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The Influence of Approach and Avoidance Motor Actions on Creative Cognition

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This study tested whether internal nonaffective processing cues independently influence two major varieties of creative cognition: insight problem solving and creative generation. In Experiments 1 and 2, bodily cues associated with positive or negative hedonic states were manipulated by means of arm flexor or extensor contraction, respectively, and the effects of these internal cues on creative insight and generation were observed. In line with our cognitive tuning approach, it was predicted that the "riskier," more explorative processing style elicited by arm flexion, relative to the more risk-averse, perseverant processing style elicited by arm extension, would facilitate performance on both tasks. These predictions were strongly supported. In addition, Experiments 3 and 4 provided the first direct evidence that the effects of these internal processing cues on creativity are mediated by a memory search-based mechanism. Reported effects were independent of mood, task enjoyment, and the effortfulness of the motor actions.

In the continuing investigation of the relationship between affect and creativity, a great deal of evidence has been adduced in support of the notion that positive affect, relative to negative or neutral affect, facilitates creative problem solving (e.g., Isen, Daubman, & Nowicki, 1987) and bolsters cognitive flexibility (e.g., Isen & Daubman, 1984; Murray, Sujan, Hirt, & Sujan, 1990; for a review, see Hirt, McDonald, & Melton, 1996). An especially parsimonious explanation for this pattern of findings has been proposed by Schwarz and Bless (Schwarz, 1990; Schwarz & Bless, 1991). According to their *cognitive tuning* theory, affective states serve to inform individuals as to the nature of their current environment. Positive affective states inform individuals that their current environment is benign and that no particular course of action is required. In response to this information, individuals in a positive affective state are posited to become more agreeable to risk taking, adopting a relatively heuristic processing style (cf. Isen, 1987) in which novel alternatives are more likely to be generated (cf. Fiedler, 1988), thereby enhancing creativity.

In contrast, according to cognitive tuning theory, negative affective states inform individuals that their current environment is problematic and that specific action is needed to rectify the prevailing state of affairs. Efforts aimed at change first require a careful assessment of the nature of the problem and of prospective means of solution, thereby inclining individuals in a negative affective state to adopt a relatively systematic, detail-oriented processing style. This style should also entail risk aversion inasmuch as the use of novel untested alternatives may stand to make a bad situation even worse (Schwarz & Bless, 1991). Therefore, according to cognitive tuning theory, negative affective states should increase adherence to established plans of action and

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perseverance on initially accessible alternatives, leading to diminished originality and impaired creative problem solving (for a review of pertinent findings, see Clore, Schwarz, & Conway, 1994).

Although affective states serve a fundamental role in cognitive tuning, according to Schwarz and Clore (1996), internal *nonaffective* states, such as feelings of familiarity and bodily feedback (e.g., Strack, Martin, & Stepper, 1988), may also serve as information regarding the processing requirements of the current situation, with implications for judgment and performance. Building on this reasoning, Friedman and Förster (2000) proposed that internal cues that are associated with positive or negative hedonic states, yet that do not themselves elicit affect, may by dint of this association come to independently trigger differential processing styles (see also Soldat, Sinclair, & Mark, 1997), thereby influencing creative cognition. Paralleling the predictions of cognitive tuning theory regarding affective cues, internal nonaffective cues associated with positive hedonic states are posited to trigger a relatively “risky” heuristic processing style, whereas bolstering creativity and nonaffective cues associated with negative hedonic states are posited to trigger a relatively risk-averse, systematic, and perseverant processing style, thereby undermining creativity.

To test this hypothesis, Friedman and Förster (2000) manipulated the extent to which nonaffective bodily feedback was associated with either positive or negative hedonic states and then examined the effects of this feedback on cognitive processes related to creative insight. The manipulation of nonaffective cues involved having participants perform either arm flexor contraction (by pressing upward on a table) or arm extensor contraction (by pressing downward on a table). According to Cacioppo, Priester, and their colleagues (Cacioppo, Priester, & Berntson, 1993; Priester, Cacioppo, & Petty, 1996), arm flexion gives rise to bodily feedback associated with approaching positive stimuli, whereas arm extension gives rise to bodily feedback associated with avoiding negative stimuli (see also Förster, 1998; Förster, Higgins, & Idson, 1998; Förster & Strack, 1997, 1998; Neumann & Strack, 2000). This hypothesis is based on the learning-theoretical notion that, over the course of a lifetime, arm flexion (where the motor action is directed toward the self) is repeatedly associated with acquiring or consuming desired objects (i.e., approach motivation), whereas arm extension (where the motor action is directed away from the self) is repeatedly associated with rejecting undesired objects (i.e., avoidance motivation).

To systematically assess the effects of these approaches and avoidance motor actions on creativity, Friedman and Förster (2000) manipulated arm flexion versus extension and then administered a number of experimental tasks gauging the three central elements of creative insight proposed by Schooler and Melcher (1995). The first of these elements, *breaking context-induced mental set,* involves overcoming fixation on misleading interpretations and strategies rendered overaccessible by the context of the problem. The second element, *restructuring,* entails reencoding problem components such as to form a novel global representation of the problem. Schooler and Melcher’s final element of creative insight entails *memory search* for novel responses and strategies (cf. Ohlsson, 1992). Simply stated, Friedman and Förster (2000) predicted that the cautious, perseverant processing style triggered by arm extension would impair all three insight-related processes, increasing *fixation* on initial problem interpretations and strategies (thereby preventing set breaking and restructuring) and prolonging attention to initially detected or recalled information (thereby undermining mental search for novel material). In direct contrast, it was predicted that the risky, explorative processing style triggered by arm flexion would facilitate insight-related processing, bolstering the ability to break away from inappropriate initial assumptions and strategies and enabling more unconstrained mental search for novel information.

These predictions were strongly supported. In four experiments, Friedman and Förster (2000) found that arm flexion, relative to arm extension, facilitated the ability to break away from initial, context-driven (mis)interpretations of complex visual figures and to restructure the figures to detect hidden target patterns. In a fifth experiment, participants who performed arm flexion, as compared to those who performed arm extension, demonstrated superior performance at solving verbal analogy problems. Inasmuch as such problems presumably involve mentally accessing potentially correspondent attributes and relations associated with the domains under comparison (Gentner, 1983), this finding may be seen as providing indirect evidence that arm flexion, relative to arm extension, facilitates mental search.

A sixth experiment was hypothesized to gauge either the extensiveness of mental search or the capacity to break contextually induced mental set. In a task inspired by Isen and Daubman (1984), participants rated the goodness-of-fit of weak exemplars (e.g., “camel”) of a given category (e.g., “vehicle”). As proposed by Isen (1987), more inclusive categorization (i.e., higher goodness-of-fit ratings) may reflect more extensive underlying search for shared features between weak and prototypical exemplars. Another possibility is that more inclusive categorization of weak exemplars reflects an enhanced ability or tendency to break mental set, specifically, to break away from initial assumptions regarding category membership criteria. In either case, arm flexion led to higher average goodness-of-fit ratings, whereas arm extension led to lower average goodness-of-fit ratings, suggesting enhancement of one or both of the insight-related mechanisms at issue. In sum, Friedman and Förster (2000) concluded from these findings that arm flexion, by dint of its association with positive hedonic states, triggers a relatively risky, explorative processing style that facilitates insight-related processes, whereas arm extension, by dint of its association with negative hedonic states, triggers a risk-averse, systematic, and perseverant processing style that impairs these processes. Additional support for a cognitive tuning interpretation of these findings and establishment of the boundary conditions for the effect was provided by a seventh experiment. Here, arm extension, relative to arm flexion, facilitated analytical reasoning, a domain of performance posited by cognitive tuning theory to benefit from a systematic, detail-oriented processing style (Schwarz & Bless, 1991). This was critical inasmuch as it demonstrated that arm flexion, relative to arm extension, does not facilitate performance across all domains. Rather, arm flexion and extension both engender distinct processing styles that may either improve or impair performance, depending on the “fit” between these processing styles and the demands of the task at hand. Finally, consistent with Friedman and Förster’s (2000) hypothesis that motor actions are *nonaffective* processing cues, there were no indications that arm flexion or extension in any way influenced mood or emotional state. Moreover, all effects of motor actions on performance remained reliable controlling for the influence of affective states, task enjoyment, and the effortfulness of the motor actions.

Although Friedman and Förster (2000) provided a fairly substantial amount of evidence for the influence of nonaffective states on creative cognition, they also left many important questions unresolved. For instance, although approach and avoidance motor actions influence the basic processes theoretically posited to underlie creative insight (Schooler & Melcher, 1995), do they actually affect performance on insight problems themselves? Do these motor actions influence aspects of creativity not traditionally considered to involve “insight”? Is there any more direct and clear-cut evidence that arm flexion and extension influence creative cognition by means of their impact on memory search processes, and if so, what is the specific mechanism by which these motor actions differentially influence recall? The four experiments in the current study comprise an attempt to answer these critical questions as well as to provide converging support for earlier findings.

EXPERIMENT 1

Method

Overview. In six experiments, Friedman and Förster (2000) adduced evidence that approach and avoidance motor actions influence contextual set breaking, restructuring, and mental search, the central elements of insight problem solving proposed by Schooler and Melcher (1995). However, Friedman and Förster (2000) stopped short of demonstrating that arm flexion and extension differentially affect performance on insight problems themselves. It is almost certainly the case that set breaking, restructuring, and memory search all are associated, at least to some extent, with varieties of cognitive processing unrelated to creative insight (Schooler & Melcher, 1995); therefore, it is critical to demonstrate that motor actions indeed affect insight problem solving and not merely the cognitive processes with which it is empirically correlated.

In an attempt to resolve this critical issue, participants in the current experiment were asked to perform either arm flexion or arm extension while completing each of three insight problems selected from well-known recent insight studies (Metcalfe & Wiebe, 1987; Schooler, Ohlsson, & Brooks, 1993). Following Schooler et al. (1993), these problems may be understood as (a) ultimately soluble by the average problem solver; (b) likely to produce an impasse, or a state of high uncertainty as to how to proceed, during the course of the solution; and (c) likely to produce an “Aha!” experience after prolonged efforts at the solution, a state in which impasse is suddenly overcome and the solution (or solution path [Ohlsson, 1992]) is suddenly discovered. In line with our earlier discussion, we predicted that the risky, novelty-seeking inclination accompanying arm flexion, as compared to the risk-averse, perseverant processing style accompanying arm extension, would enhance the ability to solve these problems. This effect was predicted to remain reliable controlling for the influence of both emotional states (e.g., mood) and nonemotional states (e.g., effortfulness of the motor actions) on performance.

Participants. A total of 30 undergraduates at the University of Maryland–College Park were recruited for an experiment on “problem solving.” Participants were run individually and were given course credit for participation.

Procedure. On arrival, participants were seated at a table approximately 29 in. in height. They were then provided with a cover story designed to prevent self-perception effects on performance (Olson & Hafer, 1990). According to Strack et al. (1988), self-perception effects require inferences regarding the meaning of the observed behavior. Taking this into account, the current cover story provided participants with a specious alternative meaning for their motor actions, one designed to prevent them from inferring that arm flexor contraction, relative to arm extensor contraction, would facilitate their problem-solving ability. Specifically, they were told the following:

> Today, you’ll be participating in a study examining the effects of hemispheric lateralization on problem solving. More specifically, we’re trying to understand the relationship between left and right brain activation and the ability to solve certain types of problems. Basically, there’s been an ongoing debate, with some people saying that the left hemisphere is the center for this type of cognitive activity and others saying that the right hemisphere is more critical.

Following these instructions, participants were told 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, who was blind to the hypothesis, subsequently demonstrated arm flexion (for those assigned to the approach motor action group) or arm extension (for those assigned to the avoidance motor action group). The arm flexion manipulation involved having participants lightly press their right palms upward against the bottom of the table with their elbows bent at a right angle. The arm extension manipulation involved having participants lightly press their right palms downward against the top of the table with their elbows kept straight. After demonstrating the assigned motor action, the experimenter tested whether participants knew how to perform it correctly.

Afterward, the experimenter administered three insight problems (Schooler et al., 1993, Appendix A, Problems 1–3). For example,

> A dealer in antique coins got an offer to buy a beautiful bronze coin. The coin had an emperor's head on one side and the date 544 B.C. stamped on the other. The dealer examined the coin, but instead of buying it, he called the police. Why? *Solution:* The year 544 B.C. predates the birth of Christ; therefore, a coin from that year would not be inscribed with an abbreviation for "Before Christ."

The experimenter timed how long it took for participants to find the solutions. A maximum time of 6 min was allotted per problem. Participants were asked to engage in the appropriate motor action (flexion vs extension) before each new problem was presented and to disengage from performing this motor action after either verbally providing the experimenter with the correct solution or running out of time. Each time a participant announced that he or she had found the solution to a given problem, the experimenter immediately stopped the timer, asked the participant to withdraw his or her arm from the table, and had the participant explain the solution. If the solution offered was incorrect, then the experimenter had the participant reengage in the appropriate motor action and continue working on the problem until he or she found the correct solution or ran out of time.

After working on three insight problems in this fashion, participants completed a paper-and-pencil survey. The first page of this survey measured participants' current affect, asking them about their mood ("How do you feel right now?") on a scale anchored at 1 (*very bad*) and 9 (*very good*) and about how "worried," "disappointed," "calm," "happy," "content," "tense," "discouraged," and "relaxed" they currently felt ("How _____ do you feel right now?") on a scale anchored at 1 (*not at all*) and 9 (*extremely*). The second page of the post-task survey was meant to address alternative mediators for the predicted effect, asking participants about the effortfulness of the motor action ("How effortful was it to maintain the arm position?") on a scale anchored at 1 (*not at all effortful*) and 9 (*very effortful*) and about enjoyment of the problem-solving task ("How much did you enjoy the task?") on a scale anchored at 1 (*not at all*) and 9 (*very much*). The final survey item was an open-ended probe for suspicions regarding the cover story. No hypothesis-consistent suspicions were voiced. Following completion of this survey, participants were debriefed and released.

Results and Discussion

Insight problem-solving scores were calculated both by summing the number of problems solved (out of the three presented) and by summing the times spent working on the three problems (with shorter total completion times indicating superior problem-solving ability). The latter is a more sensitive index of performance, motivating its use as a dependent measure in the analyses to follow. All significant effects reported using total time in this fashion are also reliable substituting total number correct as a dependent measure. Another note before proceeding: In all seven experiments conducted by Friedman and Förster (2000), arm flexion and extension were performed uninterrupted for less than 3 min at maximum (and typically for a considerably shorter period of time). The imposition of relatively brief periods of arm contraction was meant to minimize variance due to the differential effortfulness of engaging in arm flexion relative to arm extension over time. After several minutes, arm flexion, in which the weight of the forearm is not supported by the table, can become discernibly more effortful than arm extension. In the current experiment, however, relatively long contraction times (of up to 6 min per problem) were required, allowing this difference in effortfulness to emerge, as evidenced by the marginally significant difference in effortfulness ratings by participants in the arm flexion ($M = 5.50$) and arm extension ($M = 4.06$) conditions, $t(28) = -1.81$, $p = .08$. To account for this extraneous source of variation, effortfulness ratings were included as a statistical covariate in analyses of performance to follow.

To test the main experimental hypothesis that arm flexion facilitates insight problem solving relative to arm extension, a multiple regression analysis was conducted using total solution time as a dependent variable and entering motor action (arm flexion vs extension) as a predictor and effortfulness ratings as a covariate. Consistent with predictions, this analysis revealed a significant main effect of motor action, $b = -42.67$, $F(1, 27) = 6.48$, $p < .02$, suggesting that participants who engaged in arm flexion demonstrated better insight problem-solving performance than did those who engaged in arm extension. This finding supports the hypothesis that arm flexion, a nonaffective cue associated with positive hedonic states, relative to arm extension, a nonaffective cue associated with negative hedonic states, triggers a processing style that facilitates creative insight.

To determine whether the effect is independent of affective influences, a series of subsidiary multiple regression analyses were conducted again using motor action as a predictor and effortfulness as a covariate while separately entering measures of current mood and specific emotions as auxiliary predictors. In all analyses, the main effect of motor action remained statistically significant, suggesting that it is independent of affective influences. These analyses also revealed two reliable, unpredicted main effects on performance: one of disappointment, $b = 17.23$, $F(1, 26) = 7.08$, $p < .02$, and another of contentment, $b = -17.32$, $F(1, 26) = 6.60$, $p < .02$, suggesting that increased experience of disappointment is predictive of lower insight problem-solving performance and that increased experience of contentment is predictive of improved performance. These independent effects are in line with the findings of Isen (1987) and others (e.g., Hirt, Levine, McDonald, Melton, & Martin, 1997), suggesting that positive affective states bolster, and negative affective states impair, creativity.

A final series of analyses was conducted to determine whether task enjoyment mediated the effects of approach and avoidance motor actions on creative insight. In three of five experiments in which measures of enjoyment were collected, Friedman and Förster (2000) found that arm flexion bolstered task enjoyment relative to arm extension, although enjoyment did not mediate the effects of these motor actions on performance. These strong, albeit inconsistent, findings were interpreted as compatible with the work of Cacioppo et al. (1993) demonstrating that stimuli encountered under arm flexion are evaluated more positively than are those encountered under arm extension. Presumably, in Friedman and Förster's (2000) case, the evaluated stimulus may have simply been the experimental task itself, leading to differential ratings of task enjoyment under flexion versus extension.

The current experiment provided another valuable opportunity to assess the role of enjoyment in insight-related processing. To first test whether the effects of motor action on insight problem solving were independent of task enjoyment, another multiple regression analysis was conducted, this time including enjoyment as an auxiliary predictor. As predicted, this analysis revealed that the effect of motor action on insight remains reliable controlling for the effects of task enjoyment, $b = -37.87$, $F\,(1, 26) = 5.62$, $p < .03$. More interestingly, this analysis also revealed an unpredicted main effect of task enjoyment on insight problem-solving performance, $b = -13.21$, $F(1, 26) = 4.37$, $p < .05$, suggesting that increased enjoyment of the task is predictive of improved solution time. This effect is consistent with the theorizing of Amabile (1983, 1996), who posited that creativity is positively associated with intrinsic motivation (e.g., enjoyment). To determine whether arm flexion and extension themselves yielded differential effects on enjoyment, a subsequent analysis was conducted regressing task enjoyment on motor action, statistically controlling for solution time. In partial contrast to the findings of Friedman and Förster (2000), this analysis revealed no hint of an effect of approach and avoidance motor actions on task enjoyment, $t < 1$. This inconsistency only highlights the need for more systematic empirical examination of the relationship among task enjoyment, nonaffective processing cues, and insight.

In sum, Experiment 1 constitutes the first empirical evidence supporting the hypothesis that nonaffective processing cues directly influence insight problem solving, a fundamental component of creative thought. Arm flexion, a nonaffective cue associated with positive hedonic states, relative to arm extension, a nonaffective cue associated with negative hedonic states, enhanced the ability to solve a set of three "classic" insight problems. This is consistent with the hypothesis that nonaffective cues associated with positive states elicit a more risky, explorative processing style, whereas those associated with negative states elicit a more risk-averse, perseverant processing style (Schwarz & Bless, 1991). The effects of approach and avoidance motor actions remained reliable statistically controlling for the influence of mood, distinct emotional states, task enjoyment, and the effortfulness of the motor actions themselves.

Although the current experiment converges with prior empirical work to strongly support the link between nonaffective cues and insight-related cognition, it also raises an interesting question: Do nonaffective cues also influence aspects of creativity not traditionally considered to involve insight? Unlike insight problems, many of the experimental tasks used in the study of creativity do not have a fixed solution and do not typically or clearly produce an impasse to be overcome (Schooler et al., 1993). Instead, many of these tasks simply involve generation of instances of preexisting or experimenter-defined categories (e.g., Hirt et al., 1997; Murray et al., 1990; Smith, Ward, & Schumacher, 1993; see also Wyer, Clore, & Isbell, 1999), which are then rated for their "creative" content.

Although creative generation tasks are not insight problems in the strict sense, there is good theoretical reason to believe that nonaffective processing cues may exert an analogous influence on these tasks. For instance, it is possible that the distinct processing styles triggered by nonaffective cues may moderate the criteria for reporting generated exemplars, thereby influencing the average creativity of the responses tendered. More specifically, the risk-averse mind-set elicited by cues associated with negative hedonic states (e.g., arm extension), relative to the risky mind-set elicited by cues associated with positive states (e.g., arm flexion), may lead individuals to adopt a more conservative criterion for reporting generated exemplars, causing them to exclude potentially innovative exemplars for fear of making "inappropriate" responses (cf. Wyer et al., 1999).

It is also possible that the cautiousness associated with negative state-associated cues, relative to the explorative bent associated with positive state-associated cues, may increase the likelihood that individuals attentionally persevere on initially generated or "tried-and-true" exemplars. This may give rise to a blocking effect, whereas the focus on initial exemplars (or the features that comprise them) serves to inhibit individuals from retrieving material needed to construct innovative new exemplars. Consequently, relative to positive state-associated cues, negative state-associated cues not only may prevent individuals from reporting innovative alternatives but also may actively prevent individuals from generating them in the first place (cf. Smith, 1995; Smith et al., 1993).

To test the hypothesis that nonaffective processing cues influence creative generation, in Experiment 2, participants were asked to engage in either arm flexion or arm extension while they completed a typical creative generation task. It was predicted that arm flexion would lead to more creative responses than would arm extension. Moreover, this effect was predicted to remain reliable controlling for the influence of both emotional (e.g., mood) and nonemotional states (e.g., effortfulness) on creativity.

EXPERIMENT 2

Method

Participants. A total of 26 undergraduates at the University of Würzburg were recruited for an experiment on "hemispheric activation." Participants were run individually and were given a chocolate bar for participation. One participant failed to follow instructions and, therefore, was excluded from the analyses.

Procedure. On arrival, participants were seated at a table and provided with the same "hemispheric lateralization" cover story employed in Experiment 1. To rule out any mediating role of pre-task mood, interest, or changes in these states, participants were next administered a pre-task measure of mood and anticipated task enjoyment for use as auxiliary predictors. Specifically, participants filled out a brief questionnaire asking them "How do you feel right now?" on a scale anchored at 1 (*very bad*) and 9 (*very good*) and "How much do you think you would enjoy the task?" on a scale anchored at 1 (*I would not enjoy it at all*) and 9 (*I would enjoy it very much*).

Afterward, participants put on headphones, through which they could hear the tape-recorded experimental instructions, and engaged in the right-arm motor action (flexion or extension) to which they had been randomly assigned. The tape instructed participants to generate as many creative uses for a brick as they could think of. They were asked to refrain from listing typical uses or from listing uses that were virtually impossible. Participants announced their responses into a microphone that was connected to another tape recorder, allowing them to keep their right arms free for use in performing the appropriate motor action. Participants were interrupted after 1 min, told to stop generating uses and to discontinue their motor action, and asked to fill out a final questionnaire. This questionnaire gauged participants' current mood ("How do you feel right now?") on a scale anchored at 1 (*very bad*) and 9 (*very good*), their enjoyment of the creative generation task ("How much did you enjoy the task?") on a scale anchored at 1 (*not at all*) and 9 (*very much*), the difficulty of the task ("How difficult was the task?") on a scale anchored at 1 (*not at all difficult*) and 9 (*very difficult*), the pleasantness of the motor action ("How pleasant was the arm position?") on a scale anchored at 1 (*not at all pleasant*) and 9 (*very pleasant*), and the effortfulness of the motor action ("How effortful was it to maintain the arm position?") on a scale anchored at 1 (*not at all effortful*) and 9 (*very effortful*). After completion of the post-task survey, participants were debriefed, sworn to secrecy, and given a chocolate bar for their participation.

Data coding. The dependent variable of interest was the creativity of the uses for a brick generated by participants. To assess the creativity of these responses objectively, 12 independent scorers (members of the University of Würzburg psychology department) were asked to rate the creativity of the 117 different uses that participants generated on a 9-point scale ("How creative is this response?") anchored at 1 (*very uncreative*) and 9 (*very creative*) and 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 calculated by summing the number of responses that exceeded the midpoint (5) of the creativity scale. An example of a creative response was "using [the brick] as a slide for my hamster"; an example of an uncreative solution was "to throw it."

Results and Discussion

Before analyzing creativity scores, we first examined the between-groups difference in total number of responses tendered. Motor action (arm flexion vs extension) had no reliable effect on the total number of uses for a brick listed by participants ($M_{\text{Flexion}} = 6.5$, $M_{\text{Extension}} = 7.0$), $t < .50$, suggesting that approach and avoidance motor actions do not differentially influence the sheer volume of production. To test the main experimental hypothesis that arm flexion bolsters creative generation relative to arm extension, a t test was conducted comparing mean creativity scores within in the two experimental groups. In line with predictions, participants who performed arm flexion while completing the generation task demonstrated higher creativity ($M = 5.10$) than did those who performed arm extension ($M = 4.41$), $t(23) = 3.74$, $p < .002$. Likewise, a t test substituting total number of creative responses as a dependent measure revealed that arm flexion led to generation of more creative uses for a brick ($M = 4.08$) than did arm extension ($M = 2.38$), $t(23) = 2.58$, $p < .02$. These findings are consistent with the hypothesis that nonaffective cues associated with positive hedonic states (e.g., arm flexion), relative to those associated with negative hedonic states (e.g., arm extension), elicit a processing style that facilitates the generation of creative alternatives.

In supplementary multiple regression analyses using total number of creative responses as a dependent variable and separately entering pre- and post-task mood and enjoyment, change in mood and enjoyment scores (post-task–pre-task), as well as task difficulty and motor action pleasantness and effortfulness ratings as covariates, the main effect of motor action remained equally reliable in every case. Once again, this supports the notion that the effects of approach and avoidance motor actions on creativity are independent of the influences of emotional and nonemotional phenomenological states (Friedman & Förster, 2000). These analyses also revealed a single, unpredicted main effect of change of enjoyment on total number of creative responses, with increased differential enjoyment predicting increased creativity, $b = 0.31$, $F(1, 22) = 4.58$, $p < .05$. A follow-up analysis regressing change in enjoyment on motor action and total number of creative responses again revealed the same significant positive relationship between differential enjoyment and creativity while failing to indicate any effect of motor action on differential enjoyment, $t < 1$. This pattern of results suggests that the relationship between approach and avoidance motor actions and creative generation is unmediated by differential task enjoyment (Kenny, Kashy, & Bolger, 1998). However, as in Experiment 1, these results are consistent with Amabile's (1983, 1996) proposal of a positive association between intrinsic motivation (e.g., enjoyment) and creativity. Of course, the correlational nature of the current findings precludes determination of the direction of this relationship (cf. Hirt, McDonald, & Melton, 1996).

Overall, the results of Experiment 2 complement those of the first experiment quite well, demonstrating that internal, nonaffective processing cues not only influence creative insight but also influence the generation of creative alternatives. Arm extension, a nonaffective, negative state-associated internal cue, relative to arm flexion, a nonaffective, positive state-associated internal cue, diminished the ability (or propensity) of individuals to generate creative uses for a brick. Again, this finding is quite consistent with the notion that nonaffective cues associated with negative hedonic states trigger a more risk-averse, more perseverant, and less explorative processing style than do nonaffective cues associated with positive hedonic states. In the current case, activation of these differential processing styles may have led individuals performing arm extension, relative to those performing arm flexion, to more readily exclude innovative yet potentially "inappropriate" answers from their response sets and/or to attentionally persevere on initially generated exemplars, thereby undermining the creativity of their subsequent responses. As predicted, the influence of approach and avoidance motor actions on creative generation remained statistically reliable controlling for mood, task enjoyment, and the pleasantness and effortfulness of the arm contractions.

Before proceeding, it is important to reiterate that the lack of a control group in Experiments 1 and 2 precluded estimation of the absolute effects of arm flexion and extension on creative cognition. To rectify this state of affairs, in the following two experiments we included a "no arm contraction" condition as a control group.

EXPERIMENT 3

Method

Overview. The results of the first two experiments offer direct evidence that approach and avoidance motor actions influence both insight problem solving and creative generation. This helps to resolve two critical questions raised by Friedman and Förster's (2000) initial exploration of the impact of internal nonaffective cues on creative cognition. As discussed earlier, Friedman and Förster adduced evidence that arm flexion, relative to arm extension, facilitates three elementary, insight-related processes: contextual set breaking, restructuring, and memory search for novel responses and strategies (Schooler & Melcher, 1995). Whereas evidence regarding the first two processes was drawn from performance on well-validated tests of set breaking and mental restructuring (e.g., the Embedded Figures Test [Witkin, Oltman, Raskin, & Karp, 1971]), evidence for more extensive memory search under arm flexion was relatively indirect, based on inferences from differential performance on tasks presumed to at least partially involve mental search processes (e.g., analogical reasoning). To provide more convincing empirical support for the hypothesis that arm flexion, relative to arm extension, engenders more extensive mental search, in Experiment 3 participants engaged in these arm contractions while performing a word puzzle task specifically designed to require retrieval from memory of viable solutions. A control group (no arm contraction) was also included to explore whether memory search is facilitated by arm flexion, impaired by arm extension, or both.

Experiment 3 also provided an opportunity to examine the underlying process by which arm contractions affect memory search. We have posited that the mechanism driving this influence may involve memory blocking, specifically an attentional perseverance on initial responses (or their associates) that can act to inhibit individuals from retrieving material required to produce novel responses (Smith, 1995; Smith & Tindell, 1997). Inasmuch as the risky, explorative processing style accompanying arm flexion, relative to the risk-averse, vigilant processing style accompanying arm extension, diminishes perseverance on initially accessed material, arm flexion should produce less memory blocking than should arm extension. If so, then arm flexion may not generally facilitate memory search (e.g., via more extensive spreading activation [cf. Ohlsson, 1992]) but rather may facilitate search only under conditions in which potentially "occlusive" (Anderson & Bjork, 1994) information is initially presented or retrieved.

To test whether arm flexion, relative to arm extension, generally facilitates memory search or merely prevents impairment due to retrieval blocking, the word puzzle task in Experiment 3 was designed to activate information in an initial memory search that could serve to block retrieval on a subsequent search. We reasoned that facilitation of performance on both searches under arm flexion, relative to extension, would suggest that approach motor actions generally bolster memory search, perhaps by engendering activation of more and/or more distant nodes in a semantic network (Bower, 1981). However, if arm flexion, relative to arm extension, indeed facilitates memory search by diminishing retrieval blocking, then arm flexion should improve performance only on the second search, following the activation of potentially obstructive material.

Participants. A total of 63 right-handed undergraduates at the University of Würzburg were recruited for an experiment on "hemispheric activation." Participants were run individually and were given a chocolate bar for participation. Four participants failed to follow instructions and, therefore, excluded from the analyses.

Procedure. On arrival, participants were seated at a table approximately 29 in. high and were provided with the same "hemispheric lateralization" cover story employed in Experiments 1 and 2 with a single exception: All participants were instructed that they were in the right, as opposed to the left, hemisphere activation condition and were instructed to perform the arm motor actions with their left, as opposed to their right, hands. This change was necessary so as to allow participants to write in their solutions to the word puzzle task (see below). To rule out any mediating role of emotional states and task interest, participants were next 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*); how "happy," "concerned," "disappointed," "calm," "content," "tense," "discouraged," "relaxed," "down," "depressed," "relieved," "cheerful," and "nervous" they currently felt ("How _____ do you feel right now?") on a scale anchored at 1 (*not at all*) and 9 (*extremely*); and their anticipated task interest ("How much do you think you would enjoy the task?") on a scale anchored at 1 (*I would not enjoy it at all*) and 9 (*I would enjoy it very much*).

Afterward, according to condition, participants were asked to either engage in arm flexion, engage in arm extension, or lay out their left arms on the chair arms without any tension (control) while the experimenter instructed them regarding the word puzzle task. This task was comprised of a sheet containing 15 letter strings printed twice: once in one column and again in a second column. Each letter string contained blank spaces to which missing letters could be added to form German words. For instance, the fifth row was "FL_CH FL_CH," which could be solved with "flach" (shallow) and "Fluch" (curse). Participants were instructed that they had to solve as many word puzzles as possible within 1 min and that each of the puzzles had more than one solution. The sheet containing the puzzles was taped to the table so as to make writing with one arm easier.

As alluded to above, it was assumed that words initially accessed to complete the first column of puzzles, along with semantic associates of these words, may be differentially attended to or ignored, thereby leading to more or less interference with the retrieval of novel solutions for the second column of puzzles (cf. Smith, 1995). For instance, following its use as a solution for the word puzzle "FL_CH," perseverant retrieval of "flach" (shallow) when "FL_CH" is re-presented may block retrieval of "Fluch" (curse). In addition, perseverance on "flach" (shallow) may increase the accessibility of concepts such as "depth" and "water," preventing the individual from accessing the semantic network related to "Fluch" (curse) and thereby impeding retrieval of this second solution. Based on this logic, we concluded that a higher number of word completions for the 15 puzzles in the second column alone would largely reflect improved ability to escape the inhibitory effects of material retrieved during completion of the 15 puzzles in the first column. Improved performance on both the first and second sets of puzzles would instead suggest a more general facilitation of memory search rather than the proposed "disinhibition."

Participants were interrupted after 1 min had elapsed, told to stop working, and told to discontinue their arm positions. Afterward, they were administered a final survey that again gauged their current mood and specific emotions using the same scales employed at the beginning of the session. They were also asked about their enjoyment of the word puzzle task ("How much did you enjoy the task?") on a scale anchored at 1 (*not at all*) and 9 (*very much*), the difficulty of the task ("How difficult was the task?") on a scale anchored at 1 (*not at all difficult*) and 9 (*very difficult*), the pleasantness of the arm position ("How pleasant was the arm position?") on a scale anchored at 1 (*not at all pleasant*) and 9 (*very pleasant*), and the effortfulness of the arm position ("How effortful was it to maintain the arm position?") on a scale anchored at 1 (*not at all effortful*) and 9 (*very effortful*). After completion of the post-task survey, participants were debriefed, sworn to secrecy, and given a chocolate bar for their participation.

Results and Discussion

We predicted that participants in the arm flexion condition would solve more word puzzles in the second column (out of 15) than would those in the control condition, suggesting that internal nonaffective cues associated with positive hedonic states facilitate memory search via diminished retrieval blocking. In corresponding fashion, we predicted that participants in the arm extension condition would solve fewer puzzles in the second column than would those in the control condition, suggesting that internal nonaffective cues associated with negative hedonic states impair memory search via increased retrieval blocking. No difference between conditions was expected for the first column of word puzzles inasmuch as completion of these puzzles was not preceded by activation of retrieval-obstructive material.

To test the prediction that arm flexion bolsters, and arm extension impairs, word completion performance on the second column of puzzles alone, we subjected the total number of correct solutions to a repeated-measures analysis of variance (ANOVA) (Motor Action: control vs arm extension vs arm flexion × Column: first vs second). This revealed a significant main effect of column, $F(2, 56) = 85.27$, $p < .0001$, reflecting that performance on the first column of puzzles reliably surpassed that on the second column, presumably due in large part to retrieval blocking of second-column solutions by first-column solutions as well as to fatigue. More important, this analysis revealed a borderline significant Motor Action × Column interaction, $F(2, 56) = 2.98$, $p = .059$, suggesting that the effects of motor action differed within the first and second columns of word fragments. To clarify this interaction, we subjected total number of correct solutions for each column to separate one-way ANOVAs, entering motor action as a predictor. As predicted, performance did not differ reliably as a function of motor action for the first column ($M_{\text{Extension}} = 10.90$, $M_{\text{Control}} = 12.39$, $M_{\text{Flexion}} = 11.90$), $F < 1$; however, it was indeed reliably different for the second column ($M_{\text{Extension}} = 6.60$, $M_{\text{Control}} = 5.67$, $M_{\text{Flexion}} = 8.19$), $F(2, 56) = 3.47$, $p < .04$. Planned comparisons supplemented this ANOVA, suggesting that, as predicted, arm flexion led to improved second-column performance relative to no arm contraction (control), $t(56) = 2.58$, $p = .01$. Contrary to predictions, there was no difference between the arm extension and control groups, $t < 1$, although these groups together demonstrated worse second-column performance than did the arm flexion condition, $t(56) = 2.46$, $p < .02$.

As an additional means of assessing the notion that arm flexion facilitates mental search by enabling greater freedom from retrieval inhibition, we also analyzed zero-order correlations between performance on first- and second-column word puzzles within each experimental condition. Holding all else equal, one might expect a positive correlation between first- and second-column word puzzle performance due to individual differences in ability (e.g., vocabulary) and/or due to priming, by either the target string or first-column solutions, of orthographically similar words that may serve as second-column solutions (e.g., "flach" might at least weakly prime "Fluch"). However, this prospective correlation should be reduced in magnitude by retrieval blocking due to perseverance on initial solutions and related material; better first-column performance may also provide more material that can serve to "occlude" second-column solutions. Therefore, if arm flexion indeed diminishes perseverance, then there should be a stronger positive correlation between first- and second-column performance within the arm flexion condition than there is within the other conditions. Interestingly enough, this is exactly what we found: $r_{\text{Extension}} = 0.16$, $p > .47$; $r_{\text{Control}} = -0.17$, $p > .46$; and $r_{\text{Flexion}} = 0.48$, $p < .03$.

As a final step, to examine whether the effect of motor action on second-column word completion performance was independent of the effects of emotional and nonemotional states, several supplementary ANOVAs were conducted, using total number of second-column solutions as a dependent variable and separately entering pre- and post-task mood, specific emotion ratings, task enjoyment, changes in these states (post-task–pre-task), as well as task difficulty and the pleasantness and effortfulness of the arm positions as covariates. As in the first two experiments, the effect of motor action remained equally reliable in every case. These analyses also revealed a single, unpredicted main effect: Unsurprisingly, task difficulty ratings were negatively predictive of second-column word puzzle performance, $F(1, 55) = 4.78$, $p < .04$. There were no other significant effects.

In sum, these findings are consistent with the notion that arm flexion produces less retrieval blocking of second-column puzzle solutions by first-column solutions (or co-activated material to which they are related). At this point, we can only speculate as to why arm extension did not impair second-column performance relative to no arm contraction. One possibility is that memory blocking is a default process; it may be fundamentally adaptive to maintain attentional focus on currently active material (e.g., a current plan [cf. Gollwitzer & Moskowitz, 1996]) until it is clearly "safe" to change course. The internal nonaffective feedback provided by arm flexion may provide just this sort of "safety" signal (Friedman & Förster, 2000), enabling activation of alternative responses and strategies. The current findings should not be taken as evidence that arm extension generally has no effect on cognitive processing. For instance, Friedman and Förster (2000) found strong and reliable differences between control and arm extension groups on measures of both word categorization (Study 6) and analytical reasoning (Study 7).

In conclusion, Experiment 3 provides the first direct evidence that internal, nonaffective processing cues influence memory search processes. Arm flexion, a positive state-associated internal cue, bolstered retrieval of verbal solutions on a letter string completion task relative to both arm extension, a negative state-associated internal cue, and no arm contraction. The pattern of findings was also consistent with a retrieval blocking-based process account; the risky, explorative processing style elicited by positive state-associated cues appears to facilitate memory search by reducing perseverance on potentially obstructive, initially activated cognitive material. Finally, as predicted, the differential effects of approach and avoidance motor actions on memory search were statistically independent of the influence of both emotional (e.g., mood) and nonemotional states (e.g., task enjoyment).

EXPERIMENT 4

Method

Overview. Although the results of Experiment 3 offered encouraging initial support for the hypothesized process account, there were two crucial aspects of the design that limited the interpretability, and possibly the strength, of the findings. First, the instructions to participants did not explicitly require that they complete each first-column word fragment in a pair prior to completing its counterpart in the second column. Although unlikely among German-speaking participants who read from left to right, it is possible that participants did in fact solve a number of second-column fragments prior to attempting their first-column counterparts. If participants did in fact work from right to left as such, then it would invalidate the critical hypothesis that differences in second-column word puzzle performance were related to the interposition of a first-column of puzzles that served to activate blocking material. Another shortcoming of Experiment 3 was that it relied on participants to self-generate blocking material in completing the first column of puzzles. This rendered it impossible to ensure that participants would indeed produce, or even try to produce, first-column responses that could later serve to impair second-column performance. For each word puzzle on which an initial "blocking" response was not produced or attempted, the power to detect a blocking-based effect was correspondingly diminished. Although speculative, this weakening of the experiment's ability to induce, and subsequently to detect evidence of, retrieval blocking may have contributed to the absence of a significant, second-column performance difference between the arm extension and control groups.

To rectify this state of affairs, in Experiment 4 participants were *provided* with solutions for the first column of word fragments, after which they were explicitly instructed to solve each remaining fragment in the second column. This modification obviated interpretational concerns deriving from the possibility that participants had worked from right to left and ensured that all participants, on all puzzles, were exposed to initial material that could serve to block retrieval of alternative solutions. It was predicted that arm flexion would bolster, and arm extension would diminish, word puzzle completion performance relative to a no arm contraction control group.

Participants. A total of 30 right-handed undergraduates at the University of Würzburg were recruited for an experiment on "hemispheric activation." Participants were run individually and were given a chocolate bar for participation.

Procedure. The procedure for Experiment 4 was virtually identical to that for Experiment 3, with the following exceptions. First, in place of a first column of word fragments, participants were provided with a column of complete words, each representing a correct solution to its adjacent, second-column word fragment. Each specific first-column solution was randomly assigned. To illustrate, in place of the puzzle "FL_CH FL_CH" administered in Experiment 3, in the current experiment participants were randomly provided with either "FLUCH FL_CH" or "FLACH FL_CH." Second, a few additional items were added to the pre- and post-task questionnaires. Specifically, prior to and immediately following the word fragment completion task, participants were asked about their task motivation ("How motivated are/were you to do well on the task?") and about their current state of arousal ("How aroused do you feel right now?") on a scale anchored at 1(*not at all*) and 9 (*extremely*).

Results and Discussion

It was predicted that participants in the arm flexion condition would solve more word puzzles (out of 15) than would those in the control condition, suggesting that internal nonaffective cues associated with positive hedonic states facilitate memory search via diminished retrieval blocking. In contrast, it was predicted that participants in the arm extension condition would solve fewer puzzles than would those in the control condition, suggesting that internal nonaffective cues associated with negative hedonic states impair memory search via increased retrieval blocking. To test these predictions, we subjected the total number of correct word fragment solutions to an ANOVA (Motor Action: arm flexion vs arm extension vs control). This ANOVA revealed that performance differed between conditions in a pattern very much in line with predictions ($M_{\text{Flexion}} = 9.2$, $M_{\text{Control}} = 7.5$, $M_{\text{Extension}} = 5.6$), $F(2, 27) = 11.45$, $p < .0003$. Planned comparisons supplementing this ANOVA suggested that arm flexion led to improved word fragment completion relative to no arm contraction (control), $t(27) = 2.26$, $p < .04$, and that arm extension indeed led to impaired word fragment completion relative to no arm contraction, $t(27) = 2.52$, $p < .02$.

To assess whether the effect of motor action on word fragment completion performance was independent of the effects of emotional and nonemotional states, several additional ANOVAs were conducted using total number of completions as a dependent variable and separately entering pre- and post-task mood, specific emotion ratings, arousal, task enjoyment, task motivation, and changes in these states (post-task–pre-task) as covariates. As in Experiments 1 to 3, the main effect of motor action remained reliable in every case. There were no other significant effects. A final series of analyses separately using each of the aforementioned covariates as a dependent measure and including motor action and performance as covariates revealed only one reliable effect, a main effect of motor action on change in task enjoyment ($M_{\text{Flexion}} = 0.4$, $M_{\text{Control}} = -0.6$, $M_{\text{Extension}} = 1.5$), $F(2, 26) = 8.67$, $p < .002$, suggesting, rather unsurprisingly, that participants enjoyed working on the task more when no arm contraction was required. Supplementary planned comparisons simply revealed a reliable difference in change in enjoyment between the control group and the arm flexion and extension groups combined, $t(26) = 3.65$, $p < .002$. The latter two groups did not differ from one another on this measure, $t < 1.20$.

In sum, the findings of Experiment 4 converge with those of Experiment 3 to suggest that positive state-associated internal cues (e.g., arm flexion) bolster and that negative state-associated internal cues (e.g., arm extension) impair memory search for novel responses. Moreover, the current study overcomes two critical shortcomings of Experiment 3 (i.e., the lack of instructions to proceed from left to right and the failure to ensure activation of initial “blocker” solutions on every puzzle) to provide more compelling evidence for the corollary hypothesis that arm flexion improves, and arm extension diminishes, the ability to escape perseverance on potentially obstructive, initially activated cognitive material. As predicted, the effects of approach and avoidance motor actions on memory search were once again statistically independent of the influence of emotional states (e.g., arousal) and nonemotional states (e.g., subjective task motivation). However, despite the strength of the current findings, it must be reiterated that the lack of a significant difference between the arm extension and control groups in Experiment 3 still renders it unclear as to whether avoidance motor actions yield effects on memory search that reliably differ from baseline.

GENERAL DISCUSSION

This series of experiments tested whether internal, nonaffective processing cues independently influence two major varieties of creative cognition: insight problem solving and creative generation. Furthermore, it provided the first direct test of the notion that the effects of internal processing cues on creativity may be at least partly mediated by a memory search-based mechanism. In each of four experiments, bodily cues associated with positive or negative hedonic states were manipulated by means of arm flexor or extensor contraction, respectively, and the effects of these internal cues on creative insight, creative generation, and memory search were observed. It was predicted that the riskier, more explorative processing style elicited by arm flexion, relative to the more risk-averse, perseverant processing style elicited by arm extension, would facilitate performance on all three tasks, thereby supporting our cognitive tuning model of creativity (Friedman & Förster, 2000).

These predictions were supported. Arm flexion, relative to arm extension, enhanced the ability to solve “classic” insight problems (Experiment 1), providing critical evidence that approach and avoidance motor actions influence creative insight and not merely the rudimentary cognitive processes with which it is empirically correlated. Relative to arm extension, arm flexion also facilitated the ability to generate creative uses for a brick (Experiment 2), demonstrating that the influence of approach and avoidance motor actions on creativity carries beyond the domain of insight problem solving. In addition, arm flexion, relative to arm extension, improved retrieval of verbal solutions from memory on a letter string completion task (Experiments 3 and 4), providing the first clear-cut evidence that motor actions influence the memory search processes posited to affect creativity. Experiments 3 and 4 also provided preliminary support for the hypothesis that positive state-associated processing cues, such as arm flexion, facilitate memory search by diminishing retrieval blocking. All reported findings were highly reliable and found within two culturally distinct population samples.

Alternative Explanations

Throughout the study, steps were taken to rule out a number of alternative explanations for the effects of approach and avoidance motor actions on creative cognition. One simple alternative explanation is that arm flexor contraction may have been more pleasant or less effortful than arm extensor contraction, thereby minimizing task distraction and enhancing performance. To address this possibility, all experiments included measures of the pleasantness and effortfulness of the arm contractions. These measures revealed no statistically reliable differences between conditions, although there was a nonsignificant trend in Experiment 1 for arm flexion to be experienced as somewhat *more* effortful than arm extension. More important, the facilitative effects of approach motor actions on creative cognition were not altered in statistical reliability by the inclusion of pleasantness or effortfulness ratings as auxiliary predictors. This suggests that the differential effects of arm flexion and extension found in the current study were not mediated by the subjective comfort or ease of the motor actions themselves.

A more plausible, theoretically driven alternative explanation for the current findings is that approach and avoidance arm motor actions differentially influenced emotional experience or mood, which then mediated effects on creativity. Several researchers have proposed or adduced evidence that positive affective states facilitate and/or that negative affective states impair creative thought (e.g., Hirt, McDonald, & Melton, 1996; Isen, 1987; Schwarz & Bless, 1991). As such, it is critical to control for prospective affective influences in making claims about the effects of nonaffective internal processing cues on creativity. To rule out affective mediation of the current findings, all four experiments included measures of mood and/or distinct emotional states for use as statistical covariates in all essential analyses. Whereas Experiment 1 included only a post-task measure of affective states, Experiments 2 to 4 also included pre-task measures of these states to control for the effects of preexisting differences in mood or emotions.

Summarizing across analyses, the effects of arm flexion and extension on creative cognition were not diminished in reliability by the inclusion of any measure of affect or change in affect as an auxiliary predictor. Although these findings are consistent with the notion that transient affect fails to mediate the influence of motor actions on creative cognition, they do not conclusively rule out the existence of any such mediational role. To rule out affective mediation more conclusively, future studies should at least include affective measures that are collected during, and not merely before and after, task engagement. That said, supplementary analyses of the influence of affective states on creative cognition using the measures collected in the current study revealed only two reliable effects, both found in Experiment 1: increased current levels of contentment predicted improved insight problem solving, and increased current levels of disappointment predicted impaired insight problem solving. Again, these independent effects are consistent with the many theoretical approaches proposing differential effects of positive and negative affective states on creativity, including the cognitive tuning framework currently espoused (Friedman & Förster, 2000; Schwarz & Bless, 1991). It should be emphasized that the current findings in no way imply that the effects of nonaffective internal cues supersede or mediate the effects of affective cues on creativity; instead, they merely suggest that nonaffective internal cues may *independently* influence cognitive processing in a parallel fashion (Friedman & Förster, 2000).

Another plausible alternative explanation for the current effects of approach and avoidance motor actions on creative thought is that positive state-associated internal cues, such as arm flexion, bolster creativity not by eliciting a more explorative processing style but rather by enhancing task enjoyment. As discussed earlier, the hypothesis that intrinsic motivation (one component of which is task enjoyment) increases creativity has been proposed by Amabile (1983, 1996). To rule out this possibility, measures of post-task enjoyment were included in Experiment 1, and measures of both pre- and post-task enjoyment were included in Experiments 2 to 4, for use as auxiliary predictors. Critically, the inclusion of enjoyment and change in enjoyment as covariates did not diminish the reliability of the effects of arm flexion and extension on creativity. Moreover, contrary to sporadic findings by Friedman and Förster (2000), there was absolutely no evidence that approach and avoidance motor actions differentially influenced task enjoyment, casting additional doubt on the possibility that intrinsic motivation plays a mediational role. Interestingly, in contrast to Friedman and Förster's findings and consistent with Amabile's (1983, 1996) predictions, there was evidence that task enjoyment (post-rated, Experiment 1) and change in enjoyment (Experiment 2) did positively predict insight problem solving and creative generation performance, respectively. The inconsistency of our findings regarding task enjoyment across current and past studies only suggests that assessment of the influence of enjoyment (and intrinsic motivation more generally) on creativity requires additional, more theoretically driven empirical exploration.

Future Directions

As discussed earlier, the main objective of Experiments 3 and 4 was to find direct evidence that arm flexion, relative to arm extension, enhances memory search for novel responses. Interestingly enough, Experiments 3 and 4 not only supported this prediction but also provided preliminary evidence that the influence of approach and avoidance motor actions on memory search is driven by differences in retrieval interference. More specifically, arm flexion was found to enhance performance following the activation of material that could block access to new solutions. Theoretically speaking, this is consistent with the notion that the risky, explorative processing style triggered by arm flexion engenders less perseverance on initially activated material in memory than does the risk-averse, vigilant processing style triggered by arm extension. Again, the increased tendency or capacity to escape fixation on initial cognitive content presumably bolsters the ability of individuals performing arm flexion, relative to those performing arm extension, to retrieve novel responses.

Although the aforementioned findings are certainly suggestive, they merely comprise a first step toward empirically assessing the notion that nonaffective processing cues influence creativity by way of their impact on retrieval inhibition. Consistent with this approach, Smith (Smith, 1995; Smith & Blankenship, 1991; Smith et al., 1993; Smith & Tindell, 1997) has recently proposed that the same mechanism that produces various forms of memory blocking, such as part–set cueing (e.g., Rundus, 1973) and output interference (e.g., Karchmer & Winograd, 1971), may underlie the "fixation" effects that are a hallmark of creative problem solving (for a review of research on retrieval blocking, see Roediger & Neely, 1982). If so, then given the fact that approach and avoidance motor actions significantly influence creative cognition, these motor actions should analogously influence traditional varieties of memory blocking, with arm flexion diminishing and arm extension increasing retrieval interference. We are currently seeking evidence to this effect, which we believe would significantly elucidate the process (or at least one of the processes) through which internal, nonaffective tuning cues render their impact on creativity.

Another intriguing avenue for future research has been inspired by Higgins (1997), who posited that the influence of affect on creativity might be mediated not by the hedonic pleasure or pain accompanying affective states but rather by the motivational orientations, or *regulatory foci,* underlying and cross-cutting these states. Simply stated, Higgins' regulatory focus theory proposes that there are two distinct self-regulatory systems: the promotion system, which regulates motivation to attain nurturance (e.g., food), and the prevention system, which regulates motivation to attain security (e.g., shelter). In terms of emotional experience, successful attainment of promotion goals engenders cheerfulness-related affect, whereas failed promotion gives rise to dejection-related affect. In complementary fashion, successful attainment of prevention goals engenders quiescence-related affect, whereas failed prevention gives rise to agitation-related affect (Higgins, Shah, & Friedman, 1997).

Although speculative at present, it is possible that the distinct regulatory systems proposed by Higgins and his colleagues may substantially mediate the effects of arm flexion and extension on creativity. Specifically, arm flexor contraction might be associated not merely with the pleasure of consumption but rather with the *motivation* to attain one's wishes by approaching beneficial objects, that is, with a promotion focus. Likewise, arm extensor contraction might be associated not merely with the pain of noxious stimulation but rather with the *motivation* to attain safety by avoiding noxious stimuli, that is, with a prevention focus. In terms of cognitive tuning, inasmuch as the prevention system is generally concerned with attaining or maintaining security, activation of this motivational system (or cues associated with it such as arm extension) may signal to the individual that the environment is prospectively threatening, thereby leading to the adoption of a more risk-averse, vigilant processing style and diminishing creativity. Correspondingly, inasmuch as the promotion system is generally concerned with attaining nurturance, activation of this motivational system (or cues associated with it such as arm flexion) may signal that the environment is prospectively benign, thereby engendering adoption of a more risky, explorative processing style and bolstering creativity.

If the latter account is veridical, at least three intriguing empirical implications follow. First, activation of a promotion or prevention focus via task framing or priming (e.g., Higgins, Roney, Crowe, & Hymes, 1994; Shah, Higgins, & Friedman, 1998) should produce effects on creativity analogous to those of arm flexion and extension, respectively. Second, individual differences in chronic promotion or prevention focus (Higgins et al., 1997) should also lead to analogous effects on creativity. Third, and perhaps most interesting, *negative* affective states associated with a promotion focus (e.g., disappointment) should significantly *bolster*, and *positive* affective states associated with a prevention focus (e.g., relaxation) should significantly *diminish,* creativity. Again, Higgins' (1997) reasoning suggests that it is the underlying regulatory focus, not the hedonic tone (i.e., pleasure vs pain), of the affective state that drives its impact on cognition. At present, we are actively exploring the first two implications and plan to begin work examining the third.

Another planned line of empirical inquiry has been inspired by the work of Elliot (Elliot, 1999; Elliot & Harackiewicz, 1996), who has integrated the literature on achievement motivation by proposing a trichotomous classification of achievement goals. These include mastery goals, which are approach-oriented strivings focused on the development of competence, performance approach goals, which are focused on the demonstration of normative competence, and performance avoidance goals, which are focused on avoiding the demonstration of normative incompetence.

Although not specifically suggested by Elliot, it is possible that performance approach and mastery strivings (goals adopted when the individual is challenged by the prospect of attaining normative success and achieving task mastery, respectively) may lead to the adoption of a relatively risky, explorative processing style, a style most suitable for thriving within approach contexts (Schwarz, 1990). If so, then self-regulation driven by either performance approach or mastery goals may bolster creativity on the task at hand. In corresponding fashion, it is possible that performance avoidance strivings (goals adopted when the individual is threatened by the prospect of demonstrating normative failure) may lead to the adoption of a relatively risk-averse, vigilant processing style, a style best suited for successful self-regulation within avoidance contexts (Schwarz, 1990). If so, then performance avoidance goals may impair creativity on the task at hand.

Interestingly, Elliot (Elliot, 1999; Elliot & Harackiewicz, 1996) has adduced evidence that performance approach and mastery goals, those sharing an approach orientation, significantly facilitate intrinsic motivation. Inasmuch as Amabile (1983, 1996) documented that intrinsic motivation bolsters creativity, it seems only reasonable to assume that performance approach or mastery goals may facilitate innovation by way of their influence on intrinsic motivation.

Given this assumption, it may be the case that performance approach and mastery goals are more potent elicitors of creative cognition than are mere positive state-associated cognitive tuning cues (e.g., arm flexion) inasmuch as they not only engender an explorative processing style but also significantly enhance intrinsic motivation.

In conclusion, the current study has opened up a number of intriguing avenues for future research. Regardless of where these lines of inquiry eventually lead, we hope that in conjunction with the current findings, they will help us to shed new light on the integral relationship among affect, motivation, and creative cognition.

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