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For Which Side the Bell Tolls:

The Laterality of Approach-Avoidance Associative Networks

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Abstract

The two hemispheres of the brain appear to play different roles in emotion and/or motivation. A great deal of previous research has examined the valence hypothesis (left hemisphere = positive; right = negative), but an increasing body of work has supported the motivational hypothesis (left hemisphere = approach; right = avoidance) as an alternative. The present investigation (N = 117) sought to provide novel support for the latter perspective. Left versus right hemispheres were briefly activated by neutral lateralized auditory primes. Subsequently, participants categorized approach versus avoidance words as quickly and accurately as possible. Performance in the task revealed that approach-related thoughts were more accessible following left-hemispheric activation, whereas avoidance-related thoughts were more accessible following right-hemispheric activation. The present results are the first to examine such lateralized differences in accessible motivational thoughts, which may underlie more "downstream" manifestations of approach and avoidance motivation such as judgments, decision making, and behavior.

KEYWORDS: Approach, Avoidance, Motivation, Priming, Laterality

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The left and right hemispheres of the brain appear to play differential roles in emotion and/or motivation. Much of this research has focused on what is termed the valence hypothesis (Davidson, 1984). Accordingly to this hypothesis, positive affect is differentially lateralized to the left hemisphere, whereas negative affect is differentially lateralized to the right hemisphere. Early support for this valence hypothesis came from lesion-related research, which suggested that lesions to the left hemisphere render individuals more depressed, whereas lesions to the right hemisphere render individuals more excitable or manic (Robinson & Price, 1982). Some subsequent work found evidence for the idea that individuals with higher levels of left brain activation in resting electroencephalogram (EEG) records reported experiencing higher levels of positive relative to negative emotion (e.g., Tomarken, Davidson, Wheeler, & Doss, 1992). Further, there is also some evidence for the idea that pleasant (e.g., sweet tastes) relative to unpleasant (e.g., bitter tastes) sources of stimulation shift brain activation (again, as assessed in EEG terms) leftward (Davidson, 1992).

Increasingly so, though, results have favored a motivational hypothesis of cerebral asymmetry instead. According to this hypothesis, the left hemisphere differentially specializes in approach motivation, whereas the right hemisphere differentially specializes in avoidance motivation (Harmon-Jones, Gable, & Peterson, 2010). In favor of this idea is the fact that resting EEG asymmetries are better predictors of reactions to motivation-relevant stimuli rather than resting mood states (Davidson, 1999). In addition, Sutton and Davidson (1997) found that EEG asymmetries better predicted individual differences in approach versus avoidance motivation than individual differences in positive versus negative emotional experiences. Perhaps most compelling, though, are results involving anger. Anger is negatively valenced (Russell & Barrett, 1999) and yet approach-oriented in nature (Carver & Harmon-Jones, 2009). A series of studies has shown that leftward asymmetries in the EEG predict higher levels of trait and state anger as well as aggressive responses to provocations (Harmon-Jones et al., 2010). Moreover, anger inductions shift the EEG asymmetry leftward (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003), good evidence for the motivational hypothesis.

Asymmetry Manipulations and Their Consequences

The studies reviewed above measured rather than manipulated cortical asymmetry (or treated it as a dependent measure: Davidson, 1992). In this context, manipulations of asymmetry may have a high degree of value. Fortunately, there is considerable support for the idea that rightward manipulations of the body activate the left hemisphere and leftward manipulations of the body activate the right hemisphere (Kinsbourne & Hicks, 1978). Therefore, causal support for either the valence or motivational hypothesis can be obtained by manipulating such lateralized inputs (Bryden, 1982; Ehrlichman, 1984; Malamed & Larsen, 1977).

Studies using such manipulations have primarily sought to test the valence hypothesis, but several results appear to implicate the motivational hypothesis in addition or instead. Drake (1987) found that people were more optimistic concerning the future when relevant events (e.g., traveling to Europe) were presented to the left relative to right hemisphere in auditory terms. Optimism is not only positive, but is thought to result from higher levels of approach motivation (Carver & Scheier, 1998). Bassel and Schiff (2001) found that tactile stimulation to the right arm (which would activate the left hemisphere) relative to the left arm led to greater persistence on unsolvable puzzles. This might be interpreted in terms of positive expectations of performance, but persistence is perhaps a better marker of approach motivation in the achievement realm (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). Finally, there is evidence that activation of the left (right) hemisphere results in faster finger flexion (extension) movements (Maxwell & Davidson, 2007; Schiff & Bassel, 1996). It is difficult to view these results in terms of the valence hypotheses, but movements are also complex indicators of approach and avoidance motivation, in that several studies have shown that the same movements appear to be conceptualized as approach- or avoidance-related in different conditions (Eder & Rothermund, 2008; Bonezzi, Brendl, & De Angelis, 2011; Seibt, Neumann, Nussinson, & Strack, 2008).

Accordingly, one purpose of the present experiment was to provide more definitive evidence for the motivational hypothesis in the realm of manipulations of asymmetry. A second purpose was to extend our understanding of the consequences of asymmetry manipulations. In relation to both goals, we focused on cognitive accessibility processes, which have not – to our knowledge – been investigated in prior studies of the present type. The importance of this line of investigation is that several prominent social cognitive theories contend that people's motivations follow from their accessible (presumably more activated) motivation-related thoughts, with supporting evidence (Gollwitzer & Bargh, 2005; Kruglanski et al., 2002). For example, primes of achievement motivation result in behaviors consistent with higher levels of achievement motivation (Bargh & Chartrand, 1999; Ferguson, Hassin, & Bargh, 2008).

Accessibility is conceptually defined in terms of the ease with which stimuli can be recognized as examples of their categories (Bruner, 1957; Higgins, 1996). The best way of *assessing* accessibility, we maintain, is to ask individuals to categorize stimuli as quickly as possible, with accessibility defined in terms of a faster speed of categorization (Robinson, 2004). This method of assessing accessibility has yielded many dividends in previous studies (e.g., Robinson & Compton, 2008; Robinson & Neighbors, 2006). To examine the motivational hypothesis in the present investigation, then, each trial began with a lateral auditory prime designed to activate one hemisphere or the other. Subsequently, participants categorized an action word as approach-related (e.g., approach, pursue) or avoidance-related (e.g., avoid, retreat) in nature. Approach categorizations should be faster following left-hemisphere activation and avoidance categorizations should be faster following right-hemisphere activation, results that would significantly extend prior work the motivational hypothesis of cerebral asymmetry.

Method

Participants and General Procedures. Participants were 117 (72 female) undergraduates from North Dakota State University seeking course credit. They completed an E-Prime program in groups of 6 or less on personal computers while wearing headphones capable of presenting lateralized auditory input. Instructions stated that they should listen to sounds and then categorize words as quickly and accurately as possible and that these were two independent tasks.

Manipulation. Lateralized sounds have been shown to activate the contralateral hemisphere in EEG paradigms (Kinsbourne & Hicks, 1978) and to shift attention in a manner favoring the activated hemisphere (Malamed & Larsen, 1977). Accordingly, lateralized sounds were used as hemispheric primes in the present investigation. Specifically, we presented the Windows XP Ringout tone to either the left or right ear prior to each categorization effort in a within-subject cognitive design. We chose this tone because we deemed it affectively neutral in that it was lacking in semantic content, not loud, and relatively mundane.

Dependent Task. The dependent task asked individuals to as quickly and accurately as possible categorize verbs consistent with approach-related actions (stimuli = advance, approach, proceed, pursue, & seek) versus avoidance-related actions (stimuli = avoid, escape, evade, retreat, & withdrawal). The words were drawn from a thesaurus and were face-valid. It was deemed best to repeat these words rather than including marginal exemplars (e.g., “investigate” for approach), which would be associated with lower accuracy rates and effortful decision processes not suited to examine the accessibility construct (Higgins, 1996; Robinson, 2004). The approach and avoidance words did not significantly differ in their number of letters, $t = 0.22$, $p > .80$, or word frequency – i.e., the frequency of the word’s usage in typical English language texts (Kucera & Francis, 1967), $t = 1.23$, $p > .25$.

Word stimuli were assigned to trials at random, capitalized, and presented in a white 18 point Arial font against a black background. Participants used a button box, associated with low millisecond error, to make their categorizations. It was deemed best to use a constant set of response mappings for the task, thereby mitigating response factors in the interpretation of the results. Avoidance words were to be categorized by pressing the 1 key of the response box using the left hand pointer finger, whereas approach words were to be categorized by pressing the 5 key of the response box using the right hand pointer finger.

Trial Procedures. Each trial began with a 250 ms blank screen. Then, the Windows XP Ringout tone was presented for 500 ms, lateralized to either the left or right ear. Following offset, there was a brief 100 ms delay before the trial-specific word was presented. To facilitate accurate responding, a 1000 ms visual error message followed incorrect responses. There were 120 total trials. The task took approximately 5 to 10 minutes to complete.

Data Preparation. In the computation of reaction time means, we used standard procedures. Inaccurate responses were dropped (Ratcliff, 1993). Millisecond values were then log-transformed to reduce positive skew and log-transformed times lesser or greater than 2.5 *SD*s from the grand latency mean were replaced with such 2.5 *SD* values (Robinson, 2007a).

Accuracy rates were not outside acceptable skew values and did not require transformation. We then averaged (log-transformed) reaction time values and accuracy rates as a function of the 2 (auditory side) by 2 (word type) repeated measures design. Although raw millisecond values were not analyzed, they will be reported in understanding the nature of significant effects.

Results

Results Involving Reaction Time

We hypothesized that approach words would be categorized more quickly following right-ear auditory primes and that avoidance words would be categorized more quickly following left-ear auditory primes. To examine this hypothesis, a repeated-measures ANOVA was performed with log-transformed reaction times as the dependent variable. The main effect for Auditory Side was not significant, $F < 1$. Thus, it was not the case that right-lateralized sounds facilitated response times in general. On the other hand, there was a significant main effect for Word Type, F (1, 116) = 5.03, $p < .05$ $\eta_p^2 = .04$, such that approach words were generally categorized more quickly (M = 663 ms) than avoidance words (M = 672 ms). This main effect for word type appears consistent with the idea that individuals typically adopt an approach-related orientation to the environment (Cacioppo, Gardner, & Berntson, 1999).

Of more importance, the hypothesized Auditory Side by Word Type interaction was significant, F (1, 116) = 21.10, $p < .01$ $\eta_p^2 = .15$. For illustrative purposes, millisecond means for the interaction are graphically displayed in Figure 1. To further understand the nature of the interaction, we performed two follow-up one-way repeated-measures ANOVAs to test priming effects for each motivation type separately considered. Approach words were categorized more quickly following right than left ear auditory primes, F (1, 116) = 12.00, $p < .01$ $\eta_p^2 = .09$. Conversely, avoidance words were categorized more quickly following left than right auditory primes, *F* (1, 116) = 9.88, $p < .01$ $\eta_p^2 = .08$. Such results provide novel support for the idea that approach and avoidance motivation are lateralized, importantly extending such effects to the burgeoning social cognitive literature examining accessibility processes in basic categorization tasks (Fazio & Olson, 2003).

Results Involving Accuracy Rates

Accuracy rates were examined to rule out speed-accuracy tradeoffs in responding. Additionally, though, we deemed it possible that categorization accuracy, too, would support our interactive predictions. In a repeated-measures ANOVA parallel to that above, there was no main effect for Auditory Side, $F < 1$. In addition, the main effect for Word Type was not significant, $p > .10$. On the other hand, a significant Auditory Side by Word Type interaction was found, *F* (1, 116) = 7.51, $p < .05$ $\eta_p^2 = .06$. Two follow-up repeated-measures ANOVAs, one for each word type, were performed. Approach words were categorized more accurately following right ear (*M* = 95.01%) than left ear (*M* = 93.45%) auditory stimulation, a marginally significant effect, *F* (1, 116) = 3.22, $p < .10$ $\eta_p^2 = .03$. By contrast, avoidance words were categorized more accurately following left ear (*M* = 93.87%) than right ear (*M* = 92.36%) auditory stimulation, a significant effect, *F* (1, 116) = 5.00, $p < .05$ $\eta_p^2 = .04$. Accordingly, accuracy rates too suggested that priming the left (right) hemisphere facilitates the categorization of approach (avoidance) action words and associated motivational states.

Discussion

The present work sought to make two unique contributions. First, prior manipulation work – in which one hemisphere versus the other is activated through lateral priming manipulations – has largely focused on the valence hypothesis. Instead, we focused on the motivational hypothesis. Second, no prior work has examined whether cognitive accessibility processes, as can be assessed in reaction time paradigms (Robinson, 2004), systematically differ as the motivational hypothesis might contend. In fact, we found that approach-related words were categorized more quickly when the left hemisphere was primed, whereas avoidance-related words were categorized more quickly when the right hemisphere was primed. In sum, the results both support the motivational hypothesis and extend it to the novel realm of accessible thoughts related to approach versus avoidance.

Theoretical Considerations

Accessibility perspectives of social cognition are typically straightforward from a semantic content perspective (Higgins & Bargh, 1987). For example, the activation of hostile thoughts typically results in hostile feelings and behaviors (Anderson & Bushman, 2002). The present results are novel to this literature in the sense that primes were neutral, constant across hemispheres, and yet it was found that such primes activated approach-related thoughts when presented to the left hemisphere, but avoidance-related thoughts when presented to the right hemisphere. Such findings contribute to a small but growing body of work suggesting that there are significant bodily inputs to accessible thoughts that are not well-captured by traditional, content-based theories of social cognitive priming (Landau, Meier, & Keefer, 2010; Niedenthal, Barsalou, Winkielman, Krauth-Gruber & Ric, 2005).

Accessible thoughts are thought to guide subsequent behavior and decision making (Bargh & Chartrand, 1999). Further, several prominent theories of motivation adopt an accessibility perspective (Gollwitzer & Bargh, 2005; Ferguson et al., 2008; Kruglanski et al., 2002). Along these lines, and of direct relevance to the present findings, previous studies of ours have shown that reaction time tasks designed to assess the accessibility of approach and avoidance information possess considerable value in predicting individual differences in extraversion (Robinson, Moeller, Ode, 2010), neuroticism (Robinson, Ode, Moeller, & Goetz, 2007), self-regulation (Robinson, 2007b), emotion regulation (Tamir, Robinson, & Soldberg, 2006), and numerous outcomes purported to follow from approach or avoidance motivation (Robinson, Meier, Tamir, Wilkowski, & Ode, 2009). These considerations suggest, but do not demonstrate, that the present interactive tendencies might mediate some of the other presumably more downstream effects of lateral stimulation such as optimism (Drake, 1987) or task persistence (Bassel & Schiff, 2001).

Finally, motivation is typically conceptualized in terms of long-term efforts to achieve relevant outcomes (McClelland, 1987). The present priming effects suggest a greater degree of malleability to approach and avoidance motivation than captured by such long-term perspectives. Indeed, we found pronounced and rapid trial-to-trial variations in the accessibility of approach versus avoidance thoughts. Further, although approach and avoidance motivation are viewed as largely independent on the basis of trait literatures (e.g., Elliot & Thrash, 2002), state levels of approach and avoidance motivation may be more inversely related (Cacioppo et al., 1999). Our results support this point in that lateralized primes resulted in a cross-over interaction in the accessibility of approach versus avoidance thoughts.

Additional Considerations

There are multiple opportunities to replicate the present results in more brain-based terms. First, it may be useful to determine whether lesions to the right (relative to the left) hemisphere are predictive of accessibility favoring approach-related thoughts (Robinson & Price, 1982). Second, we suggest that resting EEG asymmetry favoring the left hemisphere may predict faster categorizations of approach relative to avoidance stimuli (Davidson, 1999). Third, it might be useful to examine whether repeated practice in categorizing stimuli as approach-related (versus avoidance-related) would shift cerebral asymmetry in a leftward direction, much as triggers of approach motivation (e.g., a pleasant taste) have done so in previous EEG studies (Davidson, 1992; Harmon-Jones et al., 2003).

Murphy, Nimmo-Smith, and Lawrence (2003) found that EEG evidence for the left hemisphere’s role in approach-motivated emotions was quite a bit more consistent than the right hemisphere’s role in avoidance-motivated emotions. Our findings might be viewed as supporting this asymmetry in motivational asymmetry. Specifically, following left-hemisphere activation, people categorized approach-related stimuli faster than avoidance-related stimuli (see Figure 1). On the other hand, following right-hemisphere activation, accessibility for approach and avoidance thoughts was roughly equal (again, see Figure 1). However, this component of the interaction should probably be interpreted in the context of a main effect for word type which would tend to work against the idea that the right hemisphere is more accessible for avoidance- than approach-related thoughts. Regardless, future manipulation studies of the present type should be mindful of such potential asymmetries in asymmetry.

In addition, a role for asymmetry in emotion and/or motivation has received much better support in EEG studies than in fMRI studies (Herrington et al., 2010). This is likely so because asymmetries in approach-avoidance motivation rely on large-scale cortical networks of the EEG type rather than quite localized activity of the fMRI type (Harmon-Jones et al., 2010). Given the present results, and the results of prior asymmetry manipulation studies (Bryden, 1982; Ehrlichman, 1984; Malamed & Larsen, 1977), it is probably safe to say that large-scale asymmetric cortical networks were involved.

We do not wish to suggest that the left hemisphere possesses no capacities for avoidance and that the right hemisphere possesses no capacities for approach. Instead, we emphasize the *relative* nature of specialization in approach versus avoidance motivation of the two hemispheres, as others do (e.g., Maxwell & Davidson, 2007; Schiff & Bassel, 1996). In these terms, at least, we showed that the accessibility of approach-related thoughts was left-lateralized, whereas the accessibility of avoidance-related thoughts was right-lateralized. This division of motivational labor is likely functional in supporting potentially rapid shifts in approach-avoidance motivation in a manner that would be more difficult to accomplish without this division of labor (Davidson, 1999; Harmon-Jones et al., 2010).

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Figure 1

Categorization Speed as a Function of Word Type and Lateral Auditory Side