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# The Different Role of Cognitive Inhibition in Early Versus Late Creative Problem Finding

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Previous research has suggested that ideas generated late in the creative process might require more executive control than those generated earlier. This in turn leads to the prediction that cognitive inhibition might play one role early in the process but a different role late in the process. The present investigation tested this prediction using a test of creative problem finding. Low cognitive inhibition was expected to facilitate an associative mode of processing, whereas high cognitive inhibition was expected to enable a deliberate, systematic mode of processing. An experiment involving 70 undergraduate students indicated that individuals' cognitive inhibition was correlated with fluency and flexibility, but not originality, on the problem-finding tasks. An interaction indicated that low cognitive inhibition enhanced originality initially, but later in the process, high cognitive inhibition was beneficial. Limitations of this investigation and future directions are explored.

*Keywords:* cognitive inhibition, creative problem finding, early versus late phases



Creativity is the foundation of human civilization. It depends on the human capacity to break from existing thinking patterns and build something new (Dietrich & Kanso, 2010). Many investigations have explored creativity, often looking to the cognitive processes required for creative ideation (Benedek, Franz, Heene, & Neubauer, 2012). Most previous studies have focused on creative problem solving (Dietrich & Kanso, 2010). As a somewhat underrepresented subject, problem finding has been found to be a key element of creative thinking and creative achievement (Chand & Runco, 1993; Hu, Shi, Han, Wang, & Adey, 2010; Jay & Perkins, 1997). Kabanoff and Rossiter (1994) cited problem finding as one of the vital directions for creativity research and a crucial element of creative behavior, especially real-world creativity in applied settings. The ability to identify worthwhile problems is important in many fields, including the arts and sciences (Alon, 2009; Chand & Runco, 1993; Jay & Perkins, 1997). Problem finding entails the ability to notice discrepancies and apparent contradictions and entertain new hypotheses about old problems, or to generate entirely novel questions or problems to be solved (D. K. Carson & Runco, 1999; Runco, 1994).

Problem-finding skill may be broad and general or tied to a particular subject domain, or it may be related to a particular context (e.g., problems related to space travel; Hu et al., 2010). In the present study, creative problem finding was defined as the process supporting the production and expression of novel and useful questions, using existing contexts and experience (Han, Hu, Liu, Jia, & Adey, 2013). There is reason to believe that the mechanisms underlying problem finding may be uncovered by manipulating cognitive inhibition. Many researchers have explored the relationship between cognitive inhibition and creativity.

## Cognitive Inhibition and Creativity

There is substantial evidence that creative people have a tendency to lack both cognitive and behavioral inhibition (Eysenck, 1995; Martindale, 1999, p. 143). This may in turn explain why creative individuals tend to ideate with shallow associative hier-

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archies, often appear to be impulsive (Burch, Hemsley, Pavelis, & Corr, 2006; Schuldberg, 2001), and are low in latent inhibition (S. H. Carson, Peterson, & Higgins, 2003; Fink, Slamar-Halbedl, Unterrainer, & Weiss, 2012). Also relevant is the tendency to attend to irrelevant stimuli, which apparently can contribute to original ideation (Howard-Jones & Murray, 2003).

The role of cognitive inhibition in creativity is not entirely straightforward. Golden (1975), for example, found cognitive inhibition to be associated with divergent thinking performances. Similar results have been reported using the Stroop test and a measure of random motor generation (Benedek et al., 2012; Golden, 1975; Groborz & Necka, 2003; Zabelina, Robinson, Council, & Bresin, 2012). It makes sense that stronger cognitive control may help individuals efficiently suppress competing dominant, but irrelevant, actions, processes, or mental activities (Edl, Benedek, Papousek, Weiss, & Fink, 2014).

Various investigations have explored the role of cognitive inhibition in creativity (Edl et al., 2014), but they have tended to focused on the broad question of whether creative cognition is related to inhibition or disinhibition. The present study was designed to dig deeper into the role of cognitive inhibition. Given that different levels of cognitive inhibition may functionally associate with different processing modes (Ellamil, Dobson, Beeman, & Christoff, 2012), we considered the possibility that both high and low cognitive inhibition could contribute to creative ideation through these different modes.

## The Role of Different Processing Modes

Dreisbach and Goschke (2004) demonstrated that reduced cognitive inhibition is associated with associative thinking, whereas Koch, Holland, and van Knippenberg (2008) reported that enhanced cognitive inhibition is related to systematic search processes. Nijstad, De Dreu, Rietzschel, and Baas (2010) found that systematic search processes require more executive control than associative thinking. Stanovich (1999) found that the choice of processing mode depends partly on variables of individual differences. Thus, low and high cognitive inhibition relates to creativity in several different ways. Low cognitive inhibition may facilitate an associative mode of processing that in turn supports the generation of novel ideas (Dorfman, Martindale, Gassimova, & Vartanian, 2008; Howard-Jones & Murray, 2003; Vartanian, Martindale, & Kwiatkowski, 2007). Perhaps it provides individuals with access to more diverse, nonobvious pieces of information to combine and use as building blocks for novel ideas (Fyfe, Williams, Mason, & Pickup, 2008; Rominger, Weiss, Fink, Schulter, & Papousek, 2011; Rossmann & Fink, 2010). High cognitive inhibition enables a deliberate, systematic mode of information processing (Ellamil et al., 2012), and may allow individuals to switch to a new strategy by inhibiting the dominant and typical strategy (Edl et al., 2014), thereby facilitating novel responding and divergent production (Gilhooly, Fioratou, Anthony, & Wynn, 2007).

As the process of ideation progresses, these two processing modes may contribute to different levels of creativity. Early on, low inhibition could easily allow more distant associations and ideas to enter working memory, leading to more original responses (Dorfman et al., 2008; Nijstad et al., 2010; White & Shah, 2011). However, as the process progresses, associative thinking may activate task-irrelevant material in memory and promote cognitive overload, thereby contributing to a decline in originality and a trade-off between flexibility versus stability (Cools, 2008; Dreisbach & Goschke, 2004; Dreisbach et al., 2005; Müller et al., 2007). A dysfunctional type of disinhibition can even lead to perseverative thoughts and the inability to digress from initial ideas (Benedek et al., 2012).

Systematic thinking, on the other hand, requires that distracting and irrelevant thoughts are blocked out of working memory and that attention is fully focused on the task at hand (Dreisbach & Goschke, 2004; Koch et al., 2008). More distant associates are not readily considered, because they are filtered out before they reach the threshold of activation needed to enter working memory (Harkins, 2006). The result is that obvious and readily available ideas are initially available. However, systematic search switches to a new strategy more easily by inhibiting the dominant and comfortable strategy, avoiding perseverative thoughts and repetition of initial ideas (Edl et al., 2014), thereby facilitating the generation of new and original ideas at later stages of the process (Benedek et al., 2012).

## Cognitive Inhibition and Creative Problem-Finding Process

Given that the relationship of cognitive inhibition with creativity may be contingent upon the type of creative task (Lin & Lien, 2013) and the importance of problem finding for creativity (Jay & Perkins, 1997), it seemed worthwhile to test cognitive inhibition using problem-finding tasks. Previous research suggests that problem finding involves both divergent and convergent thinking (Runco & Chand, 1994). There is some suggestion that divergent and associative thinking initially drive problem finding (Allen & Thomas, 2011), whereas convergent thinking contributes later, when people encounter a discrepancy between what they expect and what they observe. That discrepancy may be what cues the recognition that a problem exists (Bensley, 2009). There is reason to suspect that cognitive (dis)inhibition may not be beneficial to the entire problem-finding process but instead has a varied impact at different points within the process.

Early on, individuals with low cognitive inhibition may be privileged to access a large inventory of unfiltered stimuli, thereby increasing the odds of original recombinant ideation (S. H. Carson et al., 2003). However, a disadvantage of reduced cognitive inhibition is that it is associated with increased distractibility (Dreisbach & Goschke, 2004). The systematic thinking that is facilitated by high cognitive inhibition would cue easily accessible problems and thus not result in originality (Nijstad et al., 2010). Ideas generated later probably require more executive control than those generated earlier (Gilhooly et al., 2007), though individuals with high cognitive inhibition may switch to a new strategy and find original ideas, at least after more readily available ideas have been examined and discarded.

## The Role of Different Types of Instruction

There is another consideration when problem finding occurs in any sort of constrained context, including the classroom, organization, or lab. This is the type of presentation or instruction given with the tasks. A simple way of viewing such instructions is as "open" or "closed". Previous research demonstrated that the type of instruction had a significant impact on creative problem-finding ability (Chen, Hu, & Plucker, 2014; Runco & Okuda, 1991). In the present study, two types of instructions were given. The open instruction asked participants to generate scientific questions based on their everyday life experience and observations, and the closed instruction asked participants to generate scientific questions related to a picture of an astronaut standing on the moon (Chen et al., 2014).

Open instruction apparently gives participants more freedom to think creatively and allows individuals to take an active role in problem finding. Closed instruction, in contrast, provides individuals with a predefined context, which may confine the imagery and ideation of participants (Chen et al., 2014). Cognitive inhibition is again relevant in that it may help with the choice of useful elements from what is provided by the information given by instructions (Dietrich, 2004; Iyer et al., 2009). Hence, the present investigation manipulated instructions in an attempt to examine differences between open and closed problem finding.

## The Present Study

This study explored the relationship between cognitive inhibition and creative problem finding. The first question concerned the moderating effect of time. As just noted, both open and closed instructions were used, the expectation being that the relationship between cognitive inhibition and creative problem finding is moderated by instructions as well as time.

Hypotheses were that (1) the relationship between cognitive inhibition and creative problem finding changes as the process progresses (e.g., early vs. late); (2) open instructions would lead to greater creativity than closed instructions; (3) the relationship between cognitive inhibition and creative problem finding is moderated by type of instruction; and (4) as the process progresses, the relationship between cognitive inhibition and creative problem finding changes, depending on instructions given.

## Method

### Participants

Participants were 70 undergraduate students from Shaanxi Normal University, Xi'an, China, selected from 130 recruited undergraduates. A high-cognition-inhibition group consisted of nine males and 26 females ($n = 35$; mean age = 20.48 years) with scores in the top 27%, and a low-cognition-inhibition group consisted of 11 males and 24 females ($n = 35$; mean age = 20.39 years) with scores in the bottom 27%. All 70 participants received a textbook for participation. The 130 recruited undergraduate students received ¥5 ($0.8).

**Participant recruitment and selection procedure.** To select participants for the high-cognition-inhibition and low-cognitive-inhibition groups, a random motor generation (RMG) test was administered to measure cognition inhibition. An adapted computerized version of the Mittenecker Pointing Test (Mittenecker, 1958; Schulter, Mittenecker, & Papousek, 2010) was used. It requires participants to press nine unlabeled keys "as random as possible" (Schulter et al., 2010). The task was paced (1.2 responses per second; 180 responses). The response rate was guided by a regular acoustic beat presented via headphones. Data were then analyzed by the Mittenecker Pointing Test software program, which gives various parameters related to randomization behavior. The performance of cognitive inhibition was scored for context redundancy of sequence pairs ($CR_1$; for details, see Benedek et al., 2012; Schulter et al., 2010).

High context redundancy reflects dominant use of certain sequences of keys; low context redundancy reflects inhibition of "prepotent associates" and indicates executive inhibition (Miyake et al., 2000; Towse & Neil, 1998). Because the scale range of $CR_1$ is between 0 and 1, for further analyses, we reversed the scale by $CR^* = 1 - CR$, so that high scores reflect high inhibition. By the order of scores ($CR^*$), we assigned the top 27% of participants ($n = 35$; nine boys, 26 girls) as the cognitive inhibition group, whereas the bottom 27% of participants ($n = 35$; 11 boys, 24 girls) were assigned to the cognitive disinhibition group. The cognitive inhibition disinhibition groups were administered Creative Problem Finding Test (Hu et al., 2010) 1 day later.

**Cognitive inhibition test.** Cognitive inhibition was measured with the RMG. This test shows good internal consistency (Cronbach's alpha = .80; Benedek et al., 2012). There is substantial empirical evidence that RMG indicates the efficiency of inhibitory processes (Schulter et al., 2010; Weiss et al., 2014). Effective generation of random sequences requires the inhibition of the naturally occurring tendency to repeat previously selected sequences (Benedek et al., 2012). Furthermore, latent variable analysis of executive functions has confirmed that random sequence generation is solely related to inhibition, but not to shifting or updating (Miyake et al., 2000).

**Creative Problem Finding Test.** The Creative Problem Finding Test (Hu et al., 2010) provides scores for Fluency (how many ideas), Flexibility (variety of ideas), and Originality (rarity of ideas), each of which is based on theories divergent thinking, including those of Guilford (1968), Runco (1991, 2013), and Torrance (1966). The test itself consists of two open-ended questions. One question is open and asks the examinees to generate questions based on their everyday life experience and observations. The other question is more confined and asks examinees to generate scientific questions related to a picture of an astronaut standing on the moon. The open instructions were presented before the closed instructions to limit a possible order effect and bias. If the closed instruction was presented before the open instruction, the closed instruction item would give the participant a thinking set and would decrease the performance of open instruction. Previous studies have shown this to be the case (e.g., Chen et al., 2014). The open instruction has no impact on the closed instruction items when the open instruction task is presented first.

Examinees are given 8 min for each of the two tasks. Previous research has supported the reliability and usefulness of the Creative Problem Finding Test (Chen et al., 2014; Hu et al., 2010). The two items from the test were presented as PowerPoint slides, as follows:

> Slide 1 (instruction): "The ability to ask creative questions is very important. Today you have an opportunity to put your creativity to work. Please try to come up with as many questions as you can, from as many angles as you can, and try to produce as unique questions as you can."

Slide 2: "Based on your life experiences and daily observations of things, write down all questions you are curious about."

Slide 3 (Shows an astronaut standing on the moon): "This picture contains many science related questions, write down as many as you can think of."

**Early versus late creative problem finding.** Following previous work (Baas, De Dreu, & Nijstad, 2011; Coskun, Paulus, Brown, & Sherwood, 2000), the 8 min of problem finding under open instructions were divided into four time blocks, each 2 min, to trace creative problem-finding performance as a function of time. Similarly, the 8 min of problem finding under closed instruction were divided into four time blocks of 2 min to trace problem finding under closed instructions.

## Procedure

Selected by the Mittenecker Pointing Test (Schulter et al., 2010), high-cognition-inhibition and low-cognitive-inhibition groups were invited back to the lab 1 day after the RMG. Upon arrival, participants were seated at computer stations, visually isolated from one another by a distance of approximately 1 m. The entire procedure was screen-captured by the Camtasia Studio computer software. The Creative Problem Finding Test was administered to these two groups.

Two trained raters who were blind to conditions coded the ideas that were generated by the participants. Fluency was calculated from the number of nonredundant ideas per participant. Originality was based on the relative infrequency of ideas (Guilford, 1967; Torrance, 1966). To this end, the frequency of each problem generated within the sample (across all participants) was determined. Ideas found by 5% or less were given 2 points, ideas found by 5% to 10% given 1 point, and ideas found by 10% or more given 0. Totals were calculated by adding all points for each participant during each time block. The flexibility score was the number of conceptual categories across a subject's questions. The categories were predetermined (a priori) before any individual's response was scored, by pooling all responses together and categorizing them based on the nature of all questions. Because categories are possibly repeated across the time blocks, only total flexibility scores are analyzed and scores in each time block are excluded. Table 1 shows the interrater reliabilities (Pearson product-moment coefficients) for the Creative Problem Finding Test.

Table 1
*Interrater Reliabilities for Creative Problem Finding Test*

| Dimensions | Instructions | Block 1 | Block 2 | Block 3 | Block 4 |
|---|---|---|---|---|---|
| Flexibility | Open | | .85 | | |
| | Closed | | .87 | | |
| Fluency | Open | .89 | .86 | .87 | .88 |
| | Closed | .91 | .89 | .88 | .90 |
| Originality | Open | .72 | .69 | .70 | .73 |
| | Closed | .78 | .73 | .71 | .75 |

## Analyses

Hypothesis 2 was tested with simple ANOVAs, whereas Hypotheses 1, 3, and 4 imply interaction effects between several variables. Accordingly, a mixed model ANOVA was used for testing Hypothesis 1, with cognitive inhibition as the between-subjects variable and creative performance in each time block as the within-subjects variable (also see Baas et al., 2011; Coskun et al., 2000); Hypothesis 3, with cognitive inhibition as the between-subjects variable and instruction as the within-subjects variable; and Hypothesis 4, with cognitive inhibition as the between-subjects variable, creative performance in each time block as one within-subjects variable, and creative performance under different instructions as the other within-subjects variable.

# Results

Means and standard deviations of all relevant variables and correlations between the variables are presented in Table 2.

## Fluency

The number of ideas generated per participant in each 2-min time block was submitted to a repeated measures ANOVA with cognitive inhibition as the between-subjects variable and instruction and time block as within-subject variables. The results are presented in Table 3.

Table 3 indicates two significant main effects and a significant interaction. Contrary to Hypothesis 2, the significant within-subject effect indicated that the closed instructions contributed to more ideas than open instructions. More importantly, this effect was moderated by time blocks. Under open instruction, the level of fluency increased over time. Under closed instruction, the opposite tendency occurred. These tendencies are readily apparent in Figure 1.

Very importantly, a significant between-subjects effect was found. Participants with cognitive inhibition showed a higher level of fluency regardless of instruction and time block.

Because the choice for specific time blocks is arbitrary (e.g., one could also use two blocks of 4 min), the data were also analyzed using within-subjects regression (Baas et al., 2011). The number of ideas generated by each participant was regressed on the serial position of each of the eight 1-min time blocks. The resulting regression weights indicated the linear change in creativity over time. The regression coefficients were then used in a one-way ANOVA with cognitive inhibition as the between-subjects factor. In support of Hypothesis 4, results showed that under open instruction, the linear rise in production across 8 min was steeper for high inhibition ($M$ = .28, $SD$ = .42) than for low inhibition ($M$ = .08, $SD$ = .43), $F(1, 68) = 4.08$, $p < .05$, $\eta_p^2 = .06$. There was no significant difference under closed instructions.

## Originality

The originality scores generated by each participant in each 2-min time block were used in a repeated measures ANOVA with inhibition as the between-subjects variable and instruction and time block as within-subject variables. The results are presented in Table 4.

Table 2
*Means, SDs and Correlations of All Relevant Variables*

| Variables | *M* | *SD* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0. Inhibition | .73 | .08 | | | | | | | | | | | | | | | | | | |
| 1. O flu1 | 2.74 | 1.67 | .21 | | | | | | | | | | | | | | | | | |
| 2. O flu2 | 2.97 | 1.47 | .08 | .68*** | | | | | | | | | | | | | | | | |
| 3. O flu3 | 3.24 | 1.65 | .21 | .55*** | .62*** | | | | | | | | | | | | | | | |
| 4. O flu4 | 3.20 | 1.78 | .19 | .56*** | .63*** | .63*** | | | | | | | | | | | | | | |
| 5. C flu1 | 4.30 | 1.90 | .15 | .39** | .37** | .45*** | .47*** | | | | | | | | | | | | | |
| 6. C flu2 | 4.20 | 1.76 | .20 | .58*** | .53*** | .56*** | .72*** | .53*** | | | | | | | | | | | | |
| 7. C flu3 | 3.89 | 1.67 | .15 | .32** | .57*** | .51*** | .60*** | .46*** | .62*** | | | | | | | | | | | |
| 8. C flu4 | 3.54 | 1.82 | .02 | .47*** | .51*** | .60*** | .62*** | .44*** | .60*** | .62*** | | | | | | | | | | |
| 9. O ori1 | 2.92 | 1.70 | −.26* | .77*** | .64*** | .49*** | .54*** | .30* | .48*** | .27* | .44** | | | | | | | | | |
| 10. O ori2 | 2.93 | 1.55 | −.04 | .64*** | .88*** | .71*** | .74*** | .51*** | .61*** | .61*** | .49*** | .70*** | | | | | | | | |
| 11. O ori3 | 3.22 | 1.74 | .27* | .58*** | .66*** | .67*** | .52*** | .42** | .51*** | .44** | .49*** | .40** | .60*** | | | | | | | |
| 12. O ori4 | 3.80 | 2.07 | .45*** | .55*** | .54*** | .52*** | .61*** | .40** | .56*** | .42** | .35** | .29* | .56*** | .77*** | | | | | | |
| 13. C ori1 | 1.81 | 1.29 | −.05 | .07 | .06 | .03 | −.03 | .35** | .15 | .07 | .12 | .01 | .11 | .07 | .08 | | | | | |
| 14. C ori2 | 2.17 | 1.30 | −.06 | .18 | .22 | .03 | .42** | .36** | .29* | .41** | .18 | .19 | .34** | .13 | .21 | .22 | | | | |
| 15. C ori3 | 2.08 | 1.39 | .13 | −.01 | .08 | .13 | .16 | .35** | .26* | .31* | .09 | −.10 | .10 | .27* | .23 | .33* | .28* | | | |
| 16. C ori4 | 2.22 | 1.40 | .26* | .07 | .16 | .15 | .31* | .12 | .27* | .48*** | .20 | −.11 | .16 | .22 | .21 | .04 | .43** | .30* | | |
| 17. O fle | 3.05 | 1.06 | .36** | .18 | .11 | .22 | .21 | .19 | .21 | .21 | .11 | .07 | .17 | .19 | .42** | .01 | .07 | .02 | .06 | |
| 18. C fle | 2.79 | .96 | −.01 | .21 | .02 | −.04 | −.02 | −.04 | .05 | −.02 | .13 | .04 | −.03 | .17 | .18 | .19 | .21 | .13 | .33* | .11 |

*Note.* O flu1 = fluency scores in the first time block under open instruction; C flu1 = fluency scores in the first time block under closed instructions; O ori1 = originality scores in the first time block under open instruction; C ori1= originality in the first time block under closed instruction; O fle = flexibility scores under open instruction; C fle = flexibility scores under closed instruction.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4 reveals two significant main effects. First, there was no significant main effect of cognitive inhibition on creative problem finding. Second, in contrast to the fluency results, participants generated more original ideas under open instructions than under closed instructions. Third, late blocks contained more original ideas than early blocks.

Three interaction effects were also found. First, the Inhibition × Block effect showed that the high-cognitive-inhibition group performed better in late, but not early, blocks, whereas the low-cognitive-inhibition group showed the opposite. Figure 2 shows that originality of the high-cognitive-inhibition group climbed across the time blocks, whereas the low-inhibition group dropped slightly.

The Instruction × Block effect showed that originality scores under open instruction rose smoothly across the time blocks, whereas under closed instruction, originality scores climbed until the second time block, dropped for the third time block, and then rose slightly until the task finished. Figure 3 shows that, in contradiction to fluency, open instruction contributed to more original ideas than closed instruction.

Third was a significant Inhibition × Instruction × Block interaction. Figure 4 shows that under open instruction, the high-cognitive-inhibition group tended to generate fewer original ideas than the low-inhibition group in the first time block, $F(1, 68) = 3.161$, $p = .081$, $\eta_p^2 = .052$, whereas in the second block, no significant effect of cognitive inhibition was observed. In the third time block, the effect reversed, showing that the high-inhibition group generated more original ideas than the low-inhibition group, $F(1, 68) = 4.244$, $p = .044$, $\eta_p^2 = .068$. In the fourth time block, the reversed effect became more significant, $F(1, 68) = 13.750$, $p = .000$, $\eta_p^2 = .192$.

Figure 5 shows that under closed instruction, the low-cognitive-inhibition group tended to generate more original ideas than the high-inhibition group earlier. There was no significant difference between these two groups in first three time blocks, whereas in the last block, the effect became apparent, showing that the high-inhibition group generated more original ideas than the low-inhibition group, $F(1, 68) = 4.086$, $p = .048$, $\eta_p^2 = .067$.

Table 3
*Results of Repeated Measure ANOVA: Effects of Cognitive Inhibition on Creative Problem Finding Fluency*

| Variables | *F* | *df* | *p* | Partial $\eta^2$ |
|---|---|---|---|---|
| Inhibition | 8.066** | 1 | .006 | .106 |
| Instruction | 63.890*** | 1 | .000 | .484 |
| Block | 1.027 | 3 | .381 | .015 |
| Inhibition × Instruction | .297 | 1 | .588 | .004 |
| Inhibition × Block | .138 | 3 | .937 | .002 |
| Instruction × Block | 8.177*** | 3 | .000 | .107 |
| Inhibition × Instruction × Block | .545 | 3 | .652 | .008 |

*Note.* *df* = degrees of freedom.
** $p < .01$. *** $p < .001$.

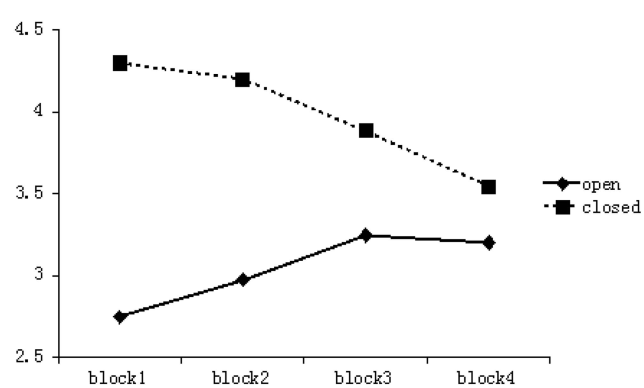


*Figure 1.* Fluency as a function of problem-finding instruction and time.

Table 4
*Results of Repeated Measure ANOVA: Effects of Cognitive Inhibition on Creative Problem Finding Originality*

| Variables | *F* | *df* | *p* | Partial $\eta^2$ |
|---|---|---|---|---|
| Inhibition | 1.489 | 1 | .227 | .025 |
| Instruction | 35.771*** | 1 | .000 | .386 |
| Block | 6.605*** | 3 | .000 | .104 |
| Inhibition × Instruction | .897 | 1 | .347 | .015 |
| Inhibition × Block | 14.380*** | 3 | .000 | .201 |
| Instruction × Block | 2.971* | 3 | .033 | .050 |
| Inhibition × Instruction × Block | 2.946* | 3 | .034 | .049 |

*Note.* *df* = degrees of freedom.
* $p < .05$. *** $p < .001$.



## Flexibility

The effect of cognitive inhibition on the level of cognitive flexibility was examined by submitting the flexibility scores to a repeated measures ANOVA with cognitive inhibition as the between-subjects variable and instruction as the within-subject variable. The results are presented in Table 5. (Only Hypotheses 2 and 3 could be tested with flexibility because there was a finite number of conceptual categories used for scoring, thus making comparisons from block to block unequal.)

The results indicated a significant between-subjects effect and a marginally significant interaction. Contrary to Hypothesis 2, high cognitive inhibition was associated with higher levels of flexibility, and there was no significant difference in flexibility scores under open and closed instructions. Consistent with Hypothesis 3, a simple effects analysis showed that the relationship between cognitive inhibition and creative problem-finding flexibility changed as the instruction varied. Under open instruction, the difference was significant, $F(1, 68) = 8.579$, $p = .005$, $\eta_p^2 = .125$. Under closed instruction, these two groups did not show any differences, $F(1, 68) = .363$, $p = .549$, $\eta_p^2 = .006$.

## Discussion

The results support the major hypothesis that the expected pattern of problem finding across early and late stages of the creative process was uncovered. Results also support the prediction that these differences reflect the cognitive inhibition of the

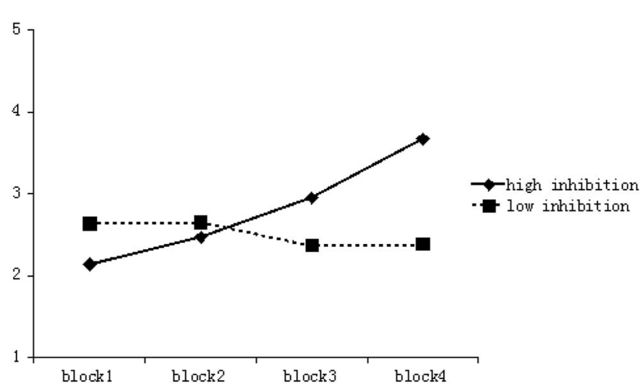


*Figure 2.* Originality as a function of cognitive inhibition and time.

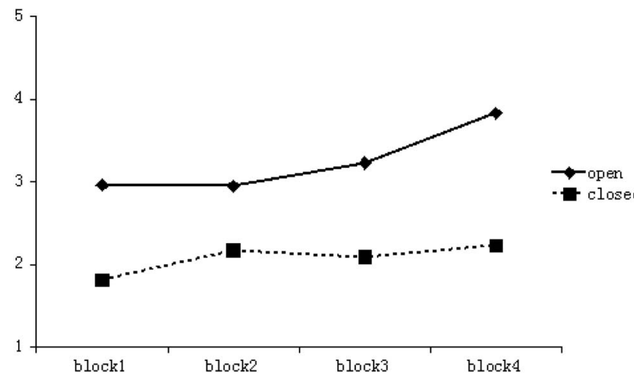


*Figure 3.* Originality as a function of problem-finding instruction and time.

participants. Low cognitive inhibition seems to have been superior early on, whereas high cognitive inhibition was advantageous later. As noted earlier, early and late creative problem finding might involve different levels of executive capacity and therefore exhibit different relationships with cognitive inhibition. Finding problems earlier may very well have relied more on associative thinking, which favors low cognitive inhibition (Allen & Thomas, 2011; Dreisbach & Goschke, 2004), whereas finding problems in later phases may involve more analytic systems, in which execution relies on cognitive inhibition (Lin & Lien, 2013; Nijstad et al., 2010). These results suggest that problem generation does not come easily to many people (Csikszentmihalyi, 1988); it requires more than one kind of processing mode (Runco & Chand, 1994). This view is consistent with the dual-process account of creative thinking, which proposes that although both types of thinking are active in creativity, the extent to which they are active and the nature of their contribution to creativity will vary between stages of the creative process (Allen & Thomas, 2011). Future research should directly examine dual process and problem finding.

## Cognitive Inhibition and Early Versus Late Creative Problem Finding

The results demonstrated that time block was related to originality, which fits with previous studies indicating that original

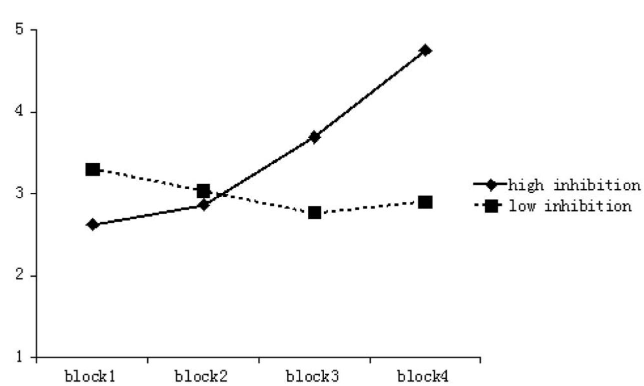


*Figure 4.* Originality under open instruction as a function of cognitive inhibition and time.

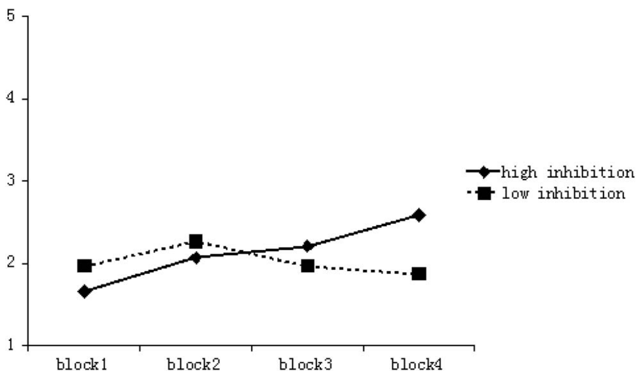


*Figure 5.* Originality under closed instruction as a function of cognitive inhibition and time.

ideas are typically generated after obvious ideas (Mednick, 1962; Milgram & Rabkin, 1980; Runco, 1986; Yuan & Zhou, 2008). Many studies, using a variety of methods and samples, have found that later ideas tend to be better than early ideas. For example, Milgram and Rabkin (1980) examined ideational patterns by comparing the first half of each individual's ideational set with the second half. They found that the number of uncommon ideas was significantly higher in the second half of the ideational set and that the number of common ideas was significantly lower. Using similar methods, Runco (1986) found that individuals demonstrated higher levels of originality and flexibility in the second half of the ideational set than in the first half.

However, a differential pattern of problem finding across early and late time blocks was found to be associated with cognitive inhibition. The originality lagging effect was only pronounced for the high-cognitive-inhibition group. The low-cognitive-inhibition group showed an opposite trend, generating more original problems initially. Taken in the context of problem-finding tasks, it is likely that the initial search for creative problems activates highly related associates in semantic memory. Low cognitive inhibition allows more information into the focus of attention for processing (Dorfman et al., 2008; Vartanian et al., 2007), thus helping an individual build new connections between stimuli that are normally experienced as being unrelated (Fyfe et al., 2008; Rominger et al., 2011; Rossmann & Fink, 2010). By allowing individuals to notice and store details that may be missed under conditions of high cognitive control (Gabora, 2010), low cognitive inhibition enables an associative mode of information processing that facilitates and ensures the generation of novel ideas initially (Edl et al., 2014; Howard-Jones & Murray, 2003). But it gets off track easily over time as a result of executive capacity deficiency, and declines steeply because of a trade-off between flexibility and stability (Dreisbach et al., 2005; Muller et al., 2007).

On the other hand, high cognitive inhibition seems to enable a deliberate, analytic mode of information processing (Ellamil et al., 2012), and allows individuals to focus on the pertinent task details and to select the relevant generated ideas (Gabora, 2010; Heilman, Nadeau, & Beversdorf, 2003; Lépine, Bernardin, & Barrouillet, 2005; Vartanian et al., 2007). Systematic thinking requires that distracting and irrelevant thoughts are blocked out of working memory and that attention is fully focused on the task at hand (Dreisbach & Goschke, 2004; Koch et al., 2008), which may imply that more distant associates are not readily considered initially (Harkins, 2006). However, finding problems in later phases drew on strategies that required more executive processes (Gilhooly et al., 2007). Effective cognitive inhibition helps individuals switch to a new strategy by inhibiting the dominant and comforting strategy (Edl et al., 2014), which would lead to later problems being better than earlier ones (Milgram & Rabkin, 1980).

## Cognitive Inhibition and Creative Problem Finding

Cognitive inhibition was related to the total fluency and flexibility scores, but not the total problem-finding originality scores. This might suggest that different kinds of processing modes affect the total quantity, but not the quality, of problem-finding performance. Originality can be achieved earlier through associative thinking employed by individuals with low cognitive inhibition (using many distant and unrelated resources), as well as in the later phases through systematic thinking employed by individuals with high cognitive inhibition (persistent exploration and flexible strategies; Nijstad et al., 2010). Thus, the total effect of cognitive inhibition on originality across all the time might be masked.

Results showed that cognitive inhibition is associated with enhanced fluency and flexibility. As an indicator of cognitive inhibition, low context redundancy was interpreted as an effective control over perseveration (Edl et al., 2014; Miyake et al., 2000; Weiss et al., 2014), which was related to enhanced cognitive flexibility (Benedek et al., 2012; Schulter et al., 2010). The inhibitory processes may help an individual to find problems in a flexible manner not only by inhibiting the dominant and comforting strategy (Edl et al., 2014) but also by keeping a stable systematic exploration of problem space to guarantee fluency (Dietrich, 2004; Nijstad et al., 2010). The present results mesh nicely with previous research showing that executive control predicts fluency and flexibility in creative thinking tasks (Lin, Hsu, Chen, & Chang, 2013). However, the effect size of cognitive inhibition on fluency and flexibility are so small that these results require replication.

## Cognitive Inhibition and Open Versus Closed Instruction

This study also analyzed the effects of problem-finding instructions. High cognitive inhibition was associated with enhanced flexibility and fluency under open instructions. This effect disappeared under closed instructions. It might imply that cognitive inhibition (an "idea monitor") was needed to choose appropriate problems from the unrestricted situation (Dietrich, 2004; Iyer et

Table 5
*Results of Repeated Measure ANOVA: Effects of Cognitive Inhibition on Creative Problem Finding Flexibility*

| Variables | *F* | *df* | *p* | Partial $\eta^2$ |
|---|---|---|---|---|
| Inhibition | 6.184* | 1 | .018 | .089 |
| Instruction | 2.505 | 1 | .119 | .040 |
| Inhibition × Instruction | 3.123 | 1 | .082 | .049 |

*Note.* *df* = degrees of freedom.
* $p < .05$.

al., 2009). When demands for ideas to enter working memory lack restrictions, it is inevitable that irrelevant thoughts are also considered (Nijstad et al., 2010). The process of contemplating and choosing from among a large set of combinatorial possibilities is not a simple one (Chua & Iyengar, 2008). This process becomes even more complex and difficult when the number of initial elements increases because of low cognitive inhibition. Thus, cognitive inhibition is more important under open instruction to keep our thinking in line with our goals and intentions (Nijstad & Stroebe, 2006), and to avoid experiencing more difficulty and frustration (Iyengar & Lepper, 2000). However, this should be examined in future work because of the small effect size.

It should also be noted that open instructions promoted originality but impeded fluency, whereas closed instructions promoted fluency but impeded originality. This is very similar to previous research comparing explicit instructions for originality and flexibility (Runco & Okuda, 1991). As a restricted situation, closed instruction leads to available problems more easily but inhibits imagination and uniqueness. Conversely, although open instructions make it more difficult to generate ideas, they provide broader space for individuals to find original problems. The larger the choice set of initial elements, the more flexibility there is in the generation of different combinations (Chua & Iyengar, 2008). This gives rise to closer access to originality. Open instruction can give participants more freedom to think creatively, as it allows individuals to exert imagination in problem finding (Chen et al., 2014) and take an enduringly active role to guarantee the ascent of fluency and originality.

## Some Limitations and Directions for Future Work

The present research indicated that cognitive inhibition plays different roles in early versus late creative problem finding, offering a new interpretation of the relationship between cognitive inhibition and creativity. However, there are several limitations that would serve as fruitful directions for future work. First, some results in this study have much lower effect sizes, which might be triggered by the number of recruited participants, which may be not enough to distinguish the high- and low-cognitive-inhibition groups significantly. In future work, more participants should be recruited. Second, the closed instruction utilized a problem-finding task from a specific domain; it should be considered whether familiarity and comfort with the domain of science was an issue. This type of variable should be used as a covariate in future work. Also, a wider variety of different instructions should be tested in future research, as this might capture more potential ability related to creative problem finding and make differences between the instructions much clearer.

Open-ended tasks like those on the Creative Problem Finding Test have proved to be reliable predictors of creative potential in a number of previous investigations (Guilford, 1968; Runco, 1991, 2013). Certainly, divergent thinking is not synonymous with actual creativity, but tests of divergent thinking do provide reliable information about the potential for creative problem solving (Hu & Adey, 2002). Whether time blocks and different kinds of instruction moderate the relationship between mood and creativity, or the relationship between working memory and creativity, is another interesting issue that remains for future investigation.

## References

Allen, A. P., & Thomas, K. E. (2011). A dual-process account of creative thinking. *Creativity Research Journal, 23,* 109–118. http://dx.doi.org/10.1080/10400419.2011.571183

Alon, U. (2009). How to choose a good scientific problem. *Molecular Cell, 35,* 726–728. http://dx.doi.org/10.1016/j.molcel.2009.09.013

Baas, M., De Dreu, C. K. W., & Nijstad, B. A. (2011). Creative production by angry people peaks early on, decreases over time, and is relatively unstructured. *Journal of Experimental Social Psychology, 47,* 1107–1115. http://dx.doi.org/10.1016/j.jesp.2011.05.009

Benedek, M., Franz, F., Heene, M., & Neubauer, A. C. (2012). Differential effects of cognitive inhibition and intelligence on creativity. *Personality and Individual Differences, 53,* 480–485. http://dx.doi.org/10.1016/j.paid.2012.04.014

Bensley, D. A. (2009). Thinking critically about critical thinking approaches: Comment on Yancher, Slife, and Warne (2008). *Review of General Psychology, 13,* 275–277. http://dx.doi.org/10.1037/a0015654

Burch, G. S., Hemsley, D. R., Pavelis, C., & Corr, P. J. (2006). Personality, creativity and latent inhibition. *European Journal of Personality, 20,* 107–122. http://dx.doi.org/10.1002/per.572

Carson, D. K., & Runco, M. A. (1999). Creative problem solving and problem finding in young adults: Interconnections with stress, hassles, and coping abilities. *The Journal of Creative Behavior, 33,* 167–188. http://dx.doi.org/10.1002/j.2162-6057.1999.tb01195.x

Carson, S. H., Peterson, J. B., & Higgins, D. M. (2003). Decreased latent inhibition is associated with increased creative achievement in high-functioning individuals. *Journal of Personality and Social Psychology, 85,* 499–506. http://dx.doi.org/10.1037/0022-3514.85.3.499

Chand, I., & Runco, M. A. (1993). Problem finding skills as components in the creative process. *Personality and Individual Differences, 14,* 155–162. http://dx.doi.org/10.1016/0191-8869(93)90185-6

Chen, B., Hu, W., & Plucker, J. A. (2014). The effect of mood on problem finding in scientific creativity. *The Journal of Creative Behavior*. Advance online publication. http://dx.doi.org/10.1002/jocb.79

Chua, R. Y. J., & Iyengar, S. S. (2008). Creativity as a matter of choice: Prior experience and task instruction as boundary conditions for the positive effect of choice on creativity. *The Journal of Creative Behavior, 42,* 164–180. http://dx.doi.org/10.1002/j.2162-6057.2008.tb01293.x

Cools, R. (2008). Role of dopamine in the motivational and cognitive control of behavior. *The Neuroscientist, 14,* 381–395. http://dx.doi.org/10.1177/1073858408317009

Coskun, H., Paulus, P. B., Brown, V., & Sherwood, J. J. (2000). Cognitive stimulation and problem presentation in idea-generating groups. *Group Dynamics: Theory, Research, and Practice, 4,* 307–329. http://dx.doi.org/10.1037/1089-2699.4.4.307

Csikszentmihalyi, M. (1988). Solving a problem is not finding a new one: A reply to Simon. *New Ideas in Psychology, 6,* 183–186. http://dx.doi.org/10.1016/0732-118X(88)90003-7

Dietrich, A. (2004). The cognitive neuroscience of creativity. *Psychonomic Bulletin & Review, 11,* 1011–1026. http://dx.doi.org/10.3758/BF03196731

Dietrich, A., & Kanso, R. (2010). A review of EEG, ERP, and neuroimaging studies of creativity and insight. *Psychological Bulletin, 136,* 822–848. http://dx.doi.org/10.1037/a0019749

Dorfman, L., Martindale, C., Gassimova, V., & Vartanian, O. (2008). Creativity and speed of information processing: A double dissociation involving elementary versus inhibitory cognitive tasks. *Personality and Individual Differences, 44,* 1382–1390. http://dx.doi.org/10.1016/j.paid.2007.12.006

Dreisbach, G., & Goschke, T. (2004). How positive affect modulates cognitive control: Reduced perseveration at the cost of increased distractibility. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 343–353. http://dx.doi.org/10.1037/0278-7393.30.2.343

Dreisbach, G., Müller, J., Goschke, T., Strobel, A., Schulze, K., Lesch, K. P., & Brocke, B. (2005). Dopamine and cognitive control: The influence of spontaneous eyeblink rate and dopamine gene polymorphisms on perseveration and distractibility. *Behavioral Neuroscience, 119,* 483–490. http://dx.doi.org/10.1037/0735-7044.119.2.483

Edl, S., Benedek, M., Papousek, I., Weiss, E. M., & Fink, A. (2014). Creativity and the Stroop interference effect. *Personality and Individual Differences, 69,* 38–42. http://dx.doi.org/10.1016/j.paid.2014.05.009

Ellamil, M., Dobson, C., Beeman, M., & Christoff, K. (2012). Evaluative and generative modes of thought during the creative process. *NeuroImage, 59,* 1783–1794. http://dx.doi.org/10.1016/j.neuroimage.2011.08.008

Eysenck, H. J. (1995). *Genius: The natural history of creativity*. Cambridge, UK: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511752247

Fink, A., Slamar-Halbedl, M., Unterrainer, H. F., & Weiss, E. M. (2012). Creativity: Genius, madness, or a combination of both? *Psychology of Aesthetics, Creativity, and the Arts, 6,* 11–18. http://dx.doi.org/10.1037/a0024874

Fyfe, S., Williams, C., Mason, O. J., & Pickup, G. J. (2008). Apophenia, theory of mind and schizotypy: Perceiving meaning and intentionality in randomness. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 44,* 1316–1325. http://dx.doi.org/10.1016/j.cortex.2007.07.009

Gabora, L. (2010). Revenge of the "neurds": Characterizing creative thought in terms of the structure and dynamics of memory. *Creativity Research Journal, 22,* 1–13. http://dx.doi.org/10.1080/10400410903579494

Gilhooly, K. J., Fioratou, E., Anthony, S. H., & Wynn, V. (2007). Divergent thinking: Strategies and executive involvement in generating novel uses for familiar objects. *British Journal of Psychology, 98,* 611–625. http://dx.doi.org/10.1111/j.2044-8295.2007.tb00467.x

Golden, C. J. (1975). The measurement of creativity by the Stroop color and word test. *Journal of Personality Assessment, 39,* 502–506. http://dx.doi.org/10.1207/s15327752jpa3905_9

Groborz, M., & Necka, E. (2003). Creativity and cognitive control: Explorations of generation and evaluation skills. *Creativity Research Journal, 15,* 183–197. http://dx.doi.org/10.1080/10400419.2003.9651411

Guilford, J. P. (1967). *The nature of human intelligence*. New York, NY: McGraw-Hill.

Guilford, J. P. (1968). *Creativity, intelligence, and their educational implications*. San Diego, CA: EDITS/Knapp.

Han, Q., Hu, W., Liu, J., Jia, X., & Adey, P. (2013). The influence of peer interaction on students' creative problem-finding ability. *Creativity Research Journal, 25,* 248–258. http://dx.doi.org/10.1080/10400419.2013.813754

Harkins, S. G. (2006). Mere effort as the mediator of the evaluation-performance relationship. *Journal of Personality and Social Psychology, 91,* 436–455. http://dx.doi.org/10.1037/0022-3514.91.3.436

Heilman, K. M., Nadeau, S. E., & Beversdorf, D. O. (2003). Creative innovation: Possible brain mechanisms. *Neurocase, 9,* 369–379. http://dx.doi.org/10.1076/neur.9.5.369.16553

Howard-Jones, P. A., & Murray, S. (2003). Ideational productivity, focus of attention, and context. *Creativity Research Journal, 15,* 153–166. http://dx.doi.org/10.1080/10400419.2003.9651409

Hu, W. P., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education, 24,* 389–403.

Hu, W., Shi, Q. Z., Han, Q., Wang, X., & Adey, P. (2010). Creative scientific problem finding and its developmental trend. *Creativity Research Journal, 22,* 46–52. http://dx.doi.org/10.1080/10400410903579551

Iyengar, S. S., & Lepper, M. R. (2000). When choice is demotivating: Can one desire too much of a good thing? *Journal of Personality and Social Psychology, 79,* 995–1006. http://dx.doi.org/10.1037/0022-3514.79.6.995

Iyer, L. R., Doboli, S., Minai, A. A., Brown, V. R., Levine, D. S., & Paulus, P. B. (2009). Neural dynamics of idea generation and the effects of priming. *Neural Networks, 22,* 674–686. http://dx.doi.org/10.1016/j.neunet.2009.06.019

Jay, E., & Perkins, D. N. (1997). Creativity's compass: A review of problem finding. *Creativity Research Handbook, 1,* 257–293.

Kabanoff, B., & Rossiter, J. R. (1994). Recent developments in applied creativity. *International Review of Industrial and Organizational Psychology, 9,* 283–324.

Koch, S., Holland, R. W., & van Knippenberg, A. (2008). Regulating cognitive control through approach-avoidance motor actions. *Cognition, 109,* 133–142. http://dx.doi.org/10.1016/j.cognition.2008.07.014

Lépine, R., Bernardin, S., & Barrouillet, P. (2005). Attention switching and working memory spans. *European Journal of Cognitive Psychology, 17,* 329–345. http://dx.doi.org/10.1080/09541440440000014

Lin, W. L., Hsu, K. Y., Chen, H. C., & Chang, W. (2013). Different attentional traits, different creativities. *Thinking Skills and Creativity, 9,* 96–106. http://dx.doi.org/10.1016/j.tsc.2012.10.002

Lin, W. L., & Lien, Y. W. (2013). Exploration of the relationships between retrieval-induced forgetting effects with open-ended versus closed-ended creative problem solving. *Thinking Skills and Creativity, 10,* 40–49. http://dx.doi.org/10.1016/j.tsc.2013.05.004

Martindale, C. (1999). The biological basis of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 137–152). Cambridge, UK: Cambridge University Press.

Mednick, S. (1962). The associative basis of the creative process. *Psychological Review, 69,* 220–232.

Milgram, R. M., & Rabkin, L. (1980). Developmental test of Mednick's associative hierarchies of original thinking. *Developmental Psychology, 16,* 157–158. http://dx.doi.org/10.1037/0012-1649.16.2.157

Mittenecker, E. (1958). Die Analyse "zufälliger" Reaktionsfolgen [The analysis of "random" action sequences]. *Zeitschrift für Experimentelle und Angewandte Psychologie, 5,* 45–60.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41,* 49–100. http://dx.doi.org/10.1006/cogp.1999.0734

Müller, J., Dreisbach, G., Goschke, T., Hensch, T., Lesch, K. P., & Brocke, B. (2007). Dopamine and cognitive control: The prospect of monetary gains influences the balance between flexibility and stability in a set-shifting paradigm. *European Journal of Neuroscience, 26,* 3661–3668. http://dx.doi.org/10.1111/j.1460-9568.2007.05949.x

Nijstad, B. A., De Dreu, C. K. W., Rietzschel, E. F., & Baas, M. (2010). The dual pathway to creativity model: Creative ideation as a function of flexibility and persistence. *European Review of Social Psychology, 21,* 34–77. http://dx.doi.org/10.1080/10463281003765323

Nijstad, B. A., & Stroebe, W. (2006). How the group affects the mind: A cognitive model of idea generation in groups. *Personality and Social Psychology Review, 10,* 186–213. http://dx.doi.org/10.1207/s15327957pspr1003_1

Rominger, C., Weiss, E. M., Fink, A., Schulter, G., & Papousek, I. (2011). Allusive thinking (cognitive looseness) and the propensity to perceive "meaningful" coincidences. *Personality and Individual Differences, 51,* 1002–1006. http://dx.doi.org/10.1016/j.paid.2011.08.012

Rossmann, E., & Fink, A. (2010). Do creative people use shorter associative pathways? *Personality and Individual Differences, 49,* 891–895. http://dx.doi.org/10.1016/j.paid.2010.07.025

Runco, M. A. (1986). Flexibility and originality in children's divergent thinking. *The Journal of Psychology: Interdisciplinary and Applied, 120,* 345–352. http://dx.doi.org/10.1080/00223980.1986.9712632

Runco, M. A. (Ed.). (1991). *Divergent thinking*. Norwood, NJ: Ablex Publishing Corporation.

Runco, M. A. (2013). *Divergent thinking and creative potential*. Cresskill, NJ: Hampton Press.

Runco, M. A. (Ed.). (1994). *Problem finding, problem solving, and creativity*. Norwood, NJ: Ablex.

Runco, M. A., & Chand, I. (1994). Problem finding, evaluative thinking, and creativity. In M. A. Runco (Ed.), *Problem finding, problem solving, and creativity* (pp. 40–76). Norwood, NJ: Ablex.

Runco, M. A., & Okuda, S. M. (1991). The instructional enhancement of the ideational flexibility and originality scores of divergent thinking tests. *Applied Cognitive Psychology, 5,* 435–441. http://dx.doi.org/10.1002/acp.2350050505

Schuldberg, D. (2001). Six subclinical spectrum traits in normal creativity. *Creativity Research Journal, 13,* 5–16. http://dx.doi.org/10.1207/S15326934CRJ1301_2

Schulter, G., Mittenecker, E., & Papousek, I. (2010). A computer program for testing and analyzing random generation behavior in normal and clinical samples: The Mittenecker Pointing Test. *Behavior Research Methods, 42,* 333–341. http://dx.doi.org/10.3758/BRM.42.1.333

Stanovich, K. E. (1999). *Who is rational? Studies of individual differences in reasoning*. Mahwah, NJ: Erlbaum.

Torrance, E. P. (1966). *Torrance tests of creative thinking*. Princeton, NJ: Personnel Press.

Towse, J. N., & Neil, D. (1998). Analyzing human random generation behavior: A review of methods used and a computer program for describing performance. *Behavior Research Methods, Instruments & Computers, 30,* 583–591. http://dx.doi.org/10.3758/BF03209475

Vartanian, O., Martindale, C., & Kwiatkowski, J. (2007). Creative potential, attention, and speed of information processing. *Personality and Individual Differences, 34,* 1370–1380.

Weiss, E. M., Schulter, G., Fink, A., Reiser, E. M., Mittenecker, E., Niederstätter, H., . . . Papousek, I. (2014). Influences of COMT and 5-HTTLPR polymorphisms on cognitive flexibility in healthy women: Inhibition of prepotent responses and memory updating. *PLoS ONE, 9*(1), e85506. http://dx.doi.org/10.1371/journal.pone.0085506

White, H. A., & Shah, P. (2011). Creative style and achievement in adults with attention-deficit/hyperactivity disorder. *Personality and Individual Differences, 50,* 673–677. http://dx.doi.org/10.1016/j.paid.2010.12.015

Yuan, F., & Zhou, J. (2008). Differential effects of expected external evaluation on different parts of the creative idea production process and on final product creativity. *Creativity Research Journal, 20,* 391–403. http://dx.doi.org/10.1080/10400410802391827

Zabelina, D. L., Robinson, M. D., Council, J. R., & Bresin, K. (2012). Patterning and nonpatterning in creative cognition: Insights from performance in a random number generation task. *Psychology of Aesthetics, Creativity, and the Arts, 6,* 137–145. http://dx.doi.org/10.1037/a0025452

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