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Abstract. Designers are always looking for inspiration. Many disciplines use inspiration from nature to create something new, a practice often referred to as "bio-inspired". Biology-inspired design has been widely applied and studied in engineering, architecture, products and many other disciplines, but in the field of visual design, although there are some works but few research. This article through the review of existing literature on bio-inspired design thinking, and bio-inspired interdisciplinary design development and trend of bio-inspired design in the future, in order to investigate the existing bio-inspired design tools whether can fit for visual designers, and provides a new tool for visual designers and students develop their creative development space.

Keywords. Bio-inspired, analogies, designer’s toolkit, visual communication design, inspiration

1. Introduction

Bio-inspired has been widely applied into engineering, architecture, products and other fields (Vattam et al., 2010; Cheong et al., 2010; Volstad & Boks, 2012; Fu et al., 2014; Badarnaha, 2015; Al-Obaidi, 2017). Generally, biologists lack knowledge of design and engineering, while engineers and designers are laymen of biology. Thus, connecting the interdisciplinary knowledge transfer, communication and creation becomes the key that should be considered in the field of bio-inspired thinking (Vattam, 2008; Vattam, 2013; Cohen, 2016). In the past decade, growing efforts have been devoted to interdisciplinary research that can connect biology and other disciplines, and many bio-inspired design strategies from relevant disciplines have been formulated (Bogatyreva et al., 2002; Vattam et al., 2010; Baumeister, 2012; Badarnaha, 2015). However, there is no definite research on applying bio-inspired into visual design.

As for the application of bio-inspired design, Benyus (1997) divided it into three levels from shallow to deep, including mimic of natural surfaces (forms), mimic of natural processes, and simulation of natural ecosystems (Belletire, 2005). Compared with other disciplines, though bio-inspired design has been applied into visual design, the applications are mostly at the shallow (surface) level, and there is no profound thinking or research on the knowledge transfer between biology and visual design.
When bio-inspired design methods are used into creative thinking, bio-inspired design databases (AskNature, 2008) are indispensable tools for designers. So far, online searching (AskNature, 2008), interactive software (Vattam et al., 2010; Chakrabarti, 2005), bio-inspired cards (Volstad, 2012; Bio-inspired 3.8, 2016) and other databases have been exploited and developed, which can be used as tools in engineering, architecture, products and packing. When bio-inspired design is used into different disciplines, however, the languages adopted, the views concerning design, the limitations to design issues, and the sources used to realize abstract design concepts all differ to some extent (Vattam, 2007). For instance, the focus in the field of architecture is how to use the physical space and building structures, but how to optimize functions, values, appearance and material quality in the fields of engineering and product design, and is how to optimize information transfer in the field of visual design. Thus, when designers from different disciplines use bio-inspired databases, they have similarity in some areas, but also emphasize differently and use different connection languages. However, so far, there is no specific bio-inspired tool for visual design.

Given the above analysis and the interdisciplinary interaction of future design (Oxman, 2016) and since bio-inspired design is a promising discipline in the future (Gamage & Hyde, 2012), we find the applications of bio-inspired into the vision field are superficial, but not profound or comprehensive. The problems to be solved in this study are: bio-inspired design is a tool for vision designers to exploit creativity and innovation potential, but are the existing bio-inspired design tools developed in the fields of engineering, architecture and product design feasible to visual design? If yes, will the tools help to enhance the novelty and profundity of visual designers? If not, what characteristics should be possessed by bio-inspired design tools that are feasible to visual design?

2. Methodology and Steps

Here, cognitive protocol analysis was adopted, which consisted of three steps. Step 1-- test 1: no-bio-inspired design experience visual designers were asked to use three ways of thinking (no-bio-inspired inspired thinking, thinking assisted by bio-inspired resource cards, thinking assisted by bio-inspired design cases) during visual design. Step 2-- test 2: have bio-inspired design experience visual designers were asked to use the three thinking ways as in step 1 during visual design. Step 3: Tests 1 and 2 were compared for discussion and analysis.

This study was aimed to explore whether the existing bio-inspired design tools would help the subjects during creative conception and to explore the feasibility of these tools. Given the advances of design thinking in recent decades, Cross (1999) reorganized the existing research methods. Of them, 'oral analysis' was a complete observation of the design processes of designers (Suwa & Tversky, 1997). Oral information is the source of scientific data and the basis of studying the problem-solving process of subjects (Ericsson et al., 1980). Oral analysis is the best way to acquire oral data for studies on 'thinking aloud' in the design field (Ginsburg et al., 1983; Stewart, 1983; Finegold & Mass, 1985). The oral data reflect the process how a subject finishes the design objectives (Ericsson et al., 1980) and can be used to extract the complex structure of problem solving and to uncover the hidden internal mechanisms (Ginsburg et al., 1983). Thus, in
In this study, 'thinking aloud' was used as an experimental method. The whole processes were audio- and video-recorded, and photos were taken.

2.1. Step 1: No Bio-inspired Designer

2.1.1 Subjects

All subjects enrolled had sufficient experience in designing. In step 1, two no-bio-inspired vision designers with more than 15 years of experience in visual design were selected.

Since this study was aimed to differentiate the effects of some creative conception tools on the conception of the subjects, the test topics should be operated by the same subjects.

2.1.2 Design Topics

As for selection of topics, visual design covers graphic design, ad design, commercial design and other aspects, and graphic design is subdivided into logo design, book design and inset design. Given that none of the above different classifications can fully manifest visual design, we, after comprehensive analysis, selected poster design as the direction of test topics. This is because poster design covers many aspects of visual design, and posters are widely-accepted popular transmission ways and are aimed at information delivery.

In this study, three topics were used to test the subjects. The subjects should be the same, which avoided between-topic interference due to continuous thinking. As for topic design, topic 1 and topic 2 were parallel, but the themes were different, and topic 2 and topic 3 both involved bio-inspired design and thus the directions were largely different.

**Topic 1:** [Future] themed poster design (the subjects were encouraged to break through two-dimensionality and paper media and to use multi-sensory factors into creation, but not to use bio-inspired design thinking).

**Topic 2:** [Environmental protection] themed poster design (in addition to the encouragement in topic 1, the subjects were provided bio-inspired resource cards to help with the inspired creative conception).

**Topic 3:** [Break] themed poster design (in addition to the encouragement in topic 1, the subjects were provided bio-inspired design cases to help with the inspired creative conceiving). Since topic 2 and topic 3 both involved the inspired creative conceiving and to avoid the interference of topic 2 on topic 3, we set them at different aspects of thinking, while ensuring both were poster design. Thus, topic 3 was an abstract concept of [break], so the subjects can comprehend it as [break through] or [break down] according to their conceptions.

2.1.3 Design Tools

**Topic 1:** The plotting tools (including drawing sheets, pencils, marker pens, colored pencils) and computers (as demanded by the designers) were all commonly-used by the subjects.

**Topic 2:** Bio-inspired resource cards were also provided in addition to those in topic 1.

**Topic 3:** Bio-inspired design cases were also provided in addition to those in topic 1.
2.1.4 Experimental Operation
Since the subjects should be the same person, the subjects may also be interfered by the memory from the previous topic he/she had finished, in addition to the between-topic interference. Thus, to avoid such interference from previous tests, certain intervals were set: one week between topics 1 and 2, and one month between topics 2 and 3.

**Topic 1:** During this no-bio-inspired design, the subjects conceived topic 1 without using bio-inspired design and were informed with the instruction prior to the test. During the test, the subjects creatively conceived and drafted within 30-60 minutes. The whole processes were audio- and video-recorded, and photos were taken, and the conception and drafting were photographed by digital cameras.

**Topic 2:** During this bio-inspired design, the subjects conceived topic 2 by using **biomimicry resource cards** (Figure 1.) and were familiarized with the cards in advance. During the test, the subjects creatively conceived and drafted within 30-60 minutes. The whole processes were audio- and video-recorded, and the conception and drafting were photographed by digital cameras.

![Figure 1. biomimicry resource card.](image)

**Topic 3:** During this bio-inspired design, the subjects conceived topic 3 by using bio-inspired design cases and were familiarized with the cases in advance. During the test, the subjects creatively conceived and drafted within 30-60 minutes. The whole processes were audio- and video-recorded, and the conception and drafting were photographed by digital cameras.

![Figure 2. bio-inspired design cases.](image)

2.2 Step 2: Bio-inspired Designer
In step 2, the two subjects enrolled should be vision designers with experience of bio-inspired design, with more than 15 years of experience in visual design, and with experience of using bio-inspired design to think in the past 3 years. Design Topic, design Tools and experimental Operation, are the same as step 1.
3. Results and Discussion

Totally 12 groups (4 subjects × 3 topics) of data were obtained, including audio records, videos, drafts and photos. Firstly, the oral data were transcribed into literal data, which were then segmented, and finally each segmentation was encoded. During the transcription, the videos and drafts from the designing process were used, and the segmentation was based on each design idea as a unit. The segmentations were encoded according to an encoding system, and the feasibility of the bio-inspired tools was discussed on basis of the results.

The results were comprehensively compared to investigate whether they can be used as effective supplementary tools by vision designers for the creative conception. If yes, we discussed how to use these tools during the design process so as to improve the novelty and depth of vision designers during the creative conception. If not, we discussed how to adjust these tools so they would become usable for vision designers.

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<thead>
<tr>
<th>Subjects</th>
<th>Topic 1</th>
<th>Topic 2</th>
<th>Topic 3</th>
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<td>Bio-experience</td>
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<td>No Bio-experience</td>
<td>Subjects3</td>
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<td>Subjects4</td>
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☑ no more inspired ☩ a little inspired ☠ commonly inspired ☚ more inspired ☛ very inspired

4. Conclusions

The analysis of test data shows that none of the existing bio-inspired tools are fully feasible for vision design, so we propose three directions or recommendations for the development of new tools. 1 Many bio-inspired cases suggest biological data are very helpful for inspired designers, but the major challenge in vision design may be that the existing tools focus on the combination of biological data with engineering and structures, but rarely on the combination with vision design language. Thus, using vision language to link biology knowledge will make the tools more effective. 2 Since the bio-inspired research often involves multiple disciplines, when it is used into vision design, relevant research cases will endow designers with more direct vision experience and make them more clearly inspired. Thus, more interdisciplinary cases involving bio-inspired should be offered to vision designers. 3 When the existing bio-inspired design tools and relevant databases are to be used by vision designers as supplementary tools in creative thinking, the biology knowledge and relevant cases should be summarized and classified using the vision design language, so that the knowledge can be effectively and rapidly used by vision designers according to their demands.
References


