neural substrates as action and emotional experience itself.

Movement time results from the current study provide strong support for the theory that emotions differentially affect bodily activity and that emotion itself functions to prepare the body to take effective action. Beyond merely suggesting that sadness subdued the amount of general arousal and slowed action in general relative to anger, the present study revealed that these emotions may each facilitate different types of action. As predicted, bringing the

lever towards the body was facilitated by sadness relative to moving the lever away from the body with anger. Thus, the findings suggest that emotion maybe a key component in the body's ability to mobilize resources to act effectively in different situation.

An alternative explanation of the findings is that the effects are attributable to processing of action words in the sentences, as in the phrase, "you slam the car door as hard as you can," rather than to emotional content *per se*. On this account, sad sentences contain more withdrawal-related action words or concepts than angry sentences, while angry sentences contain more approach-related words than sad sentences. There are two reasons why this account is less preferred. First, it is not clear on such an account how readers might construe isolated action words like "slam" or "give" to indicate approach or withdrawal apart from the sentence context. Second, the results of our norming study clearly shows that subjects perceive the situations described by our sentences as emotional. Previously, we have suggested that emotional language understanding involves a simulation using action systems that underlie emotional experience (Havas, Glenberg, & Rinck, in press). The present study expands this account to show how emotion simulation can influence subsequent actions.

A caveat to the understanding of the present results is the similarity between the effects of Neutral and Angry sentences on the motor system. Analysis of the percent of trials in which participants correctly indicated that a sentence was sense or nonsense reveals a main effect in accuracy rates for sad trials (M = 92%) versus angry and neutral trials (both M = 89%), $F(2, 100) = 11.57$, $MSe=.002$, $p = 0.00$. Thus, greater difficulty in interpreting the sentences may have obscured any effects of the lever for these sentences. A second possibility is that outside of the context of the norming study, participants may have reacted to angry sentences with a degree of amusement (See Table 1); however, the authors have no statistical justification for this possibility.

In conclusion, the present study accomplishes two goals. First, it demonstrates how language about emotional situations can be embodied. Second, it documents a potentially useful method of investigating the effect of emotion on action.

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