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The be-creative effect in divergent thinking: The interplay of instruction and object frequency☆

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ABSTRACT

Associative thinking and executive functions are discussed as possible underlying cognitive processes in divergent thinking. In the current study, the impact of these processes was investigated in an Alternate Uses Task. Whereas lemma frequency (word stem frequency) was manipulated to draw conclusions on the influence of associations, the instructions (standard vs. creative) were designed to influence the involved executive functions. Ideas for eight alternate uses objects were generated by 249 participants. The interaction of lemma frequency and instruction provided the best prediction of fluency in an extended Rasch Poisson counts model. Increasing lemma frequencies led to increased fluency. Whereas the fluency with high-frequency objects was higher in the standard compared to the "be-creative" instruction condition, the fluency with low-frequency objects remained roughly equal in both instruction conditions. Moreover, we analyzed the same effects on creativity ratings of the idea sets in a linear response tree model. Here frequency had differential effects over the rating scale, whereas the expected be-creative effect on creativity was found. Interactive effects of frequency and instruction on creativity indicated higher response probabilities for low-frequency objects at the lowest scale point with a be-fluent instruction and at the two highest scale points with a be-creative instruction. Altogether, this study demonstrates a role of both, associative processes and executive control.

1. Introduction

Creative problem solving can be seen as interplay of divergent (ideation) and convergent (evaluative and integrative) modes of thought (Brophy, 1998; Lubart, Besançon, & Barbot, 2011). Based on this view, divergent thinking (DT) is regarded as a sub-process of creativity and is often recognized in the research on creativity (Lubart, 2001; Runco & Acar, 2012). DT tests require many different solutions to one existing problem (Guilford, 1968). The underlying cognitive processes such as general associative ability and executive functions have lately been studied extensively and authors suggest an interplay of both cognitive processes for DT (e.g. Beaty, Silvia, Nusbaum, Jauk, & Benedek, 2014). Predominantly, the relevant cognitive processes with respect to DT are analyzed in correlational studies by means of structural equation modeling (see for example Beaty et al., 2014; Silvia, Beaty & Nusbaum, 2013). However, the experimental evidence for the role of both processes is still sparse and, therefore, we argue for a change of perspective by assuming that the amount of associations a person can have and the involvement of specific executive functions while working on DT tasks can be influenced by manipulating task-characteristics. In this study we concentrated on the content of the *alternate uses task* (AUT; Wallach & Kogan, 1965), one of the most widely-used tests in DT research and combined a manipulation of a psycholinguistic variable, namely word frequency, with a traditional experimental manipulation of task-instructions from divergent-thinking research. Thus, we sought to determine the role of associations in DT for two different instructions and to examine instructional variations in DT for AUT objects that were either frequently used in language or less so. The task-characteristics, instruction and object frequency, were modeled as interacting task-covariates within an item-response theory (IRT) framework that extends the Rasch-Poisson counts model (Graßhoff, Holling, & Schwabe, 2013) and a linear response tree model (De Boeck & Partchev, 2012) in order to model divergent thinking fluency and creativity set ratings, respectively.

According to the controlled-attention theory of creativity, creative ideas happen as a result of executive control over attention in a top-down process (Beaty et al., 2014; Silvia, 2015). Recent studies support the involvement of executive ability in DT. For example, the relationship to fluid intelligence was demonstrated several times (Benedek, Franz,

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Heene, & Neubauer, 2012; Lee & Therriault, 2013; Nusbaum & Silvia, 2011; Nusbaum, Silvia, & Beaty, 2014; Silvia, 2008). More evidence comes from research in which DT is related to three common facets of executive function (*updating*, *switching*, *inhibition*; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000) or to the involvement of strategy-use (Gilhooly, Fioratou, Anthony, & Wynn, 2007; Nusbaum & Silvia, 2011). Inhibition (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014; Benedek, Franz, et al., 2012) and updating/working memory (Benedek et al., 2014; Süß, Oberauer, Wittmann, Wilhelm, & Schulze, 2002) were shown to be related to DT performance, while the evidence for switching is ambiguous. For example, Benedek et al. (2014) found no effect for switching as measured by the number-letter task on DT, whereas Süß et al. (2002) report small effects for switching on DT. In addition, the ability to switch between semantic categories during DT was found to be related with creativity scores in Nusbaum and Silvia (2011). Moreover, the notion of strategic involvement exists in DT research for a long time (Schoppe, 1975), but more recently Gilhooly et al. (2007) explored strategies in DT by means of the think-aloud method. They revealed that more abstract strategies while working on the alternate uses task, such as a disassembly strategy in which the participants focus on single parts of the object, are related to the perceived novelty of the generated ideas. This work was then extended by Nusbaum and Silvia (2011), who explicitly instructed participants to use the Gilhooly strategies. They found that the strategies helped to generate more creative ideas and this enhancement effect was even more pronounced for people higher in fluid intelligence. In a nutshell, there is clear evidence for the controlled-attention view of creativity, although the involvement of specific executive abilities such as switching seems to be an open issue.

A frequent finding for DT and other creativity tasks is a performance advantage on creativity scores when people are instructed to be creative (Chen et al., 2005; Harrington, 1975). A be-creative instruction leads to more creative ideas but also to less generated ideas (Nusbaum et al., 2014) and, in the current work, this complete pattern of results (benefit for creativity and reduction of fluency) is referred to when we use the term *be-creative effect*. The be-creative effect is interpreted from the controlled-attention view in terms of a focus shift from quantity to quality, or more explicitly, a shift from simple retrieval strategies to more goal-directed and efficient strategies (Nusbaum et al., 2014). Studies in which the be-creative effect was demonstrated for DT used only very few tasks (Harrington, 1975; Nusbaum et al., 2014). Thus, a replication of the finding with a larger set of tasks is needed and we expect a lower mean fluency with the be-creative instruction. Based on a reanalysis of the data of Nusbaum et al. (2014) we expect a change of fluency by a factor of 0.80 when instructing participants to be creative instead of being fluent. For creativity scores a main effect for instruction, the "be-creative" effect, was expected.

The ability to discover and to connect remote associations leading to novel and useful ideas is one of the key roles of DT (Benedek, Könen, & Neubauer, 2012; Lee & Therriault, 2013; Mednick, 1962). An underlying concept is the *Spreading Activation Network* (Collins & Loftus, 1975). Based on this view, the mental lexicon is constructed as a neural network and the associative process is seen as an activation of interrelated nodes. These activations spread equally into all possible directions. The expanding network activates initially close associations, and over time more distant ones. Associations thus happen as unconscious thoughts in a bottom-up process (Allen & Thomas, 2011). Mednick (1962) stated, that individual differences in creativity appeared due to the associative network hierarchy meaning that highly creative people tend to have a broader and more flexible associative network ("flat hierarchy") compared to less creative people having usually few and common associations ("steep hierarchy"). More recently, Kenett, Anaki, and Faust (2014) expanded this theory by comparing semantic memory networks of high vs. less creative people and found that highly creative people have a less structured semantic network with shorter activation paths than less creative people which, in turn, leads to better connectivity between the nodes and facilitates the activation of remote associations. Moreover, associative or general retrieval ability is one basis of divergent thinking (Benedek, Könen, et al., 2012; Silvia et al., 2013) and the number of associations, and in turn fluency in divergent thinking, should increase with higher frequency objects (Cofer & Shevitz, 1952; Forster, 2008). We applied further word frequency data from the British National Corpus (corpus.byu.edu/bnc/) to the stimuli of Cofer and Shevitz (1952) in order to reanalyze their finding. Based on this reanalysis, we expect a change of fluency by a factor of 1.13 for a one unit change in log10-transformed frequencies. Because free association tasks are much more similar to verbal fluency tasks, we expect this effect to be present when participants are instructed to generate as many ideas as possible.

However, it remains unclear if the detrimental effect of the be-creative instruction on fluency generalizes to low-frequency objects. Because low-frequency objects lead to less associations than high-frequency objects and hence less possibilities of idea generation under the simple strategy "memory use", an early change to executively demanding, but more effective strategies is expected (Gilhooly et al., 2007). Thus, the performance difference on fluency between the be-creative instruction and the be-fluent instruction should be clearly less pronounced for low-frequency objects.

For high-frequency objects, on the other hand, the opposite could be assumed. The standard instruction, in contrast to the be-creative instruction, requires the generation of many uses without any restrictions. Due to the non-restrictive type of instruction, the idea generating process can be based on episodic memory (cf. memory use, Gilhooly et al., 2007) and on associative processes and, thus, should be more facilitated by high-frequency objects. Moreover, the be-creative instruction requires modifications in the idea generating process. To access remote associations for the generation of unusual ideas, strong superficial and irrelevant associations must be inhibited (Beaty & Silvia, 2012; Benedek, Franz, et al., 2012). Due to the greater amount of associations, the need for inhibiting processes should be larger for high-frequency objects compared to low-frequency objects. Consequently, we argue that for high-frequency objects the fluency difference between both instructions should be particularly high. Thus, the be-creative effect should be a function of lemma frequency. This variation of the be-creative effect on fluency would be manifested as an interaction effect of frequency and instruction type. Analogously, a negative effect for frequency on creativity scores could be expected when participants are instructed to be creative due to the higher inhibition demands. For an instruction with a focus on production, however, it is harder to give a good guess on the expected effect size. For example, Forster (2008) provided a hybrid-instruction with a production focus (*as many original uses as possible*) and assessed the effect of frequency on an originality measure based on latent semantic analysis and found no effect. However, a familiarity index, indicating how familiar people are with the given AUT object, was negatively related to originality. Given these ambiguous results, we only explored the relation between frequency and creativity scores for the be-fluent instruction.

2. Method

2.1. Sample

A total of 297 subjects participated in this study. Incomplete records of 41 participants (dropout-rate: 13.80%; 95%-CI: [10.14%, 18.26%]) were not included in the data analysis. This dropout-rate was significantly lower than the estimated 30% in online studies (Galesic, 2006). Six participants had to be excluded because they reported imperfect German language ability. The data of one participant was further removed because of the instructions were not properly followed. This resulted in a final sample size of $n = 249$. The age ranged from 18 to 60 years ($M = 23.48$, $SD = 6.44$). There were 79.12% female participants. The sample was composed of undergraduates ($n = 219$; 83.13%