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EXTRACTION AND TRANSFER OF BIOLOGICAL ANALOGIES FOR CREATIVE CONCEPT GENERATION

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ABSTRACT

Biomimetic design, which borrows ideas from nature to solve engineering problems, has been identified as a promising method of concept generation. However, there are still many challenges. Previous research has revealed that novice designers have difficulties in extracting the analogical strategy present in biological phenomena and mapping the strategy even if the strategy is provided. This research, therefore, attempts to develop tools that could assist novice designers to execute effective biomimetic design and ultimately generate creative concepts.

In particular, we investigated the use of tools developed by the authors: 1) a *causal relation template* that helps retrieve relevant strategies from biological descriptions and 2) *instructional mapping rules* that aid structural mapping of the strategies to design concepts and abstraction of the enabling functions of the strategies. We found that the participants who used both tools generated concepts with significant correlation between the correctness of analogical transfer and creativity of the concepts. This effect was not observed for the participants who only used the first tool, mainly because of the participants' inability to explore enabling solutions for the applied biological strategy and generate concepts that are wholly developed. To encourage generation of creative ideas in biomimetic design, the tools must be devised to facilitate abstraction of biological strategies, enable effective mapping of strategies from biology to engineering, and discourage design fixation.

1. INTRODUCTION

Many researchers in the past have noted that analogical reasoning plays a key role in creative design (Goel 1997, Gentner et al. 2001, Brown 2008). Biomimetic design involves analogical reasoning, as it borrows ideas from nature to solve engineering problems. Biology has been well recognized as a promising source of analogies (Gordon 1961, Vincent and Mann 2002, Bar-Cohen 2006, Wilson and Rosen 2007) and there are now numerous successful applications of biomimetic design in the literature. Furthermore, an almost infinite amount of potential analogies in biology is yet to be explored, as biological knowledge is quickly expanding (Rebholz-Schuhmann et al. 2005).

Despite its promising prospect and successful case studies in the past (Hacco and Shu 2002, Shu et al. 2006, Davidson et al. 2009), there are obstacles that hinder designers from effectively executing biomimetic design. First, there are issues associated with interdomain information retrieval and finding biological information relevant to design problems (Chiu and Shu 2007, Ke et al. 2009). Other difficulties are also present when designers attempt to make analogical transfer from the relevant biological information to design solutions. This paper focuses on addressing and solving the latter difficulties.

Our previous research at the Biomimetic for Innovation and Design Laboratory (BIDLAB) at the University of Toronto identified that novice designers tend to fixate on irrelevant aspects of biological information; have difficulties in extracting analogical strategies present in biological information; and need support for structural mapping between biological information