Creative analogy use in a heterogeneous design team: The pervasive role of background domain knowledge

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We integrated two research traditions — one focusing on analogical reasoning, the other on knowledge sharing — with the aim of examining how designers' unique knowledge backgrounds can fuel analogy-based creativity. The present dataset afforded a unique opportunity to pursue this aim since the design dialogue derived from team members with highly disparate educational backgrounds. Our analyses revealed that analogies that matched (versus mismatched) educational backgrounds were generated and revisited more frequently, presumably because they were more accessible. Matching analogies were also associated with increased epistemic uncertainty, perhaps because domain experts appreciate the challenge of mapping such analogies between domains. Our findings support claims from the knowledge-sharing literature for a direct route from knowledge diversity through analogical reasoning to novel idea production.
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The design process typically involves designers drawing on personal experiences relating to their past design work as well as on knowledge of other design projects or products (e.g., Ball, Lambell, Reed, & Reid, 2001; Cross, 2006). Such prior experience and knowledge then serves to inform a solution for the current design problem, shaping both its initial development and its subsequent refinement. Indeed, the very notion of 'design-by-analogy' (e.g., Helms, Vattam, & Goel, 2009; Moreno et al., 2014) points specifically to the frequent capacity for designers to transfer solution structures or elements from a known source domain to a target design problem.

In studying such design-by-analogy, researchers have often tended — perhaps inadvertently — to *control out* individual variation in the background domain knowledge of the designers being analysed, instead focusing on homogeneous participants with very similar backgrounds in terms of their design education,

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training and company-based experiences, for example, in domains such as industrial product design (e.g., Ball, Ormerod, & Morley, 2004), electronic engineering design (e.g., Jagodzinski, Reid, Culverhouse, Parsons, & Phillips, 2000) or the design of medical plastics (e.g., Christensen & Schunn, 2007). In the extreme case of numerous laboratory experiments that have investigated design-by-analogy the source analogies are presented *directly* to individual participants in the form of one or more initial examples for perusal (e.g., Casakin, 2004; Casakin & Goldschmidt, 1999; Goldschmidt, 1995). In this way very tight constraints are placed on the experimental setting so that the researcher can assess the specific role that such source materials have on the design process and the resulting design products.

These latter kinds of laboratory studies are actually rather paradoxical, since although it is assumed that analogy sources in *real-world* design practice are frequently drawn from a designer's own background knowledge and experience, the examination of analogy use in highly controlled experimental situations does not readily allow for an investigation of the way in which individual variation between designers makes a difference to the analogies that are retrieved and the design solutions that are produced. We contend, however, that the role of individual variation in background knowledge is vitally important for attaining a full understanding of the basis of design creativity and innovation. This view is supported by established research on 'knowledge sharing' in teams (e.g., Cummings, 2004; Pulakos, Dorsey, & Borman, 2003), which is often concerned with examining the nature of *individual differences* in knowledge backgrounds in order to estimate the impact of such differences on outcome measures such as creativity and innovation. In such research the exchange of previously unshared knowledge in heterogeneous or multifunctional teams and organizations is often observed to be beneficial (e.g., Argote, 1999; Nonaka, 1994).

What is fascinating about the separate research traditions that focus on design-by-analogy on the one hand and knowledge sharing in team creativity on the other hand is that they both seem intuitively to be closely connected in terms of their concern with the application of prior knowledge to new problems. Indeed, on reflection, it is apparent that both traditions seem to assume that the central path by which background domain knowledge may be transferred into innovative outputs is through a process of analogical reasoning. Yet achieving a theoretical rapprochement between these two disparate traditions is far from straightforward because of their methodological differences. As we have noted, experimentally-driven, design-by-analogy research typically aims to hold background knowledge constant either by utilizing homogeneous design participants or else by presenting source analogies that are equally available to each participant in the experimental context, thereby making it unclear whether individual variation in background domain knowledge makes any difference at all to the analogizing process. In contrast, the knowledge-