

PAPER • OPEN ACCESS

## Analysis on the Establishment of Bionic Design Thinking Model in Design Innovation

To cite this article: Meina Wang 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **573** 012070

View the [article online](#) for updates and enhancements.

# Analysis on the Establishment of Bionic Design Thinking Model in Design Innovation

Meina Wang<sup>1\*</sup>

<sup>1</sup>Departments of Art, Sichuan University Jinjiang college, 610000, China

\*Email: cimona@126.com

**Abstract.** Our purpose was to evaluate the usefulness of the Bionic Design Thinking Model. On the basis of previous studies, a set of innovative product design thinking models have formed, based on the theoretical basis of product modeling design thinking and the theories of bionics, design psychology and thinking science. This paper calls for a high degree of harmony and unity between human society and nature through bionic philosophy of design, and calls for a reasonable symbiotic dialogue platform between human and machine, ecological nature and artificial nature.

## 1. INTRODUCTION

In recent years, the research on the thinking mode and method of product innovation design has become a hot spot in foreign design research, but the domestic research on this is still relatively insufficient. LIU studied the psychological phenomenon of the designer when designing the product shape, and initially established a mapping relationship between the product shape and the psychological response. GERO et al. analyzed the problem-solving process of innovative design of modeling, and pointed out that analogy reasoning is an important means to generate innovative design of modeling. SAKOL et al. put forward a creative design method of modeling based on design knowledge and user knowledge, and established a knowledge transformation model in modeling design. At home, Zhao Jianghong, Su Jianning et al. have mainly put forward image-based design methods. These studies have expounded the innovative design thinking of products from various angles, but have not yet formed a simple and effective design thinking model system.

Therefore, on the basis of previous studies, I have formed a set of innovative product design thinking model taking bionic design as an example based on the theoretical basis of product modeling design thinking and the theories of bionics, design psychology and thinking science, which will be described in detail below.



2. MATERIAL AND METHODS

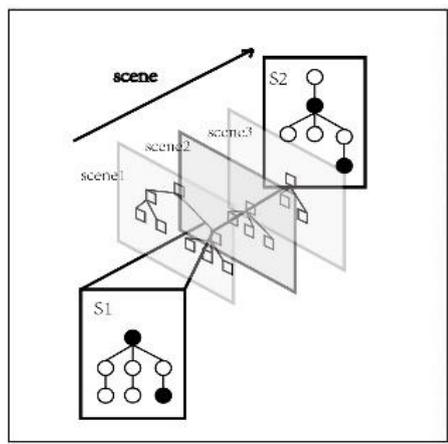


Figure 1. The different answers of one problem and their problem scenes

The answer S1 correspond with the problem P1, the answer S2 correspond with the problem P2, S1 and S2 are different because of the different scene

From the perspective of logic, product innovation design is a generalized problem-solving process, and the result of design may not be a specific final solution of an actual problem, but rather an "intermediate" solution from the initial problem state to the final solution. As the problem scene changes, the solution is adjusted and changed accordingly. As shown in **Figure 1**, for the same design problem, the solution may also change due to different scenes.

At the same time, the problem domain of product innovation design is a typical pathological domain. Under such circumstance, the initial state of the problem (design requirements), the target state of the problem (design results) and the operation mode of the problem (design rules) are not clear. So, it is difficult to solve the product modeling design problem through rule reasoning, and the solution process of the problem needs to be completed through the expert knowledge and experience of the designer. However, compared with the expert knowledge and experience of other fields (such as product reliability, manufacturability, etc.), the expert knowledge and experience of innovative design have greater uncertainty and fuzziness. The strategy adopted by many innovative designs is to generate new design ideas through analysis of past or other design cases. Therefore, the problem solving of product innovation design is a typical analogical reasoning process, as shown in Figure 2, from solution s in scene 1 to solution in scene 2.

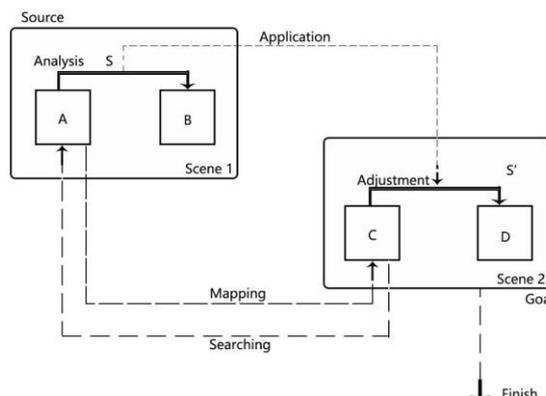


Figure 2. The analogical reasoning process of product design

- A—primeval state in scene 1
- B—objective state in scene 1
- C—primeval state in scene 2
- D—objective state in scene 2
- S—solution of the problem in scene 1
- S'—solution of the problem in scene 2

### 2.1 Design Thinking Dominates the Problem-Solving Process

Product innovative design requires the designer's expert knowledge and experience to complete the problem-solving process, while knowledge and experience form the designer's design thinking, in other words, design thinking plays a leading role in the solution process of innovative design.

### 2.2 Using Bionic Design Thinking to Solve Problems

The process of bionic design of common products can be simply shown in **Figure 3**:

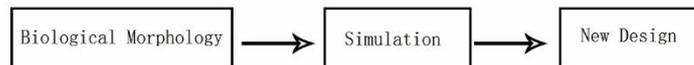


Figure 3. The normal bionic design thinking model

However, starting from the "quasi-materialized" design and using bionic design thinking to carry out product innovation design process, it can be shown in **Figure 4**:

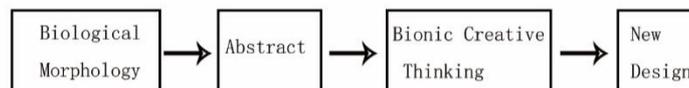


Figure 4. The product design thinking model based on bionic design thinking

It is worth pointing out here that bionic design is not an exact imitation of biological prototype, but based on biological prototype, through creative thinking, carries out secondary or even multiple innovations to obtain the design form--this is the essence of bionic design thinking. The model is shown in Figure 1.5.

Therefore, if people want to make the "enlightenment" of bionic design enter into the advanced stage, they need to abandon the pure natural form (i.e. biological prototype), use its principle to carry out the "quasi-materialized" design, and enter the "transformation" from "quasi", so as to create a real new design.

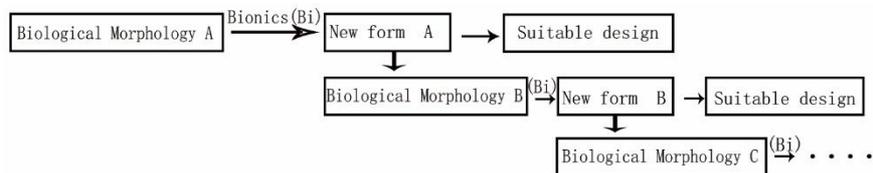


Figure 5. The flow chart of the bionic design thinking model

## 3. RESULTS

### 3.1 Establishment and perfection of bionic design thinking model in product innovation design

Product design is a systematic project, so it needs to be carried out in an orderly way. According to the design's own regular program, it reflects the different links of design behavior, and each link should show clear stage goals.

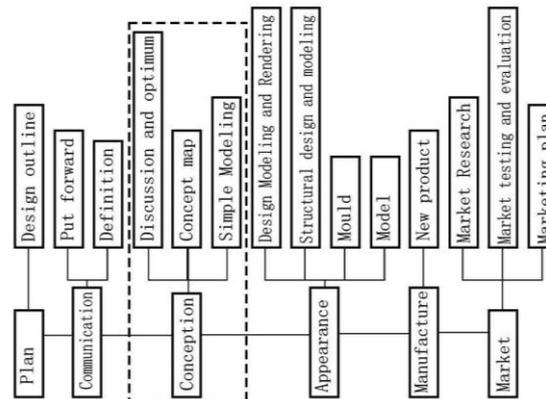


Figure 6. The flow chart of product design

As shown in **Figure 6**, this is a basic design process. Each stage in the process has its own method and theoretical guidance, and this paper mainly studies the part outlined by dotted lines in the figure--the conception stage, which is of course an important link before a good design work come out.

From the decomposition part of the figure, we can know that the "conception" part includes three parts: discussion and revision, conceptual diagram and simple modeling. Through these three tasks, it is undoubtedly the designer's thinking, that is, the interpretation and understanding of this design task in his mind. From this point of view, it is the next work that we have to complete--form a set of effective bionic design thinking models, which will provide designers with broader thinking space and more references in the conception stage.

### 3.2 Establishment Process of Design Thinking Model

#### 3.2.1 Research on the Difference between Designers' Rational and Perceptual Thinking Modes

##### 1) Cognitive Test of Product Innovation Design

Innovative design of products is mainly to code and reproduce the modeling elements (symbol information, semantic information and performance information) of products. In this process, we can use interviews, oral analysis and design concept sketches to study the thinking characteristics and performance methods of designers, to externalize and transfer their perceived images, and to discover their innovative design rules. This paper uses the experimental method of "process research" in psychological research--oral analysis method 1, and takes a typical household product--seat as the design object to analyze the rules in the designer's thinking mode.

##### 2) Test process

In the test, a total of 30 industrial design-related staff or university teachers and students were selected to provide design requirements and reference materials with seats as design objects, and the subjects were required to carry out bionic modeling design work. The test uses real-time oral report, requiring the subjects to speak out their thinking process and focus of attention in words and record them in the whole process.

##### 3) Test analysis

After the test is completed, the collected oral materials are classified and summarized. Through analysis, it is found that in the process of product modeling design with the use of bionic design thinking, there are mainly two different modeling thinking models according to the designer's thinking mode: Designers with rational thinking mode, after being familiar with the design task, try to decompose the design task into several subtasks, and then answer several subtasks respectively. Finally, they synthesize the final design scheme as shown in **Figure 7**(left). For example, when designing a seat shape, they will decompose the task into subtasks such as side contour shape, seat back shape, armrest layout, man-machine relationship and color matching, and then synthesize them after answering respectively. Designers with perceptual thinking are more inclined to describe their design plan in the design process

through semantic concepts, such as curved surface, straight face, unified and changed words, and then carry out step-by-step optimization design with unique ability to grasp modeling semantics and artistry, combined with product design positioning. Based on the analysis of modeling design tasks and questionnaires, the design thinking process flow chart was established. As shown in **Figure 7** (right):

Through comparison and summary, it is found that designers with rational thinking mode follow the characteristic of designing from low abstract level to high abstract level, which is a bottom-up reasoning process of design thinking. This way of thinking analyzes the design tasks hierarchically according to the modeling characteristics, decomposes them into several subtasks, then seeks the solutions of the subtasks, and finally integrates the results. However, designers with perceptual thinking mode follow a characteristic of designing from high abstract level to low abstract level, which is a top-down thinking process. It is guided by concept to process the information of the design content, starting from the overall form, through the design semantics, looking for a breakthrough, combined with their own design knowledge, put forward creative design scheme. As shown in **Figure 8**.

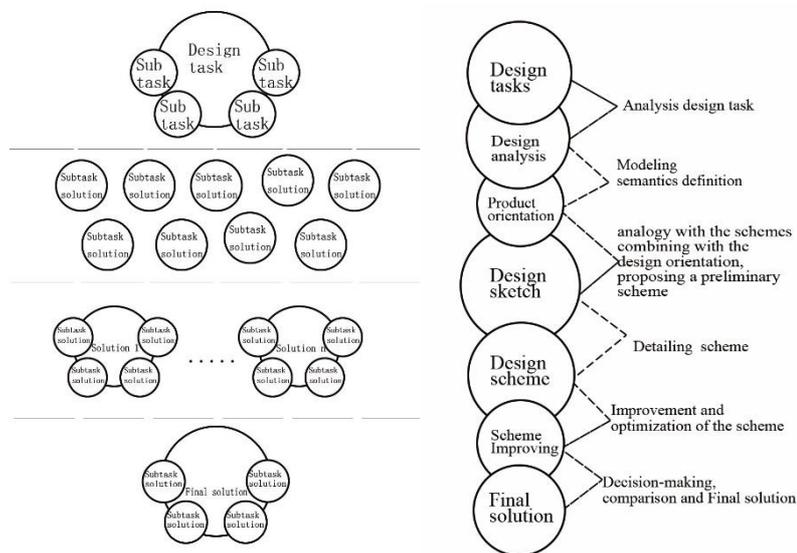


Figure 7. The rational thinking mode (left) and the perceptual thinking mode (right)

To sum up, the design thinking mode is to follow a bottom-up or top-down design information processing process, in which the designer's knowledge is externalized into product modeling. This is the premise of establishing bionic design thinking model. Through this step, designers can be helped to find their own way of thinking more quickly and apply it comprehensively to open the door of creative inspiration.

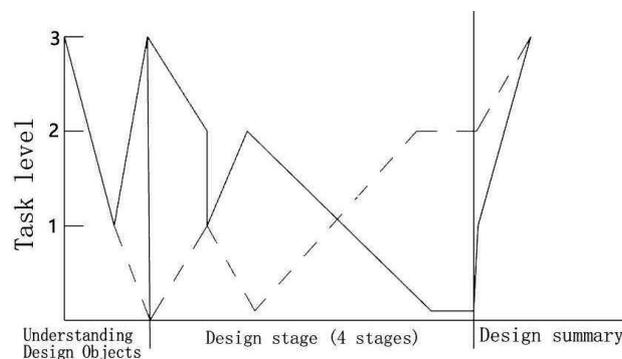


Figure 8. The different designer based on different thinking way have different thinking mode  
 —————perceptual thinking      - - - - -rational thinking

### 3.2.2 Designer's Perceptual Image Model

Whether it is a bottom-up or top-down thinking mode, the application of bionic design thinking means a process from concrete to abstract. It's just that the designers with rational thinking mode ask questions first, then seek corresponding "answers" in natural objects according to the questions asked, i.e. corresponding objects, and then abstract them. However, most designers with perceptual thinking mode first discover their excellent characteristics in the nature, and then abstract the design concepts they need according to the inspiration of such characteristics, and then create a concept of new product. This process from concrete to abstract requires the designer's perception and idea model to guide it.

First, look at Figure 4. The thinking mode model diagram mentioned earlier is already a basic framework, but it is still too simple. We need to further refine and perfect it to form a set of thinking model that can be generalized, that is, specifically discuss how to use creative thinking to carry out bionic design product innovation. After investigation and summary, bionic innovation can be summarized as fixed-point method, the association method, combination method, extraordinary method and Imitation. These skills can effectively help designers divergent thinking and put forward more suitable design schemes. These methods and theories have been mentioned in previous studies and will not be repeated here. To sum up, it can be represented by the following figure. As shown in **Figure 9**.

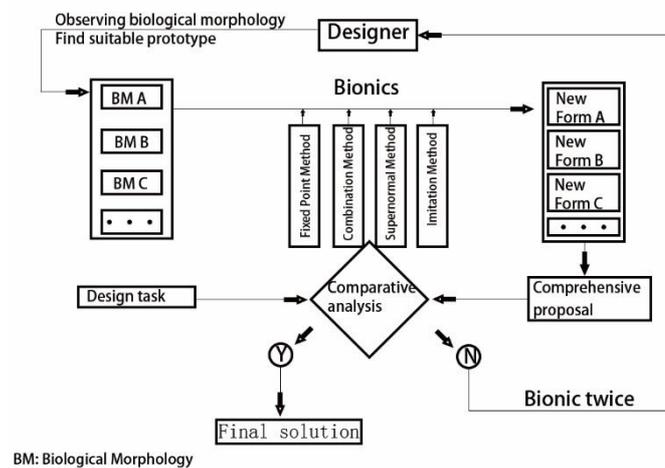


Figure 9. The thinking model based on bionic design thinking for designer

In short, it is based on the requirements of product design tasks, seeking all kinds of suitable biological prototypes in nature, and then through various innovative techniques to spread and sum up, forming new design proposals. If the proposal is not passed, it will be returned to carry out secondary or even tertiary bionic innovation to form the sketch scheme that best meets the design task requirements.

The establishment of this model is mainly to help designers expand their thinking and accelerate the formation of concepts. However, in order to strengthen the design scheme and form the final design product, the following perceptual image matching model between the user and the designer needs to be used to achieve the ultimate goal of user demand.

### 3.2.3 Perceived Image Matching Model between Users and Designers

At the conception stage, we should not only pay attention to the designer's way of thinking, but also the user is a group we cannot ignore, after all, they are the ultimate users of the product. Therefore, it is necessary to study the user's perception image before the design starts, standardize the design knowledge and make it match with the user's perception intention. On this basis, we proposed a perceptual image matching model between users and designers as shown in **Figure 10**.

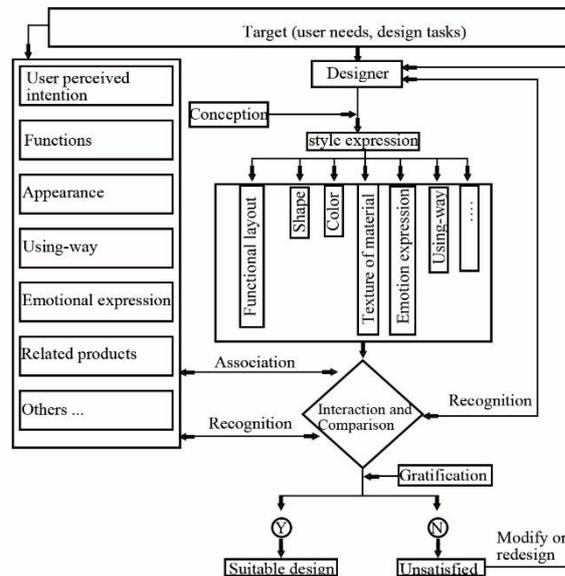


Figure 10. The thinking model based on bionic design thinking for matching between the designer and the user

Designers combine design goals (user requirements) with their own experience and skill, transform ideas into the appearance of products (including interfaces, symbols and colors, etc.), giving users a kind of induction. Users, with association way of perception to their own experience and needs, have an interaction with the product shape designed by the designer, using the help of the previous product usage. When the interaction is consistent or some kind of coupling, the design of this form meets the needs of users to a certain extent. When the interaction is not consistent, the satisfaction of the user cannot be achieved, and even the user's behavior may be misled, requiring modification or redesign.

So far, we have come up with an interlocking product innovation design thinking model based on bionics and creative thinking. The model firstly obtains two basic thinking modes of sensibility and rationality through investigation and research, which can be used as references for designers according to different people. After that, the designer's perceptual image model was consulted to carry out innovative thinking, and the design inspiration was drawn from biology to form a preliminary sketch plan. In the end, the user's needs were further adapted through the user and designer's perceptual image matching model, and the design plan was screened and re-innovated, so that the design plan was "Right the first time". The specific flow chart is shown in **Figure 11**.

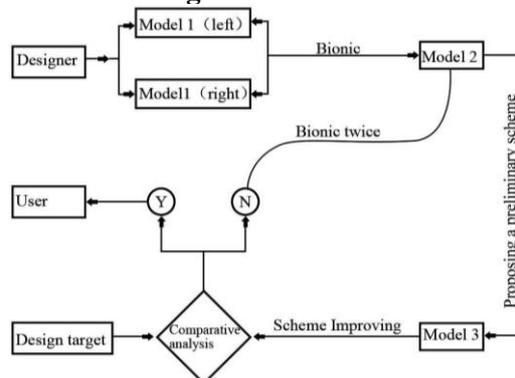


Figure 11. The general thinking model based on the bionic design thinking Model 1 is Figure.7, Model 2 is Figure.9, Model 3 is Figure.10

#### 4. CONCLUSIONS

The establishment of the bionic design thinking model has the following obvious advantages:

1. It can explore in the nature with infinite charm and stimulate the designers' inspiration.
2. From a psychological point of view, the launch of a new product is a new stimulus with a certain intensity for consumers. The process of being recognized is actually a process in which consumers are not accustomed to it and become accustomed to it. The design works produced under the guidance of bionic design thinking model are easily recognized by consumers because they are drawn from familiar biological forms, and the adaptation time will be shortened accordingly.
3. Focusing on breaking the traditional thinking set and innovating concepts, it focuses on the theme of harmony and unity between human and nature. It advocates to study the laws and functions of the relationship among human, machine and environment while designing products, to reconcile the contradiction between function and creativity, and to adapt engineering technology to the functional aesthetics of products, to the needs of human beings, to the physiological and psychological structures of human beings and to the development of the surrounding environment.
4. The source of design comes from nature, and the design results are projected to nature, thus achieving a balance point in the transformation. It not only makes the human-machine-environment system dynamically balanced, coordinated and consistent, but also can make people obtain physical comfort and psychological pleasure, thus winning the most, the largest and the highest working efficiency and economic benefits with the least, the smallest and the lowest cost.

Barry Shepard, one of the founders of SHR Perceptual Management Company, which designed Beetle for Volkswagen, pointed out: "Manufacturers realize that consumers are not only pursuing the function of a product, an important product should reflect the personality of its owner." Using bionic techniques, the product is endowed with the tension of life, and a large number of bionic elements full of ideal colors and realistic personalities, which makes the product stand out from the dazzling variety of shelves. The beauty of unfettered and unabashed personality is irresistible. Moreover, the morphological structure of living organisms evolved and developed in the long-term survival principle of survival of the fittest, which can make people feel a kind of life and vitality of self-consciousness, arouse people's potential consciousness of cherishing life and merging with nature. This paper calls for a high degree of harmony and unity between human society and nature through bionic philosophy of design, and calls for a reasonable symbiotic dialogue platform between human and machine, ecological nature and artificial nature.

#### References:

- [1] Li Leshan. Industrial Design Psychology [M]. Beijing: Higher Education Press. 2004. 1
- [2] Gao Longchang, Lu Shuhe, Li Zongfang. An Introduction to Thinking Science [M]. Chengdu: Southwest Jiaotong University Press. October 2004. 10
- [3] Gao Nan. Methods and Cases of Industrial Design Innovation [M]. Beijing: Chemical Industry Press. 2005. 10
- [4] Su Jianning, Li Heqi. Research on Product Shape Design Method Based on Perceptual Ideas [J]. Journal of Mechanical Engineering. 2004.40 (4): 164-167
- [5] Tan Hao, Zhao Jianghong, Wang Wei, Zhang Jun. The Thinking Model and Application of Product Modeling Design. Journal of Mechanical Engineering. 2006. 5: Volume 42 supplement
- [6] Research on Construction of Multidimensional Perceptual Semantic Recognition Model [J]. Chai Chunlei, Li Dan, Bao Defu, Tong Shang. Mechanical Design. 2017(03)
- [7] Liu Jihong, Zhi Jinyi, Zhi Yu. Research on User Cognition Based on Adaptive Thinking Model in Product Design. Mechanical Design. 2018(02)
- [8] Kantowitz B H, Rodrigue H L, Ellmers D G. Experimental Psychology [M]. Translated by Guo Xiuyan. Shanghai: East China Normal University Press. 2001