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Searching outside the box in creative problem solving: The role of creative thinking skills and domain knowledge

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ABSTRACT

This study provides evidence for how factual (directly relevant for developing creative solutions) vs. range (indirectly relevant) information can be used to provoke idea generation and effective creative outcomes. Data were obtained from 127 staff, faculty, and students at a private Midwest university. The results show that the effect of type of information was moderated by the participant's creative thinking skill and domain knowledge. For individuals high in creative thinking skill, range information improved idea generation originality, which in turn enhanced creative outcome novelty but reduced outcome usefulness. Factual information, under various conditions, both helped and hindered creative outcome usefulness. Overall, presenting information during idea generation can improve creative outcome effectiveness. Managers should be careful to present the appropriate information at the appropriate time, however.

1. Introduction

Few researchers or business practitioners can deny the pervasive importance of creativity in the workplace for the economic benefit of organizations, countries, and markets (e.g., Marrocu & Paci, 2012). Thus, it is not surprising that creativity has been a key topic within the R & D design/engineering (Burbiel, 2009), marketing (Smith & Yang, 2004), entrepreneurship (Ardichvili, Cardozo, & Ray, 2003), and management literatures. In short, scholars across business disciplines seek to better understand workplace creativity and practical ways by which it can be facilitated, and a small subset of researchers seek to understand ways in which creativity is facilitated outside of employee formal job requirements (e.g., Axtell, Holman, & Wall, 2006; Kesting & Ulhøi, 2010; Unsworth, 2001). These researchers point to a key question for business: how can managers support employees in developing creative ideas when it is not a formal requirement of their job?

Existing research on idea generation fits this question well, because it often utilizes tasks in which limited domain knowledge is necessary to produce ideas (Jones & Kelly, 2009; e.g., Nijstad, Stroebe, & Lodewijkx, 2003). In expected creativity, where it is part of the job (e.g., artists, scientists, etc.), employees may need significant domain knowledge to make novel contributions. In unexpected creativity, however, employees typically have sufficient knowledge and skills to generate creative ideas without extensive training.

One common tactic for enhancing idea generation is brainstorming (Osborn, 1953). An assumption of brainstorming is that individuals will come up with more creative ideas when they build off previously generated ideas (i.e., engage in external information processing). Research in this area, however, has produced mixed results when examining the effect that ideas from others have on idea generation. Some research findings support the assumption that paying attention to others' ideas during brainstorming can improve idea generation (Brown & Paulus, 2002; Nijstad & Stroebe, 2006). On the other hand, research also shows that the presence of other's ideas can reduce idea generation productivity (Diehl & Stroebe, 1987). While production blocking, described as the delay in idea generation based on group members taking turns to express their ideas, is one possible explanation for these mixed results (e.g., Diehl & Stroebe, 1987; Nijstad et al., 2003), we test two additional factors that may help explain these inconsistencies in the existing research: information type and individual characteristics.

First, we suspect that the type of information available during idea generation will impact the creativity of the ideas generated, and we focus on two types: factual and range. With the vast array of information that is available to a person at any given time (e.g., visual, verbal, etc.) and a person's limited capacity to absorb such amounts of information (Malhotra, 1982), individuals choose the type of information on which to focus during idea generation tasks. Therefore, one key distinction is to classify information as either directly relevant to problem solutions (factual) or indirectly relevant (range) for the specific

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problem (Mumford, Baughman, Supinski, & Maher, 1996). This mirrors the idea of focusing on information that is "in the box" or "outside the box." Based on this distinction, we suspect each information type will have a unique effect on idea generation.

Second, we know that there are individual differences in cognitive processing during idea generation (e.g., Friedman & Forster, 2001). Two cognitive processes seem to be drawn upon during idea generation: procedural memory/knowledge and declarative memory/knowledge (Jin, Kwon, Jeong, Kwon, & Shin, 2006). In the current context, procedural knowledge is most reflected in creative thinking skill in idea generation, and declarative knowledge is one's level of task domain knowledge. Both creative skill and domain knowledge have both been theorized and found to improve idea generation (Amabile, 1983), but research has failed to examine *how* these individual characteristics influence idea generation. Thus, we examine the moderators under which information condition each characteristic is most helpful for creativity.

Third, the creativity research seems to be divided into at least two areas: research examining idea generation as the dependent variable (e.g., Kohn, Paulus, & Korde, 2011; Nijstad et al., 2003), and research examining creative outcomes and products as the dependent variables (e.g., Oldham & Cummings, 1996). These constructs are theoretically distinct but causally-related ideas (Montag, Maertz, & Baer, 2012). According to Amabile's Componential Theory of Creativity (1983), people take nascent ideas (such as those generated during brainstorming) and evaluate, revise, and refine them to develop a product or solution. The nascent ideas are different from creative outcomes, because the latter "final products" are refined ideas that are intended for implementation or end use. Thus, idea generation behavior affects creative outcome effectiveness (COE; Montag et al., 2012), but these are distinct. In the current paper, we separate and test the relationship between these two constructs.

In the following sections, we discuss the process of individual idea generation and the role that external information plays in this process. Then we describe our expectations for effects of factual and range information on idea generation. Four unique facets of idea generation (i.e., fluency, flexibility, originality, and elaboration) have long been theorized and measured in the literature (Guilford, 1957; Torrance, 1966). Fluency is the raw number of distinct ideas generated, flexibility is the extent to which these ideas represent different semantic categories/content areas, originality is the extent to which ideas are different from those suggested by other generators, and elaboration is the extent of detail and clarification provided in describing each idea. These different aspects of idea generation have been correlated with activity in different parts of the brain (Chávez-Eakle, Graff-Guerrero, García-Reyna, Vaugier, & Cruz-Fuentes, 2007), highlighting the importance of examining unique relationships with each facet. Thus, our hypotheses make specific predictions for the different facets of idea generation, tested simultaneously. From there we develop the rationale for the moderating effects of both creative thinking skill and domain knowledge. Finally, we explore linkages between the idea generation facets and COE.

2. Theoretical background

Idea generation is the process in which individuals use divergent thinking to develop ideas intended to solve non-algorithmic problems. We draw from the Search for Ideas in Associative Memory (SIAM; Nijstad & Stroebe, 2006; Nijstad, Stroebe, & Lodewijkx, 2002; Nijstad et al., 2003) model of idea generation to understand the information processing that occurs during idea generation. According to SIAM, information is stored in memory in semantic clusters or images (Nijstad et al., 2003). Information within a cluster is strongly related, and clusters of information are weakly related to other clusters. In the idea generation process people first search their long-term memory for solutions using the problem definition as a search cue (Nijstad & Stroebe, 2006). During this search, they activate idea clusters, and ideas from one cluster can easily be connected, meaning people will generate many ideas quickly when drawing from one semantic cluster (i.e., fluency; Nijstad et al., 2003). Building on this idea, we expect that external information will increase idea generation fluency to the extent that it can be easily integrated with or prompts recall from easily accessible idea clusters.

SIAM also proposes that idea generation results from cognitive processes such as conceptual combination or the use of analogies (e.g., Kohn, Paulus, & Korde, 2011). As information (both external and internal) is activated in working memory, people form new associations between those pieces of information. As each new association comes into working memory, it potentially brings along additional search/focus cues, which may then activate new semantic clusters. This process is repeated until new associations are exhausted using that search cue. At this point a person may activate a new search cue to repeat this process with different information. When people shift to a new semantic cluster they are more likely to develop ideas from multiple semantic categories, which represents greater flexibility (Nijstad et al., 2003). Moreover, the ideas generated later in this process tend to be more original (Kohn, Paulus, & Choi, 2011). Building on these arguments, we expect that external information will increase idea generation flexibility and originality to the extent that it can be integrated within one's semantic network and expands that semantic network.

SIAM does not make direct predictions about idea generation elaboration. However, elaboration requires focus in working memory on one semantic cluster in detail, and searching for how the idea can be explained and clarified through more detail. Given that this is similar to within category fluency (e.g., Nijstad et al., 2002), it would seem that any information could aid in detail elaboration, but this would be especially true of information within one semantic category.

3. Hypothesis development

We suggest that different types of information are interpreted by individuals differently. Information can be classified into several types. In fact, creativity researchers have examined multiple types of information that have been shown to influence the creative process. Mumford and colleagues (Friedrich & Mumford, 2009; Mumford et al., 1996), for example, found that people who produced high quality and original solutions (high COE) spent less time on irrelevant information and more time on inconsistent and factual information. In this paper, we focus on factual and range information, which best approximates the concept of focusing inside vs. outside "the box", respectively.

Factual information is defined as information that is directly relevant for coming up with solutions to a creative problem (Mumford et al., 1996). This information is typically explored early in the idea generation process, and can also be used to verify or evaluate ideas. Exposure to factual information, just like common ideas generated in a brainstorming session, should spur many associations within a limited semantic network (Nijstad et al., 2002), which should directly increase idea generation fluency (Kohn, Paulus, & Choi, 2011; Nijstad & Stroebe, 2006). Elaboration is defined as extending and clarifying an idea through adding detail. Factual information, usually within a given sematic category but differing by sub-category, could allow more details to be added to a particular idea, improving elaboration more than having no such information. Factual information should aid individuals in generating responses from a similar category, which reduces the total number of categories from which they produce ideas (Brown & Paulus, 2002). Thus, factual information reduces idea generation flexibility. Likewise, factual information may cause individuals to get stuck thinking within a limited range of solutions (Runco, 2004) due to functional fixedness, described as a mental block against seeing or using something in a new way to solve a problem (Duncker, 1945), thereby reducing idea generation originality.

Hypothesis 1a. Factual information will increase idea generation