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The importance of iteration in creative conceptual combination

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ABSTRACT

Theories of creative conceptual combination hypothesize that, to generate highly creative concepts, one should attempt to combine source concepts that are very different from each other. While lab studies show a robust link between far combinations and increased novelty of concepts, empirical evidence that far combinations lead to more creative concepts (i.e., both more novel and of higher quality) is mixed. Drawing on models of the creative process, we frame conceptual combination as a divergent process, and hypothesize that iteration is necessary to convert far combinations into creative concepts. We trace conceptual genealogies of many hundreds of concepts proposed for a dozen different problems on a large-scale Web-based innovation platform, and model the effects of combination distance on creative outcomes of concepts. The results are consistent with our predictions: (1) direct effects of far combinations have a mean zero effect, and (2) indirect effects of far combinations (i.e., building on concepts that themselves build on far combinations) have more consistently positive effects. This pattern of effects is robust across problems on the platform. These findings lend clarity to theories of creative conceptual combination, and highlight the importance of iteration for generating creative concepts.

1. Introduction

How are creative outcomes produced? Conceptual combination is one strategy that has been examined in some depth. It is deceptively simple and process-free in definition: it involves two or more concepts combined into a new concept. Real-world examples of the products of conceptual combination abound, from "mash-ups" and hip-hop sampling in music, to "fusion" cooking, to compound engineered products (like the Apple iPhone, and component/module reuse in engineering). Lab studies have identified a number of different cognitive processes for combining concepts, including property transfer (transferring properties from "helper" concepts to a head concept, e.g., "pet-bird" = "bird you keep in the house and feed when hungry"), hybridization (interpreting a new concept as a "cross" or "blend" between the constituent concepts, e.g., "saw-scissors" = "dual purpose tool that both cuts and saws"), and relational linking (constituent concepts play distinct roles in a thematic relation, e.g., pet-bird = "bird for grooming pets").

Here, we are particularly interested in how conceptual *combination distance* — the degree of semantic distance between the component concepts — influences the creativity of the produced concepts. Specifically, many theorists and eminent creators (Blasko & Mokwa, 1986; Koestler, 1964; Mednick, 1962; Rothenberg, 1979) contend that far combinations are more likely to lead to creative outcomes than near combinations, and numerous anecdotes of eminent creative accomplishments are consistent with this claim (Johansson, 2006; Rothenberg, 1995; Ward, 2001). Is this hypothesis supported by empirical evidence?

Lab studies have consistently shown that *far* combinations — where constituent concepts are semantically distant from each other (e.g., "kitchen utensil" and "bird" vs. "kitchen utensil" and "plate") — lead to more novel combinations (Doboli, Umbarkar, Subramanian, & Doboli, 2014; Gielnik, Frese, Graf, & Kampschulte, 2011; Mobley, Doares, & Mumford, 1992; Nagai, Taura, & Mukai, 2009; Wilkenfeld & Ward, 2001; Wilkenfeld, 1995; Wisniewski, 1997). A major factor in why this effect occurs is that people generate attributes of the product concept that are emergent, i.e., not characteristic of its constituent concepts. For example, one might say that a "kitchen-utensil bird" is a bird that has a strong jaw for hammering (where neither property is likely to be listed as characteristic of either kitchen utensils or birds when considered separately). Emergent attributes can be generated through first identifying alignable conflicts through analogical mapping (Hampton, 1997) and performing causal reasoning to generate attributes to reconcile those conflicts (Kunda, Miller, & Claire, 1990). Another reason novel concepts are more likely to

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emerge from combining dissimilar concepts is that people are more likely to think of abstract relations and attributes of constituent concepts (e.g., using metaphor) when those concepts are distantly related (Mumford, Baughman, Maher, Costanza, & Supinski, 1997).

In contrast to the link between combination distance and novelty that has been well established in the lab, the impact of combination distance on idea *creativity* is less clear. Most major models of creativity agree that products are creative if they are both novel and good (of high quality, useful; Boden, 2004; Finke, Ward, & Smith, 1996; Hennessey & Amabile, 2010; Runco, 2004; Sawyer, 2012; Shah, Vargas-Hernandez, & Smith, 2003). However, relatively few studies of conceptual combination and creativity have actually measured quality or creativity. Two lab studies have shown that more distant combinations lead to lower quality ideas (Baughman & Mumford, 1995; Mobley et al., 1992), while one lab study has shown that it has no significant effect, but trending toward higher quality (Doboli et al., 2014). Thus, the connection to quality is unclear. Four lab studies have examined effects on creativity (i.e., the joining of novelty and quality): two found positive effects (Howard-Jones, Blakemore, Samuel, Summers, & Claxton, 2005; Zeng, Proctor, & Salvendy, 2011), while the other two found no effect (Jang, 2014; Siangliulue, Arnold, Gajos, & Dow, 2015), with Siangliulue et al. (2015) showing a trend in favor of lower diversity leading to higher creativity.

The relatively small number of studies with mixed results leaves us with uncertainty about the relationship between concept similarity in conceptual combination and creativity. One interpretation of these mixed findings is that far combinations lead only to increased novelty *per se*, not necessarily increased creativity. A related controversy exists in the literature on analogical distance, where studies are divided on whether the most creative analogically inspired ideas come from analogies outside of the problem domain (in other words, from far analogies). Some researchers argue that the best interpretation of the data is that there is no clear/general advantage of far analogies for creative ideation (e.g., Chan, Dow, & Schunn, 2015; Dunbar, 1997; Perkins, 1983; Weisberg, 2009, 2011). Is a similar conclusion (combination distance does not influence creativity) warranted based on the extant empirical data on combination distance? We believe it is plausible, but argue that alternative theoretical interpretations should first be ruled out before accepting it. In this paper, we develop and test one theoretically motivated alternative explanation for the conflicting findings: the benefits of combination distance depend on how much convergence has happened from the point of combination. We argue that, to detect the benefits of combination distance, we need to observe and evaluate the resulting solution path further down its path of development (vs. early on in its development).

To develop our alternative explanation, we draw on a generally shared process model of creativity as involving first, divergent (generating new ideas), then convergent (selecting and building on the best ideas) processes (Amabile, 1983; Finke et al., 1996; Sawyer, 2012; Simonton, 2011; Wallas, 1926; Warr & O'Neill, 2005). For example, Amabile's (1983) prominent process model prominently includes a movement from divergent processes (response generation) to convergent processes (response validation). Similarly, the Geneplore model (Finke et al., 1996) specifies a Generate phase (initial generation of candidate ideas) followed by an Explore phase (extensive exploration of those ideas). Simplistically, one can view the creative process as linearly progressing from a divergent to a convergent phase. Realistically, creators often go through many divergent-convergent cycles when developing creative products (Herring, Jones, & Bailey, 2009; Jin & Chusilp, 2006). They also sometimes interleave divergent and convergent processes throughout, but transition from earlier periods with more divergence to later periods with less divergence (Atman et al., 2007; Ball, Evans, Dennis, & Ormerod, 1997; Goel & Pirolli, 1992; Shih, Venolia, & Olson, 2011), where convergence on a few promising prototypes becomes necessary to move forward. Overall, there is theoretical consensus that divergent and convergent processes are distinct and jointly necessary for successful creative production, and the creative process moves from an emphasis on divergent processes early on to convergent processes later on.

This theoretical framework provides a principled justification for the hypothesis that far combinations should lead to more creative ideas. If creativity is the production of artifacts that are both new and valuable, then at least some novelty is necessary to create new value. It follows, then, that a creative process that lacked divergence entirely (e.g., only selected from existing ideas) would be highly unlikely to produce a creative idea. Relatedly, models of firm innovation often focus on the tradeoff between exploring uncertain new opportunities and exploiting existing/old certainties (March, 1991). In such models, an exclusive focus on exploitation might be beneficial in the short run, but usually leads to an eventual loss of competitive advantage in dynamically competitive environments. We claim that *far* conceptual combinations in particular — given the usual nature of their conceptual products — are a primarily divergent process for generating new ideas. Therefore, incorporating them into the creative process should eventually increase the likelihood of a highly creative idea, even if they only raise the novelty of ideas considered (but hold quality constant). By contrast, near conceptual combinations could serve both divergent and convergent thinking purposes.

Importantly, understanding far conceptual combination as primarily a divergent process can help explain the conflicting findings on far combinations and creative outcomes. Within this framing, we can draw on the literature on divergent/convergent creative processes to suggest multiple reasons why combination distance might not have an immediate benefit for creativity. First, some researchers argue that a good divergent process increases quality variance in order to make it more likely that the best ideas will be generated (Girotra, Terwiesch, & Ulrich, 2010; Terwiesch & Ulrich, 2009). Therefore, far combination will likely produce both good and bad ideas. Some form of selection process should then be necessary to separate the good ideas from the bad ideas. Secondly, if we conceive of a solution space for creative problems as possessing no more than a few "peaks" (i.e., really good ideas), then statistically there should be many more mediocre or bad ideas than good ideas. It follows from this sparse quality peaks perspective that initial forays into very new regions of the space, if they are "blind" (Simonton, 2011, 2012), will more likely land on mediocre or bad ideas than good ones on the first try. Thus, some time must be allowed to pass in order for some convergent process to select and refine the "good novel" ideas (i.e., to move from the low quality initial landing spot in a novel conceptual region to the nearby high quality variants in that conceptual region). Finally, models and studies of idea generation consistently find that better ideas overall (i.e., combinations of both novelty and quality) tend to be generated later down a solution path (Basadur & Thompson, 1986; Benedek & Neubauer, 2013; Kohn, Paulus, & Choi, 2011; Krynicki, 2014; Nijstad, De Dreu, Rietzschel, & Baas, 2010; Nijstad & Stroebe, 2006; Parnes, 1961; Parnes & Meadow, 1959; Paulus, Kohn, Arditti, & Korde, 2013; Rhodes & Turvey, 2007; Rietzschel, Nijstad, & Stroebe, 2007).

These theoretical insights suggest a potential resolution to the mixed findings regarding combination distance and idea creativity: to observe the benefits of combination distance, one needs to examine its effects well into the convergent phase of the creative process. Given the high-quality-variance nature of far conceptual combination as a creative strategy, a longer convergent phase