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The cognitive underpinnings of creative thought: A latent variable analysis exploring the roles of intelligence and working memory in three creative thinking processes

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ABSTRACT

The field of creativity has largely focused on individual differences in divergent thinking abilities. Recently, contemporary creativity researchers have shown that intelligence and executive functions play an important role in divergent thought, opening new lines of research to examine how higher-order cognitive mechanisms may uniquely contribute to creative thinking. The present study extends previous research on the intelligence and divergent thinking link by systematically examining the relationships among intelligence, working memory, and three fundamental creative processes: associative fluency, divergent thinking, and convergent thinking. Two hundred and sixty five participants were recruited to complete a battery of tasks that assessed a range of elementary to higher-order cognitive processes related to intelligence and creativity. Results provide evidence for an associative basis in two distinct creative processes: divergent thinking and convergent thinking. Findings also supported recent work suggesting that intelligence significantly influences creative thinking. Finally, working memory played a significant role in creative thinking processes. Recasting creativity as a construct consisting of distinct higher-order cognitive processes has important implications for future approaches to studying creativity within an individual differences framework.

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1. Introduction

Creative problem solving involves the generation of novel approaches to complex problems to develop innovative ideas and solutions (Batey & Furnham, 2006; Runco, 2007). Although the importance of creative thinking is acknowledged in educational and professional contexts, creativity remains a construct that is actively debated in the psychological literature (Dietrich & Kanso, 2010; Plucker, Beghetto, & Dow, 2004). Researchers studying the cognitive underpinnings of creativity are examining specific associative (e.g., Benedek, Konen, & Neubauer, 2012), divergent (e.g., Cho, Nijenhuis, Vianen, Kim, & Lee, 2010; Nusbaum & Silvia, 2011), and convergent (e.g., Brophy, 2000; Finke, Ward, & Smith, 1992; Ward, Smith, & Vaid, 1997) thinking processes in creativity. In addition, contemporary creativity research shows that fluid intelligence (e.g., Silvia, 2008b; Sub, Oberauer, Wittmann, Wilhelm, & Schulze, 2002), crystallized intelligence (e.g., Cho et al., 2010; Sligh, Conners, & Roskos-Ewoldsen, 2005), and executive functions (e.g., Gilhooly, Fioratou, Anthony, & Wynn, 2007; Nusbaum & Silvia, 2011) also play central roles in creative thinking. Taken together, modern creativity research is delineating specific creative processes and re-examining the relationship between these processes and higher-order cognition.

The aim of this study was to contribute to the emerging field of creative cognition by exploring the role of various cognitive

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abilities and processes involved in creativity. Drawing from recent research that underscores the importance of intelligence in creative thinking, structural equation modeling was used to explore the roles of intelligence and working memory in three specific creative–cognitive processes: associative fluency, divergent thinking, and convergent thinking.

2. Cognitive processes involved in creativity

To better understand the underlying cognitive mechanisms of creative production, it is important to appreciate the diverse mental processes that make up creative thinking. Many researchers have proposed that creativity involves both deliberate and spontaneous, or explicit and implicit, thinking processes (e.g., Arden, Chavez, Grazioplene, & Jung, 2010; Csikszentmihalyi, 1999; Eysenck, 1995; Finke, 1996; Kaufman, DeYoung, Gray, Brown, & Mackintosh, 2009; Martindale, 1995). Similarly, creativity researchers also argue that seemingly contradictory processes such as divergent thinking and convergent thinking serve complementary functions in the creative process (e.g., Brophy, 2000; Dietrich, 2004; Runco, 2007). Below, we review three specific cognitive processes that have garnered significant attention in creativity research.

2.1. Divergent thinking

Guilford (1967) distinguished between divergent thinking and convergent thinking in his structure of intellect (SI) model, emphasizing divergent thinking as a critical creative process. Divergent thinking is an inductive, ideational process that involves generating a broad range of solutions or ideas to a given stimulus (Guilford, 1967; Runco, 2007). It is often contrasted with convergent thinking, a deductive process that involves systematically applying rules to arrive at a single, correct solution (Brophy, 1998; Guilford, 1967). Divergent thinking is prominently assessed by pencil-and-paper tests that present open-ended prompts (e.g., "Think of as many unusual uses as possible for a wooden pencil", Guilford, 1967; Guilford, Merrifield, & Wilson, 1958). A participant's goal in these tests is to generate as many responses as possible. Responses are typically scored according to a standardized procedure; assessing creativity indicators, such as fluency, originality, and flexibility (Batey & Furnham, 2006; Goff & Torrance, 2002; Plucker & Renzulli, 1999). This psychometric approach to studying creativity provides an objective procedure to administer and score creativity, contributing to their appeal when conducting experimental studies (Sternberg & Lubart, 1996).

Although divergent thinking tests were originally developed to measure individual differences in ideation, these tests have become the primary method of studying creativity; many current approaches to assessing creative thinking employ the same materials and methods proposed over fifty years ago (Plucker & Renzulli, 1999; Simonton, 2000). This may be surprising given that evidence for the validity of divergent thinking tests is mixed. It has been pointed out that divergent thinking tests reduce the study of creativity to statistically rare responses specific to a given sample, leading to psychometric issues with larger samples when using traditional scoring procedures (Nusbaum & Silvia, 2011) and oversimplifying the criteria for creativity to merely generating a large amount of different ideas to unrealistic situations (Barron & Harrington, 1981; Cattell, 1971; Kim, 2005, 2006; Simonton, 2000; Sternberg & Lubart, 1996).

In other studies, performance on divergent thinking tests has been linked to real-life creative behaviors. In a review of creativity research, Barron and Harrington (1981) state that evidence for the validity of divergent thinking tests include positive and statistically significant relationships between divergent thinking test scores and various creativity indicators at the elementary, junior high school; undergraduate, and graduate levels. Early validation studies have shown that divergent thinking tests are highly correlated with measures of creativity in real life including: number of patents gained, producing plays and novels, and founding new businesses or professional organizations (Barron, 1963; Getzels & Jackson, 1962; Runco, 2004, Torrance, 1972; Wallas, 1926). More recent evidence for the predictive validity of divergent thinking tests has also been documented. For instance, a series of studies conducted by Hong and Milgram (1991), Hong, Milgram, and Gorsky (1995), Hong, Milgram, and Whiston (1993) provide evidence that performance on divergent thinking tests in early childhood and adolescence predicted real-life creative behaviors in domains including art, music, sport, drama, literature, and dance (Hong & Milgram, 1991; Hong et al., 1993, 1995). Finally, Plucker's (1999) re-analysis of Torrance's (1968, 1969) data from a longitudinal study of over 200 elementary students using structural equation modeling showed that divergent thinking strongly predicted creative achievements (e.g., inventions, awards, published articles) ($r = .60, p < .001$), explaining nearly half of the variance in adult creative achievement.

Divergent thinking tests continue to be the most widely used measure for assessing creativity (Batey & Furnham, 2006; Runco, 2010). Nevertheless, the sole use of these tests to assess and draw conclusions about an individual's overall creative potential is viewed as problematic, and there is insufficient evidence that creative cognition alone is psychometrically unitary (Arden et al., 2010). In this study, we treat divergent thinking as one of many cognitive processes in creative thinking, and explore the relationship of divergent thinking among other cognitive abilities and processes important for creativity, including convergent thinking and associative fluency.

2.2. Convergent thinking

Convergent thinking has been reported as both an antithesis (e.g., Guilford, 1967) as well as a complementary creativity process (e.g., Brophy, 2000). However, compared to divergent thinking, much less attention has been given to the role of convergent processes in creative thought. Convergent thinking tests measure cognitive processes that include discerning which ideas are most appropriate or of highest quality with the objective of arriving at a single, correct solution (Brophy, 2000; Guilford, 1967). Creativity tasks that engage convergent thinking processes include the Remote Associates Test (RAT, Mednick, 1962) as well as insight problems (e.g., Duncker's (1945) candle problem). The process of finding the solution to convergent thinking tests of creativity is often referred to as 'thinking outside of the box', as the problem-solver is required to break away from obvious responses and common mental sets in order to view the problem