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Differential effects of cognitive inhibition and intelligence on creativity

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ABSTRACT

There are different conceptions about how cognitive inhibition is related to creativity. Creativity has either been associated with effective inhibition, or with disinhibition, or with an adaptive engagement of inhibition. In this study, we examined the relationship of cognitive inhibition, assessed by means of the random motor generation task, with different measures of creativity. We also analyzed whether this relation is mediated by intelligence. We generally found a positive correlation of inhibition and creativity measures. Moreover, latent variable analyses indicate that inhibition may primarily promote the fluency of ideas, whereas intelligence specifically promotes the originality of ideas. These findings support the notion that creative thought involves executive processes and may help to better understand the differential role of inhibition and intelligence in creativity.

1. Introduction

At the heart of every conception of creativity stands the creation of new ideas. Research, therefore, targets at a better understanding of the cognitive processes involved in creative ideation. Gilhooly, Fioratou, Anthony, and Wynn (2007) performed a detailed analysis of the alternate uses task and found that the fluent production of new uses was predicted by the "executively loading task" letter fluency, while the production of familiar uses (i.e., retrieved from long-term memory rather than created during the task) was not. They assumed that people with higher executive capacity may find it easier to inhibit dominant responses and switch strategies or categories. In a similar vein, Nusbaum and Silvia (2011) showed that fluid intelligence predicts higher switching of categories during an idea generation task, which corresponds to high divergent thinking performance. A study by Benedek, Könen, and Neubauer (in press) showed that creativity is substantially predicted by the abilities of dissociation and associative combination. This suggests that the generation of creative ideas requires fluent generation and combination of mutually remote associative elements (Mednick, 1962). At this, it was hypothesized that dissociation ability may reflect an indicator of semantic inhibition facilitating the fluent access to new and remote concepts.

These findings suggest that creative ability is related to executive functioning. Some other studies have addressed this issue by using explicit tests of executive function and specifically with tests of cognitive inhibition. Golden (1975) reports that, in a study involving high school students, high performance in the color-word Stroop task (i.e., a classic measure of cognitive inhibition which requires to name the font color of words which can be incongruent to the word meaning) was positively related to divergent thinking performance and to teacher ratings of students' creativity. Similar evidence was obtained by Groborz and Nęcka (2003), who showed that creativity assessed by divergent figural production was related to higher cognitive control as indexed by the Stroop and the Navon task (i.e., a task which requires to focus either on local or global features of a stimulus and to inhibit incongruent features).

However, not all studies find support for a positive relation of creativity and cognitive inhibition. Some studies report no correlation of creativity and cognitive inhibition (Burch, Hemsley, Pavelis, & Corr, 2006; Green & Williams, 1999; Stavridou & Furnham, 1996). And more interestingly, there also exists the opposite view that "creative people are characterized by a lack of both cognitive and behavioral inhibition" (Martindale, 1999, p. 143; see also, Eysenck, 1995). This notion may stem from the general observation that creative people are usually characterized by high ideational fluency, high associative fluency (Benedek et al., in press; Mednick, Mednick, & Jung, 1964), and are associated with increased impulsivity (Burch et al., 2006; Schuldenberg, 2000). Empirical evidence for this notion comes from a study showing that high creative achievers were found to show decreased latent inhibition as compared to low creative achievers (Carson, Peterson, & Higgins, 2003).

As a third perspective, creativity has been related to differential or flexible engagement of inhibition. It was shown that creative people show slower responses in tasks requiring inhibition of interfering information, but faster responses in tasks without interference (Dorfman, Martindale, Gassimova, & Vartanian,

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2008; Kwiatkowski, Vartanian, & Martindale, 1999; Vartanian, Martindale, & Kwiatkowski, 2007). These findings have been interpreted in terms of a differential focusing of attention; that is, creative people may be able to focus or defocus attention depending on task demands. In a similar vein, Zabelina and Robinson (2010) found that divergent thinking and creative achievement were not generally related to inhibition as measured by the common Stroop effect, but rather to a more flexible trial-to-trial modulation of cognitive control.

Hence, although there is increasing evidence that creativity is related to cognitive inhibition, this evidence appears to be conflicting, either associating creativity with high cognitive inhibition, with cognitive disinhibition, or an adaptive cognitive control. It should also be noted that most studies on creativity and inhibition so far have not considered the role of intelligence. Executive functions such as cognitive inhibition are commonly conceived to reflect essential cognitive processes underlying general intelligence (e.g., Arffa, 2007). Moreover, intelligence shows a moderate but consistent relationship with creativity (e.g., Kim, 2005), and there is an increasing understanding on how intelligence may facilitate creative thought (Nusbaum & Silvia, 2011; Silvia & Beaty, in press). Taken together, intelligence may qualify as a mediator of the inhibition-creativity relationship.

The first main aim of this study is to examine the correlation of cognitive inhibition and creativity and see whether it is consistent for different indicators of creativity. Since inhibition as defined above is related to cognitive flexibility and non-perseverative behavior, we hypothesize that there generally should be a positive correlation. The second main aim of this study is to examine whether the relation of creativity and inhibition is mediated by intelligence. Analyses shall be performed at latent level in order to estimate the correlations devoid of the influence of measurement error.

2. Methods

2.1. Participants

A total of 109 students enrolled in local universities participated in this study. Five people were excluded because of substantial missing data, resulting in a final sample of 104 (79 women, 25 men; mean age: 23.6 years, $SD = 4.0$). The sample had a wide range of majors with the most common being Psychology (53.8%). Participants received either a feedback on personality structure or course credits for participation.

2.2. Psychometric tests and questionnaires

2.2.1. Cognitive inhibition

Cognitive inhibition was measured by means of a random motor generation (RMG) test. We used an adapted computerized version of the Mittenecker Pointing Test (Mittenecker, 1958 Schulter, Mittenecker, & Papousek, 2010), which requires participants to generate random sequences of key responses at a specified response rate. There is substantial empirical evidence that RMG indicates the efficiency of inhibitory processes (cf., Schulter et al., 2010). Effective generation of random sequences requires the inhibition of the naturally occurring tendency to repeat previously selected sequences. Therefore, task performance is usually lower when the task is performed at higher pace or with a larger set of response alternatives (Brugger, 1997). Moreover, low RMG performance was consistently related to reduced executive functioning in neurological disorders such as schizophrenia (e.g., Morrens, Hulstijn, & Sabbe, 2006) and Parkinsons' disease (e.g., Stoffers, Berendse, Deijen, & Wolters, 2001). Finally, latent variable analyses of executive functions revealed that random sequence generation is solely related to inhibition, but not to shifting or updating (Miyake et al., 2000).

We realized four task conditions by varying the number of keys (4 vs. 9) and the response rate (2 Hz vs. 1 Hz). The response rate was guided by a regular acoustic beat presented via headphones. The performance in the RMG task was scored for context redundancy of sequence pairs (CR_1; for details, see 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). Since 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. The inhibition score showed good internal consistency (Cronbach's $\alpha = .80$).

2.2.2. Creativity measures

In order to obtain a comprehensive measure of the multi-faceted construct of creativity, a set of different well-established tests and questionnaires was employed. We used five tests of divergent thinking from the Berlin-Intelligence-Structure test (BIS; Jäger, Süß, & Beauducel, 1997), including three verbal tests AM ("Anwendungs-Möglichkeiten"; find many alternative uses for a cushion), EF ("Eigenschaften-Fähigkeiten"; find characteristics that a good salesman should not have), IT ("Insight-Test"; find many explanations why many people think that person X is likeable), and two figural tests OJ ("Objekt-Gestaltung"; compose many objects out of given figural elements), ZF ("Zeichen-Fortsetzen"; draw many different objects by completing a figural element). These five tasks were selected because for them the test manual provides category lists allowing for the scoring of ideational flexibility. The working time per task ranged from 120 to 150 s resulting in a total working time of about 12 min. After completing all tasks, participants were instructed to select their three most creative ideas in each task by marking the responses with corresponding numbers ("1", "2", or "3"). All tasks were scored for the three most relevant indicators of divergent thinking ability (Runco, 2010) including ideational fluency (i.e., number of ideas), ideational flexibility (i.e., number of categorically different ideas), and ideational originality (i.e., originality and creativity of ideas). For the scoring of ideational originality, the selected three ideas per task were compiled to idea lists, and then rated for creativity/originality by five independent raters (inter-rater reliability ranging from ICC = .47 [AM task] to .84 [ZF task]). This method allows one to obtain a score of ideational originality that is not directly dependent on ideational fluency (Silvia et al., 2008). The originality scores of the five tasks showed only moderate internal consistency (Cronbach's $\alpha = .54$). We also tried alternative scorings using the two most creative ideas (cf., Silvia et al., 2008), or the single most creative idea, which, however, resulted in even lower reliabilities (Cronbach's $\alpha = .47$ or .30, respectively). Additionally, a compound score of divergent thinking was computed as the average of the three z-standardized measures of divergent thinking (i.e., ideational fluency, flexibility, and originality).

We measured self-reported ideational behavior by means of a German version of the Runco Ideational Behavior Scale (RIBS; Runco, Plucker, & Lim, 2000), and creative personality by means of a German version of the Creative Personality Scale (CPS; Gough, 1979). We also devised an inventory of creative accomplishments which lists 48 creative accomplishments (e.g., "I wrote a poem") from eight different domains (cf., Hocevar, 1979). Participants indicated how often they had done each activity within the last 10 years (never, 1–2 times, 3–5 times, 6–10 times, more than 10 times). We computed domain scores and the scale showed good internal consistency over domains (Cronbach's $\alpha = .81$). Finally, we administered two items of a dissociation task, which requires