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Fluid Movement and Creativity

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Cognitive scientists describe creativity as fluid thought. Drawing from findings on gesture and embodied cognition, we hypothesized that the physical experience of fluidity, relative to nonfluidity, would lead to more fluid, creative thought. Across 3 experiments, fluid arm movement led to enhanced creativity in 3 domains: creative generation, cognitive flexibility, and remote associations. Alternative mechanisms such as enhanced mood and motivation were also examined. These results suggest that creativity can be influenced by certain types of physical movement.

Keywords: creativity, embodiment, metaphor

Theories of creativity describe creative thinking and intelligence as fluid (Hofstadter, 1995; Sternberg, 1985), likening thought to the movement of fluids: moving flexibly and smoothly in any direction with fluency or ease. Such language reflects a metaphor for thinking about creative thought. For instance, creative thought is often contrasted with analytical thought, which is more rigid and precise; a fluid can move in multiple directions with ease, and the ability to fluently and flexibly generate multiple thoughts is essential for creativity (Guilford, 1967). Fluid thinking, thus, is a metaphor for certain elements of creativity (Hofstadter, 1995).[1]

Influential models of grounded cognition (Barsalou, 1999, 2008; Lakoff & Johnson, 1980, 1999) assert that abstract concepts are metaphorically grounded in concrete experience. For example, the abstract concept of importance might be understood via the metaphor "weighty," which references the concrete sensation of holding something heavy. Indeed, participants who held a heavy, relative to a light, clipboard judged a variety of issues and items as having greater importance (Jostmann, Lakens, & Schubert, 2009). Similarly, conceptions of interpersonal warmth (Williams & Bargh, 2008), interpersonal roughness (Ackerman, Nocera, & Bargh, 2010), moral purity (Lee & Schwarz, 2010; Zhong & Liljenquist, 2006), gender (Slepian, Weisbuch, Rule, & Ambady, 2011), and time (Miles, Nind, & Macrae, 2010) are grounded in bodily movement and sensation. This growing body of work has demonstrated that cognitive content (concepts) can be metaphorically embodied in sensorimotor systems (Landau, Meier, & Keefer, 2010)—showing that the body provides a scaffold for abstract concepts (Williams, Huang, & Bargh, 2009). A separate body of work also demonstrates that gestures influence thought processes (e.g., Casasanto, 2011; Goldin-Meadow & Beilock, 2010). Gestures, for instance, can aid in spatial representation by allowing direct expression of spatial properties, lessening the need for a translation to verbal codes, and therefore alleviating working memory resources (Hostetter & Alibali, 2008), consequently improving spatial problem solving and enhancing speech fluency (Goldin-Meadow & Beilock, 2010). Additionally, motor experience can also change cognitive processes. For instance, right-handers evaluate items on the right more positively, whereas left-handers prefer items on the left (Casasanto, 2009), a likely result of the positive valence of motor fluency (e.g., Topolinski & Strack, 2009).

Lakoff and Johnson (1980, 1999) suggested that the body can influence cognitive processes by means of metaphor, whereby cognitive–linguistic analyses suggested a role for the body in how categories are formed. In the current work, we hypothesize that fluid, creative thinking is grounded in fluid movement. This hypothesis is tested across three studies that induce fluid and nonfluid bodily movement and measure creativity in three domains: creative generation, cognitive flexibility, and connecting remote associates. Finally, alternative mechanisms, enhanced mood and motivation, were examined, and the boundary conditions of the demonstrated effect were explored. Implications for theories of embodied cognition are discussed as well as the related, but distinct, literature on gesture and problem solving.

Pilot Experiments

We designed two sets of drawings for participants to trace, hypothesizing one would elicit fluid arm movement whereas the other would elicit nonfluid arm movement. These stimuli were created so that that the nonfluid line drawings were precisely the same drawings as the fluid ones but without line curvature (the element that led to fluid movement; see Figure 1).

We sought to confirm in a set of three pilot experiments that this manipulation did indeed lead to fluid and nonfluid movements and to ensure that they did not differ in difficulty of tracing or affect

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[1] The fluid thought metaphor for creativity captures only some elements of creative thought, such as flexibility and making remote connections, but not all elements of creativity are captured by this metaphor (e.g., perseverance or elaboration; see De Dreu, Baas, & Nijstad, 2008).

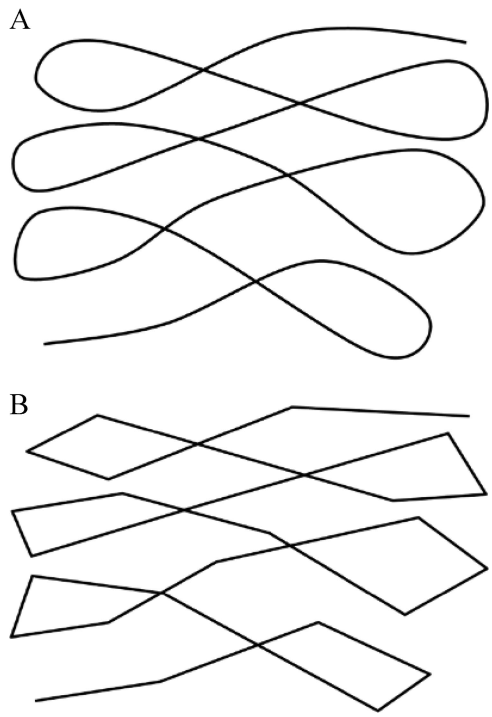

Figure 1. Example line drawing stimuli, which participants traced to induce fluid arm movements (A) or nonfluid movement (B).

induced. In all studies in the current work, participants believed the study was examining hand–eye coordination and cognition.

It was important that the two sets of drawings did not differ in dimensions other than fluidity of movement. For instance, angular lines convey more threat whereas rounded lines convey more warmth (Aronoff, Woike, & Hyman, 1992). A group of 30 undergraduate participants traced one set of drawings, based on random assignment, and subsequently completed a self-report mood measure (Friedman & Förster, 2000). They first indicated their overall current mood ("How do you feel right now?") on a scale of 1 (*very bad*) to 9 (*very good*) and then rated specific feelings (*calm, concerned, content, disappointed, nervous, down, happy, joyful, nervous, relaxed,* and *tense*) from 1 (*not at all*) to 9 (*extremely*). The positive and negative feelings were averaged together to create indices of positive (α = .76) and negative (α = .68) affect. Participants did not differ in mood (M_{fluid} = 6.67, SD = 0.91; M_{nonfluid} = 6.20, SD = 1.61), $t(22.18)$ = 0.70, p = .49, r = .15;[2] positive affect (M_{fluid} = 6.17, SD = 1.11; M_{nonfluid} = 6.39, SD = 1.30), $t(28)$ = 0.48, p = .63, r = .09; or negative affect (M_{fluid} = 2.91, SD = 1.02; M_{nonfluid} = 2.88, SD = 1.22), $t(28)$ = 0.07, p = .95 r = .01. Thus, tracing the line drawings did not differentially influence the conscious experience of affect.

We also examined whether the drawings differed in difficulty of tracing. A second set of 30 undergraduate participants traced one set of drawings, based on random assignment, and rated how difficult it was to trace the drawings. Drawings did not differ in tracing difficulty (M_{fluid} = 1.47, SD = 0.74; M_{nonfluid} = 1.53, SD = 0.64), $t(28)$ = 0.26, p = .79, r = .05.

Finally, in a third pilot experiment, 12 participants traced the two sets of drawings, in a counterbalanced order, and subsequently were asked to indicate how the two sets of drawings differed with respect to the movements the participants made while tracing them. Because this request occurred last, participants were unaware that the drawings would be compared or that they would be asked to evaluate them on the basis of movements elicited during tracing. We extracted all nouns and adjectives used to describe the drawings. For example, *continuous*, *curved*, and *smooth* were used often to describe the fluid drawings, and *angular*, *choppy*, and *jagged* were used often to describe the nonfluid drawings. These participant-generated responses suggested that the drawings did induce two distinct movements: fluid and nonfluid. Q-sort methodology was used to examine whether these generated responses represented diverging movement inductions that yielded two categories, which corresponded to the two sets of drawings. Two independent judges unaware of the experimental hypothesis were given the unique descriptions, which had been randomly shuffled, and asked to sort the descriptions into two groups, however they deemed appropriate. The two judges agreed with each other, Cohen's κ = .81, and with the categories created by participants, yielding a hit ratio of .95 (Moore & Benbasat, 1991). These pilot experiments indicate that the fluidity of movement was the critical difference between the two sets of drawings.

Experiment 1

In the first experiment, we examined whether fluid, relative to nonfluid, movements would enhance creative generation.

Method

Thirty undergraduates (63% women) participated in a study ostensibly on hand–eye coordination and traced either the three fluid or the three nonfluid drawings, based on random assignment. Subsequently, participants generated as many creative uses for a newspaper as possible within 1 min (Guilford, 1967) and completed the self-report mood measure described previously.

Results and Discussion

Uses were coded for fluency (defined as the number of responses) and originality.[3] Three independent judges, unaware of condition, rated the originality of each use (α = .75) using a scale of 1 (*not at all*) to 7 (*very*). An example of an original response was to "create black-out poems," whereas an unoriginal response was to "use as scrap paper."

Participants who made fluid movements demonstrated greater fluency and originality than did those who made nonfluid movements: For fluency, $t(28)$ = 2.71, p = .01, r = .46; for originality, $t(28)$ = 2.29, p = .03, r = .40 (see Figure 2 for means).

There were no differences in overall self-reported mood (M_{fluid} = 6.73, SD = 0.96; M_{nonfluid} = 6.65, SD = 1.50), $t(28)$ = 0.19, p = .85, r = .09; the positive affect index (α = .86;

[2] Levene's test revealed unequal variances, F = 4.49, p = .04; therefore, a correction factor changed the degrees of freedom from 28 to 22.18. This did not change the level of significance.

[3] Given the minute limit, time was insufficient to elaborate or provide multiple categories for uses (which provide other ways to code responses). Only fluency and originality, therefore, were coded (see De Vet & De Dreu, 2007). Flexibility is measured, however, in Experiment 2.

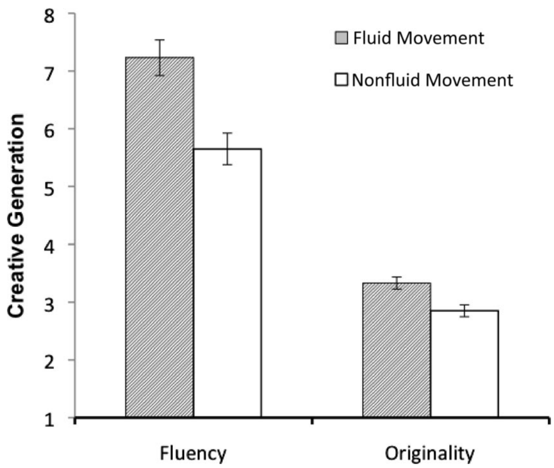

Figure 2. Fluency and originality scores on the alternative uses task as a function of fluidity of arm movement in Study 1. Error bars denote standard errors of the mean.

$M_{\text{fluid}} = 6.76$, $SD = 1.04$; $M_{\text{nonfluid}} = 6.45$, $SD = 1.04$), $t(28) = 0.85$, $p = .40$, $r = .16$; or the negative affect index ($\alpha = .71$; $M_{\text{fluid}} = 2.13$, $SD = 0.93$; $M_{\text{nonfluid}} = 2.56$, $SD = 1.02$), $t(28) = 1.24$, $p = .22$, $r = .23$. Thus, embodying fluidity, relative to nonfluidity, via bodily movement enhanced creative generation, and this was not due to conscious experiences of affect.

Experiment 2

In a second experiment, we examined another domain of creativity, cognitive flexibility. Cognitive flexibility allows one to conceive of an entity in an atypical manner (i.e., set breaking; Duncker, 1945). One element of fluid movement is its flexibility in changing direction of movement. We hypothesized that the flexibility embodied by fluid movement could lead to a similar flexible thought process. We tested this by measuring category inclusiveness, an indicator of flexible processing. For instance, flexible thinkers are more likely to include *camel* in the category *vehicle* (Isen & Daubman, 1984).

Method

Thirty undergraduates (53% women) participated in a procedure identical to Experiment 1, with a change in the dependent measure. After tracing the drawings, participants performed the category-inclusiveness task. Similar to Isen and Daubman (1984), three strong, moderate, and weak exemplars per four categories (*furniture, vehicle, vegetable,* and *clothing*) were chosen using Rosch's (1975) norms, for a total of 36 exemplars. Exemplars were blocked in their respective categories, with the order of blocks randomized and exemplars within blocks also randomized (however, the first exemplar in a new block was always strong, as in Isen & Daubman, 1984). Participants were asked to indicate how well each exemplar belonged to the category on a scale of 1 (*definitely does not belong*) to 10 (*definitely does belong*). Subsequently, participants completed the self-report mood measure from Experiment 1. We predicted that fluid, relative to nonfluid, movement would lead participants to judge weak exemplars to be better fits to the categories, exemplifying high cognitive flexibility (Isen & Daubman, 1984).

Results and Discussion

As predicted, participants who made fluid movements, compared with those who made nonfluid movements, indicated more strongly that weak exemplars belonged to the provided category, $t(28) = 2.19$, $p = .04$, $r = .38$. Although we did not make predictions for other exemplars, participants also rated moderate exemplars to be better fits, $t(28) = 3.10$, $p = .004$, $r = .51$, but their ratings of strong exemplars did not differ from the ratings of those who made nonfluid movements, $t(28) = 1.58$, $p = .12$, $r = .29$ (see Figure 3 for means). Finally, there was no significant difference in overall self-reported mood ($M_{\text{fluid}} = 6.00$, $SD = 1.69$; $M_{\text{nonfluid}} = 6.20$, $SD = 1.61$), $t(28) = 0.33$, $p = .74$, $r = .06$; the positive affect index ($\alpha = .83$; $M_{\text{fluid}} = 5.96$, $SD = 1.25$; $M_{\text{nonfluid}} = 5.85$, $SD = 1.34$), $t(28) = 0.23$, $p = .82$, $r = .04$; or the negative affect index ($\alpha = .82$; $M_{\text{fluid}} = 2.85$, $SD = 1.47$; $M_{\text{nonfluid}} = 3.11$, $SD = 1.36$), $t(28) = 0.49$, $p = .63$, $r = .09$, between participants in the two conditions. Fluid, relative to nonfluid, movement, therefore, enhanced flexible thinking, and this was not a result of differential affect.

Experiment 3

In a final experiment, we examined a third domain of creativity, making remote associations. Another element of fluid movement is its fluency in moving in multiple directions with ease. Likewise, connecting remotely associated concepts requires an associative search that fluently considers multiple directions. We used the Remote Associates Test (RAT; Mednick, 1962) to examine the relationship between fluid movement and making remote associations. Additionally, we hypothesized that fluid movement would enhance creativity, but not mental performance, more generally, such as in the performance of analytical tasks.

Method

Undergraduate participants ($N = 150$, 54% men) traced the same drawings as in Experiment 1. Subsequently, half completed

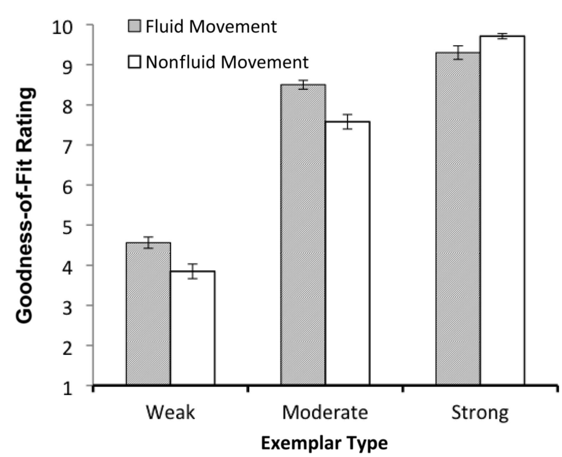

Figure 3. Goodness-of-fit ratings of weak, moderate and strong exemplars as a function of fluidity of arm movement in Study 2. Error bars denote standard errors of the mean.

the RAT and half completed problems from the U.S. Graduate Record Exam (GRE). The RAT included 15 three-word triads, and participants had to generate a fourth word that formed a compound with the other three (e.g., "race" is the correct response to "horse, human, drag"). The triads used were selected from Bowden and Jung-Beeman (2003) and were rated moderately difficult. Triads were randomly presented onscreen, and participants were instructed to type in their answer after 5 s. If they did not have one at that time, they were instructed to type "no" and move on rather than using the extra time to try to generate an answer. This time limit was set to ensure that answers were discovered by connecting remotely associated concepts rather than by brute-force searching (see Dorfman, Shames, & Kihlstrom, 1996; Slepian, Weisbuch, Rutchick, Newman, & Ambady, 2010). The GRE task was similarly structured, with six multiple-choice math problems requiring paper and pencil only and a 1-min limit per question.

Results and Discussion

As predicted, participants who made fluid movements solved more RAT triads than did those who made nonfluid movements, $t(65) = 2.13$, $p = .04$, $r = .25$, but they did not solve a different number of GRE math problems, $t(73) = 0.34$, $p = .74$, $r = .04$ (see Figure 4 for means).[4] Embodying fluidity, relative to nonfluidity, led to an enhanced ability to connect remotely associated concepts but did not improve performance on an analytical task.

General Discussion

Previous work demonstrates that concepts can be metaphorically embodied (Landau et al., 2010). Other work demonstrates that the body and gestures can influence thought (Casasanto, 2011; Goldin-Meadow & Beilock, 2010; Thomas & Lleras, 2009; Wolff & Gutstein, 1972). In the current research, we integrate these lines of work by examining the fluid thought metaphor for creativity, whereby creative thought is likened to the movement of fluid. Indeed, fluid movement enhanced creativity in three domains: creative generation, cognitive flexibility, and the ability to make remote connections. Fluid movement enhanced creative but not analytic performance (only the former requires fluid thought), and the influence of fluid movement on creativity was not a result of enhanced conscious experiences of positive affect. One possibility that remains and awaits future research is that fluid movement serves as an implicit affective cue, suggesting a safe environment where explorative creative processing is encouraged (see Friedman & Förster, 2010; Topolinski & Reber, 2010).

We found that fluid movement influenced cognitive processing. Generating creative uses for a newspaper (e.g., "printing type on wet nail polish"); believing *camel* to be a good fit for the category *vehicle*; and realizing *common* creates compound words with *sense, courtesy,* and *place* all seem unlikely to be aided by the mental representations involved in fluid movements. It seems more likely that such performance is facilitated by means of the proprioceptive–motor kinematics experienced during fluid movement. Moving one's arm in multiple directions in a fluid and fluent manner seems to cue a metaphorically similar fluid thought process, enhancing creative processing and generation.

The current findings also extend extant work on embodied metaphor. Current models of embodied metaphor posit that concepts are embodied in sensorimotor systems (Barsalou, 1999; Lakoff & Johnson, 1999). Building from this framework, we extend it to show that cognitive processing can also be embodied in sensorimotor systems by means of metaphor. Bodily movement can influence cognitive processing, with fluid movement leading to fluid thinking.

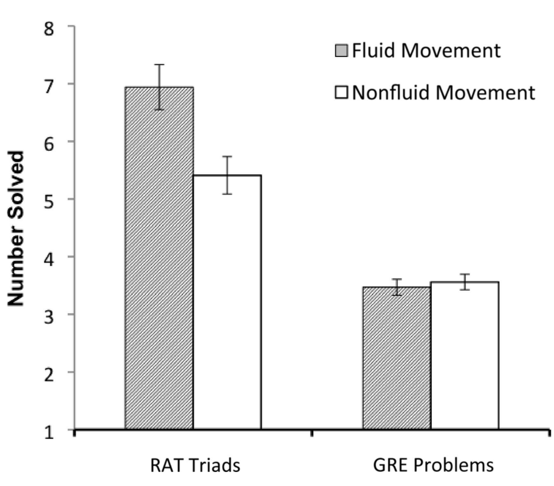

Figure 4. Number of Remote Associates Test (RAT) triads and U.S. Graduate Record Exam (GRE) problems solved as a function of fluidity of arm movement in Study 3. Error bars denote standard errors of the mean.

[4] In the RAT condition, eight participants used extra time to generate their answers and were excluded for this reason.

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