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Effects of Motivational Cues on Perceptual Asymmetry: Implications for Creativity and Analytical Problem Solving

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In 4 experiments, participants were led to focus on either the prospect of positive outcomes (approach anticipation) or the prospect of negative outcomes (avoidance anticipation) and were subsequently administered behavioral measures of relative hemispheric activation. It was found that approach, relative to avoidance-related anticipatory states, produced greater relative right (diminished relative left) hemispheric activation. Experiment 3 additionally demonstrated that this pattern of activation was reversed when approach and avoidance states were not merely anticipatory but were also emotionally arousing. Finally, Experiment 4 replicated earlier findings demonstrating an influence of approach and avoidance anticipatory states on creativity and analytical problem solving (R. S. Friedman & J. Förster, 2001, 2003) and provided evidence that such effects are mediated by differences in relative hemispheric activation.

In recent years, affective scientists have increasingly sought to elucidate the link between emotion and attention. Although much of the research in this domain of inquiry has examined how transient and chronic variations in affective experience (e.g., state and trait anxiety) moderate attentional receptivity to distinct classes of information (e.g., threat-related words; see Mathews & MacLeod, 1994, for a review), other research has been aimed at exploring how affect influences the structure, as opposed to the content, of attentional selection. This research has been profoundly inspired by the Easterbrook hypothesis (Easterbrook, 1959), the seminal proposition that "arousal acts. . . to reduce the range of cues that an organism uses" (p. 183). This notion, originally expressed in learning-theoretical terms, has been subsequently reinterpreted in the language of cognitive science to suggest that aversive motivational states narrow the scope of perceptual attention, engendering visual focus on local, as opposed to global, details (Burke, Heuer, & Reisberg, 1992; Cacioppo, Berntson, & Crites, 1996). Over the past several decades, this proposition has won empirical support from a range of studies demonstrating that aversive motivational states, such as stress or anxiety, indeed diminish one's ability to detect and process noncentral targets (e.g., Burke et al., 1992; Christianson, 1984; Reeves & Bergum, 1972) and train attention on local, as opposed to global, perceptual features (Derryberry & Reed, 1998; Tyler & Tucker, 1982).

Unfortunately, as a general model of the impact of motivational states on the scope of attention, the Easterbrook hypothesis suffers from at least two significant limitations. First, inasmuch as the hypothesis merely predicts variations in the scope of perceptual attention, it is silent regarding how motivational states may influence performance on *conceptual* tasks (e.g., tests of logical reasoning) that entail little in the way of perceptual processing. Second, insofar as Easterbrook (1959) conceptualized "arousal" as an avoidance-related motivational state, his hypothesis is silent regarding how *approach-related* motivational states may influence attention and thereby task performance.

More recently, Derryberry, Tucker, and their associates (Derryberry & Reed, 1998; Derryberry & Tucker, 1994; Luu, Tucker, & Derryberry, 1998) have developed an integrative conceptual framework that refines and extends the Easterbrook hypothesis in a manner that overcomes the aforementioned shortcomings. In essence, Derryberry and Tucker (1994) have proposed that motivational states not only influence the scope of perceptual attention (i.e., the degree to which attention is trained on central as opposed to peripheral perceptual cues) but also analogously influence the scope of *conceptual attention*. Conceptual attention is defined as internal attention to cognitive representations as opposed to external percepts (see, e.g., Anderson & Neely, 1996). As such, a narrower scope of conceptual attention entails restriction of the activation of mental representations to those with the highest a priori accessibility in the context at hand (e.g., dominant semantic associates to a lexical prime), whereas a broader scope of conceptual attention entails expansion of the range of activation to addi-

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tionally target representations with lower a priori accessibility (e.g., subordinate semantic associates to a lexical prime).

Beyond this, Derryberry, Tucker, and their colleagues have posited that different motivational states differentially influence both the perceptual and conceptual scope of attention. Specifically, in agreement with Easterbrook (1959), Derryberry and Tucker (1994) proposed that avoidance-related states constrict the focus of attention; however, they also proposed that approach-related states broaden the focus of attention, augmenting responsiveness to peripheral cues on the perceptual level and increasing activation of relatively inaccessible mental representations on the conceptual level.

Empirically speaking, a large and growing body of research findings may be viewed as consistent with Derryberry and Tucker's (1994) framework. First, obviously, research put forth in support of the Easterbrook hypothesis may also be seen as supporting Derryberry and Tucker's model inasmuch as their account incorporates the notion that avoidance-related motivational states constrict the focus of perceptual attention. Regarding Derryberry and Tucker's (1994) contention that approach-related states broaden the scope of perceptual attention, in a series of recent studies, Gasper (Gasper, 2004; Gasper & Clore, 2002) has experimentally demonstrated that positive mood (an affective concomitant of approach motivation; Carver, Sutton, & Scheier, 2000; Higgins, 2000; Roseman, 1984) engenders a perceptual focus on global form as opposed to local details. Specifically, participants induced to feel happy, relative to those in a control group, tended to classify figures on the basis of their overall shape as opposed to the shape of their component parts. In another study, Basso, Schefft, Ris, and Dember (1996) analogously discovered that trait happiness was positively related to the tendency to perceive figures on the basis of their global rather than local structure.

Beyond these findings supporting the proposition that motivational states moderate the scope of perceptual attention, a number of findings may also be adduced in support of the notion that avoidance-related states narrow and that approach-related states broaden the scope of conceptual attention. For instance, in a study conducted by Mikulincer, Kedem, and Paz (1990; see also, Mikulincer, Paz, & Kedem, 1990) participants were asked to rate the goodness of fit of a number of exemplars to their respective categories. Mikulincer and his colleagues found that both trait and state anxiety were positively associated with the tendency to reject items from category membership. This suggests that avoidance-related motivational states, such as anxiety, narrow the scope of conceptual attention, preventing activation of relatively inaccessible features shared between fringe exemplars and other category members and thereby reducing the ability to detect similarities between more and less prototypical exemplars (see also, Crowe & Higgins, 1997).

On the flip side of the coin, Isen and Daubman (1984) demonstrated that mild positive mood bolsters the ability to detect similarities between category exemplars. In addition, Murray, Sujan, Hirt, and Sujan (1990) found complementary evidence that positive mood improves performance in detection of both similarities and differences between exemplars. Together, their findings suggest that approach-related states expand the breadth of conceptual attention, enhancing working memory access to shared, as well as to unshared, exemplar features and thereby enhancing flexibility in online categorization. Isen and her associates (see Isen, 2000, for a review) have also amassed an extensive array of evidence suggesting that positive mood bolsters creativity, for instance, by showing that transient happiness facilitates insight problem solving (Isen, Daubman, & Nowicki, 1987) and enhances the unusualness of free associations (Isen, Johnson, Mertz, & Robinson, 1985; see also, Hirt, McDonald, & Melton, 1996). Inasmuch as solving insight problems and generating unusual associations both demand recruiting relatively inaccessible cognitive material from long-term memory (Schooler & Melcher, 1995), these results also support the notion that approach-related motivational states broaden the focus of conceptual attention, enabling internal targeting and activation of relatively remote cognitive representations.

Notably, the aforementioned findings were all obtained using measures or manipulations of the phenomenal experiences associated with approach and avoidance motivational states (e.g., feelings of elation or tension). However, as alluded to earlier, according to Derryberry and Tucker (1994), conscious affective experiences associated with the activation of approach or avoidance motivational states are by no means required for these states to moderate attentional scope. In line with this proposition, Friedman and Förster (2001; Förster, Friedman, Özelsel, & Denzler, 2004) have recently found evidence suggesting that rudimentary cues that are associated with approach and avoidance states, yet which do not themselves elicit conscious affective experience, regulate the scope of attention in a manner consistent with Derryberry and Tucker's (1994) predictions.

In these experiments, participants completed an initial task that was ostensibly unrelated to the dependent measures that followed. Specifically, participants worked through a paper-and-pencil maze in which they had to lead a cartoon mouse from the center of the maze to the exit. In the approach condition, a piece of cheese was depicted as lying at the exit. Friedman and Förster (2001; Förster et al., 2004) posited that by priming the cognitive representation of "seeking reward," completion of this maze would subtly activate the approach motivational system. In the avoidance condition, instead of cheese at the end, a cartoon owl was portrayed as hovering over the maze, ready to capture the mouse if it could not escape the labyrinth. Completion of this maze was posited to prime the cognitive representation of "avoiding punishment," thereby subtly activating the avoidance motivational system (see also Neumann & Strack, 2000). As predicted, Friedman and Förster (2001) found that completion of the cheese maze, relative to the owl maze, enhanced both perceptual disembedding and creative generation, suggesting that approach cues broaden the scope of both perceptual and conceptual attention, bolstering performance on tasks that profit from expanded attentional focus. Friedman and Förster (2003) have also found that the owl maze, relative to the cheese maze, enhances logical problem solving, suggesting that external avoidance cues constrict the scope of conceptual attention, facilitating performance on tasks that profit from restricted conceptual activation. Notably, these effects were all independent of any changes in conscious affective experience, none of which were elicited by the maze manipulations. This is unsurprising, given that maze completion merely involved helping a cartoon rodent obtain cartoon cheese or escape a cartoon owl.

In sum, a prodigious amount of empirical evidence may be seen as consistent with the behavioral predictions of Derryberry and Tucker's (1994) model of motivated attentional tuning.

Of course, this raises the question: What is the mechanism by which these various and sundry behavioral effects are wrought?

On the basis of an earlier theory developed by Tucker and Williamson (1984), Derryberry and Tucker (1994) have argued for the existence of two distinct brain-based arousal systems that serve to regulate the approach of incentives and avoidance of threats, respectively. The *phasic arousal* system is proposed to function in incentive seeking. When incentive cues are detected, consciously or unconsciously, the system is hypothesized to automatically generate a *habituation bias*, expanding the scope of attention and enabling it to flexibly encompass novel as well as initially accessible information. In contrast, the *tonic activation* system is proposed to function in maintaining vigilance under threat. In the face of threat cues, the system is posited to automatically generate a *redundancy bias*, constricting the scope of attention such that initially accessible information is maintained in working memory over time, whereas access to other material is "choked off."

Critically, following Tucker and Williamson (1984), Derryberry and Tucker (1994) posited that the tonic activation system intensifies left hemispheric contributions to cognitive processing, whereas the phasic arousal system intensifies right hemispheric contributions. They suggest that the effects of motivational states on cognition may be understood as involving differential allocation of processing demands by these tonic and phasic arousal systems to the left versus right hemispheres. In support of this model, they have put forth evidence suggesting that trait anxiety (representing chronic activation of an avoidance-related motivational state) is associated with greater left hemispheric activity (Tucker, Antes, Stenslie, & Barnhardt, 1978; Tyler & Tucker, 1982; see also, e.g., Baxter et al., 1987; Buchsbaum, Hazlett, Sicotte, Stein, Wu, & Zetin, 1985; Carter, Johnson, & Borkovec, 1986) and that this enhanced left hemispheric activation is associated with a narrowed focus of perceptual attention (Derryberry & Reed, 1998).

Despite such support, Derryberry and Tucker's (1994) neuropsychological model has not gone unchallenged. In fact, the vast majority of available psychophysiological evidence has demonstrated a pattern of association between motivational states and hemispheric activation that is, at least outwardly, the exact opposite of that predicted by Derryberry and Tucker (1994). Specifically, a large and growing body of research has shown that approach-related affective arousal states (e.g., elation) and personality traits associated with chronic approach-related arousal (e.g., BAS sensitivity and extraversion) are associated with greater relative left as opposed to right hemispheric activation, whereas avoidance-related affective arousal states (e.g., fear) and traits associated with chronic avoidance-related arousal (e.g., BIS sensitivity and neuroticism) are associated with greater relative right than left hemispheric activation (e.g., Davidson & Tomarken, 1989; Davidson, 1992, 1995; see Coan & Allen, 2003; Davidson, Pizzagalli, Nitschke, & Kalin, 2002; for reviews).

Interestingly, as suggested by Derryberry and Reed (1998), a potential reconciliation between Derryberry and Tucker's (1994) predictions and this spate of ostensibly discrepant findings may be derived from the theorizing of Heller (see, e.g., Heller, Koven, & Miller, 2003; Heller & Nitschke, 1998; Heller, Nitschke, Etienne, & Miller, 1997; Nitschke, Heller, Palmieri, & Miller, 1999). According to Heller and her colleagues, anxiety, an avoidance-related motivational state, has two distinct components, a "somatic" component, reflecting the physiological arousal engendered by aversive states (e.g., panic), and a "cognitive" component, reflecting the apprehension (i.e., anticipation of threats) engendered by such states. Critically, Heller and her group have put forth an array of psychophysiological evidence demonstrating that the arousal and apprehension components of anxiety are associated with opposing patterns of relative hemispheric activation (see Heller et al., 2003, for a review) and with anxious apprehension (e.g., worry) associated with greater left (lesser right) hemispheric activity than anxious arousal.

On the basis of Heller's findings, Derryberry and Reed (1998) have posited that an association between avoidance motivational states and greater left than right hemispheric activation may result from the use of manipulations or measures that predominantly tap into the cognitive rather than the somatic aspect of anxiety. According to this reasoning, it is the focus on the prospect of negative outcomes rather than aversive arousal that engenders relative left hemispheric activation, constricting the scope of attention and enhancing analytical problem solving. Derryberry and Reed's proposal also implies that manipulations of approach-related anticipation (i.e., cognitive focus on the prospect of positive outcomes), as opposed to approach-related arousal (e.g., elation), may shift the balance of activation away from the left and toward the right hemisphere, expanding the scope of attention and bolstering creativity.

Although conceptually coherent, the aforementioned proposal faces at least two empirical challenges to its viability. First, as reviewed earlier, a number of studies have purported to demonstrate that states of affective arousal, such as happy or tense mood, influence creative or analytical problem solving (see Isen, 2000, for a review). Such findings suggest that the arousal component of approach or avoidance motivational states is central to producing the cognitive effects predicted by Derryberry and Tucker (1994). However, this conclusion is tenuous because the experimental affective inductions that have been used in past research undoubtedly elicit the cognitive as well as the somatic (arousal-related) aspects of appetitive and aversive motivational states. Given this confound, it may indeed be that the cognitive (anticipation-related) component of these states has mediated the behavioral effects that have been obtained. This possibility is reinforced by the fact that many of the most prominent experimental demonstrations of the influence of mood on cognitive processing have used mild affective inductions (e.g., a gift of chewing gum; Isen, 2000), suggesting that the arousal component of the elicited states may have been relatively faint and that the anticipation component may have therefore held greater sway.

A second challenge to the viability of Derryberry and Reed's (1998) reconciliatory proposal comes from a recent study by Amodio, Shah, Sigelman, Brazy, and Harmon-Jones (2004). Amodio et al. measured individual differences in promotion and prevention regulatory focus (Higgins, 2000). Promotion focus may be conceived of as the tendency to self-regulate with respect to, and thereby cognitively focus on, the prospect of positive outcomes, whereas prevention focus may be viewed as the tendency to self-regulate with respect to, and thereby focus on, the prospect of negative outcomes (Higgins, Shah, & Friedman, 1997; Shah, Higgins, & Friedman, 1998). Interestingly, Amodio et al. found that trait promotion focus was associated with greater left hemispheric activity, whereas trait prevention focus was associated with greater right hemispheric activity. Assuming that the regulatory focus measures used by Amodio et al. truly assess the cognitive or anticipatory component of promotion (i.e., approach) and prevention (i.e., avoidance) motivational states rather than the arousal component of these states, these findings directly contradict the predictions of Derryberry and his colleagues (Derryberry & Reed, 1998; Derryberry & Tucker, 1994).

However, there is reason to question this assumption. The trait promotion focus measure used by Amodio et al. (2004) gauges the time it takes respondents to enter their approach-related goals (i.e., "ideals"), whereas the prevention focus measure they used gauges the time it take them to enter their avoidance-related goals (i.e., "oughts"). Theoretically speaking, the more rapidly respondents enter their approach or avoidance goals, the more accessible they are to them, suggesting that they think about these goals more often and that these goals therefore represent more important concerns (Higgins et al., 1997). However, if approach or avoidance goals are more important, this suggests that individuals with higher trait promotion or prevention scores are *both* more likely to cognitively anticipate positive or negative outcomes *and* to experience the distinct varieties of affective arousal that accompany attempts to approach or avoid such outcomes (Higgins, 2000; Strauman, 1992). As such, it remains unclear from the results of Amodio et al. whether the correlational pattern of hemispheric asymmetry they discovered was driven by the anticipatory or arousal-related aspects of approach and avoidance motivational states. However, inasmuch as the trait measures of regulatory foci used by Amodio et al. indeed assess the importance of approach versus avoidance goals, these measures may be predominantly correlated with "hot" arousal as opposed to "cool" anticipation, because the former is a more diagnostic signal of the urgency of goal pursuit (Metcalfe & Mischel, 1999).

In any case, considering the interpretive ambiguities inherent in the existing research findings, in the present study, we sought to test whether rudimentary approach and avoidance motivational cues, stimuli that prompt individuals to focus on the prospect of positive versus negative outcomes without concomitantly eliciting conscious affective arousal, shift the balance of hemispheric activation in the manner predicted by Derryberry and his associates (Derryberry & Reed, 1998; Derryberry & Tucker, 1994). Specifically, we predicted that approach-related cues, compared with avoidance-related cues, would engender relatively greater right hemispheric (lesser left hemispheric) activation. We assessed this prediction using variants of the cheese and owl maze manipulations described earlier and using two different behavioral measures of relative hemispheric activation, a line-bisection task (Experiments 1, 3, and 4) and a chimeric faces task (CFT; Experiment 2). In Experiment 3, we also assessed whether a manipulation that predominantly elicits affective arousal, as opposed to anticipation, would give rise to the opposite pattern of activation (with approach-related arousal engendering greater left hemispheric [lesser right hemispheric] activation than avoidance-related arousal). Finally, in Experiment 4, we took the opportunity to replicate our findings regarding the influence of these approach and avoidance cues on creativity and analytical problem solving (Friedman & Förster, 2001, 2003) and additionally examined whether these effects were statistically mediated by differences in relative hemispheric activation.

Experiment 1

Method

Overview. In this experiment, motivational cues were manipulated with variants of the cheese and owl maze tasks described previously, then relative hemispheric activation was gauged using a line-bisection task (Milner, Brechmann, & Pagliarini, 1992; see also, Bisiach, Geminiani, Berti, & Rusconi, 1990; Bowers & Heilman, 1980; Bradshaw, Nathan, Nettleton, Wilson, & Pierson, 1987). There are multiple versions of this task. In one type, participants are provided with a series of lines and asked to mark the center of each line. Typically, normative participants commit a leftward error, signifying an attentional bias toward the left visual field (LVF), manifesting itself in attentional neglect of the rightward extension of the line (Milner et al., 1992). Presumably, this nomothetic LVF bias reflects increased relative right hemispheric activation and is engendered by the perceptual-motor demands of the task. However, there is also demonstrable ideographic variation in the extent of this bias, which enables the line-bisection task to serve as a behavioral index of transient as well as of chronic individual differences in relative hemispheric activation (see, e.g., Martin, Shrira, & Startup, in press; Morton, 2003). In another version of the task, participants are presented with centrally bisected lines and asked to indicate which segment of each line is longer (left vs. right). In this forced-choice variant of the line-bisection paradigm, the tendency to view the leftward segments of the centrally bisected lines as longer is posited to reflect an LVF bias (an inadvertent proclivity to neglect the full rightward extension of the lines), signifying greater relative right hemispheric activation (Milner et al., 1992). In the present experiment, we used the latter variant of the test and therefore predicted that completion of the cheese maze, relative to the owl maze, would engender a more pronounced leftward decision bias, suggesting that anticipatory approach, compared with avoidance cues, intensify relative right hemispheric activation (and diminish relative left hemispheric activation).

Participants. Fifty-three undergraduates (25 men, 28 women) at the University of Würzburg (Würzburg, Germany) majoring in disciplines other than psychology were recruited for an experimental session consisting of "diverse psychological tasks." The entire session lasted about 1 hr and participants received DM 12 (about U.S.$8) for their participation.

Procedure. On arrival, participants completed a cheese maze (approach cue condition), an owl maze (avoidance cue condition), or an equivalent maze task depicting neither cheese nor owl (no cue condition). As discussed earlier, the cheese maze task involves helping a cartoon mouse find its way from the center of a maze to a piece of Swiss cheese that is depicted as situated outside the maze. Correspondingly, the owl maze task entails helping the cartoon mouse escape an owl, depicted as hovering over the maze. Again, we posit that these mazes prompt individuals to cognitively focus on (i.e., anticipate) the prospect of attaining incentives or avoiding threats, without eliciting corresponding changes in conscious affective arousal. The mazes were introduced as pretests for an assessment of concentration in children for which the experimenters required an adult sample as a comparison group. Participants were given 2 min to solve these simple paper-and-pencil mazes, which all were completed in the allotted time.

After finishing the mazes, participants were administered a questionnaire gauging their current mood ("How do you feel right now?") on a scale anchored at 1 (*very bad*) and 9 (*very good*) and asked how "happy," "worried," "content," "relaxed," "nervous," "sad," "disappointed," "joyful," "calm," "tense," "depressed," and "relieved" they currently felt ("How _____ do you feel right now?") on a scale anchored at 1 (*not at all*) and 9 (*extremely*). Inclusion of these items allowed for computation of a number of composite affective indices, including indices for positively valenced, negatively valenced, approach-related, and avoidance-related affect. As discussed by Higgins (2000), it is important to distinguish between the valence (i.e., hedonic tone) and motivational orientation (i.e., appetitive vs. aversive) associated with different emotions because these dimensions of classification are orthogonal—confounding them (i.e., by conflating all emotional pleasures and pains, respectively) may obscure or distort detection of affective experiences (e.g., by suggesting that participants experienced no change in positive or negative affect when they did in fact experience such a change, but only for approach- or avoidance-related positive or negative emotions). According to Higgins (e.g., Higgins et al., 1997), whereas “happy,” “content,” and “joyful” reflect approach-related positive emotions, “calm,” “relieved,” and “relaxed” reflect avoidance-related positive emotions. Correspondingly, whereas “sad,” “disappointed,” and “depressed” are approach-related negative emotions, “nervous,” “worried,” and “tense” are avoidance-related negative emotions. The posttask survey also included a measure of expected task performance (“How well do you think you will perform on the task?”), on a Likert scale anchored at 1 (*very poorly*) and 9 (*very well*), and a measure of prospective task enjoyment (“How much do you think you will enjoy the task?”), on a scale anchored at 1 (*not at all*) and 9 (*very much*).

Participants were next asked to complete a test of perception accuracy that would be conducted on the computer. Here, participants were presented with a series of 54 lines, each 20 cm in length and prebisected with vertical marks 10 mm in length. Participants were asked to choose which part of each bisected line was longer and to indicate their decisions (i.e., “left” vs. “right”) on a prepared response sheet. Altogether, participants were randomly presented with 18 centrally bisected lines, 18 lines that were bisected 5 mm left of center, and 18 lines that were bisected 5 mm right of center. The noncentrally bisected lines were included to preserve the credibility of the cover story (cf. Milner et al., 1992).

After completing the line-bisection task, participants were administered another questionnaire, which again gauged their current mood and emotional states. This survey also included a single item assessing perceived task difficulty (“How difficult was the task?”) on a scale anchored at 1 (*not at all difficult*) and 9 (*very difficult*). Finally, participants were probed for suspicions, debriefed, paid, and released. Participants expressed no suspicions that were in any way relevant to our hypothesis.

Results and Discussion

We predicted that approach-cued participants would make more leftward judgments on the centrally bisected lines than control group participants, who we predicted would make more leftward judgments than those in the avoidance group. To test this, we assigned leftward judgments a value of -1 and rightward judgments a value of $+1$ and averaged these values for the 18 critical (centrally bisected) lines to create an overall bias index. Given the aforementioned coding scheme, lower average values are associated with an increased bias toward viewing leftward line segments as longer and thereby with increased relative right (decreased relative left) hemispheric activation.

Bias scores were submitted to a one-way analysis of variance (ANOVA) by using cue (approach [cheese maze] vs. control [neutral maze] vs. avoidance [owl maze]) as a predictor variable. On average, participants exhibited a rightward bias (M = 0.15); however, in line with predictions, this bias was moderated by cue. Specifically, participants in the avoidance cue condition ($M = 0.36$) demonstrated a greater rightward judgment bias than those in the control ($M = 0.13$) and approach cue conditions ($M = -0.04$), $F(2, 50) = 8.79$, $p < .01$. Supplemental planned comparisons revealed that the judgment bias exhibited by avoidance-cued participants was significantly different from that exhibited by control participants, $t(50) = 2.36$, $p < .03$, and that the bias exhibited by approach-cued participants was marginally different from that exhibited by those in the control group, $t(50) = 1.76$, $p < .09$. In line with the predictions of Derryberry and his colleagues (Derryberry & Reed, 1998; Derryberry & Tucker, 1994), these results suggest that approach, relative to avoidance, motivational cues engender greater relative right (lesser relative left) hemispheric activation when the cues predominantly influence the anticipation of positive versus negative outcomes, as opposed to when they primarily influence positive versus negative emotional arousal.

To rule out the possibility that the effect of motivational cuing on relative hemispheric activation was mediated by the influence of the maze manipulations on expected task performance, expected task enjoyment, or subjective task difficulty, we performed a series of supplementary analyses of covariance (ANCOVAs), separately entering each of our Likert measures of these variables as statistical covariates. In all of these analyses, the effect of cue remained equally reliable, suggesting that it was not mediated by these measures. (These measures were not reliably influenced by the maze manipulations, all Fs < 1.)

In addition, although many previous studies have failed to reveal any reliable influence of the maze manipulations on affective experience (Friedman & Förster, 2001, 2003), we still opted to conduct a series of analyses aimed at ruling out the possibility that the effect of motivational cuing on relative hemispheric activation was mediated by the influence of the maze manipulations on transient emotional arousal. Here, we first computed a number of composite affective indices: (a) pre- and posttask positive affect indices representing the average of participants’ responses to the six positive emotional state probes; (b) pre- and posttask negative affect indices representing the average of participants’ responses to the six negative emotional state probes; (c) pre- and posttask indices of approach-related affect (see Carver, Sutton, & Scheier, 2000; Higgins, 2000; Roseman, 1984), computed by averaging participants’ responses to the three emotion probes theorized to gauge affective experience associated with successful approach motivation (“content,” “happy,” “joyful”) and their (reverse-scored) responses to the three probes theorized to gauge affective experience associated with unsuccessful approach motivation (“sad,” “disappointed,” and “depressed”); (d) pre- and posttask indices of avoidance-related affect (see Carver et al., 2000; Higgins, 2000; Roseman, 1984), computed by averaging participants’ responses to the three emotion probes theorized to gauge affective experience associated with successful avoidance motivation (“relaxed,” “calm,” and “relieved”) and their (reverse-scored) responses to the three probes theorized to gauge affective experience associated with unsuccessful avoidance motivation (“worried,” “nervous,” and “tense”); and (e) difference scores representing pre- versus posttask changes in self-reported mood, as well as positive, negative, approach-related, and avoidance-related emotions. After computing these composite indices, we conducted another series of ANCOVAs, separately entering each index as a statistical covariate. In all analyses, the main effect of cue remained reliable, suggesting that it was not mediated by conscious affective experience. In line with previous findings, and consistent with the proposition that the cue manipulation affected anticipatory rather than arousal-related components of motivational states, there was also no evidence that maze completion independently influenced mood or emotions (all Fs < 1).

Together, the results of Experiment 1 support the notion that anticipatory approach, relative to avoidance, motivational cues engender greater relative right hemispheric activation. In Experiment 2, we sought to replicate these findings by using a different measure of relative activation, the CFT (Compton, Fisher, Koenig, McKeown, & Muñoz, 2003; Levy, Heller, Banich, & Burton, 1983a, 1983b; Voelz, Gencoz, Gencoz, Pettit, Perez, & Joiner, 2001).

Experiment 2

Method

Participants. Twenty undergraduates and high school students (10 young men, 10 young women) from the Bremen (Germany) area majoring in disciplines other than psychology were recruited for a study consisting of "diverse psychological tasks." The session was conducted at the International University Bremen and lasted about 2 hr. Participants were tested individually and received €14 (approximately U.S.$18) for participation. Two participants had to be excluded because their responses were not stored by the computer.

Procedure. On arrival, participants spent approximately 1 hr completing several tasks unrelated to the experiment. Afterward, participants completed each of the three maze manipulations (cheese, owl, and neutral) in one of six randomly assigned orders (representing every possible presentation sequence). Thus, in contrast with Experiment 1, participants were administered the cue manipulation in a within-participant as opposed to between-participants design. The mazes were introduced with the cover story that we were pretesting them for use in an intelligence test for children and required an adult control group. Following completion of each maze, participants completed a variant of the CFT, which was presented as an unrelated task, conducted by a different research team. The task was introduced as a means of validating a new test of dexterity and speed of perception and response. In the task, participants were presented on the computer with 40 pictures of faces. Twenty of these faces displayed either sad (10) or happy (10) expressions and were included as fillers. The remaining 20 faces were chimeric, in which the left and right sides of each face displayed different emotional expressions (10 displayed a happy expression on the left and a sad expression on the right, 10 displayed the obverse). Each face appeared on screen for 200 ms and participants were asked to judge as quickly as possible whether each looked happy or sad. The tendency to perceive the chimeric faces as having the expression displayed on the left side is posited to indicate an LVF bias, suggesting increased relative right hemispheric activation. Participants responded to each face with the "1" and "2" keys on the German keyboard using their free hands. These keys were fitted with either yellow or blue labels, on which was printed either *happy* or *sad*. The positions and contents of the labels were counterbalanced between participants. Between each of three blocks (i.e., each pairing of a maze with a set of CFT trials), there was a 10-min filler task in which participants were to rate the frequency with which they use each of a set of words. (This task was included to provide word frequency norms for an unrelated study.) The fact that there were three different blocks was explained to participants as a means of increasing their motivation and reducing boredom and fatigue.

Immediately preceding completion of each maze, as well as after completion of the final block of trials, participants were administered a questionnaire gauging their current mood ("How do you feel right now?") on a scale anchored at 1 (*very bad*) and 9 (*very good*) and asked how "happy," "worried," "relaxed," "nervous," "sad," "disappointed," "joyful," "calm," "tense," "depressed," and "relieved" they currently felt ("How do you feel right now?") on a scale anchored at 1 (*not at all*) and 9 (*extremely*). The survey also included a measure of expected task performance ("How well do you think you will perform on the task?"), on a Likert scale anchored at 1 (*very poorly*) and 9 (*very well*), and a measure of prospective task enjoyment ("How much do you think you will enjoy the task?"), on a scale anchored at 1 (*not at all*) and 9 (*very much*). After completing the entire session, participants were probed for suspicions, debriefed, paid, and released. Participants expressed no suspicions that were in any way relevant to our hypothesis.

Results and Discussion

We predicted that participants in the approach, relative to the control, group would make more leftward judgments regarding the emotional expressions displayed by the chimeric faces, whereas those in the control group would make more leftward judgments than avoidance-cued participants. To test this, we again assigned leftward judgments a value of -1 and rightward judgments a value of $+1$ and averaged these values for the 20 chimeric faces presented in each of the three blocks to create an overall bias index. Scores on this index were submitted to a repeated-measures ANOVA, including cue (approach [cheese maze] vs. control [neutral maze] vs. avoidance [owl maze]) as a within-participant factor. Consistent with predictions, perceptual asymmetry was again moderated by cue. Specifically, completion of the approach maze ($M = -0.09$), led to more of an inclination toward leftward judgments than did completion of the control ($M = 0.01$) or avoidance mazes ($M = 0.15$), $F(2, 17) = 4.55$, $p < .02$. Planned comparisons revealed that the mean judgment bias exhibited following avoidance cuing was significantly different from that exhibited following control cuing, $t(50) = 2.06$, $p < .05$. The planned comparison between the approach and control conditions was not significantly different from that exhibited following control cuing, $p > .17$, although it was significantly different from the mean of the control and avoidance cuing conditions combined, $t(50) = 2.78$, $p < .01$. Overall, these findings further support our contention that avoidance, relative to approach, motivational cues engender greater relative left (lesser relative right) hemispheric activation.

As in the preceding experiments, to rule out the possibility that the effect of motivational cuing on relative hemispheric activation was mediated by the influence of the manipulations on transient affective arousal, we conducted a series of ANCOVAs, separately entering as statistical covariates pre- and posttask mood indices as well as pre- and posttask positive, negative, approach-related, and avoidance-related composite affect indices (computed for each of the four waves of measurement). In all analyses, the main effect of cue remained reliable, suggesting that it was not mediated by conscious emotional experience. (Again, there was no evidence that the maze manipulations reliably influenced mood or emotional states.) Supplementary analyses also failed to reveal any effects of gender, left- or right-handedness, the color or position of the response keys, or the position of the emotional expressions displayed by the chimeric faces.

In sum, using two different dependent measures of relative hemispheric activation, the results of the first two experiments provided convergent support for the notion that anticipatory approach, relative to avoidance-related motivational cues, produce greater relative activation of the right hemisphere (lesser activation of the left hemisphere). In Experiment 3, we sought to replicate this basic effect, this time using another version of the line-bisection task. Moreover, we added a new variant of the maze task that would lead participants to experience positive or negative emotional arousal as opposed to merely focusing them on the prospect of positive or negative outcomes. As discussed earlier, a prodigious body of evidence has been put forth suggesting that approach-related affective arousal states and personality traits associated with chronic approach-related arousal are associated with greater relative left, as opposed to right, hemispheric activation, whereas avoidance-related affective arousal states and traits associated with chronic avoidance-related arousal are associated with the obverse pattern of activation (see Coan & Allen, 2003; Davidson et al., 2002, for reviews). In light of these robust findings, with regard to our newly appended experimental condition, we predicted that approach, relative to avoidance-related, emotional arousal would be associated with increased left (decreased right) hemispheric activation (a pattern opposite that presumably engendered by mere anticipation of appetitive or aversive outcomes).

Experiment 3

Method

Participants. Ninety-six undergraduates (42 men, 54 women) at the International University Bremen majoring in disciplines other than psychology were recruited for an experimental session consisting of "diverse psychological tasks." The entire session lasted about 2 hr, and participants received €20 (approximately U.S.$26) for their participation. Two participants had to be excluded because of data loss.

Procedure. Participants first completed several tasks unrelated to the experiment at hand. After approximately 15 min, they were administered either a cheese or an owl maze task followed by the line-bisection task. For the maze task, half of the participants followed the instructions presented in Experiment 1. This group constituted the anticipation condition. The other group was asked to look at the maze and write a vivid story from the perspective of the mouse. More specifically, in the approach arousal condition, participants were asked to look at the cheese maze and to imagine the mouse finding the way to the cheese, getting closer to it, and eventually eating it. The title of the story was to be "The Happiest Day in the Life of the Mouse." In the avoidance arousal condition, participants were asked to look at the owl maze and to imagine that the mouse attempts to escape from the owl and eventually gets caught, killed, and eaten. The title of the story was to be "The Terrible Death of the Mouse." In the arousal control condition, participants were exposed to a maze depicting neither cheese nor an owl and were asked to write a story entitled "A Typical Day for the Mouse." The task was framed as an attempt to determine whether people can take the perspective of others and imagine their circumstances. Participants were given 10 min to write the story. All participants had to answer three questions before either completing the maze (anticipation condition) or writing the story (arousal condition): "How do you feel right now?," on a scale anchored at 1 (*very bad*) and 9 (*very good*); "How well do you think you will perform on the task?," on a scale anchored at 1 (*very poorly*) and 9 (*very well*); and "How much do you think you will enjoy the task?," on a scale anchored at 1 (*not at all*) and 9 (*very much*). To assess changes in emotional arousal, after participants completed the maze or writing the story, we again checked mood using the probes above.

Next, participants completed the line-bisection task of perceptual asymmetry, which was introduced as an independent, unrelated activity. Here, participants were told that they would be asked to mark the center of each of a series of lines that would be printed out in hard copy. Participants used writing implements held in their hands (right or left was not specified) to bisect 22 lines of different lengths (in cm, 11.5, 9.0, 11.5, 11.5, 14.3, 10.8, 13.4, 10.5, 11.5, 13.5, 10.3, 14.3, 9.4, 12.8, 12.3, 12.3, 12.3, 11.9, 10.4, 11.9, 13.4, 13.8) that were distributed across two pages of paper. Right- or left-handedness was subsequently assessed by self-report.

Finally, all participants were given a questionnaire that included the following items: "How did you like working on the task?" anchored at 1 (*I did not like it*) and 9 (*I liked it a lot*); "How difficult was the task?," anchored at 1 (*very easy*) and 9 (*very difficult*); and "How important was the study?," anchored at 1 (*very unimportant*) and 9 (*very important*). After completing another set of unrelated tasks, participants were probed for suspicions, debriefed, paid, and released. Participants expressed no suspicions that were in any way relevant to our hypothesis.

Results and Discussion

Manipulation check. We expected that in the anticipation condition (standard maze task), cue (approach vs. control vs. avoidance) would have no influence on emotional arousal, whereas in the arousal condition (writing task), participants in the approach group would feel more positive than those in the control group, who would feel more positive than those in the avoidance group (signifying a successful emotion induction). As shown by the pattern of mean posttask mood ratings (see Figure 1), these predictions were supported. The reliability of this pattern was confirmed by subjecting posttask mood ratings to a 3 (cue) × 2 (task: anticipation vs. arousal) ANOVA, which revealed only the predicted Cue × Task interaction, $F(2, 88) = 3.88$, $p < .03$. Separate analyses of variance within each task group further confirmed that cue had significantly influenced emotional experience in the arousal condition, $F(2, 45) = 9.48$, $p < .01$, yet had no influence on self-reported affective arousal in the anticipation condition, $F < 1$.

Perceptual asymmetry. To reiterate, within the anticipation group, we predicted that approach-cued participants would exhibit more pronounced leftward bisection errors, demonstrating greater relative right (lesser relative left) hemispheric activation than those in the control group, who would exhibit more pronounced leftward errors than avoidance-cued participants. In contrast, for the arousal group, we predicted the exact obverse. To assess these predictions, we measured the deviations of participants' bisection marks from the lines' true midpoints. These values were averaged across the 22 lines to create an overall bisection error index with negative values indicating a leftward bias (i.e., a mean leftward deviation from center, with greater deviations signifying greater relative right hemispheric activation).

As shown in Figure 2, the pattern of bisection errors accorded with predictions, as more formally revealed by the results of a Cue × Task ANOVA, which indicated a significant interaction between the experimental factors, $F(1, 90) = 23.12$, $p < .01$. Separate analyses of variance within each task group revealed that the effect of cue within the anticipation group alone was reliable, $F(2, 43) = 5.97$, $p < .01$, as was its (obverse) effect within the arousal group, $F(2, 45) = 5.44$, $p < .01$. To further decompose these effects, we also computed planned comparisons within task groups. Within the anticipation condition, these revealed that the avoidance group demonstrated reliably greater relative left hemispheric (lesser relative right hemispheric) activation than did the control, $t(88) = 2.04$, $p < .05$, and approach groups, $t(88) = 3.31$, $p < .01$. In contrast, within the arousal condition, these analyses revealed that the avoidance group demonstrated marginally greater relative right hemispheric (lesser relative left hemispheric) activation than did the control group, $t(88) = 1.81$, $p < .08$, and significantly greater relative right hemispheric activation than did the approach group, $t(88) = 3.40$, $p < .01$. Overall, consistent with the ideas of Heller (e.g., Heller et al., 2003) and Derryberry and Reed (1998), these results suggest that the mere anticipation of positive versus negative outcomes engenders a pattern of relative hemispheric activation that is the obverse of that associated with positive versus negative affective arousal.

Supplementary analyses. As a final step in our analyses, we recomputed all aforementioned analyses, entering self-report measures of pretask mood, task liking, task difficulty, and the subjective importance of the study as statistical covariates. All effects at issue remained reliable after inclusion of these auxiliary predictors. However, when analyzing the effects of cue within each task group separately, we found that the inclusion of mood as a covariate greatly reduced the reliability of the cue effect within the arousal group (i.e., the p was increased approximately sevenfold) yet had no influence on the reliability of this effect within the anticipation

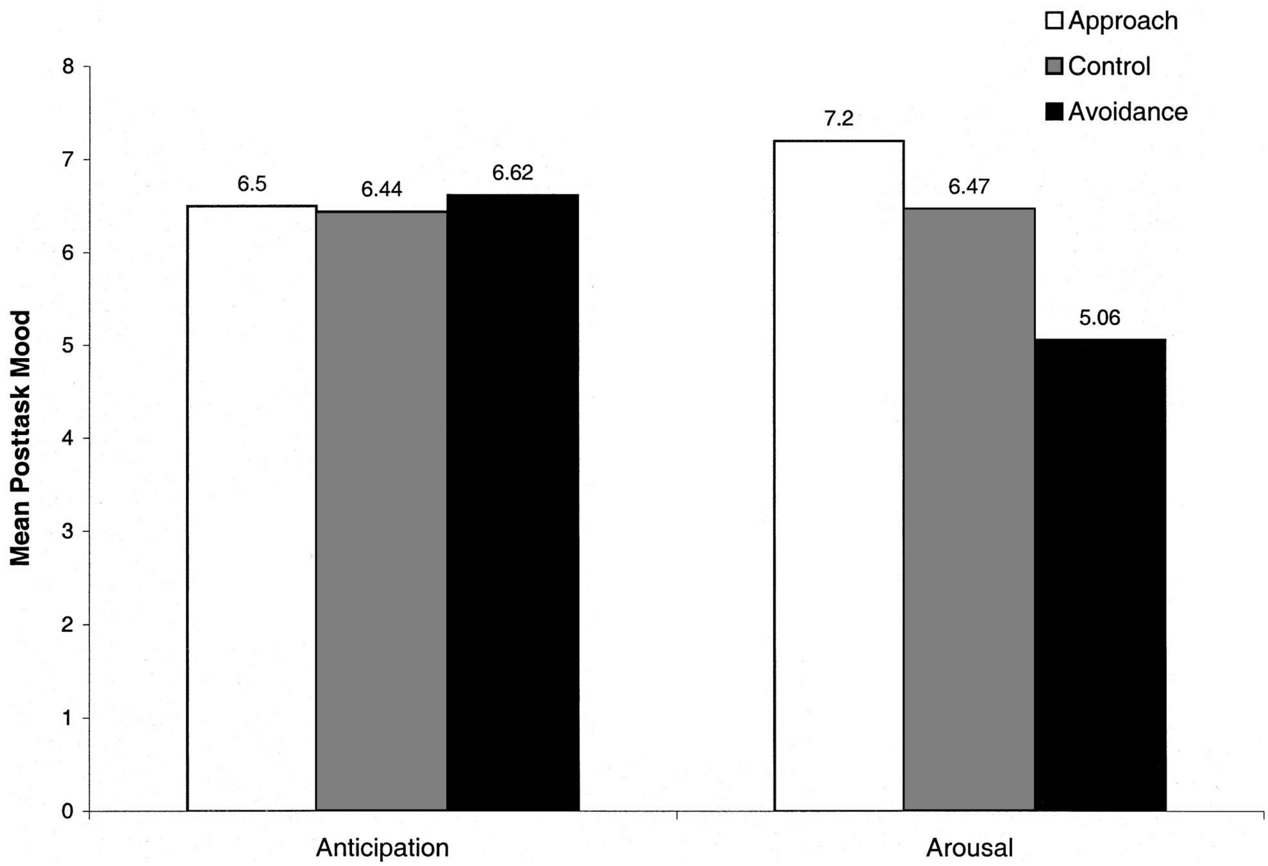

Figure 1. Mean posttask mood, indexed by cue and task.

group. Consistent with predictions, this suggests that emotional arousal may have at least partially mediated the effect of cue on hemispheric activation in the arousal condition alone.[1]

In sum, convergent with the findings of the first two experiments, the results of Experiment 3 suggest that approach- and avoidance-related anticipation give rise to a different pattern of hemispheric activation than that typically associated with approach- and avoidance-related arousal. The nature of this differential pattern is consistent with the predictions of Derryberry and his colleagues (Derryberry & Reed, 1998; Derryberry & Tucker, 1994). This suggests that the attentional effects of motivational states hypothesized by Derryberry and Tucker (1994) may indeed be mediated by differential hemispheric activation, with anticipatory approach states engendering greater relative right (lesser relative left) hemispheric activation, bolstering creativity, and anticipatory avoidance states engendering greater relative left (lesser relative right) hemispheric activation, bolstering analytical problem solving. We attempted to test this mediational model in Experiment 4.

Experiment 4

Method

Participants. Participants were 103 German-speaking train passengers, railway station visitors, and visitors to movie theaters (49 men, 54 women), ranging in age from 18 to 82 years, with an average age of 42.04 years. Participants were approached at several train stations (Bremen, Cologne, and Würzburg), in several trains (from Bremen to Cologne, from Cologne to Würzburg, and from Würzburg to Bremen) and in the waiting rooms of movie theaters in Cologne and Würzburg and asked to participate in a "university study involving several unrelated psychological tasks." They were tested individually and received a chocolate bar for participation.

Procedure. Participants received a booklet explaining to them that for the sake of cost efficiency we were conducting various tests within a single session that would last about 10 min. Afterward, they completed a procedure that was identical to that of Experiment 1 with two major exceptions: first, the forced-choice line-bisection task was presented in paper-and-pencil format, with lines printed in a fixed random order and with responses ("left" vs. "right") to be indicated below each line; second, after completion of the line-bisection task, participants were administered a creativity task, followed by an analytical reasoning task. Both tasks had been previously used by Friedman and Förster (2000, 2001, 2002) to demonstrate the influence of motivational cues on creative and analytical problem solving. In the creativity task, participants were simply asked to list as many creative uses for a brick as they could think of. They were told to avoid mundane solutions or solutions that were virtually impossible. Participants were stopped after 1 min and given 5 min to solve a series of

[1] To formally test for mediation, we conducted a supplementary path analysis. Unfortunately, according to this analysis, mood did not reliably mediate the relationship between cue and hemispheric activation. Of course, given the apparent strength of the mood induction, collinearity with the manipulation check, along with a relatively low sample size within the arousal group alone, may have undermined the ability to properly estimate mediation in this case.

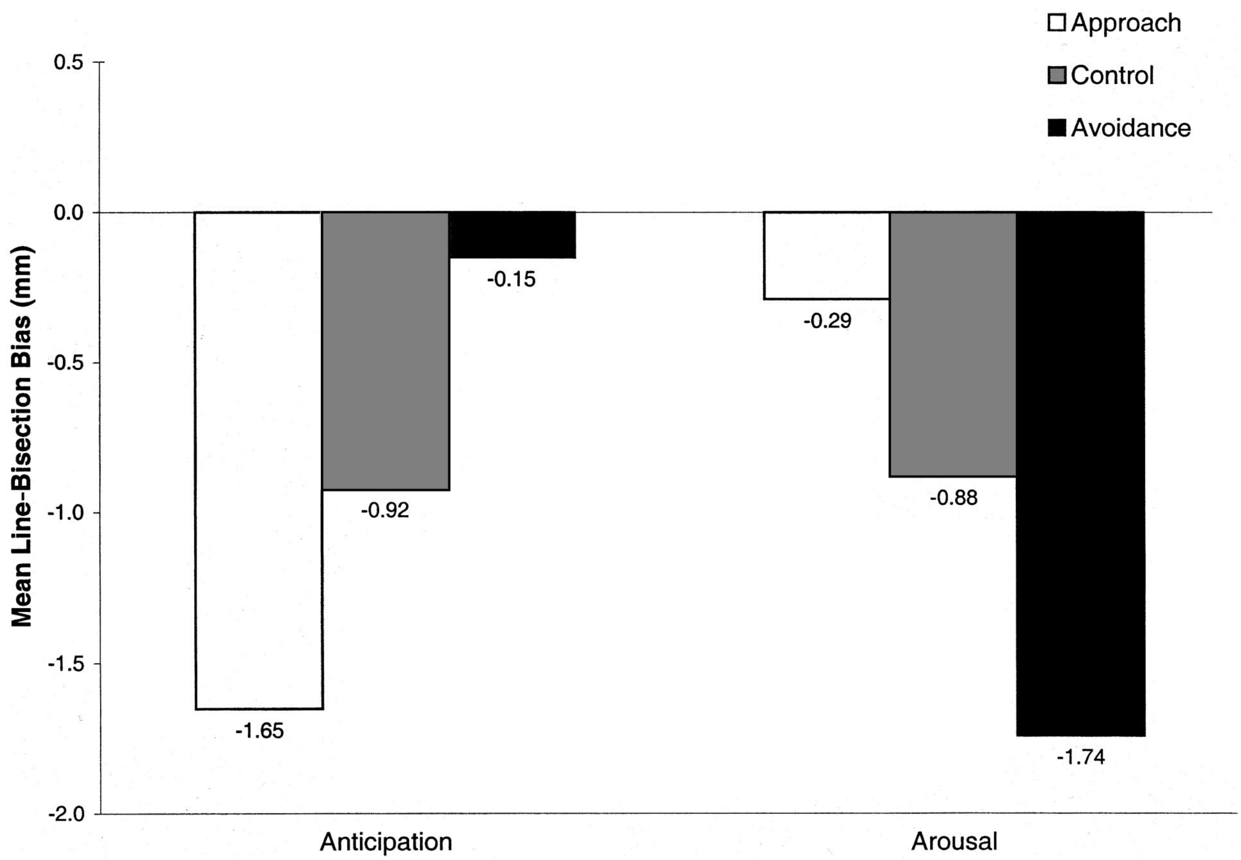

Figure 2. Mean line-bisection bias, indexed by cue and task.

four logical reasoning problems from the Graduate Record Examination (GRE) Analytical test, translated into German. These problems involve evaluating the truth value of a number of propositions given an initial set of basic facts. As discussed earlier, unlike creativity tasks, the latter problems may be seen as benefiting from a constriction of the scope of conceptual attention inasmuch as they demand concentrating on, as opposed to "going beyond" the information given. After completing the entire procedure, participants were probed for suspicions, debriefed, given a chocolate bar, and released. Participants expressed no suspicions that were in any way relevant to our hypothesis.

Results and Discussion

Line bisection. As in Experiment 1, we predicted that participants in the approach group would make more leftward judgments (fewer rightward judgments) on the centrally bisected lines than those in the control group, who would make more leftward judgments than those in the avoidance group. To test this prediction, we submitted the mean bias index (calculated in the same fashion as in Experiment 1) to a one-way ANOVA using cue (approach [cheese maze] vs. control [neutral maze] vs. avoidance [owl maze]) as a predictor variable. Once again, consistent with predictions, a leftward bias was demonstrated by participants in the approach cue condition ($M = -0.23$). This bias was less pronounced in the control condition ($M = -0.03$) and was reversed among avoidance-cued participants ($M = 0.23$), $F(2, 100) = 12.09$, $p < .01$. Planned comparisons revealed that the difference between the approach and control conditions was statistically reliable, $t(100) = 2.06$, $p < .05$, as was the difference between the avoidance and control conditions, $t(100) = 2.87$, $p < .01$. Supplementary ANCOVAs also revealed no effects of age, gender, expected task performance, expected task enjoyment, or transient affective experience when the indices representing these variables were included as covariates. (There were no main effects or interactions involving any of these variables.)

Creativity. To objectively assess the creativity of the brick-uses generated by participants, we asked 10 independent scorers to rate the creativity of each of the different uses that participants generated on a 9-point scale ("How creative is this response?") anchored at 1 (*very uncreative*) and 9 (*very creative*) with an explicit midpoint of 5 (*neither creative nor uncreative*). These ratings were used to calculate a mean creativity score for each participant (summed ratings for each response tendered divided by the total number of responses). In addition, a measure of the total number of creative responses was computed by summing the number of responses that exceeded the midpoint (5) of the creativity scale.

Before analyzing creativity scores, we first examined the between-groups difference in the total number of responses tendered. Consistent with previous findings (Friedman & Förster, 2001, 2002), an ANOVA revealed that cue had no reliable effect on the total number of uses for a brick listed by participants ($M_{\text{approach}} = 7.06$; $M_{\text{control}} = 6.77$; $M_{\text{avoidance}} = 6.54$), $F < 1$, suggesting that motivational cues do not reliably influence the sheer volume of production. To assess the hypothesis that approach, relative to avoidance, cues enhance creativity, we then submitted the mean creativity score to an ANOVA, using cue as a predictor. In line with predictions, participants who completed the approach (cheese) maze demonstrated higher creativity (M = 5.30), than those in the control group (M = 4.93), who demonstrated higher creativity than those who completed the avoidance (owl) maze (M = 4.47), $F(2, 100) = 11.42$, $p < .01$. Both the planned comparison between the approach and control groups, $t(100) = 2.13$, $p < .04$, and that between the avoidance and control groups, $t(100) = 2.68$, $p < .01$, were statistically reliable. An ANOVA substituting total number of creative responses as a dependent variable revealed an analogous pattern ($M_{\text{approach}} = 4.70$; $M_{\text{control}} = 3.69$; $M_{\text{avoidance}} = 2.66$), $F(2, 100) = 9.49$, $p < .01$ (all planned comparisons, $p < .05$).

Given the reliable differences between experimental groups in the present experiment, we proceeded to conduct a series of path analyses aimed at assessing whether the aforementioned effects of motivational cues on creativity were statistically mediated by the influence of these cues on relative hemispheric activation. Again, Derryberry and Tucker (1994) have proposed that approach motivational states bolster creativity by shifting activation toward right lateralized systems that broaden the scope of conceptual attention, permitting access to innovative alternatives and the material required to construct them. To test this proposal, we followed the guidelines of Kenny, Kashy, and Bolger (1998) for establishing mediation and conducted a series of multiple regression analyses, examining whether the differences in creativity between the approach and control groups and between the avoidance and control groups remained reliable after statistically controlling for line-bisection bias. In these analyses, both contrasts at issue were reduced to nonsignificance by the inclusion of the bias index as a covariate, whereas this index continued to reliably predict variation in creativity, $\beta = -.238$, $t(99) = 2.42$, $p < .02$. In line with Derryberry and Tucker's (1994) model, this suggests that the effects of motivational cues on creative generation were mediated by relative hemispheric activation. This conclusion was further supported by the results of a Sobel test (Sobel, 1982), that used cue (approach vs. control vs. avoidance) as the predictor, $z = 2.81$, $p < .01$.

Analytical problem solving. To assess the complementary hypothesis that avoidance, relative to approach, cues facilitate analytical problem solving, we submitted the mean number of GRE Analytical problems solved (out of 4) to an ANOVA, using cue as a predictor. Consistent with predictions, and in line with previous findings (Friedman & Förster, 2001, 2003), avoidance-cued participants solved more GRE problems (M = 2.43) than those in the control condition (M = 1.77), who solved more GRE problems than approach-cued participants (M = 1.12), $F(2, 100) = 8.33$, $p < .01$. Planned comparisons between the avoidance and control groups, $t(100) = 2.08$, $p < .04$, and between the approach and control groups, $t(100) = 2.03$, $p < .05$, were both statistically reliable. Multiple regression analyses analogous to those conducted on the mean creativity index revealed that the aforementioned contrasts were significantly mediated by line-bisection bias. More specifically, the differences between the avoidance and control groups and between the approach and control groups were reduced to nonsignificance by the inclusion of the bias index as a covariate, whereas the index continued to reliably account for variation in analytical problem solving, $\beta = .368$, $t(99) = 3.80$, $p < .01$. Further support for mediation was again drawn from the results of a Sobel test, which used cue (approach vs. control vs. avoidance) as the predictor, $z = 3.02$, $p < .01$. Consistent with the theorizing of Derryberry and Tucker (1994), these findings suggest that (anticipatory) avoidance motivational cues may bolster analytical reasoning by shifting activation toward left lateralized systems that narrow the scope of conceptual attention, training focus on the information at hand and excluding unrelated material that may foster distraction.

General Discussion

In this study, we tested the hypothesis, derived from the theorizing of Derryberry and his colleagues (Derryberry & Reed, 1998; Derryberry & Tucker, 1994; see also, Luu et al., 1998) that rudimentary approach, relative to avoidance, motivational cues engender relatively greater right hemispheric (lesser left hemispheric) activation. This hypothesis was supported by the results of four experiments, which used multiple variants of two different behavioral measures of relative hemispheric activation, a line-bisection task (Experiments 1, 3, and 4) and a chimeric faces task (Experiment 2). Consistent with earlier findings (Friedman & Förster, 2000, 2001, 2002, 2003), we also found evidence that approach, relative to avoidance, cues bolster creativity and that avoidance, relative to approach, cues bolster analytical problem solving. Moreover, we collected evidence that the facilitative influence of approach cues on creative generation is mediated by increased relative right (diminished relative left) hemispheric activation and that the facilitative influence of avoidance cues on analytical problem solving is mediated by increased relative activation of the left (diminished relative activation of the right) hemisphere (Experiment 4).

Critically, consistent with the speculations of Derryberry and Reed (1998), in Experiment 3, we demonstrated that the pattern of activation predicted by Derryberry and Tucker (1994) is only limited to anticipatory motivational states, states constituting a cognitive focus on the prospect of positive or negative outcomes (cf. Higgins, 2000). When full-blown approach- or avoidance-related emotional experiences are elicited, these affective arousal states appear to reverse the pattern of hemispheric activation detected under conditions of mere outcome anticipation. This suggests that downstream effects of motivational states on attention, memory, and problem solving (including creativity) may rely heavily on the extent to which the anticipatory versus arousal components are rendered predominant. Ironically, it follows from this reasoning that many of the effects of emotion on cognition may result from the "cold" cognitive aspect of emotion states (e.g., their regulatory focus; Higgins, 2000; or their underlying appraisal themes; Lerner & Keltner, 2000) rather than their "hot" arousing aspect (the aspect that is intuitively most representative of emotional phenomena).

Of course, the conclusiveness of our account is tempered by the fact that our results are potentially inconsistent with those of a number of previous studies. As discussed earlier, a great deal of research has been put forth suggesting that emotional arousal (e.g., happiness) influences creativity and analytical reasoning in a manner we have attributed to the effects of mere outcome anticipation (Isen, 2000; cf. Crowe & Higgins, 1997). However, we argue that many of these influential studies implemented extremely weak affective inductions, suggesting that they may have inadvertently manipulated the cognitive anticipation of positive or negative outcomes rather than positive or negative emotional arousal. Unfortunately, the present study offers no direct evidence to back this contention; therefore, additional research will be required in which the effects of anticipation and arousal on creative and analytical problem solving are pitted against one another experimentally. It would be particularly fascinating if this work revealed that *both* arousal and anticipation influence creativity and analytical reasoning yet do so with regard to distinct facets of these general abilities and/or in a fashion that is differentially moderated by situational factors. Moreover, inasmuch as nearly all motivational manipulations presumably elicit both arousal and anticipatory states, the nature of the *interaction* between these components remains an open question: Which component will attain dominance? Is dominance absolute (e.g., with arousal perpetually winning out), or is it somehow contextually or ideographically moderated (e.g., by variance in attention to feelings)?

As mentioned previously, the present findings may also be seen as inconsistent with the results of a recent study conducted by Amodio et al. (2004). To reiterate, Amodio et al. adduced evidence that trait promotion focus is associated with greater left hemispheric activity and that trait prevention focus is associated with greater right hemispheric activity. Therefore, to the extent that the regulatory focus measures they used predominantly gauge the tendency to anticipate either positive or negative outcomes, their results directly contradict our findings. However, as we alluded to earlier, the "strength of guide" measure implemented by Amodio et al. was not developed to directly assess such anticipatory tendencies but rather to assess the magnitude of chronic concerns with approach- and avoidance-related goals (Higgins et al., 1997; Shah et al., 1998). Conceptually speaking, individuals holding greater concerns with approach or avoidance goals should be more likely to anticipate positive or negative outcomes *as well as* more likely to experience the distinct varieties of affective arousal that accompany attempts to approach or avoid such outcomes. If anything, affective arousal may more directly reflect the importance or urgency of approach- or avoidance-related concerns than does mere anticipation of positive versus negative outcomes, suggesting that the strength of guide measure should be more robustly associated with the former than the latter. If so, the correlations between promotion and prevention strength of guide and hemispheric asymmetry reported by Amodio et al. would be entirely compatible with our results. Unfortunately, there is currently no evidence bearing on the correlation between the strength of guide measure and well-validated measures of either trait anticipation (e.g., the Penn State Worry Questionnaire; Meyer, Miller, Metzger, & Borkovec, 1990) or trait arousal (e.g., the Anxious Arousal subscale of the Mood and Anxiety Symptom Questionnaire; Clark & Watson, 1991). Therefore, assessment of the proposed reconciliation between the current findings and those of Amodio et al. must await the results of additional research.

Assessing Absolute Activation

Although the results of the present study are consistently supportive of our hypotheses, the methodologies used to obtain these findings suffer from important limitations that must be taken into account. Specifically, this program of research solely used behavioral measures of relative hemispheric activation. As such, as we have tried to emphasize throughout our discussion, the current findings offer no evidence as to the *absolute* patterns of activation in specific neural loci elicited by our motivational cue manipulations. The behavioral measures we used are only posited to indicate the relative allocation of activation to the left versus right hemispheres on the basis of the assumption that activation of one hemisphere draws activation from the other (Kinsbourne, 1970, 1975; Kosslyn, 1987). To determine whether our motivational cue manipulations truly shift activation between hemispheres (and to ascertain the absolute extent and distribution pattern of this shift), future research will need to use measures with far greater spatiotemporal resolution (e.g., EEG).

Ironically, the distribution pattern of any shift, an issue that has heretofore escaped our focus, may actually be particularly important for understanding the nature of motivational influences on attention and cognition. Equivalent asymmetries in overall hemispheric activation may result from a shifting of activation not only from left to right, or vice versa, but also from a shifting of activation to different loci within each hemisphere (e.g., anterior vs. posterior; see Heller et al., 2003). This notion has substantial implications for psychological theorizing—for instance, if we can determine what areas of the left or right hemispheres are differentially activated by anticipation- versus arousal-related aspects of motivational states, and we possess neuropsychological evidence regarding how these specific loci contribute to cognitive processing, we can use this knowledge to make novel inductive inferences about the types of behavioral effects we should expect from approach and avoidance anticipation versus arousal states (see Cacioppo & Berntson, 2002, for a more general discussion of how neuroscientific advances may promote psychological theorizing).

Generalizing Our Current Predictions

If, as we have proposed at present, approach, relative to avoidance, cues influence task performance by shifting activation to the right hemisphere, then such cues may not only bolster creativity but also facilitate performance on a range of tasks associated with differential right hemispheric processing (RHP). Consistent with the theorizing of Derryberry and Tucker (1994), RHP has been characterized as involving an expanded scope of attention on the perceptual and conceptual levels (see, e.g., Beeman, 1998; Burgess & Simpson, 1988; Fiore & Schooler, 1998). An example of a perceptual task posited to require RHP is memory for faces, which demands broadened perceptual attention to configural relations between facial features (Schooler, 2002); correspondingly, an example of a conceptual task posited to require RHP is metaphor comprehension, which demands broadened conceptual attention to nonliteral (and thereby nondominant) word meanings (Beeman, 1998). To the extent that approach, relative to avoidance, motivational cues indeed facilitate performance on these and related tasks, it will provide compelling evidence for the causal link between approach motivational processes, relative right hemispheric activation, and expanded attentional scope hypothesized by Derryberry and Tucker (1994).

In conclusion, a great deal of additional research, using more sensitive measures of hemispheric activation, and a wider array of dependent measures, will be needed to resolve the questions raised by the present study and, potentially, to extend our findings to new domains. We hope that this work will help further the efforts undertaken by Derryberry and Tucker (1994) and others to develop and validate an overarching neuropsychological model of the influence of motivation on attention, cognition, and action.

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