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Now the Left Brain Knows what the Right Brain is Doing: The Effects of Bilateral Eye-Movements and Handedness on a Creative Measure

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Abstract

The current study investigated the potential effects of bilateral eye movements (BEM) and handedness on creativity measured by the Alternate Uses Test. BEM may increase the state interaction between the left and right cerebral hemispheres, whereas handedness indicates individual differences in trait interhemispheric interaction (IHI). Based on the research reviewed, increases in IHI may enhance creativity. In order to test my hypothesis that IHI fosters creative thinking I randomly assigned participants into two different groups. Those assigned to the experimental group performed a BEM task for 30s and a control group performed a similar task, also for 30s, which does not involve BEM. Following their respective tasks, both groups completed the Alternate Uses Test and their relative creativity was compared. Participants also completed a handedness measure, where it was predicted that weak-handers will be more creative than strong-handers. Results indicate no effect of BEM on creativity but that handedness had significant effects on creativity, such that weak-handers significantly outperformed strong-handers on the Alternate Uses Test.

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The creative process, although epitomized by a broad spectrum of brilliant individuals ranging from Renaissance man, Leonardo da Vinci to Oscar-winning actor, Christopher Walken, is a process employed by everyone in their daily endeavors. For decades creativity has garnered much attention in the field of psychology (for reviews see Finke, Ward & Smith, 1992; Runco, 2006; Simonton, 2004; and Sternberg, 1998). Guilford (1950) is frequently credited for spurring the empirical study of creativity and many have followed his lead but the creative process is not yet fully understood. Freyd (1994) suggests that subjective limitations of case studies and the inability of psychometrics to reconcile the diverse, qualitative nature of creativity with its own objective, quantitative methodology, may be factors that contribute to the ambiguity surrounding the topic. Despite the difficulty of studying creativity, several researchers have done so systematically and have made significant contributions to our understanding of individual difference, cognitive and neurological influences on the creative process.

Cognitive psychologists such as Finke et al. (1992), suggest that there is no singular or defining process of creativity but that various combinations of ordinary processes moderate the creative process. They assert that the generativity and the assessment of value necessary for judging appropriateness are the primary processes of creativity and that both are present in the linguistic abilities of the average individual. They suggest that generativity is evident in everyone's ability to use language to form novel combinations of variables under the governance of a relatively small set of rules. They cite the goal-oriented nature of communicative language as support for the notion that assessment of utility is also a mundane process. Extending this notion, Dietrich (2004) suggests that the neural circuitry underlying creative proficiency in information processing is, in fact, the same circuitry that is responsible for the noncreative processing of the same information. The commonality between creative and mundane processes observed in cognitive and neural processes suggests that any neurologically intact individual should be capable of creativity. Because of logistical problems in studying creativity through case studies of extraordinary individuals and limitations of the inferences that can be drawn, discussed by Freyd (1994), it is, perhaps, more informative to study creativity as it occurs in a normal population. Importantly, findings are more likely to generalize and benefit a larger number of people.

Several researchers have developed and employed measures of creativity that have allowed them to study the subject from a psychometric approach. These measures can be divided into tests of two different types of thinking: convergent and divergent. Convergent thinking is that which requires the individual to 'converge' on a single correct answer. Some tests of convergent thinking include the Remote Associates Test (Mednick, 1962) which requires participants to find the one word that relates three words presented to them (e.g., problem: rat, blue, cottage; solution: cheese). A revised and much larger version of this test was developed by Bowden and Jung-Beeman (2003) that required participants to find the compound associate word that was shared by the three words presented (e.g., problem: cottage swiss cake; solution: cheese).

In contrast, divergent thinking is a style of thought that requires the individual to explore several different perspectives, producing an array of potential answers, situated on a gradient of utility. Guilford (1962) and Torrance (1974) developed batteries of tests to measure divergent thinking. Although the Torrance Test of Creative Thinking has been the most widely used measure of creativity (Khatena, 1989), the current study will employ an adaptation of Guilford's Alternate Uses Test (i.e., Christensen, Guilford, Merrifield, & Wilson, 1960). The Alternate Uses Test requires individuals to generate as many uses as possible for household items (e.g., paper-clip, brick, newspaper). The Alternate Uses Test is very similar to Torrance's (1974) Unusual Uses Test, which has been shown to have strong test-retest reliability (Treffinger, 1985), and predictive validity for adult achievements (Torrance, 1988). Furthermore, Martindale (1999) suggests that the Alternate Uses Test is a pure measure of the novelty and utility associated with creativity. As a result of these findings I have selected an adaptation of the Alternate Uses Test to be used as the measure of creativity in the current study.

The adaptation of the Alternate Uses Test used in the current study was obtained from Chamorro-Premuzic (2006) and requires participants to create as many uses as possible within a one-minute time range for 20 items. This test measures creativity in terms of fluency, originality, elaboration, flexibility and appropriateness, which produces five, highly inter-correlated subscores. This version is most advantageous to this study's secondary pursuit of exploring the duration of the effect of bilateral eye-movements (BEM). Its usefulness in this pursuit is supported by the large number of items and short duration of the time allocated to each item. This will allow me to plot the course of the effect in a precise fashion. Christman, Propper and Dion (2004) observed differences on a 90 sec. memory task, but did not test a longer timeframe. To date, there is no empirical research that outlines the length of this effect. Accordingly, the current study had no a priori predictions regarding the duration of the effect.

Within the previous two decades, findings from neuropsychology, neuroscience, and behavioral neuroscience have revealed cerebral asymmetries for creative processes. The work of Gazzaniga, Bogen and Sperry (1962) on split-brain patients inspired countless researchers to explore cerebral asymmetries. Split-brain patients have had their corpus callossum severed to alleviate intractable epilepsy. This procedure severs communication between the left and right hemispheres. Studies on split-brain patients have made clear that the two cerebral hemispheres are functionally different, and also that communication between the two hemispheres is integral for many tasks (Gazzaniga, et al.,1962; Kitterle, 1995).

Several researchers have suggested the right hemisphere (RH) to be the locus of creative thinking (Abeare, 2005; Beeman & Bowden, 2000; Ornstein, 1977; Springer & Deutsch 1981 and Weinstein, & Graves, 2002). Beeman et al. (2000) found that increased semantic activation in the RH is associated with increased performance on insight problems, a measure found to have positive correlations with other measures of creative thinking (Dallob & Dominowski, 1993; Schooler & Melcher, 1995). In explaining these findings Beeman, et al. suggested that the diffuse nature of activation in the RH is more conducive to recognizing the semantic overlap inherent in solutions to compound remote associate problems. Kwiatkowski (2002) found that increased activation in the RH, indicated by an electroencephalogram (EEG) was present during three creative tasks, including a divergent thinking task of imagining and writing a creative story.

While RH processes are important for creativity, a growing body of evidence suggests that a collaborative effort between the two hemispheres better qualifies the creative process. Increasing interhemispheric interaction (IHI) has implications for several cognitive processes. For example, Ramachandran (1995) suggests that the left hemisphere (LH) is responsible for forming and maintaining rules and beliefs and the RH is responsible for detecting anomalies and adjusting the belief structures of the LH accordingly. Ince and Christman (2002) suggest that the diffuse nature of the RH semantic network enables the more hierarchically organized LH to acquire new and alternate meanings for words. In their review of research on hemispheric specialization for creativity, McCallum and Glynn (1979) concluded that, here too, there are bilateral contributions.

Weissman, Banich and Puente (2000) propose that IHI fosters creative performance by dividing labor between the two hemispheres, thereby reducing the amount of information that each hemisphere must process. This is supported by Banich and Belger (1990), who found that IHI became increasingly advantageous as the task difficulty increased. In addition to the division of labor hypothesis suggested by Banich and colleagues, increases in IHI appears to facilitate access to RH processes (Christman, Brown & Propper, 2006; Christman, Propper & Dion, 2004; Propper & Christman, 2004; Propper et al., 2005; Niebauer, 2004; Niebauer, Aselage & Schutte, 2002; and Niebauer & Garvey, 2004).

This collaborative effort of the two hemispheres in information processing is supported by other researcher's findings as well. Bogen and Bogen (1988,1969) implicate the corpus callosum as an important structure governing the creative process by facilitating flexibility of thought. They suggest that IHI promotes the transfer of high-level information (e.g. value assessments) and that the transient suspension of this interaction allows for independent hemispheric specialization, creating two separate mechanisms in the brain, which can produce different suggestions/ideas that help the individual to avoid fixation. Using a divided visual field priming paradigm, Atchley, Keeney, and Burgess (1996) found that participants receiving priming in both their left and right visual fields, scored significantly higher on a creative measure than participants who received semantic priming in only one half of their visual field. Taken together, these findings suggest that increases in IHI should coincide with increases in creativity due to greater access to RH processes, a division of labor advantage, a cross-collossal integration of information, or a combination of these.

Some recent EEG studies support the benefits of IHI on creative measures. Kounios, Frymiare, Bowden, Fleck, Subramaniam, Parrish, and Jung-Beeman (2006) found that a collaborative effort between the two hemispheres preceded the successful solving of compound remote-associates problems. They observed that the LH activity (posterior temporal) coincides with preparation for solving problems using insight. Prior to discovering an insight solution there was activation of the anterior cingulate cortex, which serves as a mechanism for shifting cognitive/neurological control, followed by RH (anterior temporal) activity which almost immediately resulted in an insight solution. Jung-Beeman, et al. (2004), using functional magnetic resonance imaging (fMRI), also observed interhemispheric involvement, where the RH (anterior superior temporal gyrus) showed the most activity, but the LH (medial frontal gyrus) also showed significant amounts of activity for insight solutions. Sviderskaia, Antonov, and Butneva (2007) observed an association between IHI (measured by EEG) and divergent thinking in the creation of visual images from two geometric figures. The observation of cognitive benefits resulting from back and forth, simultaneous, and/or nonlinear activation of the two hemispheres further supports the notion that IHI may be advantageous for creative thinking.

In addition to physiological indices, handedness (for a review see Christman, 1995) and bilateral eye movement (BEM) (for a review see Charlton, Bakan & Moretti, 1989) are behavioral measures that have been used as indices of interhemispheric interaction. The connection between handedness and IHI is an assumption supported by a considerable amount of evidence and it is thought that weak-handers or individuals who do not have a strong preference for hand use, exhibit greater amounts of IHI than their strong-handed counterparts (for a review see Niebauer et al. 2002). For example, Christman (2001) observed that left-handers, a more mixed-handed group than right handers (Bryden & Steenhuis, 1991; Christman, 1995; Hellige, 1993) performed significantly better than right-handers on a Stroop task (judging if a color word and its ink are different) that required integration of the local-global processes of the two hemispheres.

Charlton et al. (1989) point out that the assumed link between hemispheric activation and BEM is grounded in substantial neurophysiological evidence. Lateral eye movements increase activation of the contralateral hemisphere (Baken & Svorad, 1969), so BEM may increase bilateral hemispheric activation, and interhemispheric interaction (Christman, et al., 2003). Additionally, Propper, Pierce, Geisler, et al. (2007) observed that bilateral eye movements were associated with changes in IHI, although the implications of these changes were not clear. While both handedness and BEM indicate IHI, handedness is a stable individual difference trait, whereas BEM is a manipulated state.

Markman, Lindberg, Kray and Galinski (2007) altered creative performance via an experimental manipulation. They induced additive counterfactual mindsets by soliciting scenarios from participants and then requiring them to write down all of the possible outcomes that would have resulted if events transpired differently. By inducing this additive counterfactual mindset, Markman et al. were able to increase performance on an abbreviated version of the Alternate Uses Test (Christensen et al., 1960). This research clearly illustrates the ability to increase creative performance, as measured by the Alternate Uses Test, by utilizing an experimental manipulation. The current study proposed to extend these findings using BEM as the manipulation rather than mindset priming.

In the current study, I investigated the hypothesis that an increase in IHI will lead to higher creativity, measured by performance on and adaptation of the Alternate Uses Test. Individuals with greater IHI may be better able to coordinate processes of the LH and RH that are important for creativity, and/or be better able to recruit RH processes that are explicitly critical for creativity. Because handedness has been suggested to be an indication of an individual's trait IHI, one hypothesis that was tested in the current study is that weak-handers may demonstrate higher scores on a creativity measure than strong-handers. Further, if BEM can induce greater state IHI, then participants who engage in the BEM activity may also demonstrate higher creativity. This is also hypothesized in the current study, which will employ both handedness and BEM measures. Also it is possible that differences between weak- and strong-handers may be canceled out in the experimental group where weak-handers may experience a pseudo-ceiling effect because of high trait levels of IHI, making the strong-handers more susceptible to the BEM effect. Lastly, because the capacity to be creative is inherent in the normal population, a representative sample of that population was used, rather than pre-testing for true extremes of creativity in the population.

Method

Participants

Sixty five undergraduate college students participated for extra or required credit in currently enrolled courses. They were obtained through an online psychology lab website (SONA, Inc.) available only to students at the college through individual participant accounts. Of the sixty five participants that data was collected for, three were discarded from analyses (1 for insufficient data and 2 for noncompliance with instructions). The remaining 62 participants consisted of 13 males and 49 females, ranging in age from 18 to 56 ($M = 22.64$, $SD = 6.43$). Since gender may be related to the morphology of the corpus callosum and interhemispheric interaction (Potter & Graves, 1988; Witelson, 1989) and the current sample includes a disproportionably large female sample, the generalisability of results may be restricted. Participants were randomly assigned to the experimental group (n=32) or the control group (n=30).

Materials/apparatus

The adaptation of the Alternate Uses Test (Chamorro-Premuzic, 2006) was administered to all participants. This is a test of creativity as a 'process' rather than a self-report inventory, allowing researchers to measure creative reasoning (Runco, 2004). It consists of 20 items (e.g. paper-clip, pencil, shoe, for full list see **Appendix A**) 15 from the original Alternate Uses Test (Christensen et al., 1960) and five from a common word bank (Snodgrass & Vanderwart, 1980). Each item was centered at the top of an 8.5 x 11" sheet of white computer paper, typed in 16 pt. Times New Roman font. Next to each item was it's common use in parentheses. To avoid any order effects that might be imposed by any specific item, two separate versions of the test were created, and items were randomly ordered within each. Practice Tests included five items printed in a booklet with a title page that displayed the printed instructions in 16 pt. Times New Roman font. Test items included the remaining 15 test items printed in a separate booklet, also with a title page containing the printed instructions.

Responses on the Alternate Uses Test were scored on five different levels: (a) fluency or the total number of uses per item (regardless of 'quality' or appropriateness); (b) originality or the number of responses not provided by more than 5% (3 points), 10% (2 points) or 15% (1 point) of all participants in the sample; (c) elaboration or level of detail provided for each use; this was assessed (on a 0–5 point scale) by a rater who was blind to the treatment conditions of participants; (d) flexibility or the number of 'categorically' distinct answers assessed by the same rater who was blind to the treatment conditions of participants and awarded 1 point for each 'category' of use); and (e) appropriateness or usefulness/ of responses, where the same rater awarded 1 point for each 'appropriate' response.

Handedness was measured using a modified version of the Edinburgh Handedness Inventory (White, & Ashton, 1976), an instrument shown to be reliable and well-validated (Bryden, 1977). This inventory asks participants to indicate their preference in the use of hands for 10 activities (e.g., writing, throwing, drawing). This measure yields a handedness score for each participant ranging from 100 (perfectly right-handed) to -100 (perfectly left-handed). There were 36 participants in the strong-handed group with an absolute score equal to or above 70 and 26 participants in the weak-handed group with an absolute score of less than 70.

The visual stimuli used for both the BEM task and control task were presented on an Apple G4 computer, using the Reaction Time module of the MacLaboratory program v.3.0.2 to control presentation of the stimuli. Experimental group participants received a Moving Circle task similar to that found in Christman et al. (2003) with the following exception: the circles were colored rather than black. The color changed each time the circle appeared on the screen pseudo-randomly such that no color appeared twice in succession. Six different colors were used (green, blue, yellow, magenta, cyan and red). This alteration has been made in order to make the experimental and control condition as similar as possible. The Moving Circle task requires participants to follow a colored circle (approximately 4 degrees of visual angle in diameter) on a white background of the computer screen as it appears sequentially on the left and right sides of the display. The circle changed positions every 500 ms producing two eye movements per second, one left-looking and one right-looking. The dot's appearances were separated by 27 degrees of visual angle. This task lasted 30s and participants were required to place their head in a chin rest during the entire duration of the task to ensure that only the eyes were moving to follow the stimuli rather than just turning the entire head.

Control condition participants received a Color Circle task identical to that found in Christman, et al. (2004). This task entailed the central presentation of a colored circle that changed color twice a second, pseudo-randomly in such a way that no color ever appeared twice in succession. The same six colors and pseudo-randomized ordering of the experimental trial were used. This task offers visual stimulation in the absence of eye movements. This task lasted 30seconds and participants were required to place their heads in a chin rest in order to accurately replicate the experimental group's treatment.

Procedure

Participants were tested independently following their written informed consent. To avoid participant reactance, participants were told that they were participating in a study on color perception and creativity. Participants then began the practice phase of the study.

During the practice phase, participants were randomly assigned to receive one of two randomly ordered versions of the altered Alternate Uses Test. Each version consisted of a 5 item practice booklet with the remaining 15 items comprising the test booklet. The randomly assigned practice booklet, consisting of five Alternate Uses trials, was administered during the practice phase. Each trial consisted of one item presented in the center at the top of the page. Participants were orally instructed to neatly print as many uses, other than the common use, as possible. Participants were allotted one minute for each item, at the end of which participants were told to stop and wait for instructions to turn the page and begin the next trial.

Immediately following the practice trials, participants placed their chin in a chin rest, and completed either the Moving Circle task (experimental condition) or the Color Circle task (control condition). Participants in the Moving Circle condition were instructed to follow the moving circle with their gaze for the next 30s until the stimuli disappear. Participants in the Color Circle condition were instructed to watch the display for the next 30s until the stimuli disappear. Compliance with these instructions was monitored by the experimenter. This procedure is identical to Christman et al. (2004).

After receiving either the Color Changing task or the Moving Circle task, all participants were given the Test Items booklet, and the exact same procedure used for the Practice Test was used here. Following completion of the Test Items booklet, participants completed the modified Edinburgh Handedness Inventory. At the conclusion of each session, participants were debriefed and informed of the true hypothesis of the study. They were provided with the researcher's contact information for any further questions pertaining to the project.

Results

To determine if the experimental and control groups were equally creative prior to the manipulation, performance on the practice trials were submitted to an independent samples t-test. Due to random assignment, no differences were expected and in fact none were found for any of the four creativity subscores; fluency: $t(60)=.21$, $p=.83$, detail: $t(60)=-.01$, $p=.99$, categorical distinctiveness: $t(60)=.07$, $p=.95$ and appropriateness: $t(60)=-.07$, $p=.94$.

To test the hypotheses that induced BEMs lead to a creative advantage, that weak-handers would have higher creativity scores than strong-handers and whether there were differences pre- v. post manipulation for handedness and/or condition the dependant measure, four sub-scores of the Alternate Uses Test (fluency, detail, categorical distinctiveness and appropriateness), were submitted to a 2 (condition: control, experimental) X 2 (handedness: weak, strong) X (2) (Test: pre, post) mixed factorial MANOVA. Mixed MANOVA results indicate significant main effects of Handedness (Wilk's $\Lambda=.831$, $F(4,55)=2.81$, $p<.05$, partial $\eta^2= .169$) and Test (Wilk's $\Lambda = .193$, $F(4,55)=3.58$, $p=.01$, partial $\eta^2=.207$) on the combined dependent variables of the four creativity subscores. No main effects for Condition (Wilk's $\Lambda = .972$, $F<1$) were observed. The main effect for Test suggests a practice effect, where participants show higher creativity on the test items than the practice items when the creativity subscores are linearly combined.

Univariate ANOVA results indicate that weak-handers (M=3.14, SE=.201) outperformed strong-handers (M=2.49, SE=.171) on the fluency variable, $F(1,58)=6.19$, $p<.016$, partial $\eta^2=.096$). Weak-handers (M=2.45, SE=.157) also outperformed strong-handers (M=1.77, SE=.134) on the categorical distinctiveness variable, $F(1,58)=11.11$, $p=.002$, partial $\eta^2=.161$).

Weak-handers (M=2.72, SE=.177) outperformed strong-handers (M=1.94, SE=.151) on the appropriateness variable, $F(1,58)=11.28$, $p=.001$, partial $\eta^2=.163$). Weak-handers (M=2.49, SE=.141) were marginally higher than strong-handers (M=2.14, SE=.12) on the detail subscore, $F(1,58)=3.63$, $p=.062$, partial $\eta^2=.059$). These results support the hypothesis that weak-handed individuals would have higher creativity scores.

No significant two-way interactions were observed for Condition x Handedness, Condition x Test, or Handedness x Test; the three-way Condition x Handedness x Test interaction was also not significant (all *F's*<1). Although no interactions were observed the hypotheses warranted a series of *a priori* tests. Of specific interest was whether the creativity of strong-handers or weak-handers in the control and experimental groups differed for Test Items. This tests the hypothesis that the creativity of weak-handers may not be manipulated, whereas that of strong-handers may be manipulated. These tests re-affirmed the MANOVA findings, where there was no differences between control and experimental groups for strong-handers (all F's<1) or weak-handers (all F's<1).

Demographic information was also collected for age and gender. A MANOVA revealed no effect of gender (Wilk's $\Lambda=.92$, $F(4,57)=1.25$, $p<.3$) on the linearly combined subscores. However, univariate analyses indicate that males (M=2.48, SE=.232) outperformed females (M=1.96, SE=.12) on the categorical distinctiveness variable, $F(1,60)=4.02$, $p=.05$, partial $\eta^2=.063$). Pearson product moment correlation analyses on age and the four creativity subscores revealed that age and categorical distinctiveness were strongly correlated, $r(59)=.25$, $p=.05$ as were age and appropriateness, $r(59)=.28$, $p<.05$.

Discussion

Bilateral eye movements, thought to increase state levels of interhemispheric interaction (IHI) (Charlton et al., 1989), had no effect on creative performance in this study. However, handedness, the physiological indicator of trait levels of IHI, had a significant effect on three of the four creativity scores with the fourth reaching marginal significance, such that weak-handers, thought to exhibit higher levels of IHI, outperformed strong-handers. These results support the hypothesis greater interhemispheric interaction, such as that associated with weak-handedness, results in greater creativity. However, the attempt to manipulate interhemispheric interaction did not increase the creativity of strong- or weak- handers. Indeed, the current findings suggest no effect of bilateral eye movements on divergent thinking.

Due to the methodological limits of the current study the debate between those in favor of an IHI model of creativity (Bogen et al., 1969, 1988; Atchley et al., 1996; Kounios et al., 2006; Jung-Beeman et al., 2004 & Sviderskaia et al., 2007) and those in favor of a right hemisphere (RH) model (Abeare, 2005; Weinstein, et al., 2002; Springer, et al., 1981 and Ornstein, 1977) is unable to be resolved. The ability to tease these two models apart is beyond the methodology of the proposed study because although it may be that weak-handers are outperforming strong-handers because of their higher levels IHI, it could also be that they are superior because of increased RH activity. Future research may be able to settle the dispute by utilizing EEG coherence analysis to see if the synchronization characteristic of IHI is present during creative performance. Using EEG, researchers would be able to see if IHI is present or if primarily RH activity is, as the aforementioned research suggests.

Christman et al. (2004) and Christman et al. (2003) found significant effects of bilateral eye movements on memory such that BEM decreased false memories and increased episodic retrieval, respectively. It may be that memory is more susceptible to this IHI manipulation while creativity is not. Because Markman et al. (2007) successfully manipulated creativity with the use of mindset priming (mentioned earlier), the findings of this study do not suggest that creativity, per se can not be manipulated. Perhaps the BEM effect is not strong enough to influence the more complex construct of creativity compared to the simple spread of activation associated with memory.

The main effect for test on the linearly combined creativity subscores suggests a practice effect. This practice effect was not mediated nor influenced by any of the other variables (condition, handedness) by virtue of the fact that all interactions were non-significant. This, and additional analyses, suggest that strong- and weak-handers do not differentially benefit from the BEM task. Further, participant's increase in creativity from Practice to Test was not differentially affected by whether they were in the control or experimental group.

Demographic results indicated that, on average, men generated more categorically distinct answers than women for the objects. This finding is questionable though because of the differences in group sizes with 49 females and just 13 males, and previous research on gender differences in divergent thinking tasks is mixed, with most observing no gender differences or similar differences reported here only in children (Lee, 2002; Houtz, Jambor, & Cifone, 1989; Rejskind, Rapagna, & Gold, 1992; Morse & Morse, 1995; Chan, Cheung, & Lau, 2001). Age was also found to be significantly correlated to categorical distinctiveness and appropriateness. It may be that with age, we are exposed to more of a variety of ways to use objects whereas younger participants were relying more on expanding on the uses they already mentioned. This reliance could lead to the production of inappropriate and irrelevant ways of using the object.

The current study introduces handedness as an important variable mediating creativity, a relation warranting further research to determine more precisely the neural substrates of creativity.

Appendix A

Original Alternate Uses Items from Christensen et al. (1960):

- newspaper
- shoe
- button
- key
- wooden pencil
- automobile tire
- eyeglasses
- bar (was "cake" in original but was altered to be more easily understood) of soap
- barrel
- sock
- paper clip
- comb
- table
- paper cup
- brick

Additional five items from common word bank (Snodgrass et al., 1980):

- toothbrush
- doorknob
- hat
- belt
- book

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