The Effects of Approach and Avoidance Motor Actions on the Elements of Creative Insight

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The authors propose that the nonaffective bodily feedback produced by arm flexion and extension informs individuals about the processing requirements of the situation, leading to the adoption of differential processing styles and thereby influencing creativity. Specifically, the authors predicted that arm flexion would elicit a heuristic processing strategy and bolster insight processes, whereas arm extension would elicit a systematic processing strategy and impair insight processes. To test these predictions, the authors assessed the effects of these motor actions on 3 central elements of creative insight: contextual set-breaking, restructuring, and mental search. As predicted, in 6 experiments, arm flexion, relative to arm extension, facilitated insight-related processes. In a 7th experiment, arm extension, relative to arm flexion, facilitated analytical reasoning, supporting a cognitive tuning interpretation of the findings.

In the ongoing exploration of the link between affect and cognition, one of the most intriguing areas of study is that examining the relationship between affect and creativity. Here, the available data generally suggest that positive affect, relative to neutral or negative affect, enhances creative problem solving (Clore, Schwarz, & Conway, 1994). For instance, in a series of pioneering studies, Isen and her associates demonstrated that experimentally induced positive affect (relative to neutral or negative affect) facilitates performance on the Duncker (1945) candle task and on the Mednick's Remote Associates Task (Isen, Daubman, & Nowicki, 1987). Isen and her colleagues also found evidence that positive affect increases flexibility of categorization (Isen, 1987). In one study, happy participants categorized more broadly and inclusively than those in a control group, for instance, by including feet and camel as members of the category vehicles (Isen & Daubman, 1984). In a related study, happy participants also categorized more narrowly and specifically than controls, sorting perceived self-characteristics into finer groupings (Isen & Daubman, 1986; cf. Murray, Sujan, Hilt, & Sujan, 1990). Together, these categorization findings suggest that positive affect promotes seeing more similarities as well as more differences between ideas, presumably facilitating creative thought (Isen, 1987). In other research, Isen, Johnson, Mertz, and Robinson (1985) found that participants in whom positive affect had been experimentally induced produced more unusual first associates to neutral words than participants in neutral or negative affect conditions (Isen, 1987). Similarly, Hilt and his colleagues demonstrated that positive mood (relative to neutral or sad mood) elicits more creative responses in listing commonalities and differences between stimuli (Hilt, Melton, McDonald, & Harackiewicz, 1996) and results in listing more creative exemplars of a given category, relative to sad mood (Hirt, Levine, McDonald, & Martin, 1997).

A variety of theoretical approaches have been adduced to explain the aforementioned effects of affect on cognitive flexibility and creative problem solving (see Hirt, McDonald, & Melton, 1996, for a review). For example, Isen (1987) offered a mood-congruent retrieval-based view. Most prominently, she argued that positive affect renders positive material in memory more accessible. As this positive material is relatively extensive, its activation may create a "complex cognitive context" (Isen, 1987, p. 237) in which novel (i.e., creative) associations may be forged between the disparate ideas copresent in working memory. Shortcomings of this approach include the fact that the phenomenon of mood-
congruent recall has been shown to be relatively unreliable (Claro et al., 1994) and limited in its generality (Blaney, 1986). In addition, Isen's mood-congruent retrieval argument does not adequately account for the typical finding of null or even detrimental effects (e.g., Mikulincer, Kedem, & Paz, 1990) of negative affect on creativity. If anything, it seems that negative affect should lead to the selective retrieval of negative material, engendering a more complex cognitive context than that under conditions of neutral affect and thereby bolstering creativity (at least relative to baseline).

Another major approach to understanding the relationship between affect and creativity that avoids these pitfalls and others (Claro et al., 1994; Hirt, McDonald, & Melton, 1996) is the so-called cognitive tuning model. Developed by Schwarz and Bless (Schwarz, 1990; Schwarz & Bless, 1991), this model essentially proposes that affective states function to inform individuals as to whether their current situations are safe or problematic. Positive affective states signal to individuals that their world is safe, that their goals are not threatened, and thereby that no specific course of action is required. Given this information, individuals in a positive affective state may become more willing to take risks, adopting a relatively nonerrorful, heuristic processing style (cf. Isen, 1987; Isen, Means, Patrick, & Nowicki, 1982) in which novel alternatives may be explored (cf. Fiedler, 1988) and novel plans of action may be undertaken (Schwarz & Bless, 1991).

As such, this relatively unconstrained and "risky" processing style is posited to facilitate innovation and to enhance creative problem solving.

In complementary fashion, the cognitive tuning model proposes that negative affective states inform individuals that their world is threatening or troublesome, that their goals are compromised, and that specific action must be taken to remedy their current situation. Attempts at change demand a systematic assessment of the problem(s) at hand and of potential means of solution, thereby leading individuals in negative affective states to adopt a relatively careful, analytical processing style. This style should also promote risk aversion—in a situation already considered troublesome, novel, untested alternatives or procedures pose the risk of making a bad situation worse (Schwarz & Bless, 1991). As a result, according to the cognitive tuning framework, negative affect should reduce the willingness to implement novel solutions, thereby undermining creative problem solving. In contrast, negative affect should bolster performance on tasks requiring detail-oriented analytical reasoning, tasks which demand adherence to established rules or procedures and less in the way of originality (Schwarz & Bless, 1991; see Clore et al., 1994, for a review of relevant findings).

The Role of Nonaffective Signals in Cognitive Tuning

Recently, Soldat, Sinclair, and Mark (1997) extended the cognitive tuning framework to include not only experienced affective cues such as mood, but also nonaffective environmental cues. More specifically, Soldat et al. (1997) proposed that external cues that are associated with positive or negative hedonic states but that do not themselves elicit affect, may independently signal whether the current situation is safe or problematic and thereby give rise to differential processing styles. One such environmental cue is color. Soldat et al. (1997) suggested that the color red signifies happiness and, by means of association, informs the individual that the current situation is benign. In contrast, the color blue signifies negative affect and informs the individual that the current situation is problematic. Using this reasoning, Soldat et al. (1997) posited that incidental exposure to either red or blue background stimuli would lead individuals to respectively adopt either a heuristic or systematic processing style, leading to corresponding differences in problem solving.

In two studies, Soldat et al. (1997) tested this hypothesis by administering an analytical problem-solving task (excerpt from the Graduate Record Examination, GRE) printed on either red or blue paper. Inasmuch as analytical problem-solving tasks require careful, detail-oriented processing, it was predicted that the systematic processing style elicited by the blue paper would bolster performance on the experimental task relative to the heuristic processing style elicited by the red paper. These predictions were supported; moreover, consistent with Soldat et al.'s extension of cognitive tuning theory, there were no differences in mood among experimental groups, suggesting that external, nonaffective cues such as color can engender differential processing styles and influence performance, independent of experienced affect.

Another recent study by Ottati, Terkildsen, and Hubbard (1997) offers compelling additional support for the notion that nonaffective environmental cues can independently elicit cognitive tuning. Here, participants watched a videotape of an individual presenting a verbal message while displaying either a happy or a neutral facial expression and were asked to form an impression of this individual. Ottati et al. (1997) proposed that the happy facial expression would signal that the current situation was benign, leading to reliance on heuristic processing in judging the speaker; in contrast, the neutral, more somber expression would signal that the current situation was relatively serious, leading to the use of more systematic processing in impression formation. As predicted, Ottati et al. (1997) found that happy facial displays gave rise to a heuristic processing style, whereas participants based their impressions of the speaker on his or her general ideology rather than the specific content of his or her message. Conversely, neutral facial displays engendered a systematic processing style, whereas participants solely judged the target on the basis of the specific views he or she espoused. Quite critically, the aforementioned effects were independent of mood, which was itself not affected by the facial displays. In sum, these findings converge with those of Soldat et al. (1997) to strongly suggest that external, nonaffective cues can independently function as signals regarding the processing requirements of the current situation, thereby significantly influencing performance.

The Influence of Nonaffective Signals on Creativity

Assuming that external, nonaffective processing cues can influence cognitive tuning in a manner parallel to affective experience, it follows that such cues should also influence creativity in like fashion. Specifically, nonaffective cues associated with positive hedonic states should give rise to a more risky, heuristic processing style and facilitate creative problem solving, whereas nonaffective cues associated with negative hedonic states should elicit a more risk-averse, systematic processing style and impair creativity. In the current study, we tested this hypothesis by (a) using internal, nonaffective cues to manipulate cognitive tuning and (b) using a
Manipulating Internal Cues: Arm Flexion vs. Extension

According to Schwarz and Clore (1996), just as internal, affective states such as happiness and sadness inform individuals about the nature of their current situations and the responses that are appropriate to these situations, so do internal, nonaffective states, including feelings of knowing (e.g., familiarity) and bodily sensations (e.g., hunger). Recent studies have demonstrated the powerful, informative effects of these nonaffective experiences. For instance, in an ingenious experiment, Strack, Martin, and Stepper (1988) had participants hold a pen either between their teeth or between their lips while rating the funniness of cartoons. The former means of holding the pen requires the same muscular actions used in smiling, whereas the latter means of holding the pen requires muscular actions which are incompatible with smiling (i.e., pursing the lips). Remarkably, although unaware of the meanings of the muscular actions they were performing, participants personally found the cartoons more amusing when their muscular actions were analogous to those involved in smiling. This demonstrates that internal, nonaffective cues, such as muscular sensations, can serve as information, in this case influencing judgments (cf. Stepper & Strack, 1993; Strack & Neumann, 1996).

An implication of the informational utility of internal, nonaffective cues is that by means of differential association with positive or negative states, such cues may convey to individuals the processing requirements of the current situation, thereby influencing cognitive tuning. To examine this possibility, we manipulated the extent to which internal cues were associated with either positive or negative evaluative states by having participants engage either in isometric arm flexor contraction (by pressing upward on a table) or in isometric arm extensor contraction (by pressing downward on a table). According to Cacioppo and his colleagues (Cacioppo, Priester, & Berntson, 1993; Priester, Cacioppo, & Petty, 1996), arm flexion produces bodily feedback that is associated with approaching positive stimuli, whereas arm extension produces bodily feedback that is associated with avoiding negative stimuli (see also, Förster, 1998; Förster & Strack, 1997, 1998). The rationale for this hypothesis is grounded in the principles of learning theory: Over the course of a lifetime, ann flexor contractions (where the force of the motor action is directed toward the self) is temporally more closely linked to the consumption or acquisition of desired stimuli (i.e., approach), whereas arm extensor contraction (where the force of the motor action is directed away from the self) is temporally more closely linked to the rejection of undesirable stimuli (i.e., avoidance).

There is an impressive and growing body of literature that is consistent with the notion of an associative link between arm flexion and approach of positive stimuli and between arm extension and avoidance of negative stimuli (e.g., Förster, 1998; Förster, Higgins, & Idson, 1998; Förster & Strack, 1997, 1998; Neumann & Strack, 2000; Priester et al., 1996). For instance, in a seminal study, Cacioppo et al. (1993) demonstrated that affectively neutral stimuli (Chinese ideographs) evaluated during arm flexion were later preferred (i.e., judged as more approach-worthy) to those evaluated during arm extension. More recently, Chen and Bargh (1999; cf. Solarz, 1960) had participants respond to positively and negatively valenced stimuli by either pushing or pulling a lever. Participants were quicker to respond to positively valenced stimuli by pulling the lever toward them (activating arm flexion) than by pushing the lever away from them (activating arm extension); conversely, participants were quicker to respond to negatively valenced stimuli by pushing rather than by pulling the lever. These findings demonstrate that positive evaluation automatically activates a motor action tendency involving arm flexion, while negative evaluation automatically activates a motor action tendency involving arm extension (see also Bargh, 1997).

Given the apparent associations between arm flexion and positive evaluation (i.e., approach-worthiness) and between arm extension and negative evaluation (i.e., avoidance-worthiness), it is likely that these arm contractions, like mood, color, or facial expressions, may respectively signal that the current situation is benign versus problematic and thereby influence processing styles. In the current study, we predicted that the nonaffective, bodily feedback elicited by arm flexion would lead to the adoption of a more carefree, heuristic processing style, thereby facilitating creativity. In contrast, the bodily feedback elicited by arm extension was predicted to lead to the adoption of a relatively careful, perseverant, systematic processing style, thereby impairing creativity.

Measuring Creativity: A Historical Approach

Having selected a manipulation of nonaffective cues, the next step was to choose a set of creativity measures with which to assess their effects. To make a systematic choice, we turned to the work of Schooler and Melcher (1995), who described three elements of creative insight that have played a central role in both early (e.g., Wertheimer, 1959; Koestler, 1964) and recent (e.g., Bowers, Regehr, Balthazard, & Parker, 1990) theoretical approaches to the phenomenon. One element of creative insight described by Schooler and Melcher (1995) is breaking context-induced mental set. This entails disregarding misleading interpretations, unwarranted assumptions, and inappropriate strategies rendered overaccessible by the context of the problem. Perhaps the most famous example is the Duncker (1945) candle task. Here, solution presumably demands overcoming context-induced assumptions about the standard function of the box (i.e., as a container for the tacks) and using the box in a novel manner (i.e., as a pedestal for the candle). Another historically discussed element, restructuring, involves globally shifting perspective or recoding stimuli such that a novel representation of the given problem emerges. A classic example is figure-ground reversal, where perceptual elements are reorganized and thereby seen in a brand new light. The final historically discussed element of creative insight is unconscious mental search for new responses, strategies, and combinations of ideas. Schooler and Melcher (1995) reconceptualized this element in information processing terms, suggesting that it comprises extensive spreading activation (cf. Ohlsson, 1992).

For the current study, we selected five dependent measures that were explicitly meant to tap into the three elements of creative insight proposed by Schooler and Melcher (1995). In Experiment 1, we employed the widely used Embedded Figures Task (EFT; Witkin, Olmert, Raskin, & Karp, 1971) to gauge the ability to break context-induced mental set. The EFT requires breaking up
complex visual patterns so as to find the simple figures hidden within them (Witkin & Goodenough, 1981; Witkin et al., 1971). In Experiment 2, we used another task that, like the EFT, requires overcoming the influence of a complex perceptual context. This task, the Snowy Pictures Test (SPT; Ekstrom, French, Harman, & Dermien, 1976) involves dis-embedding images of familiar objects (e.g., a bird) from within intricate patterns of visual noise, or "snow." We used a third visual task, the Gestalt Completion Task (GCT; Ekstrom et al., 1976) in Experiments 3 and 4 as a measure of restructuring (Schooler & Melcher, 1995). The GCT involves recognizing fragmented pictures of familiar objects. It presumably requires shifting perspective and recoding the fragmented images, thereby allowing for gestalt "closure" (cf. Bowers, Regehr, Balthazard, & Parker, 1990).

In Experiment 5, we examined performance on a verbal analogy task in hopes of indexing extensiveness of unconscious mental search, the third and final element of creative insight discussed by Schooler and Melcher (1995). Although it undoubtedly involves elements of conscious processing (e.g., mapping relations; Gentner, 1983), analogical reasoning also presumably requires extensive unconscious memory search (e.g., via spreading activation) for potentially correspondent attributes and relations associated with the two domains under comparison. It follows that more extensive unconscious mental search, leading to activation of a greater number of potentially correspondent attributes and relations, should facilitate analogical reasoning, as presently gauged by the ability to solve verbal analogy problems.

In Experiment 6, we used a measure of inclusiveness of categorization inspired by Isen and Daubman (1984). The theoretically critical component of this task requires participants to rate the goodness of fit of atypical exemplars (e.g., camel) to a given category (e.g., vehicle). In terms of the present framework, we hypothesized that this categorization task may tap into both the extensiveness of unconscious mental search as well as the capacity to break context-induced set. According to Isen (1987), extensive unconscious memory search (i.e., spreading activation), should lead to a greater amount of material in working memory and thereby facilitate seeing relationships between disparate elements. This implies that more inclusive categorization should, at least in part, reflect more extensive underlying search (Isen, 1987; Isen & Daubman, 1984). The tendency to include atypical exemplars as members of a given category may also be seen as involving set-breaking, inasmuch as it may entail overcoming preexisting assumptions regarding the criteria for category membership. For instance, purse may be included as a member of the category clothing (Isen & Daubman, 1984) if the common assumption that handbags do not represent clothing is called into question or momentarily held aside. Although the categorizational inclusiveness measure fails to distinguish between set-breaking and mental search-based processes, it was at least expected to effectively capture one or both of these elements of creative insight (Schooler & Melcher, 1993).

In addition to these five measures of insight processes, we administered part of the GRE Analytical test, a measure of non-insight problem solving, to more directly assess the hypothesized cognitive tuning-based mediational process. As discussed earlier, cognitive tuning theory (Clore et al., 1994; Schwarz, 1990; Schwarz & Bless, 1991) proposes that signals indicating a problematic current situation elicit a systematic processing style, leading to improved analytical problem-solving performance, relative to signals indicating that the current situation is benign. Several experiments have supported this proposition (see Clore et al., 1994, for a review), including those by Soldat et al. (1997) demonstrating enhanced GRE analytical test performance for individuals working on blue versus red paper. Following this logic, if it is indeed the case that arm flexion and extension yield their differential effects on insight by eliciting distinct processing styles, then just as arm flexion bolsters insight relative to arm extension, so should arm extension bolster analytical problem solving relative to arm flexion.

Predictions

To review, in each of the seven experiments reported below, internal, nonaffective processing cues were manipulated by means of approach versus avoidance motor actions (i.e., arm flexion vs. extension) and then the effects of these cues on the elements of creative insight (Experiments 1–6), and on analytical problem solving (Experiment 7) were examined. We predicted that arm flexion, which activates a heuristic processing style and an inclination toward novelty seeking, would facilitate insight-related processes (and impair analytical problem solving) relative to arm extension, which activates a systematic processing style accompanied by risk aversion and an inclination toward perseveration.

Affect

In line with our earlier discussion, all predicted differences were expected to obtain independent of the influence of affective experience. Consequently, measures of affect (e.g., mood) were taken in each experiment to statistically control for these prospective influences. Measures of related experiential states (e.g., enjoyment) were also included to further clarify the processes driving the reported effects.

Experiment 1

Method

Overview. In this experiment, participants performed either arm flexion or arm extension while completing each segment of the EFT. Following the EFT, participants were administered a brief questionnaire gauging their current affective states as well as the pleasantness and effortfulness of their arm positions. We predicted that the novelty-seeking inclination accompanying arm flexion would facilitate overcoming the initially misleading influence of each complex visual context, enhancing the capacity to disembed the simple target figures. In contrast, the risk aversion associated with arm extension was predicted to engender a relatively perseverant fixation on each highly compelling context, impairing EFT performance. Differences between conditions were predicted to remain reliable controlling for the influence of both emotional (e.g., mood) and other nonemotional (e.g., effortfulness) experiential states on set-breaking.

Participants. Twenty-seven right-handed Columbia University undergraduates were recruited as participants for an experiment ostensibly on visual perception. Participants were tested individually and were paid $5.00 for participation. Three participants were excluded from the analysis for failing to follow instructions, leaving 11 in the arm flexion (i.e., approach motor action) condition and 13 in the arm extension (i.e., avoidance motor action) condition.

Procedure. On arrival, participants were seated in a chair approximately 16 in. (41 cm) tall at a table approximately 25 in. (64 cm) tall.
Participants were then provided with a cover story meant to eliminate self-perception effects on performance (see Olson & Hafer, 1990). Self-perception effects require systematic inferences regarding the meaning of the observed behavior, inferences that can be the basis for additional judgments and subsequent actions (Strack et al., 1988). Therefore, the cover story provided participants with a spurious alternative meaning for their arm contractions, one intended to prevent them from hypothesizing that arm flexion, relative to arm extension, would bolster their task performance. Specifically, participants were told:

Today, you'll be participating in a study examining the effects of hemispheric lateralization on visual processing. More specifically, we're trying to understand the relationship between left and right brain activation and the perception of embedded figures, that is, the perception of simple designs in more complex ones. Basically, there's been an ongoing debate, with some people saying that the left hemisphere is the center for this type of processing and others saying that the right hemisphere is more critical.

Afterward, all participants were informed that they had been randomly assigned to the left hemisphere activation condition and that the "standard way" in which this hemisphere is activated is "by having participants assume a particular right arm position." The experimenter then demonstrated the arm flexion position (for participants randomly assigned to the approach motor action condition) or the arm extension position (for those randomly assigned to the avoidance motor action condition). The arm flexion position involved lightly pressing the right palm upward against the bottom of the table, keeping the elbow bent at a right angle. The arm extension position involved lightly pressing the right palm downward against the top of the table, keeping the elbow straight. After demonstrating the appropriate position, the experimenter had participants attempt it and checked that they understood how to perform it properly.

Following these instructions, the experimenter, who was blind to the hypothesis, administered the EFT. This well-known task involves presenting participants with a series of 12 complex designs. After each of these designs is shown, a simple figure is presented which the participant must locate within the complex figure that preceded it. The time to find each simple figure is unobtrusively recorded by stopwatch with a maximum time of 3 min allotted per figure. For the purposes of the current experiment, participants were additionally asked to assume the arm flexion position or the arm extension position before each new complex figure was presented and to discontinue this position after either finding the simple figure or running out of time. When a participant announced that he or she had found a given embedded figure, the experimenter immediately stopped the timer, told the participant to discontinue his or her arm position, and had the participant indicate the solution. If this solution was incorrect, the experimenter had the participant resume his or her arm position and continue working until the correct solution was found or time expired. Time pressure was maintained by keeping the stopwatch out of view.

After this modified version of the EFT was completed, participants filled out a paper-and-pencil survey. The first part of this survey gauged participants' affect, asking them about their current mood ("How do you feel right now?"). It included a series of anchored at 1 (very bad) and 9 (very good), and about how "worried," "disappointed," "calm," "happy," "content," "tense," "discouraged," and "relaxed" they currently felt (i.e., "How ____ do you feel right now?"). The second part of the survey contained questions addressing alternative potential mediators for the predicted effect. These included items gauging the subjective pleasantness of the arm position ("How pleasant was the arm position for you?"), anchored at 1 (very unpleasant) and 9 (very pleasant), and the effortfulness of the arm position ("How effortful was it to maintain the arm position?"), anchored at 1 (not at all effortful) and 9 (very effortful). The final question was an open-ended probe for suspicions regarding the cover story. No hypothesis-consistent suspicions were expressed. After completing the posttask survey, participants were debriefed and were paid for their participation.

Results and Discussion

EFT performance scores were calculated by summing the times spent dis-embedding the simple figures for each of the 12 complex figures presented (Witkin et al., 1971). Shorter total completion time indicates better performance. To test the main experimental hypothesis that arm flexion facilitates EFT performance relative to arm extension, a t test was conducted comparing task completion times (in seconds) in the two experimental conditions. Consistent with predictions, participants who engaged in arm flexion while working on the EFT were significantly faster (i.e., better) at dis-embedding the hidden figures (M = 255.45; SD = 128.24) than those who engaged in arm extension (M = 416.08; SD = 206.12), t(22) = 2.24, p < .04. This supports the hypothesis that internal, nonaffective "benign-environment" signals, relative to "problematic-environment" signals, facilitate breaking context-induced mental set, an elementary process associated with creative insight (Schouler & Melcher, 1995).

An important subsidiary question is whether this difference is independent of affective influences. To address this issue, we turned to the posttask measures of current mood and specific emotions. Here, in simultaneous multiple regression analyses using arm position (arm flexion vs. extension) as a predictor and separately entering each affective state measure as a covariate, the main effect of arm position remained statistically reliable in every case, suggesting that the facilitative effect of arm flexion on EFT performance was independent of affective experience.

Interestingly enough, the aforementioned regression analyses also revealed unpredicted main effects of three separate affective state measures on EFT performance. Specifically, current mood, B = −3.53, F(1, 21) = 4.88, p < .04, happiness, B = −5.14, F(1, 21) = 9.49, p < .01, and contentment, B = −3.58, F(1, 21) = 4.80, p < .04, were all independently predictive of EFT performance, with more positive mood, happiness, or contentment leading to faster completion times. These findings are very much consistent with the empirical and theoretical work of Ison (1987), Schwarz (1990; Schwarz & Bless, 1991), and others (e.g., Hirt et al., 1997) in suggesting that positive mood and "happy" emotional states bolster creativity. Subsequent analyses revealed no reliable interactions between arm position and the various affective state measures.

A final series of analyses was conducted to assess whether the predicted effect was mediated by the pleasantness or effortfulness of the manipulated arm positions rather than by the processing styles elicited by these positions. For instance, it may have been the case that the increased pleasantness or decreased effortfulness of arm flexion relative to arm extension may have enhanced liking for the experimental task, thereby bolstering engagement and performance on the EFT. In fact, arm flexion was generally rated as both nonsignificantly less pleasant (M = 5.45; SD = 2.22) than arm extension (M = 5.62; SD = 1.99), t < 1, and nonsignificantly more effortful (M = 3.27; SD = 1.80) than arm extension (M = 2.62; SD = 1.73), t < 1, thereby undermining this alternative explanation. In addition, simultaneous multiple regression analyses separately entering pleasantness and effortfulness ratings as covariates did not reduce the reliability of the main
effect of arm position (flexion vs. extension) on EFT completion time. However, as in the case of mood, pleasantness did yield an independent, facilitative effect on EFT performance, $B = -2.95$, $F(1, 21) = 5.15, p < .04$, suggesting that it may itself reliably influence the ability to break contextual set.

Experiment 1 constituted the first empirical evidence supporting the hypothesis that nonaffective processing cues directly influence the components of creative insight. Arm flexor contraction bolstered performance on the EFT relative to arm extensor contraction, suggesting that the bodily feedback produced by arm flexion, relative to that produced by extension, elicits cognitive tuning which enhances the insight-related ability to break context-induced mental set (Schooler & Melcher, 1995). This effect was statistically independent of the influence of distinct emotional and non-emotional experiential states; however, consistent with theoretical approaches linking positive affect to creativity (e.g., Isen, 1987), positive mood, happiness, and the pleasantness of the arm positions also independently facilitated EFT performance. In Experiment 2, an attempt was made to conceptually replicate these initial findings using a different measure of the ability to break context-induced set.

Experiment 2

Method

Participants. Thirty-two right-handed Columbia University undergraduates were recruited as participants for an experiment ostensibly on visual perception. Participants were tested individually and were paid $5.00 for participation.

Procedure. The procedure for Experiment 2 was virtually identical to that for Experiment 1, with the exception that participants completed the SPT instead of the EFT. As we alluded to earlier, the SPT involves presenting participants with a series of 24 images of simple objects hidden within complex patterns of visual noise. Participants view these images in sequence, attempting to perceptually dis-embed and then name the hidden objects they contain.

For the purposes of the current experiment, the first 12 and last 12 SPT figures were separately mounted on two 11-in. × 14-in. (28-cm × 36-cm) posterboards, which were viewed on a desktop copyholder. Participants were asked to announce their responses, which the experimenter recorded, thereby keeping participants’ right hands free for use in the arm position manipulation. The experimenter also surreptitiously timed participants’ progress on each SPT item and unobtrusively asked them to move on to the next item if they had not found the solution to the current item after 10 s. Participants were asked to assume either the arm flexion position or the arm extension position before beginning each set of 12 posterboard-mounted SPT figures and to discontinue this position after completing each set or running out of time. Afterward, participants were administered the same posttask survey used in Experiment 1. No hypothesis-consistent suspicions were expressed on the open-ended probe. Following completion of this questionnaire, participants were debriefed and were paid for their participation.

Results and Discussion

SPT performance scores were computed by summing the number of embedded images correctly named. To test the experimental hypothesis that arm flexion enhances SPT performance relative to arm extension, a $t$ test was conducted comparing the total number of correct solutions offered in the two experimental conditions. In line with predictions and consistent with Experiment 1, participants in the arm flexion condition correctly solved significantly more SPT items ($M = 13.0; SD = 2.56$) than those in the arm extension condition ($M = 9.5; SD = 3.16$), $t(30) = 3.44, p < .002$. Along with the results of Experiment 1, this finding provides converging evidence for the hypothesis that internal, nonaffective signals that the environment is benign, relative to signals that the environment is problematic, facilitate breaking context-induced mental set.

Of course, as in Experiment 1, it was necessary to determine whether the obtained effect was independent of affective influences. To address this issue, a series of simultaneous regression analyses was conducted using arm position (flexion vs. arm extension) as a predictor and separately entering each posttask affective measure both as a simple covariate and in interaction with arm position. Once again, the effect of arm position remained highly reliable in every analysis, suggesting that the influence of approach and avoidance motor actions on SPT performance was independent of mood or emotional state.

The aforementioned regression analyses also revealed marginally reliable main effects of current mood, $B = 0.52$, $F(1, 29) = 3.24, p < .09$, happiness, $B = 0.44$, $F(1, 29) = 2.62, p < .12$, and discouragement, $B = -0.40$, $F(1, 29) = 3.31, p < .08$, on SPT performance. Although statistically unreliable in the present experiment, the former two effects provide converging support along with those in the first experiment for the notion that positive mood or happiness independently enhances creativity. Unlike in Experiment 1, the effect of contentment did not approach conventional reliability, $p > .20$. The marginally reliable negative effect of discouragement on SPT found in the current experiment may be seen as lending some support to the hypothesis that negative affect undermines creative thought (Schwarz, 1990; Schwarz & Bless, 1991).

As in Experiment 1, a final set of analyses was conducted to assess the mediational role of the pleasantness or effortfulness of the flexion and extension arm positions. Here, $t$ tests revealed no significant differences in ratings of the pleasantness ($M_{\text{flexion}} = 4.62; SD = 1.75$ vs. $M_{\text{extension}} = 3.69; SD = 2.06$, $t < 1.4$) or effortfulness ($M_{\text{flexion}} = 3.31; SD = 2.09$ vs. $M_{\text{extension}} = 4.00; SD = 2.39, t < 1.2$) of the arm positions. Furthermore, simultaneous multiple regression analyses separately entered pleasantness and effortfulness ratings as statistical covariates did not reduce the reliability of the main effect of arm position on SPT performance. Once again, this supports the hypothesis that arm flexion and extension affect set-breaking by way of the heuristic and systematic processing styles they respectively elicit. In contrast to Experiment 1, there was no independent effect of the pleasantness of the arm position on SPT performance ($t < 1$) suggesting that the facilitative effect of pleasantness on contextual set-breaking found in the first experiment demands additional empirical scrutiny.

In sum, Experiment 2 conceptually replicated Experiment 1, providing converging evidence for the hypothesis that internal, nonaffective processing cues directly influence the insight-related ability to break context-induced mental set. The facilitative effect of arm flexion, relative to arm extension, on SPT performance was again statistically independent of the influence of emotional and nonemotional experiential states, suggesting that bodily feedback can autonomously serve as information regarding the processing
requirements of the current situation and thereby as a basis for cognitive tuning.

Experiment 3

Method

Overview. Experiment 3 built on the findings of the first two experiments by examining the effects of approach and avoidance motor actions on another basic component of creative insight: mental restructuring (Schooler & Melcher, 1995). In this experiment, participants were again asked to perform either arm flexor contraction or arm extensor contraction. Participants assumed and then discontinued the appropriate arm position (flexion vs. extension) before and then after a segment of the GCT. We predicted that arm flexion would enhance the tendency to attempt novel means of viewing the GCT figures, thereby increasing the likelihood of “closing” each gestalt. Conversely, arm extension was predicted to increase perseverance on initial interpretations of the fragmented GCT images, inhibiting the perceptual restructuring required for solution.

Experiment 3 also provided an opportunity to test an alternative explanation for the predicted effect, one involving task enjoyment. Recall that Cacioppo and his colleagues (Cacioppo et al., 1993) discovered that arm flexion, relative to arm extension, led to increased preference for neutral ideographs. In a similar manner, it is possible that arm flexion, relative to extension, may lead to increased preference for or perception of the experimental task, thereby bolstering creativity. This possibility would be consistent with the theorizing of Amabile (1983, 1996), who has postulated that creativity may be mediated by intrinsic motivation (e.g., enjoyment). To assess this alternative explanation, we included a posttask measure of task enjoyment for use as an auxiliary predictor. The posttask questionnaire also included measures of mood and arousal. The effect of arm contraction on restructuring performance was predicted to remain reliable statistically controlling for the influence of enjoyment as well as the influences of these other experimental states.

Participants. Thirty undergraduates at the University of Würzburg were recruited as participants for an experiment ostensibly on hemispheric activation and performance. Participants were tested individually and were paid DM 2 (approximately $0.90 at the time) for participation.

Procedure. The procedure for Experiment 3 was identical to that for the previous two experiments with the following exceptions: The procedure was translated into German, and participants completed a modified version of the GCT. As mentioned above, the GCT involves presenting participants with a series of fragmented pictures of familiar objects. Participants view these pictures and attempt to perceptually integrate them, that is, to close each gestalt, thereby enabling them to identify the objects they represent. For the purposes of Experiment 3, participants were presented with the first 10 OCT images, printed on two 8.5-in. x 11-in. (22-cm x 28-cm) sheets of paper, which were laid flat upon a countertop. Responses were announced into a microphone connected to a tape recorder; this procedure enabled participants to keep their right hands free for use in the arm position manipulation. Participants were instructed that the OCT items had to be solved within 2 min. They were asked to assume either the arm flexion position or the arm extension position before beginning the GCT task and to discontinue this position after either completing the task or running out of time.

After completing this modified version of the GCT, participants filled out a paper-and-pencil posttask survey. This survey asked participants about their enjoyment of the GCT task ("How much did you enjoy the task?"); on a scale anchored at 1 (not at all) and 9 (very much); their current mood ("How do you feel right now?"); on a scale anchored at 1 (very bad) and 9 (very good); and their current state of arousal ("How aroused are you now?"); on a scale anchored at 1 (not at all) and 9 (very aroused). The final question was an open-ended probe for suspicions regarding the cover story. No hypothesis-consistent suspicions were expressed. After completing the posttask survey, participants were debriefed and were paid for their participation.

Results and Discussion

GCT performance scores were computed by summing the number of fragmented objects correctly identified out of the 10 presented. To assess the main experimental hypothesis that arm flexion facilitates GCT performance relative to arm extension, a t test was conducted comparing the average number of correct solutions given within the two arm contraction conditions. As predicted, participants who engaged in arm flexion while working on the GCT correctly identified more fragmented objects (M = 9.33; SD = 0.72) than those who engaged in arm extension (M = 6.60; SD = 2.53), t(28) = 4.02, p < .0001. This supports the hypothesis that internal, nonaffective benign-environment signals, relative to problem-solving-environment signals, facilitate mental restructuring, a second fundamental process associated with creative insight (Schooler & Melcher, 1995).

To address whether the obtained effect was independent of mood, arousal, and enjoyment, a series of multiple regression analyses was conducted using arm position (flexion vs. extension) as a predictor and separately entering each of these three posttask measures as a covariate and in interaction with arm position. The effect of arm position remained highly reliable in each analysis, suggesting that the influence of nonaffective cues on mental restructuring was independent of these experiential states. Unlike in Experiments 1 and 2, the aforementioned analyses revealed no reliable effect of mood (t < 1), although they did reveal an unpredicted main effect of arousal, B = 0.576, F(1, 27) = 5.94, p < .03, suggesting that arousal itself independently facilitated restructuring ability. Finally, there were no reliable effects of task enjoyment on restructuring (t < 1). This enjoyment analysis included and did not reduce the magnitude of the arm position effect (see Kenny, Kashy, & Bolger, 1998), thereby failing to support the notion that creativity is mediated by intrinsic motivation (Amabile, 1983, 1996).

A final exploratory series of analyses was conducted to assess the effects of the experimental manipulations on mood, arousal, and task enjoyment. Here, each of these posttask measures was separately regressed on arm position and GCT performance (included as a covariate). Interestingly enough, the aforementioned analyses only revealed a reliable main effect of arm position on task enjoyment, B = −.686, F(1, 27) = 2.10, p < .05, indicating that arm flexion bolstered task enjoyment relative to arm extension. Again, this finding may be thought of as consistent with work by Cacioppo and his colleagues (Cacioppo et al., 1993), suggesting that stimuli encountered during arm flexion are evaluated more positively than those encountered during arm extension—in the present case, the evaluated stimulus may have simply been the GCT task itself. Notably, as discussed above, enjoyment did not mediate the influence of arm position on GCT performance, indicating that the effect of arm position on enjoyment may be epiphenomenal to its effect on cognitive restructuring. Mediational analyses (Kenny et al., 1998) also revealed no tendency for GCT performance (as influenced by arm position) to mediate self-reported enjoyment (cf. Hirt, McDonald, et al., 1996).
these experiential states prior to task performance. This leaves open the possibility that pretask mood, interest, or changes in these states over time may have played a mediating or moderating role in the reported effects. To rectify this state of affairs, in Experiment 4 we simply replicated the current GCT experiment, administering pretask measures of both mood and enjoyment for use as auxiliary predictors.

Experiment 4

Method

Participants. Forty-two undergraduates at the University of Würzburg were recruited as participants for an experiment on "hemispheric activation and performance": Participants were tested individually and were paid DM 2 (approximately $0.90 at the time) for participation.

Procedure. The procedure for Experiment 4 was virtually identical to that for Experiment 3, with two noteworthy exceptions: First, immediately following the experimental instructions but prior to assuming their arm positions, participants were asked about their current mood ("How do you feel right now?"), on a scale anchored at 1 (very bad) and 9 (very good), and about their anticipated enjoyment of the task ("How much do you think you will like the task?"), on a scale anchored at 1 (not at all) and 9 (very much); second, participants were not provided with a time limit for solving the 10 GCT items.

Results and Discussion

Again, GCT performance scores were computed by summing the number of fragmented objects correctly identified out of the 10 presented. A t test comparing the average number of correct solutions given within the two arm contraction conditions replicated the main finding of Experiment 3: Participants who engaged in arm flexion while working on the GCT correctly identified more fragmented objects (M = 9.76; SD = 0.44) than those who engaged in arm extension (M = 7.29; SD = 1.82), t(40) = 6.06, p < .0001.

To assess whether this effect was indeed independent of mood and enjoyment, a series of multiple regression analyses was again conducted using arm position as a predictor and separately entering measures of pre- and posttask mood and enjoyment, as well as mood and enjoyment change (posttask minus pretask) scores, as stand-alone covariates and in interaction with arm position. As in Experiment 3, the effect of arm position remained highly reliable in every analysis, again suggesting that the influence of approach and avoidance motor actions on mental restructuring is independent of affect. Analyses also revealed a marginally reliable main effect of pretask mood on GCT performance, B = 0.194, F(1, 39) = 2.89, p < .10, suggesting that more positive pretask mood is associated with improved restructuring ability. This finding is consistent with previous findings by Isen (see Isen, 1987) and with the predictions of cognitive tuning theory regarding the impact of mood on creativity. Significantly, regression analyses examining the effects of the experimental manipulation on pre- and posttask mood as well as change in mood revealed no reliable effects of arm position, again supporting the notion that affective and nonaffective cues may work independently to influence cognitive tuning.

With regard to enjoyment, there were no reliable effects of either pretask or posttask enjoyment or change in enjoyment on restructuring (all rs < 1.6). Moreover, unlike in Experiment 3, arm position yielded no effect on posttask enjoyment or, in this case, change in enjoyment (rs < 1). Given that this experiment was a virtual replication of Experiment 3, the absence of an arm position effect on enjoyment called into question the reliability of the previous finding and suggested that additional empirical assessment was required. As a result, we included measures of task enjoyment in Experiments 5-7.

Experiment 5

Method

Overview. Experiment 5 explored the effects of approach and avoidance motor actions on the extensiveness of mental search, Schooler and Melcher's (1995) third basic component of creative insight. In the experiment, participants performed arm flexion or arm extension while completing a series of verbal analogy problems. We predicted that arm extension, relative to arm flexion, would prompt more systematic examination of (i.e., perseveration on) attributes and relations initially activated via mental search, thereby impairing activation of the relatively inaccessible attributes or relations required to solve the analogy problems. Again, the effect of arm position was predicted to obtain independently of mood, enjoyment, or arousal.

Participants. Thirty undergraduates of the University of Würzburg were recruited as participants for an experiment on "hemispheric activation." Participants were tested individually and were paid DM 2 (approximately $0.90 at the time) for participation.

Procedure. The procedure for Experiment 5 was virtually identical to that of Experiment 3, with the exception that participants were given 7 min to complete a verbal analogy problems-solving task. This task was composed of 20 multiple-choice analogy problems borrowed from the Intelligence Structure Test (IST-70; Questions 41-60; Amthauer, 1970). An example is

Wald (Forest) : Blume (Trees) = Wiehe (Meadow) : ?
a) Gräser (Grass) b) Heu (Hay) c) Futter (Feed) d) Grün ("Green") e) Weide (Pasture)

All instructions were presented via headphones, and participants were asked to answer all problems loudly so that they could be recorded on another tape. After the 7-min time limit had expired, the participants were stopped by the experimenter. Participants then completed the same posttask survey administered in Experiments 3 and 4. No hypothesis-consistent suspicions were expressed on the open-ended probe. Afterwards, participants were debriefed and thanked and were paid for their participation.

Results and Discussion

Performance scores were computed by summing the number of analogy problems solved out of the 20 presented. To test the experimental hypothesis that arm flexion enhances analogical problem solving relative to arm extension, a t test was conducted comparing performance scores within the flexion and extension conditions. In line with predictions, participants who engaged in arm flexion while performing the task solved more analogy problems (M = 11.87; SD = 2.75) on average than those who engaged in arm extension (M = 8.60; SD = 2.99), t(28) = 3.11, p < .004, supporting the notion that internal, nonaffective benign-environment signals, relative to problematic-environment signals, engender more extensive mental search.

As in Experiments 3 and 4, to examine whether the obtained effect may have been mediated by enjoyment, mood, or arousal, a set of multiple regression analyses was conducted using arm position (flexion vs. extension) as a predictor and separately en-
tering each experiential state measure as both a covariate and in interaction with arm position. These analyses revealed only the predicted main effect of arm position, whereas there were no reliable effects of either mood (t < 1), arousal, (t < 1), or enjoyment (t < 1) on analogical problem-solving performance. In line with Experiment 3, given that these analyses included and did not reduce the magnitude of the arm position effect, the latter finding once again suggests that enjoyment does not mediate the effects of arm position on the cognitive components of insight (see Kenny et al., 1998).

A final set of analyses assessed the effects of arm position on mood, arousal, and task enjoyment by separately regressing each of the posttask experiential state measures on arm position and entering task performance as a covariate. Consistent with Experiment 3 and contrary to Experiment 4, these analyses revealed only a main effect of arm position on enjoyment, $B = -1.07, F(1, 27) = 10.18, p < .004$, suggesting that arm flexion bolsters task enjoyment relative to arm extension. Just as they revealed no tendency for enjoyment to mediate the effects of arm position on performance, mediational analyses (Kenny et al., 1998) also revealed no tendency for task performance (as influenced by arm position) to mediate self-reported enjoyment. Therefore, the present pattern of findings lends additional support to the possibility that approach and avoidance motor actions independently affect both the elements of creative insight and the experience of enjoyment. However, given that these findings were not conceptually replicated in Experiment 4, any conclusions regarding the relationship between arm position, enjoyment, and insight processes must remain tentative at the present time.

Experiment 6

Method

Overview. In this experiment, we used a categorization task closely modeled after that used by Isen and Daubman (1984) to demonstrate the effects of mood on cognitive flexibility (Isen, 1987). The critical component of this task involves having participants rate the goodness of fit of atypical exemplars of given categories. As discussed earlier, we posited that this task may tap into the processes of mental search and/or set-breaking associated with creative insight (Schooler & Melcher, 1995), rendering it a potentially valuable additional test of the effects of arm flexion and extension on these processes. In addition to this new dependent measure, the current experiment included a control group (no arm contraction manipulation), allowing for the first analysis of whether the elements of creative insight are facilitated by arm flexion, impaired by arm extension, or both.

Participants. Forty-five undergraduates at the University of Würzburg were recruited as participants for an experiment ostensibly on hemispheric activation. Participants were tested individually and were paid DM 2 (approximately $0.50 at the time) for participation.

Procedure. The experimental manipulations of approach and avoidance motor actions were administered in the same fashion as in Experiments 1–5. The newly added control group was given the same “hemispheric activation” cover story as the arm flexion and arm extension groups, yet were explicitly informed that they were in a control condition and should position their arms as they saw fit. All instructions were again presented via headphones, and participants were asked to answer all questions loudly so that they could be recorded on another tape.

Following presentation of the instructions (including the induction of the experimental manipulation), participants were administered a practice categorization task, which would allow them to become accustomed to volucally responding on a 10-point scale. On this practice trial, participants rated the extent to which 10 of their own possessions or attributes exemplify the categories to which these possessions or attributes belong. For instance, they were asked to rate the extent to which their own car was a good or poor example of the category cars. Responses were tendered on a 10-point scale anchored at 0 (very poor example) and 9 (very good example).

After this practice trial, participants performed the experimental categorization task. Here, participants were provided with four category names (furniture, vehicle, vegetable, and clothing), each followed by nine items. Three of these items were good exemplars, three were moderately good exemplars, and three were poor exemplars of the category. The poor exemplars (e.g., camel for the category vehicle) were German translations of those that Isen and Daubman (1984) had selected from Rosch’s (1975) norms. Although Isen and Daubman (1984) noted that they had also selected the remaining exemplars from Rosch’s (1975) norms, they did not specify which particular exemplars they chose; therefore, we selected our own good and moderately good exemplars from these norms and translated them into German. As in Isen and Daubman’s (1984) original procedure, these remaining exemplars were included as fillers only. Participants were asked to rate the goodness of fit of each exemplar to the relevant category on the same 10-point scale used in the practice trial. They were reminded of the scale after the ratings for each category were completed. Category order was randomly assigned.

After completing the categorization task, participants filled out the same posttask questionnaire administered in Experiments 3–5. No hypothesis-consistent suspicions were expressed on the open-ended probe. Following completion of this survey, participants were debriefed and thanked and were paid for their participation.

Results and Discussion

We hypothesized that participants in the arm flexion condition would rate atypical exemplars as better category members than would participants in the control condition, indicating that internal, nonaffective benign-environment signals facilitate the inclusiveness of categorization. Correspondingly, we also hypothesized that participants in the arm extension condition would rate atypical exemplars as worse category members than would participants in the control condition, suggesting that internal, nonaffective problemmatic-environment signals diminish the inclusiveness of categorization. To assess these predictions, we separately calculated the average goodness-of-fit ratings for both the 12 atypical (i.e., poor) exemplars and the 24 typical (i.e., good and moderately good) exemplars. These mean goodness-of-fit ratings, indexed by experimental condition and typicality, are depicted in Figure 1.

As can be seen, the pattern of means for the atypical exemplar ratings conforms to the experimental predictions—participants in the arm flexion condition rated the poor exemplars as better members of their respective categories than did participants in the control group, and participants in the arm extension condition rated the poor exemplars as worse members of their categories than did those in the control group. To assess the reliability of these differences, the goodness-of-fit ratings for the atypical exemplars were subjected to an analysis of variance (ANOVA) on arm position (arm flexion vs. arm extension condition). This analysis revealed that the obtained differences between experimental conditions were extremely reliable, $F(2, 42) = 164.76, p < .0001$. Planned contrasts between cell means supplemented this ANOVA. Here, the difference between average ratings within the arm flexion ($M = 4.70; SD = 0.29$) and arm extension ($M = 2.33; SD = 0.42$) conditions was highly reliable, $t(42) = 17.74, p <
.0001, as were the differences between these ratings within the arm flexion and control ($M = 3.07; SD = 0.38), t(42) = 13.44, p < .0001, and the arm extension and control conditions, $t(42) = 17.28, p < .0001$, separately. As expected, the same analyses on the goodness-of-fit ratings of the typical exemplars (included as fillers) revealed no reliable differences at all (all $t$s < 1.5), suggesting that the predicted effects on atypical exemplar ratings did not result from a simple response bias.

As in the previous two experiments, to examine whether the obtained effects may have been mediated by enjoyment, mood, or arousal, we ran a series of ANOVAs including atypical exemplar ratings as a dependent variable, arm position (flexion vs. no position vs. extension) as a predictor and separately entering each experiential state measure as a statistical covariate. These analyses revealed only the predicted main effect of experimental condition—there were no reliable effects of mood, arousal, or enjoyment on inclusiveness of categorization (all $t$s < 1.5). These results are again consistent with the hypothesis that approach and avoidance motor actions influence insight-related processes independent of affective experience.

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A final series of analyses assessed the effects of the experimental manipulations on mood, arousal, and task enjoyment by entering each of these posttask measures as dependent variables in separate ANOVAs covarying ratings of atypical exemplars. The ratings covariate statistically controlled for the possibility that participants found the task more or less enjoyable, pleasant, or arousing because they were seeing more or fewer connections between fringe exemplars and associated categories. Consistent with Experiments 3 and 5, these ANOVAs revealed only a main effect of arm position on task enjoyment, $F(2, 42) = 9.45, p < .0005$, which as indicated by the cell means (see Figure 2), suggests that enjoyment was bolstered by arm flexion and somewhat diminished by arm extension. Planned contrasts between individual groups supplemented the aforementioned analysis: The difference in enjoyment between the arm flexion ($M = 5.53; SD = 1.60$) and arm extension ($M = 3.73; SD = 1.03$) conditions was reliable, $t(42) = 4.27, p < .0002$, as was the difference in enjoyment between the arm flexion and control ($M = 4.33; SD = 0.61$) groups, $t(42) = 2.85, p < .007$. The difference between the arm extension and control conditions was not statistically reliable, $t(42) = 1.42, p < .17$. Along with the analogous findings of Experiments 3 and 5, the current results strongly suggest that approach and avoidance motor actions affect the experience of task enjoyment while influencing the elements of creative insight by means of an independent process.

Experiment 7

Method

Overview. Up until now, the current report has painted a rather lopsided picture, suggesting that arm flexion offers a substantial advantage over arm extension. However, as discussed earlier, if the effects of approach and avoidance motor actions on insight are indeed mediated by differential cognitive tuning, then the systematic processing style elicited by arm extension should facilitate performance on detail-oriented, analytical reasoning tasks. In Experiment 7, we assessed this critical hypothesis by having participants perform arm flexion, arm extension, or no arm contraction, while completing part of a widely used analytical reasoning test. As in the case of effects on insight processes, the predicted facilitative effect of arm extension on analytical problem solving was predicted to obtain independent of mood or enjoyment.

Participants. Fifty-nine undergraduates at the University of Würzburg were recruited as participants for a battery of short experiments. Participants were tested in groups of up to 4 and were paid DM 12 (approximately $6.30 at the time) for participation.

Procedure. Under the same "hemispheric activation" cover story used in Experiments 1–6, participants worked on four logic problems from the analytical reasoning section of the GRE, translated into German. These problems involve evaluating the truth value of a number of propositions...
given an initial set of basic facts. Unlike insight-related tasks, the current problems demand little in the way of mental restructuring and do not require cognitive search for information beyond that provided. Rather, solving these problems involves systematically organizing the information given and carefully analyzing it to determine the verity of a series of logical conclusions.

While completing the GRE items, participants were randomly assigned to perform either arm flexion, arm extension, or to lay their right arms out on the chair arm without any tension, a position found to be a viable control (Seibt & Neumann, 1999). Participants were separated by paravents so they could not see each other. Prior to receiving the “hemispheric activation” instructions, participants were asked about their current mood (“How do you feel right now?”), on a scale anchored at 1 (very bad) and 9 (very good). After working on the analytical reasoning task for 5 min, participants were stopped and administered a survey that again gauged their current mood, as well as the pleasantness of the arm position (“How pleasant was the arm position for you?”), anchored at 1 (very unpleasant) and 9 (very pleasant), and the effortfulness of the arm position (“How effortful was it to maintain the arm position?”), anchored at 1 (not at all effortful) and 9 (very effortful). The posttask survey also assessed enjoyment of the task (“How much did you enjoy the task?”), anchored at 1 (not at all) and 9 (very much). Following the posttask survey, participants were administered a number of other experimental tasks unrelated to the current study, after which they were debriefed and were paid.

Results and Discussion

We predicted that participants in the arm extension condition would demonstrate better GRE performance than those in the arm flexion and control conditions, suggesting that internal, nonaffective problematic environment signals facilitate analytical reasoning. We also predicted that participants in the arm flexion condition would demonstrate worse GRE performance than those in the control condition, suggesting that internal, nonaffective benign-environment signals impair analytical reasoning. To assess these predictions, we summed the number of GRE problems solved out of the four presented. The mean number of problems solved, indexed by experimental condition are depicted in Figure 3.

An ANOVA revealed the effect of arm position (flexion vs. no position vs. extension) on number of correct solutions to be highly reliable, $F(2, 56) = 9.01, p < .0005$. Planned contrasts between cell means clarified this finding, demonstrating, as predicted, that the number of GRE problems solved in the arm extension condition ($M = 2.60; SD = 0.75$) was reliably higher than the number solved in either the control ($M = 1.50; SD = 0.79$), $t(56) = 3.72, p < .0005$, or arm flexion ($M = 1.57; SD = 1.12$) conditions, $t(56) = 3.61, p < .0007$. Contrary to expectations, there was no reliable difference between GRE performance scores within the arm flexion and control groups ($t < 1$). The latter finding may suggest that a heuristic processing style serves as a default for analytical reasoning problems (see Fiske & Taylor, 1991), thereby rendering arm flexion redundant as a processing cue and eliminating performance differences between the arm flexion and control conditions. Alternatively, it may simply suggest a floor effect on task performance.

To determine whether these effects were independent of mood and enjoyment, a series of multiple regression analyses was conducted using arm position as a predictor and separately entering measures of pre- and posttask mood and enjoyment, as well as mood and enjoyment change (posttask minus pretask) scores, as both stand-alone covariates and in interaction with arm position. The main effect of arm position remained reliable in every case, suggesting that the facilitative effect of arm extension on GRE performance was independent of mood or enjoyment. Similar analyses including ratings of the pleasantness and effortfulness of the arm positions as auxiliary predictors also failed to reveal any reduction in the reliability of the arm position effect. There were no other significant effects ($ts < 1.8$).

A final series of analyses assessed the effects of arm position on mood, enjoyment, and the pleasantness and effortfulness of the arm positions by separately submitting each of the posttask experiential state measures to an ANOVA on arm position including task performance as a covariate. These analyses revealed only a
reliable effect of arm position on the effortfulness of the arm contractions, F(2, 55) = 4.39, p < .02. It was not surprising that a subsequent regression analysis using planned contrasts suggested that this effect was due to the control group rating their arm position as less effortful (M = 4.22; SD = 2.36) than the arm positions of the arm flexion (M = 5.67; SD = 2.39) and arm extension (M = 6.20; SD = 1.54) groups (combined), t(55) = 3.14, p < .003. There was no difference between the effortfulness ratings of the latter two (arm contraction) groups (t < 1.4).

It should be noted that the analyses of the postmeasures revealed no effect of arm position on task enjoyment (t < 1). This may be construed either as another failure to replicate the effects of approach and avoidance motor actions on enjoyment found in Experiments 3, 5, and 6, or alternatively, as evidence that these motor actions only affect enjoyment on insight-related tasks. Additional data are undoubtedly required to clarify the relationship between arm contractions and task enjoyment.

General Discussion

The present study tested the hypothesis that internal, nonaffective processing cues independently affect the basic processes involved in creative insight: contextual set-breaking, cognitive restructuring, and unconscious mental search (Schooler & Melcher, 1995). In six experiments, bodily cues signaling a benign or problematic environment were respectively activated by means of arm flexor or extensor contraction, and then the effects of these cues on insight processes were examined. We predicted that the riskier, more unconstrained, heuristic processing style associated with arm flexion would facilitate these insight-related processes relative to the more risk-averse and perseverant, systematic processing style associated with arm extension. To provide additional support for our process model, in a seventh and final experiment, we tested the effects of approach and avoidance motor actions on analytical problem solving, predicting that the systematic processing style elicited by arm extension should improve, rather than impair, performance on a task demanding detail-oriented, systematic processing.

These predictions were strongly supported. Relative to arm extension, arm flexion facilitated breaking contextual set on the EFT (Experiment 1) and the SPT (Experiment 2) and increased the ability to perceptually restructure the fragmented visual figures on the GCT (Experiments 3 and 4). In addition, arm flexion, relative to arm extension, led to improved ability to solve verbal analogy problems (Experiment 5), suggesting that nonaffective benign-environment cues give rise to or enable more extensive unconscious search for common features and relations. In Experiment 6, arm flexion, relative to arm extension, led to more inclusive categorization of atypical exemplars, suggesting that approach motor actions engender a relatively extensive mental search for shared features and/or an enhanced inclination to break away from preexisting assumptions regarding the criteria for category membership (i.e., an enhanced capacity to break mental set). Finally, in Experiment 7, arm extension, relative to arm flexion led to improved performance on a set of GRE analytical reasoning problems, suggesting that the effects of approach and avoidance motor actions on insight (and noninsight) problem solving are indeed mediated by differential (i.e., heuristic vs. systematic) processing styles. It should be noted that all predicted effects were highly reliable and were found within two culturally distinct populations.

Alternative Explanations

In the course of the study, several alternative explanations for the obtained effects were empirically examined. Included among these was the prospect that the pleasantness or effortfulness of the arm positions themselves mediated the obtained effects on the elements of creative insight. Might the enhanced pleasantness or decreased effortfulness of the arm flexion position have bolstered liking for the experimental tasks or reduced distraction from these tasks, thereby improving performance? To address this question, Experiments 1 and 2 both included measures of the pleasantness and effortfulness of the arm positions. Here, no consistent or
relative differences between arm positions with respect to either measure were found; in addition, the facilitative effects of arm flexion on EPT and SPT performance remained equally reliable statistically controlling for pleasantness and effortfulness ratings. This suggests that the obtained effects of approach and avoidance motor actions on insight-related processes were not produced by the comfort or difficulty of the motor actions themselves.

Another plausible alternative explanation for the current findings is that the arm positions differentially affected mood or emotional experience, thereby influencing insight-related processing. As discussed earlier, many theoretical approaches propose that positive affect bolsters creativity and/or that negative affect diminishes it (e.g., Isen, 1987; Schwarz & Bless, 1991). This makes it essential to control for the effects of affective experience in analyzing the influence of nonaffective cues on the elements of creative insight. To do so, each of the six insight experiments in the current report included posttask measures of mood and/or discrete emotional states for use as statistical covariates. We also included in Experiment 4 pretask measures of mood to control for the influence of any preexisting affective differences between conditions. Simply stated, in no analysis did any measure of affective experience or change in affective experience (Experiment 4) diminish the reliability of the effects of approach and avoidance motor actions on insight-related processes. Furthermore, analyses revealed no consistently reliable independent effects of affective state on insight-related processes. Of course, the latter finding should by no means be taken as a strong test of the influence of affect on creativity insomuch as such a test would likely require an experimental manipulation of emotion or mood.

A third potential alternative explanation for the effects of approach and avoidance motor actions on the elements of creative insight is that arm flexion produces greater task enjoyment than does arm extension and that this greater enjoyment, not a more “carefree” processing style, leads to enhanced creativity. Again, the notion that enjoyment (i.e., intrinsic motivation) bolsters creativity has been proposed by various theorists, including Amabile (1983, 1996). To assess this alternative explanation, in Experiments 3–6 we asked participants how much they had enjoyed the tasks they had worked on while engaging in arm flexion or extension. In Experiment 4, a pretask measure of prospective enjoyment was administered as well. Enjoyment indices were included as statistical covariates in the analyses of these four experiments. As in the case of mood, the inclusion of enjoyment as an auxiliary predictor did not reduce the reliability of the effects of approach and avoidance arm positions on insight-related processes. Meditational analyses taking this finding into account failed to produce any evidence that enjoyment mediated the relationship between arm contractions and insight processes. In addition, these analyses revealed no tendency for insight-related performance to mediate the relationship between motor actions and task enjoyment (cf. Hirt, Melton, et al., 1996).

Interestingly enough, although it demonstrated no mediational role in the current study, task enjoyment was more often than not strongly and independently influenced by the experimental manipulation—in three out of five experiments (three out of four insight experiments), arm flexion significantly enhanced task enjoyment relative to arm extension. Inasmuch as task enjoyment has been shown to have significant positive effects on task engagement and persistence (e.g., Deci & Ryan, 1985), this finding, if it proves to be reliable, may still have some intriguing mediational implications. First, even if the enjoyment differences produced by approach and avoidance motor actions or other internal processing cues do not immediately affect insight-related processing, they may do so in the long run. For instance, if an individual given a benign-environment processing cue comes to enjoy the GCT more than one given a problematic-environment cue, then this individual will be more likely to apply effort on the GCT and similar tasks in the future, thereby potentially bolstering his or her restructuring ability over time. Second, although the present study focused on the elements of creative insight, other aspects of creativity (see Sternberg, 1988) may be more immediately affected by processing cue-based differences in task enjoyment. For example, writing a creative story or painting a creative mural may require less in the way of insight than sheer persistence (Weisberg, 1995; cf. Martin, Ward, Achee, & Wyer, 1993), and this added persistence may be fueled by the task enjoyment that results from benign-environment processing cues.

**Future Directions**

Although it parsimoniously accounts for the effects of approach and avoidance motor actions on insight processes, cognitive tuning is of course not the only mechanism that may significantly influence creative insight. Another distinct mechanism that influences creative processes is regulatory focus (Higgins, 1997; Higgins, Roney, Crowe, & Hymes, 1994). According to Higgins and his colleagues, a focus on the presence or absence of positive outcomes (i.e., promotion focus) engenders a strategic inclination to approach matches to desired end-states and a focus on the presence or absence of negative outcomes (i.e., prevention focus) engenders a strategic inclination to avoid mismatches to desired end states. The approach inclination associated with a promotion focus is posited to involve a relatively risky processing style in which novel alternatives are eagerly and actively sought. Conversely, the avoidance inclination associated with a prevention focus is posited to involve a comparatively risk-averse and vigilant processing style in which repetition is favored over novelty and alternatives are carefully eliminated (Crowe & Higgins, 1997; Liberman, Idson, Camacho, & Higgins, 1999).

In a pertinent recent study, Crowe and Higgins (1997) manipulated regulatory focus and then administered a sorting task, which assessed the “creative” ability to generate alternatives (see also, Higgins, 1997). Regulatory focus was induced by means of a task-framing manipulation: In the promotion conditions, participants were instructed that the quality of their current performance would determine whether they would get to work on a desirable task later in the session; in the prevention conditions, participants were instructed that the quality of their current performance would determine whether they would have to work on an undesirable task later in the session. The sorting task merely involved sorting exemplars of fruits, then of vegetables, into subgroups according to freely selected criteria. Consistent with predictions, promotion-focused participants (in whom a strategic approach motive had presumably been elicited) generated a greater number of subgroups than prevention-focused participants (in whom a strategic avoidance motive had presumably been elicited). According to Higgins (1997), this indicates enhanced “abstract thinking” or “creativity” on the part of the former group. Crowe and Higgins...
motivational systems more "concrete" and perseverant in their use of sorting criteria, tending to choose simpler criteria and to more often repeat these criteria for both fruits and vegetables than their promotion-focused counterparts.

Inasmuch as the abstract and generative processing style associated with a promotion focus may bolster creativity (in a manner parallelizing that of benign-environment cues) and the concrete and perseverant processing style associated with a prevention focus may impair creativity (in a manner parallelizing that of problematic-environment cues), it is possible that internal nonaffective sorting signals and regulatory focus may yield significant conjoint effects on insight-related processes. For instance, insight problem-solving ability might be maximized when arm flexion is performed within a promotion focus as the compatible processing styles elicited by both factors (see Förster et al., 1998) might combine additively to heighten novelty seeking and alternative generation. In corresponding fashion, insight problem-solving ability might be minimized when arm extension is performed within a prevention focus as the compatible processing styles elicited by these factors additively intensify risk aversion and perseverance. Regardless of the ultimate merit of these conjectural predictions, the interplay between cognitive tuning and regulatory focus within the arena of creative insight clearly deserves empirical scrutiny.

Just as cognitive tuning may not be the only mechanism that influences insight-related processes, it is also entirely possible that cognitive tuning may not even be the only mechanism by which arm flexor and extensor contractions influence these processes. It is evident from the vast literature on affect and cognition that emotions can produce effects on many levels, impacting thought and action by means of multiple distinct yet interactive processes (Isen, 1987; Martin et al., 1993; Schwarz & Clore, 1996; Wegener & Petty, 1996). In the same way, nonaffective internal states, such as those produced by arm flexion and extension, quite likely bring into play multiple psychological and physiological processes, all potentially intertwining to collectively influence creative cognition.

For instance, regarding the present manipulation, it is possible that approach and avoidance motor actions not only produce bodily signals which trigger the adoption of differential processing strategies, but may also differentially activate the brain-based motivational systems posited by Lang and his colleagues (Lang, 1995; Lang, Bradley, & Cuthbert, 1990). Oversimplified, according to Lang, all emotions are driven by an appetitive system, which organizes responses to consummatory stimuli, and an aversive system, which organizes responses to noxious stimuli. Lang and his colleagues have critically posited a theory of "motivational priming," which predicts that defensive reflexes are intensified "when the aversive system is activated and the individual's emotional state is affectively unpleasant" (Lang, 1995, p. 372) and that defensive reflexes are diminished "when the appetitive system is activated and the individual's emotional state is affectively pleasant" (Lang, 1995, p. 372). In support of this theory, Lang and his associates have accumulated a great deal of empirical evidence suggesting that unpleasant emotional states lead to concurrent augmentation of (aversive) startle reflexes whereas pleasant emotional states lead to concurrent inhibition of these reflexes (e.g., Greenwald, Bradley, Cuthbert, & Lang, 1990; Vrana, Spence, & Lang, 1988).

Although highly speculative at this point, Lang's theory might be extended to make parallel motivational priming predictions for nonemotional internal states, states which do not involve hedonic experience, but are merely associated with such hedonic or evaluative states. For example, the internal, nonaffective state induced by arm extension may potentiate the startle reflex, whereas that induced by arm flexion may inhibit it. If so, we might additionally speculate that cognitive mechanisms related to insight may be "hardwired" to these physiological systems, and concomitantly augmented or inhibited by arm flexion or extension, yielding independent effects on creative problem solving. As Schwarz (1990) suggested, it may be fundamentally adaptive to eschew novelty under threat—if true, this may have favored evolution of an aversive motivational system, which, for instance, inhibits memory search for novel associates and alternatives (and an appetitive system which disinhibits such search). In a way, such a mechanism could be seen as a physiologically hardwired, largely automatic variant of cognitive tuning—the brain "tunes" cognitive processes, just as it adjusts simple behavioral propensities, to match the state of the environment it is informed about either by emotions or by evocatively relevant nonaffective signals. The prospect that cognitive tuning, in this general sense, influences creative insight by means of both experientially and nonexperientially based pathways strikes us as particularly exciting.

In conclusion, as Cacioppo et al. (1993) said of their own pathbreaking work on approach and avoidance motor actions and evaluative judgments, the current study clearly raises more questions than it answers. We hope that the ensuing search for answers will shed new light on the complex but fascinating relationship between body and mind.

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