Thinking Skills and Creativity 37 (2020) 100688

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: www.elsevier.com/locate/tsc

Adolescents with different profiles of scientific versus artistic creativity: Similarity and difference in cognitive control

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ARTICLE INFO

Keywords:
Scientific creativity
Artistic creativity
Cognitive control

ABSTRACT

This study aimed to compare performance of cognitive control functions by junior high school students with different profiles of scientific vs. artistic creativity. A total of 297 Chinese junior high school students were tested with a battery of scientific and artistic creativity tests. Out of this sample, 110 students who ranked in the top 27 % or bottom 27 % on scientific and artistic creativity were selected to form four groups, and their performance on cognitive inhibition, response inhibition, and switching was compared. Results showed that scientifically creative students had better cognitive inhibitory and response inhibitory ability than artistically creative students, but no significant difference existed between them in switching. The findings expand our knowledge of cognitive characteristics of students with different domain strengths with the following practical implications: high cognitive and response inhibition may be desirable characteristics for identifying and developing scientific talent but it may be less central for identifying and developing artistic talent.

1. Introduction

The cultivation of creativity has become one of the core goals of education worldwide. In China creativity is deemed as one of the essential core qualities in the 21 st century. The "learning framework for 2030″, developed by Organization for Economic Cooperation and Development (OECD), also takes creativity as an important indicator of national strength, which will be tested with school students across nations in 2021.

With the deepening of the research and practice on the cultivation of creativity, researchers not only pay attention to the macro perspective such as students' creative products and creative achievements, but also emphasize the micro perspective (Forthmann et al., 2019), such as underlying cognitive processes. Increasingly, studies reveal distinct cognitive processes behind creativity and teaching (He & Wong, 2015; Preiss, Cosmelli, Grau, & Ortiz, 2016), and some researchers use their cognition-related findings to support educational practice (Meichenbaum, 2017; Meltzer, 2018). However, one fundamental question to be addressed is which specific cognitive functions are involved in the creative process, especially when it comes to creative performance in particular domains. This issue has profound implications regarding how to select high potential students, how to intervene, and even how to evaluate the effect of intervention.

The present study compared two groups of students known to be strong in scientific creativity and artistic creativity, respectively,

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https://doi.org/10.1016/j.tsc.2020.100688
Received 23 December 2019; Received in revised form 30 May 2020; Accepted 22 July 2020
Available online 24 July 2020

on measures of basic cognitive control. The purpose was to find out whether individuals with high scientific creativity are cognitively different from individuals with high artistic creativity.

1.1. *Scientific creativity and artistic creativity*

Similarities and differences between scientific creativity and artistic creativity have been explored as they represent two major domains of human activity as well as two differing ways of creativity (Baer, 2015; Radel, Davranche, Fournier, & Dietrich, 2015; Yi & Hu, 2013).

Scientific creativity is defined as one kind of intellectual ability to produce or potentially produce credible and generalizable knowledge that is original and valuable (Hu et al., 2013; Simonton, 2008). The process of scientific inquiry must follow logical rules, generate theoretical or practical experiences, and serve the purpose of expanding understanding of the world. Furthermore, products of scientific creativity must be authentic, reliable, and practically meaningful.

Unlike scientific creativity, artistic creativity refers to the ability to produce new ideas or products with high aesthetic value (Feist, 1998). It includes creative expression in any aspect of art, including visual arts, music, literature, dance, drama, film and industrial art. As artistic creativity is manifested by individuals' transformation of their lived experiences through creative activities, it emphasizes the externalization or objectification of subjective experience that has aesthetic value (Shen, Liu, & Wang, 2010).

The differences between people with high scientific creativity and those with high artistic creativity have been widely studied. Since creativity is a complex concept, these studies cover a wide range of factors related to creativity, including creative performance (Charyton & Snelbecker, 2007), demographic variables (Furnham, Batey, Booth, Patel, & Lozinskaya, 2011; Hur, Jeong, & Piffer, 2014), personality factors (Feist, 1998; Furnham & Crump, 2013; Kaufman et al., 2016), divergent thinking (Beaty & Silvia, 2012), etc. For example, based on research, scientists are characterized as conservative, cool, and numerate, among other characteristics, and artists as more sensitive, imaginative, and expressive (Furnham & Crump, 2013). It is not clear, however, in areas of cognitive functioning, as to what might distinguish between scientifically and artistically creative individuals in terms of how their brains integrate, organize, and control cognitive activities. Does cognitive functioning of these two groups of individuals show distinct ways in which information is processed? This study addresses a crucial cognitive function - cognitive control.

1.2. *Cognitive control and creativity*

According to Band, van der Molen, & Logan, 2003, cognitive control refers to the control and coordination of the cognitive system in the process of completing various complex cognitive tasks, so as to ensure the achievement of specific cognitive goals as well as the orderly generation of target behaviors. Cognitive control is not a single structure, it involves adjusting attention to avoid distractions from irrelevant information, planning complex activities toward goals, capturing and processing information, and so on (Funahashi, 2001). In other words, cognitive control involves many subfunctions and subprocesses (Li, Gao, & Wang, 2004; Miyake et al., 2000).

A considerable amount of research has been accumulated concerning the relationship between cognitive control and creativity (Chrysikou et al., 2013; Nusbaum & Silvia, 2011), but the findings are not consistent. Since most of these studies do not address the specific cognitive control functions related to creative performance in certain domain, we hope to address this issue from a more focused perspective. In this study, we focus on three cognitive control subfunctions that can shed light on how cognitive control relates to scientific and artistic creativity.

1.2.1. *Cognitive inhibition and creativity*

The most concerned variable when it comes to the relationship between creativity and cognitive control is *cognitive inhibition* (Bai & Yao, 2018; Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014). However, the relationship between cognitive inhibition and creative performance is complex.

Some researchers suggest that cognitive disinhibition is beneficial for creativity. Individuals with weak inhibiting ability will bring a large amount of seemingly irrelevant information into working memory, and such information could be used in the subsequent process of making creative combinations and generate new ideas (Eysenck, 1993). For example, Peterson, Smith, and Carson (2002)) found that subjects with poor potential inhibition had stronger creative personality tendencies. Research by Carson, Peterson, and Higgins (2003)) also found that subjects who scored higher on creative tasks showed lower levels of potential inhibition. Radel et al. (2015) found that, when the subject's inhibition resources were exhausted, the originality and fluency of their ideas increased.

However, other researchers suggest that highly creative individuals have greater cognitive inhibition. Researchers found that those with higher levels of creative performance showed shorter reaction time on the Stroop task than those with lower levels of creativity (Groborz & Necka, 2003; Vartanian, Martindale, & Matthews, 2009). Camarda et al. (2018) reached the same conclusion using the double-task paradigm.

Still other researchers suggest that, rather than an either-or condition, highly creative individuals exhibit flexible cognitive inhibition; that is, they can freely switch between defocusing attention and focusing attention, so as to achieve flexible allocation of attentional resources (Liu, Cheng, & Shi, 2007; Zabelina & Robinson, 2010).

Recent research on domain-specific creativity may offer possible explanations for this discrepancy. Bai, Gong, Hu, Han, and Yao (2014) found that the performance on cognitive inhibition of people with high scientific creativity was better than those with low scientific creativity individuals. However, Cheng, Hu, and Jia (2015)) found a negative relationship between cognitive inhibition and performance on artistic creativity. The seemingly contradictory findings suggest that the relationship between creative performance and cognitive inhibition may vary from one domain to another. Therefore, we intended to compare the cognitive inhibition performance of students with differential domain strengths in one study. Scientists differ significantly from artists in that they are more constrained by logic and methodology, and they focus their attention on information highly relevant to their current goals. In comparison, artists work more freely and sometimes even welcome unexpected but seemingly irrelevant information. So, our prediction was that, compared with people with strong artistic creativity, people with strong scientific creativity are more likely to show cognitive inhibition.

Hypothesis 1. Scientifically creative individuals (i.e. the group with high scientific creativity but low artistic creativity in this study) will perform cognitive inhibition tasks better than artistically creative individuals (i.e. the group with low scientific creativity but high artistic creativity).

1.2.2. Response inhibition and creativity

In addition to cognitive inhibition, the inhibitory function of the central executive system contains another component: response inhibition. *Response inhibition* refers to the ability to suppress behaviors that are inappropriate, unsafe, or no longer required (Chambers, Garavan, & Bellgrove, 2009). The difference between cognitive inhibition and response inhibition is that cognitive inhibition inhibits irrelevant stimuli that interfere with current cognitive performance and functioning, whereas response inhibition inhibits behavioral responses that are currently inappropriate (Li et al., 2004; Zhao & Chen, 2006). People can stop a behavior at will as needed. In such cases, response inhibition function is the mechanism behind the successful control of the impending action.

Several studies have provided evidence for the possible relationship between creative performance (e.g., on divergent thinking tests) and response inhibition. First, some researchers suggest that the serial order effect, which refers to the phenomenon that subjects always start with obvious and salient answers rather than original ones in divergent thinking tasks, is attributable to response inhibition (Beaty & Silvia, 2012). When the current task is to come up with novel ideas or solve a problem in a creative way, individuals with strong response inhibition should be better at suppressing answers that come early but are not original enough. Second, results from neuroscience research show that people who are good at divergent thinking have a stronger connection between the entire default mode network and the left inferior frontal gyrus (IFG) (Beaty et al., 2014). Given that the inferior prefrontal cortex is considered to be associated with dominant response inhibition (Dodds, Morein-Zamir, & Robbins, 2010), the finding by Beaty and his colleagues seems to suggest a positive relationship between divergent thinking and dominant response inhibition. However, other studies have come to the opposite conclusion. Kipper, Green, and Prorak (2010)), for example, found creative personality to be positively related to spontaneity which is conceptually similar to response disinhibition, manifested as uncontrolled and uncensored response, ignoring social and cultural mores. Although creative personality or divergent thinking is not synonymous with creative performance (e.g. Runco, 2008), the literature suggests that they can predict creative performance (Meneely & Portillo, 2005; Wallach, 1970). However, the findings from the limited studies seem inconsistent.

To further explore possibilities beyond this discrepancy, we focused on the relationship between response inhibition and creative performance in different domains. Creative activities in different domains are considered to share the same components such as divergent thinking (Huang, Peng, Chen, Tseng, & Hsu, 2017). As a result, creativity performance in both scientific and artistic domains should be more or less supported by response inhibition. However, clear differences exist between creativity in science and art; scientific work is more concerned with appropriateness and viability, while artistic imagination can be logically less constrained (Lin, Hsu, Chen, & Wang, 2012). So, the differing nature of science and art leads to the prediction that response suppression is more important to scientifically creative individuals than to artistically creative individuals.

Hypothesis 2. Scientifically creative individuals will exhibit higher response inhibition than artistically creative individuals (i.e. the “hS-hA” and the “hS-lA” groups perform better than the “lS-hA” group and the “lS-lA” group).

1.2.3. Switching and creativity

Switching is defined as the ability to flexibly shift between different tasks or mental sets (Monsell, 2003). Many studies have shown that, compared to working on the same task, switching to another task is usually accompanied by the reduction of task performance. The difficulty of switching to another task can be manifested as the extension of reaction time and the reduction of accuracy (i.e. switch cost) (Arbuthnott, 2008; Sun, Xiao, & Guo, 2007).

Findings from the existing research on the relationship between switching and creativity consistently point to a positive relationship between switching and creativity (Pan & Yu, 2018; Zabelina, Friedman, & Andrews-Hanna, 2019). A study found that highly creative individuals performed better on flexible switching tasks (Zabelina & Robinson, 2010). Another study showed that when faced with multiple creativity tasks and goals, if the subjects were allowed to switch between tasks as needed, they would perform better (Madjar & Shalley, 2008). Lu, Akinola, & Mason (2017) also found that participants who switched between different creative tasks outperformed those who dealt with the tasks one by one; their study supports the argument that switching helps reduce cognitive fixation.

Although there is no direct evidence as to how switching affects creative performance in specific domains, we extrapolated that cognitive flexibility in terms of switching should be the same. In the complex creative activities in real life, creators often need to switch between associative and analytic thinking in both the idea generation and evaluation phase (Pringle & Sowden, 2017). However, even when encouraged to adopt task-switching strategies, most people were unable to switch continuously (Lu et al., 2017). While switching is critical to creative processes, people often fail to adopt such a strategy. Therefore, we proposed that the ability to switch between different cognitive processes in a flexible manner should be important to both scientific and artistic creativity.

Hypothesis 3. More creative people, regardless of domains, should show better switching performance (i.e. the “hS-hA” group outperforms the other three groups, or the “lS-lA” group performs not as well as the other three groups). And there shall be no significant difference in cognitive switching between individuals with high scientific creativity (i.e. the “hS-lA” group) and those with higher artistic creativity (i.e. the “lS-hA” group).

1.3. The present study

In the present study, we compared the performance of scientifically creative individuals and artistically creative individuals on three cognitive functions under equivalent conditions. To our knowledge, this was the first study to examine how individuals creative in different domains differ in their performance on cognitive control tasks. Researchers often look at the similarities and differences between different creative fields from a broader perspective, such as the personality traits or demographics of scientifically and artistically creative adolescents. We extended previous research by more closely analyzing the cognitive control performance of creative individuals in different fields. We assumed that individuals creative in science vs. art should exhibit better cognitive inhibition and response inhibition, but scientifically and artistically creative individuals should both exhibit cognitive flexibility in terms of the ability to switch tasks and cognitive functions.

2. Method

2.1. Design and procedure

Based on a large sample size, we identified four groups according to participants’ performance on scientific and artistic creativity, so as to observe differences in cognitive functions between and among the different groups. The four groups were: a) the group with high scientific creativity and high artistic creativity (“hS-hA” in short), b) the group with high scientific creativity and low artistic creativity (“hS-lA”), c) the group with low scientific creativity and high artistic creativity (“lS-hA”), and d) the group with low scientific creativity and low artistic creativity (“lS-lA”). Such a one-factor experimental design allows us to test the three hypotheses in a larger context.

The experimental process consists of two sessions. In the first session, we invited a large number of junior high school students to participate in the scientific and artistic creativity tests, from which we planned to select the appropriate experimental participants. The scientific and artistic creativity tests were conducted separately, with the former taking about 40 min and the latter about 15 min. Students chose their own free time to come to the test room and completed the test with other students. In the second session, students who met the criteria of the study (top or/and bottom 27 % on scientific and artistic creativity, respectively) were selected to participate in three cognitive control tasks. The three tasks were completed consecutively, with a 3 − 5-minute break in between. All students completed all the tasks in one class time (about 45 min). And the order of the three tasks was counterbalanced across participants.

2.2. Participants

A total of 279 seven-grade students from a junior high school in Xi'an first took a scientific and artistic creativity test. Participation of all students was voluntary and their informed consent was obtained before the test. And institutional approval by a local ethics board is not typically required for this kind of studies in China. According to students’ total scores on scientific creativity as well on artistic creativity, 110 students were selected and participated in this study.

Scientific creativity was measured by the Scientific Creativity Test for Secondary School Students (Lin, 2009). The test shows good internal consistency (Cronbach’s alpha = 0.80). It consists of five cognitive tasks, representing five dimensions of scientific creativity, including 1) creative problem-finding, 2) creative product design, 3) creative product improvement, 4) creative problem-solving and 5) creative imagination. For example, the creative product design task asks the participant to draw an apple-picking machine and explain the function of each part. Subjects will be given several pieces of paper on which to write down the answers to each question, or to draw the answers as required. Performance on the second and fourth questions was calculated by the number of functions of the product designed by the participants, or the total number of effective answers they came up with. The scores for the first, third, and fifth questions were the sums of scores on fluency, originality, and flexibility, respectively. *Fluency* was scored as the number of ideas generated; *originality* and *flexibility* were rated by three trained raters according to the test manual. Specifically, according to the list of common answers given in the manual and the classification criteria of the answers, the raters scored the originality of each answer, and calculated how many categories the subjects' answers involve (namely, the flexibility score). The three raters showed high inner-rater agreement on both dimensions ($\alpha = 0.87$ and 0.89, respectively). The total score of the five questions was used as a measure of scientific creativity.

Artistic creativity in the present study was measured by a collage task and an “alien” task; both are open-ended creative tasks and do not rely on specialized artistic skills (Niu & Sternberg, 2001). The collage task was based on Amabile’s collage design task (Amabile, 1982) and was adapted by Niu (2007) to make it amenable to use in China. In this task, each student received a set of stickers with different sizes, colors, and shapes. The students were asked to use these stickers to create a collage around any of the four given topics (i.e. happiness, sadness, anger, and fear). The alien task also has been widely used (Galinsky, Magee, Gruenfeld, Whitson, & Liljenquist, 2008). According to the procedure proposed by Ward (1994), participants were firstly instructed to imagine that they were in another planet that is very different from Earth, and encountered an alien creature there. Participants were then asked to draw this alien on a piece of paper. Performance on the two tasks was assessed by the Consensual Assessment Technique (Amabile, 1982). Seven graduate students in psychology who were familiar with the field of creativity research and had previously scored on the test participated in the evaluation. Each rater looks through all the works before the rating session and was asked to evaluate how creative a product is compared with those produced by the others, rather than to external objective criteria. The scoring criteria are based on the work of Niu and Sternberg (2001) and Yi et al. (2011), and have been used in a previous study (Cheng et al., 2015). Raters were asked to use a seven-point Likert scale to rate each work on six dimensions: creativity, likeability, imagination, art, elaboration, and impression. The combined score of the two tasks was used as a measure of artistic creativity.

The top 27 % and bottom 27 % performers on scientific creativity and artistic creativity were selected for comparison purposes. The procedure reduced the initial sample of 279 to the final sample of 110. This classification method was used because research by Kelley (1939) have shown that the 27 % cutoff could strike a balance between two objectives: to retain as many cases in each group as possible, and to find as large a difference between the two groups as possible. Therefore, there were four groups of students. The first group, the "hS-hA" group (n = 31; 14 boys, 17 girls), consisted of those who rank in the top 27 % on both scientific creativity and artistic creativity subtests. The second group was the "hS-lA" group (n = 21; 12 boys, 9 girls) in which all the students rank in the top 27 % on scientific creativity and at the bottom 27 % on artistic creativity. The rest two groups were determined in the same way; namely the "lS-hA" group (n = 23; 10 boys, 13 girls) and the "lS-lA" group (n = 35; 23 boys, 12 girls). The average age of the 110 participants was 12.75 (*SD* = .53). No participant had prior knowledge of the tasks involved in this study.

2.3. Cognitive inhibition test

The classic Stroop task (MacLeod, 1991) was used to measure cognitive inhibition in terms of executive inhibition of dominant process. The task was presented on a computer screen with a black background. Successive words ("red'' and "green'') were presented in either red or green. Participants' task was to recognize the font color and to ignore the meaning of the words. Their answers were fed back on the keyboard with the "F" or "J" key for a red word or a green word respectively. There are two experimental conditions in the Stroop task, namely the consistent condition (i.e., the color and meaning of words are "red") and the inconsistent condition (i.e., the "green" word in red color). The subjects typically have longer reaction time and a higher error rate under the inconsistent condition than in the consistent condition, which was called the Stroop interference effect (MacLeod, 1991). The cognitive inhibition performance of the subjects was reflected by Interference Loss, which was obtained by subtracting the error rate of the consistent condition from that of the inconsistent condition. And considering the participants reached a minimum of 75 % accuracy in the task, difference on reaction time between the two conditions was used as a measurement of Interference Loss.

The task included 96 consecutive test trials. Every word was presented for 1250 ms in the center of the screen, preceded by a fixation mark for 250 ms, and followed by a 2000 ms blank before the next word was shown. Participants were asked to answer as quickly as possible while maintaining high accuracy. No accuracy feedback was given.

2.4. Response inhibition test

Response inhibition was measured by the Stop-signal task designed by Logan and his collaborators (Logan & Cowan, 1984; Verbruggen & Logan, 2008). The task is seen as a good measure of response inhibition function because it does not involve selective attention to the experimental materials (Dillon & Pizzagalli, 2007). This task requires the subject to complete two types of tasks quickly and accurately, namely Go task and Stop task. In the Go task, participants were asked to determine the shape of the figure in the center of the screen. If the figure is round, they should press "F" with the index finger of the left hand; if it is square, they should press "J" with the right index finger. In the Stop task, after the graphic stimulus was presented, the subject was presented with a sound stimulus (" drip "), which means that the subjects should suppress the key response to the shape of the figure. The interval between the graphic signal and the sound signal is called SSD (i.e., stop-signal delay). The longer the SSD, the more difficult it was to suppress the button response. Considering individual difference in response inhibition, SSD in this study was changing according to a particular rule called the Tracking Algorithm (Band et al., 2003; Williams, Ponesse, Schachar, Logan, & Tannock, 1999). Specifically, at the beginning, SSD was set at 250 ms. If the subject could successfully suppress the reaction in the Stop task, the next SSD would be extended by 50 ms, thus increasing the difficulty of successful inhibition. If the inhibition is not successful, the next SSD would be reduced by 50 ms, thus increasing the probability of successful inhibition. According to the Tracking Algorithm, the successful inhibition rate of the subjects will be maintained at about 50 % (Fang, Ye, Zhao, Zhang, & Wang, 2013). Indicator of the response inhibition ability in the Stop-signal task was called the stop signal reaction time (SSRT), which was equal to the average reaction time in all Go task trials (GoRT) minus average SSD in all Stop task trials.

The procedure consisted of an exercise block and two formal experimental blocks. The formal experiment consisted of 160 trials, each block had 80 trials, of which 60 are Go task (75 %) and 20 are Stop task (25 %). The trials in each block were arranged in pseudo-random order, with no more than two consecutive stops. There was a 10 s break after each block. At the beginning of both the Go task and the Stop task trials, a 250 ms fixation point was displayed in the center of the screen, followed by graphic stimulus. The rendering time of the graphic stimulus is no more than 1250 ms. In the stop tasks, the rendering time of the sound stimulus was 75 ms.

2.5. Switching test

The switching ability was measured by the task cueing paradigm in which task sequences are unpredictable, with clues to the type of task to be performed before or at the same time as each target. Two different types of numeric categorization tasks were used in this study, namely, magnitude task and parity task (Philipp, Jolicoeur, Falkenstein, & Koch, 2007). Stimuli consisted of the digits 1–9, excluding 5, and were presented one at a time, in black. Participants were asked to decide whether a digit was greater or less than 5 (magnitude task) or whether it was odd or even (parity task). Stimuli were surrounded by a gray frame in the center of the screen. The frame, which served as the task cue, was either in square shape (4.8 cm × 4.8 cm), indicating the magnitude task, or in diamond shape (4.8 cm × 4.8 cm), indicating the parity task. The participants were asked to press the "F" key with left index finger if the number is less than 5 or even, and to press the "J" key with right index finger if the number is greater than 5 or the number is odd. Every trial can be categorized as either repetitive trial or switch trial according to whether it is same as the preceding trial. Switching trials generally require a longer response time and have a higher error rate than repetitive trials. As both speed and accuracy were emphasized in the task instruction, we used both reaction time data and error rate data in our results. The key index of switching ability was switch cost, which was computed by subtracting average reaction time (or average error data) of the repetitive condition from that of the switch condition.

The procedure consists of an exercise block and two formal experimental blocks. The practice block contains 28 trials, and each formal experimental block has 80 trials. In each block half of the trials are repetitive and the others are switch. The same task occurs no more than three times in a row, and two adjacent trials have different digital stimuli. After each block, there is a 10 s rest time. In each trial, a 500 ms fixation point was presented in the center of the screen, and then task stimuli (task clues and target stimuli) were presented in the center of the screen. The task stimuli disappeared after the subjects responded. If the subject did not respond within 2000 ms, the task stimulus disappeared automatically. The next trial starts after a 2000 ms empty screen.

3. Results

Given the research questions and hypotheses, comparison is made among four groups with a focus on hS-lA vs. lS-hA.

3.1. Grouping validity check

One-way analysis of variance (ANOVA) was used to test whether there were significant differences in the scores of scientific creativity and artistic creativity among the four groups. Descriptive statistics are shown in Table 1.

Results of scientific creativity showed that significant differences existed among the four groups, $F(3, 106) = 257.66$, $p < .001$, Partial $\eta^2 = .88$. The results of post-hoc test (Scheffe) showed that the scientific creativity of hS-hA group and hS-lA group was significantly higher than that of the group with lS-hA ($p < .001$) and lS-lA ($p < .001$). Besides, there were neither significant difference between hS-hA group and hS-lA group ($p = .66$), and nor between lS-hA group and lS-lA group ($p = .97$).

Results of artistic creativity also showed significant differences among the four groups, $F(3, 106) = 119.42$, $p < .001$, Partial $\eta^2 = .77$. The results of post-hoc test (Scheffe) showed that the scientific creativity of hS-hA group and lS-hA group was significantly higher than that of the group with hS-lA ($p < .001$) and lS-lA ($p < .001$). Besides, there were no significant difference in artistic creativity between hS-hA group and lS-hA group ($p = .96$), or between hS-lA group and lS-lA group ($p = .61$).

Table 1
Descriptive statistics of scientific creativity and artistic creativity scores (M (SD)) for the hS-hA sample,the hS-lA sample, the lS-hA sample, and the lS-lA sample.

Assessment		hS-hA	hS-lA	lS-hA	lS-lA
Scientific Creativity Test for Secondary School Students	Creative problem-finding	11.82 (1.96)	10.56 (1.37)	1.75 (0.96)	2.14 (1.75)
	Creative product design	3.77 (1.15)	4.57 (0.81)	2.57 (1.27)	2.54 (1.52)
	Creative product improvement	9.85 (1.95)	8.52 (1.40)	3.43 (1.44)	3.80 (1.79)
	Creative problem-solving	2.90 (1.56)	2.71 (1.71)	0.78 (1.09)	0.29 (1.45)
	Creative imagination	8.83 (2.01)	7.57 (1.39)	2.56 (1.46)	2.87 (1.72)
	Total scientific creativity	42.3 (4.91)	38.38 (2.95)	15.82 (4.90)	15.55 (5.21)
Collage task	Creativity	5.13 (0.49)	4.44 (0.45)	4.73 (0.40)	3.91 (0.53)
	Likeability	4.90 (0.49)	3.90 (0.67)	4.70 (0.43)	3.77 (0.34)
	Imagination	4.67 (0.68)	4.29 (0.48)	4.25 (0.46)	3.47 (0.66)
	Art	4.59 (0.55)	3.72 (0.48)	4.36 (0.48)	3.49 (0.48)
	Elaboration	4.58 (0.60)	3.80 (0.89)	4.59 (0.58)	3.42 (0.53)
	Impression	5.32 (0.41)	4.36 (0.58)	4.97 (0.44)	3.80 (0.55)
Alien task	Creativity	4.68 (0.61)	3.09 (0.52)	4.77 (0.77)	3.11 (0.83)
	Likeability	4.39 (0.63)	2.75 (0.63)	4.63 (0.86)	3.10 (0.78)
	Imagination	4.41 (0.69)	2.85 (0.61)	4.57 (0.65)	2.99 (0.93)
	Art	4.17 (0.82)	2.62 (0.67)	4.96 (1.04)	2.75 (0.71)
	Elaboration	4.25 (0.97)	2.50 (0.57)	4.83 (1.05)	2.62 (0.74)
	Impression	4.64 (0.69)	3.09 (0.75)	5.03 (0.95)	3.14 (0.76)
	Total artistic creativity	55.74 (2.76)	41.43 (5.10)	56.39 (4.86)	39.57 (4.74)

Table 2
Reaction time (ms) and error rate (%) in the classic Stroop task (M (SD)).

	Eeaction time (ms)			Error rate (%)		
	Consistent condition	Inconsistent condition	Interference loss	Consistent condition	Inconsistent condition	Interference loss
hS-hA	678.94 (94.66)	811.26 (109.52)	132.32 (59.60)	4.43 (4.95)	7.22 (6.02)	2.79 (2.50)
hS-lA	697.24 (116.19)	815.57 (127.17)	118.33 (49.98)	4.16 (4.38)	6.99 (5.35)	2.83 (1.64)
lS-hA	670.13 (107.62)	856.13 (120.46)	186.00 (71.68)	5.21 (6.11)	12.41 (6.36)	7.20 (4.58)
lS-lA	692.31 (113.99)	867.43 (94.18)	175.11 (45.42)	4.99 (4.52)	10.28 (5.21)	5.29 (2.92)

3.2. Cognitive inhibition

Descriptive statistics of student's reaction time and error rate in the classic Stroop task are shown in Table 2. One-way ANOVA was carried out for reaction time interference loss at first. The results showed that the group effect was significant, F (3, 106) = 8.36, $p < .001$, Partial $\eta^2 = .19$. Consistent with Hypothesis 1, results from post-test showed interference loss of scientifically creative individuals (the hS-lA group) was significantly lower than that of artistically creative individuals (the lS-hA group), $p < .001$. Interference loss of the hS-hA group was significantly lower than that of the lS-hA group ($p < .01$), which also supports hypothesis 1. Besides, significant differences also existed between the hS-hA group and the lS-lA group ($p < .01$), and between the hS-lA group and the lS-lA group ($p < .001$).

Then, one-way variance analysis of error rate interference loss was conducted and the results were consistent with that of reaction time. Specifically, main effect of the test group was significant, F (3, 106) = 12.05, $p < .001$, Partial $\eta^2 = .25$. Results of post-test showed that the interference loss of error rate in the hS-hA group and the hS-lA groups was significantly lower than that in the lS-hA group ($p < .001$) and the lS-lA groups ($p < .01$). Therefore, Hypothesis 1 is supported by both the reaction time interference loss and error rate interference loss.

3.3. Response inhibition

Descriptive statistics of student's performance in the Stop-signal task are shown in Table 3. In the Stop task, the Inhibition failure rate of the four groups was nearly 50 %. The results of one-way ANOVA showed that there was no significant difference between the four groups of subjects, F (3, 106) = .51, $p = .67$, Partial $\eta^2 = .01$, which indicated that the tracking algorithm in this experiment was effective.

One-way ANOVA of SSRT showed significant main effect of groups, F (3, 106) = 6.37, $p < .01$, Partial $\eta^2 = .15$. As Hypothesis 2 expected, results of post-test showed that the SSTR of the hS-hA group was significantly faster than that of the lS-hA group ($p < .05$) and the lS-lA group ($p < .01$), and the SSRT of the hS-lA group was also significantly faster than that of the lS-hA group ($p < .01$) and the lS-lA group ($p < .001$). No other effect was significant. Therefore, the advantage of highly creative people in response inhibition is only proved in scientific domain, but not in artistic domain. Hypothesis 2 is supported.

3.4. Switching

Descriptive statistics of student's performance in the switching task are shown in Table 4. Firstly, one-way ANOVA was used to analyze the switch cost in reaction time. As expected in Hypothesis 3, individuals with low scientific and artistic creativity have lower switching performance than others, and there was no difference between people with high scientific creativity and people with high artistic creativity. Specifically, main effect of the group was significant, F (3, 106) = 6.44, $p < 0.001$, Partial $\eta^2 = .15$. The post-test results showed that the switch cost of the lS-lA group was significantly higher than that of the hS-hA group ($p < .001$), hS-lA ($p < .01$), and the lS-hA ($p < .05$). There was no significant difference between these three groups.

Then, results of error rate switch cost were analyzed and the findings are consistent with those from reaction time. Specifically, main effect of the test group was significant, F (3, 106) = 3.62, $p < .05$, Partial $\eta^2 = .09$. The results of post-test showed that switch cost of the lS-lA group was significantly higher than that of the hS-hA group ($p < .001$), hS-lA ($p < .01$), and the lS-hA ($p < .05$). Therefore, Hypothesis 3 is supported by both reaction time and error rate.

Table 3
Descriptive statistics of students' performance in the Stop-signal task (M (SD)).

	Go task		Stop task	
	GoRT (ms)	Go error rate (%)	SSRT (ms)	Inhibition failure rate (%)
hS-hA	569.23 (94.23)	4.61 (2.83)	200.77 (28.96)	49.74 (4.43)
hS-lA	591.33 (101.84)	3.88 (3.35)	192.86 (33.07)	49.52 (5.08)
lS-hA	497.48 (103.36)	6.86 (3.14)	218.17 (34.59)	51.17 (5.58)
lS-lA	555.46 (126.68)	6.36 (5.94)	224.46 (26.83)	50.17 (4.80)

Table 4
Descriptive statistics of student's performance in the switching task (M (SD)).

	Reaction time (ms)			Error rate (%)		
	Repetitive trial	Switch trial	Switch cost	Repetitive trial	Switch trial	Switch cost
hS-hA	969.12 (94.86)	1117.8 (95.60)	148.65 (63.44)	6.99 (7.16)	10.49 (8.79)	3.50 (4.37)
hS-lA	972.29 (115.62)	1129.9 (128.77)	157.33 (73.95)	7.29 (7.69)	10.19 (8.98)	2.90 (4.39)
lS-hA	971.09 (110.54)	1135.5 (118.63)	165.87 (70.51)	7.95 (7.88)	13.15 (9.78)	5.29 (5.89)
lS-lA	989.49 (110.22)	1201.5 (140.29)	229.86 (85.83)	7.57 (8.38)	15.41 (8.38)	7.85 (7.17)

4. Discussion

The main aim of the present study was to explore whether cognitive control functions are differentially associated with adolescents with high scientific creativity as compared those with high artistic creativity. Results on cognitive inhibition and response inhibition were consistent: in the cognitive inhibition task, interference loss of hS-lA group was significantly lower than that of the lS-hA group; in the response inhibition task, the stop-signal reaction time of the hS-lA group was also significantly faster than that of the lS-hA group. These results suggest that adolescents with high scientific creativity have higher cognitive and response inhibition abilities than adolescents with high artistic creativity, which is consistent with Hypotheses 1 and 2. However, the results of the switching showed the same trend between the two groups: switch cost of the lS-lA group was significantly higher than that of the other three groups, but there was no difference between the hS-lA and lS-hA groups. The results on switching support Hypothesis 3, which predicts that individuals with high creativity, regardless of domains, will do better on switching.

Taken together, the results of this study indicate that the relationship between cognitive inhibition and creativity depends on specific domains of creativity. The phenomenon that the individuals with high creativity show better cognitive inhibition than those with low creativity is confined to the domain of science; there is no difference in the cognitive inhibition between the individuals with different levels of artistic creativity. This suggests that inconsistent results of previous studies are possibly due to the domain-specificity of creativity. Theories of creativity tend to emphasize different components such as creative potential, creative behavior, creative personality, creative achievement, and so on (Amabile, 1983; Nijstad, De Dreu, Rietzschel, & Baas, 2010). However, future research should pay more attention to domain-specificity of creative talent, especially with respect to the way in which cognitive control may be differentially involved, as suggested by the present study.

Previous studies in the field of creativity have paid little attention to response inhibition. This study found that response inhibition is a unique cognitive ability possessed by individuals with high scientific creativity. Students who were more creative in science had significantly higher reactivity inhibition than those who were more creative in the arts. These research findings have unique implications for the cultivation of creativity in that low cognition inhibition may work just fine for students with high artistic creativity. As a caveat, the results of this study must be interpreted with caution. Our study only showed that scientific creativity is more closely related to response inhibition than artistic creativity, but it does not necessarily mean that the process of artistic creativity does not need the support of response inhibition. Considering that previous studies have found a positive relationship between divergent thinking and artistic creativity, further studies are necessary to refine prediction regarding the relationship between artistic creativity and response inhibition.

As for the switching function, the results of this study support that high switching ability is one of the cognitive characteristics of highly creative individuals, both in science and art. This finding is consistent with most existing studies, including those on creative achievement (Zabelina & Robinson, 2010; Zabelina et al., 2019) and multi-tasking (Lu et al., 2017). After all, in science as well as art, creators need to continuously perform multiple cognitive tasks of different kinds or accomplish multiple sub-goals of different nature. For example, scientists need to envision new possibilities while thinking critically about existing knowledge or approaches; and artists need to evaluate the aesthetic value of generated ideas while coming up with new ones. But what we still can't explain is why studies using divergent thinking tasks come to different conclusions. For example, Benedek et al. (2014) and Pan and Yu (2018) both used Alternate Uses Tasks but yielded different results. More empirical research may be needed on the relationship between switching and creativity especially in general domain.

Overall, the findings of the present study indicate that adolescents with profiles of either high scientific or high artistic creativity share a good switching function, whereas those who are good at scientific creativity seem superior to those with high artistic creativity with respect to cognitive inhibition and response inhibition. The study expands our knowledge of cognitive characteristics of creative adolescents in different domains with following practical implications: high cognitive and response inhibition may be a desirable characteristic for identifying and developing scientific talent but it may be less central for identifying and developing artistic talent. In contrast, cognitive flexibility (the ability to switch cognitive functions) is a desirable for both domains of creativity. A major limitation is that the present study is correlational in nature, and the nature of the relationship between cognitive control and creativity (e.g., the direction of causality, or whether cognitive control is just a component of the more complex operation) in the two domains remains to be further understood. Future research is warranted to clarify the relationship.

CRediT authorship contribution statement

Xinru Zhang: Writing - original draft, Writing - review & editing. **Lifang Cheng:** Conceptualization, Methodology, Writing -

original draft. **David Y. Dai:** Writing - review & editing. **Weishan Tong:** Investigation. **Weiping Hu:** Conceptualization, Methodology.

Acknowledgements

This research was financially supported by the National Natural Science Foundation of China (31871118); the Research Program Funds of the Collaborative Innovation Center of Assessment toward Basic Education Quality at Beijing Normal University (2019-05-002 BZPK01); the Major Project of the National Social Science Foundation of China (14ZDB160); and the Fundamental Research Funds For the Central Universities (2019TS130).

References

Amabile, T. M. (1982). Social psychology of creativity: A consensual assessment technique. *Journal of Personality and Social Psychology, 43*(5), 997–1013.
Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology, 45*(2), 357–376.
Arbuthnott (2008). Asymmetric switch cost and backward inhibition: Carryover activation and inhibition in switching between tasks of unequal difficulty. *Canadian Journal of Experimental Psychology, 62*(2), 91–100.
Baer, J. (2015). The importance of domain-specific expertise in creativity. *Roeper Review, 37*(3), 165–178.
Bai, X. J., & Yao, H. J. (2018). Differences in cognitive inhibition between persons with high and low creativity: Evidences from behavioral and physiological studies. *Acta Psychologica Sinica, 50*(11), 1197–1211.
Bai, X. J., Gong, Y. B., Hu, W. P., Han, Q., & Yao, H. (2014). The inhibitory mechanism of individuals with different scientific creativity. *Studies of Psychology and Behavior, 12*(2), 151–155.
Band, G. P. H., van der Molen, M. W., & Logan, G. D. (2003). Horse-race model simulations of the stop-signal procedure. *Acta Psychologica, 112*(2), 105–142.
Beaty, R. E., & Silvia, P. J. (2012). Why do ideas get more creative across time? An executive interpretation of the serial order effect in divergent thinking tasks. *Psychology of Aesthetics, Creativity, and the Arts, 6*(4), 309–319.
Beaty, R. E., Benedek, M., Wilkins, R. W., Jauk, E., Fink, A., Silvia, P. J., & Neubauer, A. C. (2014). Creativity and the default network: A functional connectivity analysis of the creative brain at rest. *Neuropsychologia, 64*, 92–98.
Benedek, M., Jauk, E., Sommer, M., Arendasy, M., & Neubauer, A. C. (2014). Intelligence, creativity, and cognitive control: The common and differential involvement of executive functions in intelligence and creativity. *Intelligence, 46*(2014), 73–83.
Camarda, A., Borst, G., Agogué, M., Habib, M., Weil, B., Houdé, O., et al. (2018). Do we need inhibitory control to be creative? Evidence from a dual-task paradigm. *Psychology of Aesthetics, Creativity, and the Arts, 12*(3), 351–358.
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*(3), 499–506.
Chambers, C. D., Garavan, H., & Bellgrove, M. A. (2009). Insights into the neural basis of response inhibition from cognitive and clinical neuroscience. *Neuroscience and Biobehavioral Reviews, 33*(5), 631–646.
Charyton, C., & Snelbecker, G. E. (2007). General, artistic and scientific creativity attributes of engineering and music students. *Creativity Research Journal, 19*(2-3), 213–225.
Cheng, L. F., Hu, W. P., & Jia, X. J. (2015). Cognitive inhibition and artistic creativity: The moderating effect of cognitive style. *Psychological Development and Education, 31*(3), 287–295.
Chrysikou, E. G., Hamilton, R. H., Coslett, H. B., Datta, A., Bikson, M., & Thompson-Schill, S. L. (2013). Noninvasive transcranial direct current stimulation over the left prefrontal cortex facilitates cognitive flexibility in tool use. *Cognitive Neuroscience, 4*(2), 81–89.
Dillon, D., & Pizzagalli, D. (2007). Inhibition of action, thought, and emotion: A selective neurobiological review. *Applied and Preventive Psychology, 12*(3), 99–114.
Dodds, C. M., Morein-Zamir, S., & Robbins, T. W. (2010). Dissociating inhibition, attention, and response control in the frontoparietal network using functional magnetic resonance imaging. *Cerebral Cortex, 21*(5), 1155–1165.
Eysenck, H. J. (1993). Creativity and personality: Suggestion for a theory. *Psychological Inquiry, 4*(3), 147–178.
Fang, J., Ye, W., Zhao, W., Zhang, B., & Wang, X. (2013). Review of the stop signal task and response inhibition models. *Chinese Journal of Clinical Psychology, 21*(5), 743–746.
Feist, G. J. (1998). A meta-analysis of personality in scientific and artistic creativity. *Personality and Social Psychology Review, 2*(4), 290–309.
Forthmann, B., Jendryczko, D., Scharfen, J., Kleinkorres, R., Benedek, M., & Holling, H. (2019). Creative ideation, broad retrieval ability, and processing speed: A confirmatory study of nested cognitive abilities. *Intelligence, 75*, 59–72.
Funahashi, S. (2001). Neuronal mechanisms of executive control by the prefrontal cortex. *Neuroscience Research, 39*(2), 147–165.
Furnham, A., & Crump, J. (2013). The sensitive, imaginative, articulate art student and conservative, cool, numerate science student: Individual differences in art and science students. *Learning and Individual Differences, 25*(2013), 150–155.
Furnham, A., Batey, M., Booth, T. W., Patel, V., & Lozinskaya, D. (2011). Individual difference predictors of creativity in Art and Science students. *Thinking Skills and Creativity, 6*(2), 114–121.
Galinsky, A. D., Magee, J. C., Gruenfeld, D. H., Whitson, J., & Liljenquist, K. A. (2008). Social power reduces the strength of the situation: Implications for creativity, conformity, and dissonance. *Journal of Personality and Social Psychology, 95*(6), 1450–1466.
Groborz, M., & Necka, E. (2003). Creativity and cognitive control: Explorations of generation and evaluation skills. *Creativity Research Journal, 15*(2-3), 183–197.
He, W. J., & Wong, W. C. (2015). Creativity slump and school transition stress: A sequential study from the perspective of the cognitive-relational theory of stress. *Learning and Individual Differences, 43*(2015), 185–190.
Hu, W. P., Wu, B. J., Jia, X. J., Yi, X. F., Duan, C. Y., Meyer, W., et al. (2013). Increasing students' scientific creativity: The "Learn to think" intervention program. *The Journal of Creative Behavior, 47*(1), 3–21.
Huang, P. S., Peng, S. L., Chen, H. C., Tseng, L. C., & Hsu, L. C. (2017). The relative influences of domain knowledge and domain-general divergent thinking on scientific creativity and mathematical creativity. *Thinking Skills and Creativity, 25*(2017), 1–9.
Hur, Y. M., Jeong, H. U., & Piffer, D. (2014). Shared genetic and environmental influences on self-reported creative achievement in art and science. *Personality and Individual Differences, 68*(2014), 18–22.
Kaufman, S. B., Quilty, L. C., Grazioplene, R. G., Hirsh, J. B., Gray, J. R., Peterson, J. B., et al. (2016). Openness to experience and intellect differentially predict creative achievement in the arts and sciences. *Journal of Personality, 84*(2), 248–258.
Kelley, T. L. (1939). The selection of upper and lower groups for the validation of test items. *Journal of Educational Psychology, 30*(1), 17–24.
Kipper, D. A., Green, D. J., & Prorak, A. (2010). The relationship among spontaneity, impulsivity, and creativity. *Journal of Creativity in Mental Health, 5*(1), 39–53.
Li, H., Gao, S., & Wang, N. G. (2004). A review on research methods of executive function. *Advances in Psychological Science, 12*(5), 693–705.
Lin, C. D. (2009). *Research on innovative talents and educational innovation.* Beijing: Economic sciences press.
Lin, W. L., Hsu, K. Y., Chen, H. C., & Wang, J. W. (2012). The relations of gender and personality traits on different creativities: A dual-process theory account. *Psychology of Aesthetics, Creativity, and the Arts, 6*(12), 112–123.
Liu, Z. K., Cheng, L., & Shi, J. N. (2007). A review of researches on creativity and attention. *Psychological Science, 30*(2), 387–390.
Logan, G. D., & Cowan, W. B. (1984). On the ability to inhibit thought and action: A theory of an act of control. *Psychological Review, 91*(3), 295–327.
Lu, J. G., Akinola, M., & Mason, M. F. (2017). "Switching on" creativity: Task switching can increase creativity by reducing cognitive fixation. *Organizational Behavior*

and Human Decision Processes, 139(2017), 63–75.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109*(2), 163–203.

Madjar, N., & Shalley, C. E. (2008). Multiple tasks' and multiple goals' effect on creativity: Forced incubation or just a distraction? *Journal of Management, 34*(4), 786–805.

Meichenbaum, D. (2017). *Teaching thinking: A cognitive behavioral perspective. In the evolution of cognitive behavior therapy.* Routledge.

Meltzer, L. (Ed.). (2018). *Executive function in education: From theory to practice.*. Guilford Publications.

Meneely, J., & Portillo, M. (2005). The adaptable mind in design: Relating personality, cognitive style, and creative performance. *Creativity Research Journal, 17*(2-3), 155–166.

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*(1), 49–100.

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences, 7*(3), 134–140.

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*(1), 34–77.

Niu, W. (2007). Individual and environmental influences on Chinese student creativity. *The Journal of Creative Behavior, 41*(3), 151–175.

Niu, W., & Sternberg, R. J. (2001). Cultural influences on artistic creativity and its evaluation. *International Journal of Psychology, 36*(4), 225–241.

Nusbaum, E. C., & Silvia, P. J. (2011). Are intelligence and creativity really so different? Fluid intelligence, executive processes, and strategy use in divergent thinking. *Intelligence, 39*(2011), 36–45.

Pan, X., & Yu, H. (2018). Different effects of cognitive shifting and intelligence on creativity. *The Journal of Creative Behavior, 52*(3), 212–225.

Peterson, J. B., Smith, K. W., & Carson, S. H. (2002). Openness and extraversion are associated with reduced latent inhibition: Replication and commentary. *Personality and Individual Differences, 33*(7), 1137–1147.

Philipp, A. M., Jolicoeur, P., Falkenstein, M., & Koch, I. (2007). Response selection and response execution in task switching: Evidence from a go-signal paradigm. *Journal of Experimental Psychology Learning, Memory, and Cognition, 33*(6), 1062–1075.

Preiss, D. D., Cosmelli, D., Grau, V., & Ortiz, D. (2016). Examining the influence of mind wandering and metacognition on creativity in university and vocational students. *Learning and Individual Differences, 51*(2016), 417–426.

Pringle, A., & Sowden, P. T. (2017). The Mode Shifting Index (MSI): A new measure of the creative thinking skill of shifting between associative and analytic thinking. *Thinking Skills and Creativity, 23*(2017), 17–28.

Radel, R., Davranche, K., Fournier, M., & Dietrich, A. (2015). The role of (dis) inhibition in creativity: Decreased inhibition improves idea generation. *Cognition, 134*(2015), 110–120.

Runco, M. A. (2008). Commentary: Divergent thinking is not synonymous with creativity. *Psychology of Aesthetics, Creativity, and the Arts, 2*(2), 93–96. https://doi.org/10.1037/1931-3896.2.2.93.

Shen, W. B., Liu, C., & Wang, Y. J. (2010). Neurophysiological basis of artistic creativity. *Advances in Psychological Science, 18*(10), 1520–1528.

Simonton, D. K. (2008). Creativity and genius. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.). *Handbook of personality: Theory and research.* New York: Guilford.

Sun, T. Y., Xiao, X., & Guo, C. Y. (2007). A review on switching process research. *Advances in Psychological Science, 15*(5), 761–767.

Vartanian, O., Martindale, C., & Matthews, J. (2009). Divergent thinking ability is related to faster relatedness judgments. *Psychology of Aesthetics, Creativity, and the Arts, 3*(2), 99–103.

Verbruggen, F., & Logan, G. D. (2008). Response inhibition in the stop-signal paradigm. *Trends in Cognitive Sciences, 12*(11), 418–424.

Wallach, M. A. (1970). Creativity. In P. Mussen (Ed.). *Carmichael's handbook of child psychology* (pp. 1211–1272). New York: Wiley.

Ward, T. B. (1994). Structured imagination: The role of category structure in exemplar generation. *Cognitive Psychology, 27*(1), 1–40.

Williams, B. R., Ponesse, J. S., Schachar, R. J., Logan, G. D., & Tannock, R. (1999). Development of inhibitory control across the life span. *Developmental Psychology, 35*(1), 205–213.

Yi, X. F., & Hu, W. P. (2013). Science creativity and art creativity: Priming effect and domain influences. *Advances in Psychological Science, 21*(1), 22–30.

Yi, X. F., Lin, C. D., Cai, S. S., Huang, S. L., Chen, G., Luo, L., et al. (2011). Studying abroad experience and artistic creativity. *Psychological Science, 34*(1), 190–195.

Zabelina, D. L., & Robinson, M. D. (2010). Creativity as flexible cognitive control. *Psychology of Aesthetics, Creativity, and the Arts, 4*(3), 136–143.

Zabelina, D. L., Friedman, N. P., & Andrews-Hanna, J. (2019). Unity and diversity of executive functions in creativity. *Consciousness and Cognition, 68*(2019), 47–56.

Zhao, X. M., & Chen, Y. H. (2006). The inhibitory research in the domain of cognitive development. *Advances in Psychological Science, 14*(2), 216–222.