The effects of physical prototyping and group work on the reduction of design fixation

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Innovation is important for successful designs, but design fixation likely prevents designers from reaching their innovative potential. Participants in this study were 120 students, 80 of which had design backgrounds. Participants saw an example tool, and then worked alone or in small groups to design two new tools using a construction set. All participants designed two tools: one in a physical prototyping environment and one in an environment without physical prototyping. Results showed that designs were better and contained fewer fixations to the example tool when designed in the physical prototyping environment, but that groups designed better tools than individuals or nominal groups when no physical prototyping was available. These results underscore the importance of physical prototyping in design.
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The ability to create new technology is one of the crowning achievements of the human species' ability to reshape their own environment. Innovative products and systems make headlines and lead to large financial rewards (Amabile, 1996; Scott, Leritz, & Mumford, 2004; Simonton, 1999; Wise, 1992), but creative innovations also catalyze advances in medicine, art, and science. Of course, the ability of humans to develop innovative designs does not imply that developing innovative products is easy; to the contrary, design work in most domains constitutes what is known as an ill-defined problem (Simon, 1996), a problem with the potential, but not necessarily the propensity, for many different creative solutions. One of the recognized impediments to innovative solutions for ill-defined problems is the finding that people tend to *fixate* on features of preexisting designs, and go on to generate new designs that are similar to the prior example (Purcell & Gero, 1996; Smith, 1994, 1995, 2003). Design fixation is therefore an obstacle to innovation which, if reduced, could hold the promise of improving the number of innovative solutions humans produce. The work reported here tested the ability of two design techniques, working with physical prototypes and working in small groups, to reduce design fixation during an ill-defined design project. The

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author hypothesized that both group work and prototyping would reduce fixation, leading to superior designs.

1 Design fixation

Fixation occurs when a designer experiences an example of an existing design, and then he or she creates a new product with features similar to the prior example (Dahl & Moreau, 2002; Jaarsveld & van Leeuwen, 2005; Jansson & Smith, 1991; Marsh, Bink, & Hicks, 1999a; Marsh, Ward, & Landau, 1999b; Purcell & Gero, 1996; Smith, 1994, 1995, 2003; Smith, Ward, & Schumacher, 1993; Ward, 1994). A robust phenomenon, fixation affects what humans remember (e.g., Smith & Blankenship, 1991), how humans solve problems (e.g., Chrysikou & Weisberg, 2005; Kershaw & Ohlsson, 2004; Luchins, 1942; Luchins & Luchins, 1959), how humans adapt to instrument malfunctions (e.g., Youmans & Ohlsson, 2008), and central to this paper, how humans generate novel ideas and designs (e.g., German & Barrett, 2005; Jansson & Smith, 1991; Smith, 2003).While it may not be possible to make precise estimates of how much design fixation reduces innovation, Nijstad (2000) has argued that such tendencies certainly do so, and Ward (1994) has shown how common design fixation is likely to be — in his experiments designers who merely *visualize* past examples of products become more likely to fixate on them.

One feature that makes design fixation particularly difficult to solve is that it can occur unconsciously. Humans' associative memory systems store information via associative networks of interconnected concepts in ways that make recently-activated concepts more likely to be retrieved (Collins & Loftus, 1975), but acting on these initial ideas without realizing that they are duplicating a previous concept may explain how unconscious fixation occurs. Design instructors report that students often commit to the design ideas that they think of first (Purcell & Gero, 1996), but our first ideas are those that our memory systems make most likely to contain elements of fixation, and these ideas can persist even when they directly impair the performance or function of the new design (Jansson and Smith, 1991; Smith et al., 1993). Thus, unlike cases of artistic homage or other deliberate references to prior work, designers who experience design fixation may be unaware that they were copying prior examples, leading some researchers to label the effect 'unconscious plagiarism' or 'cryptomnesia' (Brown & Murphy, 1989; Marsh et al., 1999a, b; Marsh & Bower, 1993; Marsh & Landau, 1995).

2 Could physical prototyping reduce design fixation?

Herbert Simon once described the design process as the *mental* manipulation of conceptual representations to explore complex relationships amongst design features (Simon, 1986). This characterization rightly implies that design work is a complicated activity likely to tax cognitive abilities that we know

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