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Creativity and the Stroop interference effect

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ABSTRACT

Creative potential has been variably associated with disinhibition and defocused attention, focused attention and effective cognitive control, or a flexible adaption of cognitive control. The present study examined the relationship between creativity and cognitive control in a sample of design students and a control group. Cognitive control was assessed by a modified Stroop color naming task, in which two color words and two font colors were used to generate congruent and incongruent conditions. Design students showed stronger cognitive control as indicated by the absence of a Stroop interference effect, and performed generally better (faster) on the Stroop task than students in the control group did. Moreover, correlational analyses revealed associations between stronger cognitive control and higher scores in originality, fluency and ideational behavior in psychometric creativity tasks. These results suggest that one cognitive feature of creative individuals is effective suppression of dominant but irrelevant response tendencies.

1. Introduction

The creative thinking process has been characterized on the one hand by automatic processes like defocused attention, disinhibition and looser associations (Carson, Peterson, & Higgins, 2003; Eysenck, 1995; Mednick, 1962), but on the other hand it seems to depend on more rigorously controlled processes like focused attention and effective inhibition. Specifically, creative potential in terms of divergent thinking ability was positively associated with cognitive control assessed by the Stroop task or the random motor generation task (Benedek, Franz, Heene, & Neubauer, 2012; Golden, 1975; Groborz & Nęcka, 2003; Zabelina, Robinson, Council, & Bresin, 2012). There is not only a variety of – sometimes contradictory – approaches and theories on creativity, but creativity seems to be an antagonism by itself, which is also reflected in the various attempts to define creativity. Sternberg and Lubart (1996) referred to creativity as "the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)" (p.677). According to this definition, creative individuals do not only have the ability to produce plenty of original ideas but are also able to evaluate which of these ideas are appropriate and which are not. As Groborz and Nęcka (2003) stated, "these two processes – generation of ideas and evaluation – seem to require intellectual operations that are contradictory in nature" (p.183). Based on this notion they assumed that the ability to balance these two processes may be a main aspect of creativity. That is, inhibition, focused attention and controlled processing as well as disinhibition, defocused attention and automatic processing may be relevant for producing creative ideas. Many authors agree with this assumption, although the terms used for the required processes may differ from author to author.

In emphasizing the role of attention in the creative process, Martindale (1999) supposed the balance between focused and defocused attention to be an important factor for creative thinking. According to that view, creative individuals should be more able to adjust their attentional focus depending on actual task demands. Defocused attention may be beneficial in earlier stages of the creative process, when the problem is ill-defined and ambiguous. At this stage, interfering and seemingly irrelevant information may provide relevant components of the solution. However, the broadened attention focus may slow down the processing of the task. Focused attention, by contrast, speeds up processing and may be advantageous in later phases of the creative process when the developed ideas are verified and evaluated (Dorfman, Martindale, Gassimova, & Vartanian, 2008; Martindale, 1999; Vartanian, Martindale, & Kwiatkowski, 2007). First empirical evidence for different focusing of attention was provided by studies showing that more creative individuals showed faster reaction times on simple tasks not involving interference, but slower reaction times on tasks requiring the inhibition of interfering information than less creative persons (Dorfman et al., 2008; Vartanian et al., 2007).

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Zabelina and Robinson (2010) proposed that creativity may not generally be related to poor inhibition of interfering information. Instead they assumed that creativity may be related to flexible modulation of cognitive control (cf. Vartanian, 2009). Processing may be most effective if cognitive control resources are only recruited in contexts in which automatically evoked associations are prone to error. Kerns et al. (2004) and Kerns (2006) examined the recruitment of cognitive control on tasks involving response conflict focusing on the neural mechanisms engaged in this process. They used two different tasks involving response conflict, namely the Stroop color-naming task and the Simon task and found that people adjust their performance on a trial-to-trial basis. For example, in the Stroop task the word *green* written in green ink would be a low conflict congruent trial, whereas the word *green* written in red ink would be a high conflict incongruent trial, because it simultaneously activates two different responses. It automatically evokes the reaction to read the word and declare it as *green*, but at the same time, the instruction requests responding to the ink color (i.e., red). Kerns et al. (2004) and Kerns (2006) showed that people are faster on incongruent trials when trials are preceded by incongruent trials (II) than when they are preceded by congruent trials (CI). Also, people are slower on congruent trials preceded by incongruent trials (IC) than on congruent trials preceded by congruent trials (CC). The authors interpret these findings in terms of the conflict-monitoring hypothesis, which "explains these behavioral adjustments as the result of high conflict on incongruent trials leading to the recruitment of greater cognitive control on the subsequent trial" (Kerns et al., 2004, p.1024). In the Stroop task the recruitment of cognitive control is required to inhibit the automatically evoked reading process, which is beneficial in high conflict trials. On the other hand, it would be disadvantageous to activate cognitive control when automatic processing is more effective, for instance, because it advances generative and associative thinking. That is, automatic processing may on the one hand enhance creativity, but may on the other hand increase susceptibility to interfering stimuli thereby worsening task performance. Controlled processing, by contrast, has the benefit that processing can be sustained in a goal-directed manner, with the drawback of lower access to remote ideas. Since both of these processes are relevant for the creative process, creative individuals may be able to rapidly switch between strong and loose cognitive control, depending on the demands of the present context.

Zabelina and Robinson (2010) used a color-word Stroop task in order to assess cognitive control and its flexibility. The words "red" and "green" were consecutively presented on a black screen and participants were asked to classify the color of these words as either red or green. Each trial served as both prime and target and was coded in such a way that it reflected congruency of the present and the preceding trial. The authors found that significant cognitive control flexibility was apparent at both low and high levels of creativity, but the results suggest that high creative individuals may display this effect to a higher extent as compared to low creative individuals. Further support for this assumption was obtained by their finding that originality and creative performance were significant positive predictors of cognitive control flexibility. Besides this finding, creativity was not related to a generally higher or lower Stroop performance in that study. Zabelina and Robinson thus lend support to the notion that higher levels of cognitive control flexibility, rather than cognitive control per se, account for greater creative originality.

In this study we employed a Stroop color naming task, similar to the one used by Zabelina and Robinson (2010), to investigate whether or to which extent the cognitive processes implicated in this task (particularly cognitive control) are related to creativity. We tested two groups of students that differed with respect to creativity-related demands in their field of study. One group included design students with high creativity-related demands in their field of study, and the control group was composed of a mixed group of students with putatively lower creativity-related demands. In order to assess creativity in a comprehensive way, we administered various psychometric creativity measures, including verbal and figural divergent thinking tests as well as two measures for the self-assessment of creative behavior. Individual differences in creativity (with respect to creativity groups and scores on the creativity measures) were then related to various performance measures derived from the Stroop task. On the basis of existing conflicting evidence in this field (e.g., Golden, 1975; Groborz and Nęcka, 2003; Vartanian et al., 2007; Zabelina & Robinson, 2010), no clear a priori hypotheses on the relationship of creativity and Stroop performance appear to be warranted.

2. Method

2.1. Participants

Participants were 61 university and college students in the age range between 18 and 42 years ($M = 23.54$; $SD = 3.8$) who were either undergraduates or graduated not more than two years ago. The sample included 30 students with high creative demands in their studies (information design, media and interaction design; 8 men, 22 women) and 31 students with putatively lower creative demands in their studies (mostly psychology, social science and educational science; 9 men, 22 women). All design students had to pass acceptance tests including creativity tasks in order to get admitted to the design study. The two groups did not differ in gender ratio, age, and general cognitive ability as assessed by the Wonderlic Personnel test (WPT; Wonderlic, 1999).

2.2. Psychometric tests

As a measure of figural creativity we used the subtest picture completion of the Torrance Tests of Creative Thinking (TTCT; Torrance, 1996), in which ten incomplete abstract figures must be completed or extended as original as possible by drawing additional lines and elements. Verbal creativity was assessed by means of two self-constructed verbal idea generation tasks. In the first task – "*Why*" – two situations were presented in short sentences (e.g., "A light in the dark") and participants were required to write down possible explanations for the situations (e.g., "someone with a flashlight in a dark wood"). The second task was the "*Changes* task" in which two pictures of a certain object were presented side by side. The left one showed an initial state (e.g., a chair with four legs) and the right one showed an end status, where a detail has changed (e.g., the same chair with only three legs). This subtest included three different items – a chair, a book and a shoe. Again participants were instructed to produce as many and as original explanations for the denoted alteration as possible. Performance on these verbal tasks was quantified by means of fluency (i.e., number of ideas) and originality (i.e., statistical infrequency). The same applied to the TTCT measure, which additionally provided information about participants' flexibility (i.e., number of different categories used in the generated responses).

In addition, we administered two tests requiring self-assessment of creativity, namely self-reported ideational behavior as measured by means of a German version of Runco's Ideational Behavior Scale (RIBS; Runco, Plucker & Lim, 2000) and a German version of the Creative Personality Scale (CPS; Gough, 1979). The RIBS includes 17 positive coded statements describing actual overt behavior that reflects an individual's skill related to ideational behavior, like "I come up with an idea or solution other people