



# A Study of the Influence of Images on Design Creative Stimulation

Mengjiao Chen<sup>1</sup>, Tianjiao Zhao<sup>1(✉)</sup>, Hechen Zhang<sup>1</sup>, and Shijian Luo<sup>2</sup>

<sup>1</sup> Tianjin University, Tianjin, China  
zhaotianjiao@tju.edu.cn

<sup>2</sup> Zhejiang University, Zhejiang, China

**Abstract.** Creative idea generation is the core of the design process. Although existing literatures show that image stimulation plays a significant role in the innovation design process, it is generally unclear how to evaluate the effect of image stimuli in the design process and where the applicable point image stimulus should be set. This paper carries out a study to investigate the effect of image stimuli under different phase of product design with 28 industrial design students. We get three findings. Firstly, we find that sketching is a phase where a lot of ideas are generated by tracking designer's total design flow. Secondly, by analyzing the sketching patterns of design students, we find that at the beginning of sketching their thinking model can be divided into two types, i.e., inspirational and rational. Under different thinking model, the participants, however, report positive benefits from the availability of image stimulus during creative idea generated in different levels, and express higher satisfaction to the image-stimulating work as well. The final finding is that applying the stimulus in the middle stage of the sketch design, which is the convergent stage of thinking, can stimulate creativity more effectively and avoid the limitations of thinking from insufficient stimulus to some extent. Based on the above findings, the research on creative stimulation theory and method driven by image materials can be established, which provides a reference for the development of intelligent design mechanism.

**Keywords:** Industrial design · Sketching · Image · Creative idea stimulation  
Computer aided innovative design

## 1 Introduction

Creative idea generation is both primary and most important step in creative design. Stimulating creative inspiration timely and effectively can have a positive effect on the design process. The current methods of creative stimulation mainly include artificial-based creative stimulation method and computer-assisted creative stimulation method.

### 1.1 Method of Creative Idea Stimulation

**Artificial-Based Creative Stimulation Method.** The development of creativity first appeared in the United States in 1906 when Prindle's idea of training engineers in

creativity became the beginning of creative theory. In 1938, known as “the father of creating engineering” Osborn developed a “brainstorm”, on the basis of this method, he raised a “going-stopping method” which made the divergent thinking and convergence thinking cross over and over again [1]. In the 19th century forty or fifty’s, “synecdoche” and “equivalent transformation theory” emerged in succession, on behalf of analogy techniques; the 5W2H method, innovation from the perspective of raising questions; “six caps of thinking”, which stimulate human creativity potential, and so on.

As people-centered design extends from design-in-kind (industrial design) to design experience (including interactive design and service design), the researchers’ understanding on the meaning of innovation design is more concrete and in-depth. After analyzing the importance of FFE (Fuzzy Front End), Moon and others proposed a user experience-driven creative idea generation method [2]. After exploring the connection between curiosity and innovation, Hardy analyzed the potential of curiosity which can be a source of creative inspiration and problem-solving [3]. While, Goncalves explored the inspirational effects of images, objects and words from the perspective of creative sources [4]. IDEO, a famous creative company, looks for ways to innovate design by using the way of drawing design situation story version and role-playing. Delft University of Technology proposed “Context mapping” to stimulate designers’ creativity by looking for participatory points where users and stakeholders actively participate in the design [5]. According to statistics, the number of artificial-based creative stimulation methods is as many as 100 kinds.

The advantage of artificial-based creative stimulation method is giving full play to the importance of the human brain in the process of innovation, not emphasizing efficiency but imagination, having a high degree of dependence on people, so it requires a higher quality of creative personality. While, the disadvantage is that most of these methods are mind-driven and do not have many rules to follow. It is generally required that creative creators have a wide range of knowledge reserves themselves, so this method has some limitations for inexperienced designers.

**Computer-Assisted Creative Stimulation Method.** With the widespread popularization and application of computers, the stimulus for creativity has also from depending artificial-based method only transformed into computer-aided method gradually. From the initial CAD (Computer aided design) that computer is visualization of the designer’s creative results, to the CACD (Computer aided concept design) that computer participate requirements analysis to solution concept design process, then the algorithmic-driven innovative design of the AI era is coming, which is automated intelligent design tools backed by rules and algorithms. The computers moving from the end of the design process to the heart of the design process.

Although computer-aided technology offers a wide range of opportunities for innovative design and creativity, it still has its drawbacks. Firstly, computer-aided innovation design emphasizes the solution to the evolutionary contradictions of technological systems, focusing on innovative solutions and results, but in terms of promoting problems’ discovery and driving the stage of inspiration generation is not enough. Secondly, many methods place too much emphasis on design automation. It leads to the simplification of innovative thinking and lack of a collaborative model of human-computer

interaction, mutual assistance and mutual encouragement. Finally, when computer aided design combined with big data, most of the researches focus on the information of patented technologies, such as knowledge map [6], trend analysis [7–9], patent evasion [10], etc., however, it lacks research on large-scale design image materials and creative knowledge mining.

## 1.2 Images and Design Creative Idea Stimulation

There are two types of stimuli that produce creative inspiration, one is internal stimulus and the other is external stimulus. Internal stimuli exist in human's memory, the stimulation of metacognitive knowledge. External stimuli are stimuli from the surrounding environment, including audible, perceptible information such as graphics, language, and objects [1].

A comparative study of the stimulating effects on text, graphics, and objects, found that images are the best element to stimulate design inspiration, both for professional and non-professional designers [11]. In the design process, design beginners watch a large number of creative and inspiring image design material, which is an effective way to promoting creative thinking and inspiring design inspiration. Cognitive psychology shows that after inputting morphological problems, people will generate similar mappings under the stimulus of design resources, so as to output behaviors [12]. Therefore, finding out a method of selecting motivating design material and establishing the connection between image content and creative knowledge is the core of the image material-driven creative stimulus method.

At present, many design resource and generative design materials exist. However, in the design process, the difficulties still exist in finding the design material, and the found design materials' creative excitation is always weak or even invalid. A lot of image materials with potential creative stimulation abilities are still asleep. They do not provide powers in promoting the idea generation process for designers. Therefore, in big data era, we need to promote an image-driven creative idea generation method by adopting the deep learning technique. In this study, we focused on the first step of promoting an image driven creative method, which is exploring the influence of Images on Design Creative Stimulation. Only by defining the relationship between image, creative Stimulation and design process, can we solve the problem that "how image influence the idea generation process, how to select high quality images of stimuli creative idea, and how to apply the selected images into design process". The Image driven creative idea generation method based on deep learning technology can be developed in the next step.

In this study, through class experiment, we focus on the following two points: Firstly, during the design process, where is the applicable point that image stimulus should be set? Secondly, after the stimulation, how to evaluate the effect of image stimuli? Based on these two points, the research can help us to establish the image material-driven creative design theory and method. Then lay the foundation for the iterative evolution and innovation of intelligent design that leads from creative thinking.

## 2 Research Method

### 2.1 Image Stimulate Experiment

Our research takes product design as an example. Product design process, can be divided into five stages including design research, design elements mining, design and development, program revision and program output. New ideas are constantly being generated in the process and illustrated through sketch exploration. This project intends to apply stimulation of creative elements to all stages of the design process, and then, gradually reduce the scope of the experiment. Choose the applicable point that image stimulus should be set, by effective evaluating method of image stimuli. The whole research plan is shown in Fig. 1.

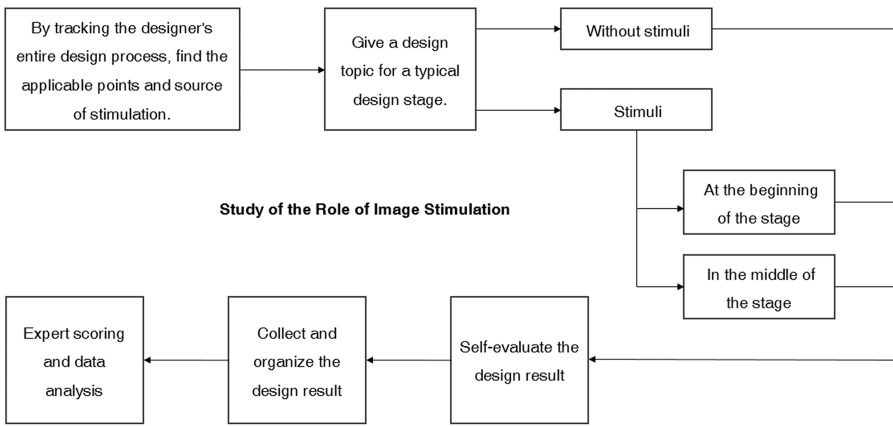


Fig. 1. Study process of the role of image stimulation

### 2.2 Demonstration Method of Design Results

Nowadays, designers have a variety of ways to express their ideas, ranging from the use of traditional words, numbers and sketches to the use of ever-expanding computer graphics and modeling software. The computer software may be only used to demonstrate the program, words and numbers can only express ideas, however, the sketches can express the functional characteristics of the idea and emotional content simultaneously. Gather the sketches in the design process, so that demonstrate the designer's thought process completely.

Sketch is accurate enough to express ideas that not be solved in fine language and in precise calculations accurately; sketch is ambiguous so that readers can get more information in the sketch even beyond itself; sketch is questionable, It solves a problem, at the same time, it can trigger new thinking; sketch is exploratory, it gives a problem a variety of possible solutions. Sketches are produced from current knowledge, and then, read or interpreted to produce new knowledge [13]. In such a repetitive process, ideas are continuously generated and iterated.

Many existing design studies show a great deal of importance in sketches. Chen Shi’s research on design knowledge analytical method during sketching, analyzed the differences in the composition of knowledge in the exploration stage and knowledge expression stage of designers [14]. Simon Laing and Masood Masoodian, in studying the role of visual images in graphic design, also used sketches as research priorities [15].

Based on the characteristics of the sketch above, we will collect, analyze and evaluate the sketches which can use as the display of creative design during the experiment. In addition, in the process of experiment, we will ask the participant to make full use of sketches in all stages of design so that we can grasp the participant’s thinking process and creative design results better.

### 2.3 Evaluation Method of Stimulate Effect of Image Material

In order to determine whether these material elements are effective in stimulating creativity or not, this paper intends to adopt a combination of quantitative and qualitative evaluation. Psychological studies show that when people look for a certain goal, human cognition and perception will be judged in different dimensions, including good and bad, positive and negative and so on. The result of this judgment will be expressed through the physiological and psychological information of the person. This study intends to use subjective evaluation scoring, vocal thinking, observation and depth of interview method to complete the evaluation of stimulate effects of material. Evaluation process as shown below (Fig. 2).

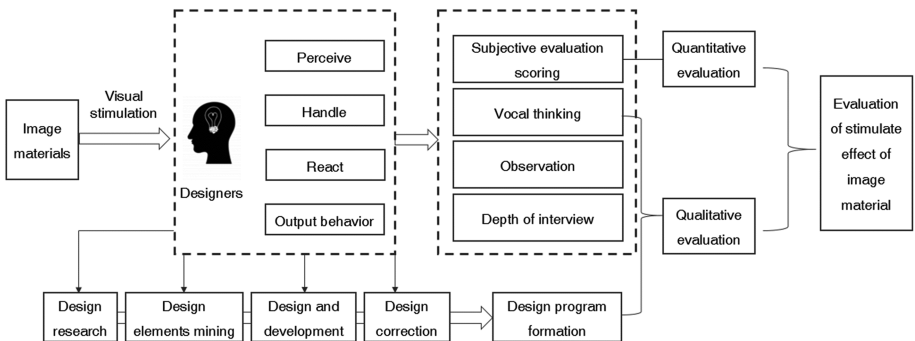


Fig. 2. Evaluation scheme of image creative stimulation effect

**Subjective Evaluation Scoring.** Let the set of test pictures be  $C = \{c_1, c_2, c_3, \dots, c_m\}$ , the set of tested persons is  $B = \{b_1, b_2, b_3, \dots, b_n\}$ , where  $m$  is the number of the material groups and  $n$  is the number of participation. The material group  $m'$  is used as the stimulus material, and the test object person  $n'$  evaluates the creative effect of  $m'$  as  $P_{n', m'}$ , then the subjects  $(b_1, b_2, b_3, \dots, b_n)$  to  $(c_1, c_2, c_3, \dots, c_m)$ 's evaluation set as:

$$P = \begin{bmatrix} p_{1,1} & p_{1,2} & \cdots & p_{1,m} \\ p_{2,1} & p_{2,2} & \cdots & p_{2,m} \\ \vdots & \vdots & \vdots & \vdots \\ p_{n,1} & p_{n,2} & \cdots & p_{n,m} \end{bmatrix}$$

The comprehensive evaluation of the material group  $i$  is:

$$p_i = \frac{p_{1,i} + p_{2,i} + \cdots + p_{n,i}}{n}$$

The subjective evaluation score of each material group is:

$$P^T = [P_{c1}, P_{c2}, \cdots, P_{cm}]$$

**Qualitative Evaluation.** The qualitative evaluation method can supplement the quantitative evaluation results and increase the reliability of the evaluation results. In design creative research, vocal thinking is an effective way to reflect on the designer's thinking. At the same time, in-depth interviewing of subjects at the end of the design process leads to the most direct and real message.

Firstly, analyze the content of the vocal thinking of the participants, and explore the tacit knowledge in the linguistic content and potential implications. Not only analyze the material evaluation stimulating effect, but also find out the potential demand in the design process. Secondly, according to the method of design investigation, we conducted in-depth interviews to find out the potential problems in the design process and the true effect of creative stimulation. Combined with the quantitative and qualitative evaluation results, the evaluation of the stimulating effect of the design material is completed, the evaluation method is established at the same time.

### 3 Images Influence on Creative Idea Generation in Design Process

As shown in Fig. 1, this paper divides our experiment into two parts:

- By tracking the designer's entire design process, find the applicable points and source of stimulation.
- Under three different cases-no image stimulation, stimulation at the beginning of the process and stimulation in the middle of the process, study a certain stage in the whole design process. Then collect the sketches and make an artificial evaluation.

#### 3.1 Stage 1: Study of the Whole Process of Design

Use in-depth interviews, vocal thinking, observation to study the stage that needs for image stimulation and the type of image stimulation in the whole product design process.

### 3.1.1 Process of Experiments

We choose an industrial design graduate student, with five-year industrial design learning experience and six months of product design work experience, as the experimenters. Track and observe the process from him received the mission of the enterprise - high-end lamp design to his works won the bidding finally, the design process lasted two months. In most cases, his place of work is in the studio, while, in a small part of the time, he did lamp design in the dormitory. Our scope of observation is his studio. After the pre-training, we asked him to describe his thought by talking as much as possible in the lamp design, and record the sound with his permission. Due to the limit of recording conditions, observers recorded the design process by taking notes and photographing. After he finished the design, the interviewers conducted in-depth interviews, focusing on the psychological activities as received the image stimulus in different stages. Finally, organize and analyze the collected material according to the design process (Fig. 3).



**Fig. 3.** Photographing of experiments progress

### 3.1.2 Sketch Data Analysis

Classify the sketches as the design stage, then combine it with the results of observation, vocal thinking and in-depth interviews to analyze the characteristic in each stage. The results as shown below.

According to the discussion, we can find the following three things. Firstly, the image materials that can stimulate the experimenter to produce creative lamp works, mostly are the existing lamp design pictures, while, others are some pictures of well-designed decoration. Secondly, during the stage 2 and the stage between stage 2 and stage 3 in the Fig. 4, the experimenter had the highest demand for the image material and the absorption effect (it can be seen from the sketch). Thirdly, in other stages, most of the image materials needed by the experimenter are in-depth analysis of the collected materials, and the collection of one certain materials. In the meantime, the absorption effect on other materials is decreasing obviously.

To sum up, creativity stimulated by image stimulus is consistent throughout the design process, and most clearly in the design research phase and the element mining phase. We will summarize this two phase as the initial stage of design production, and then, we will carry out in-depth study of this stage.

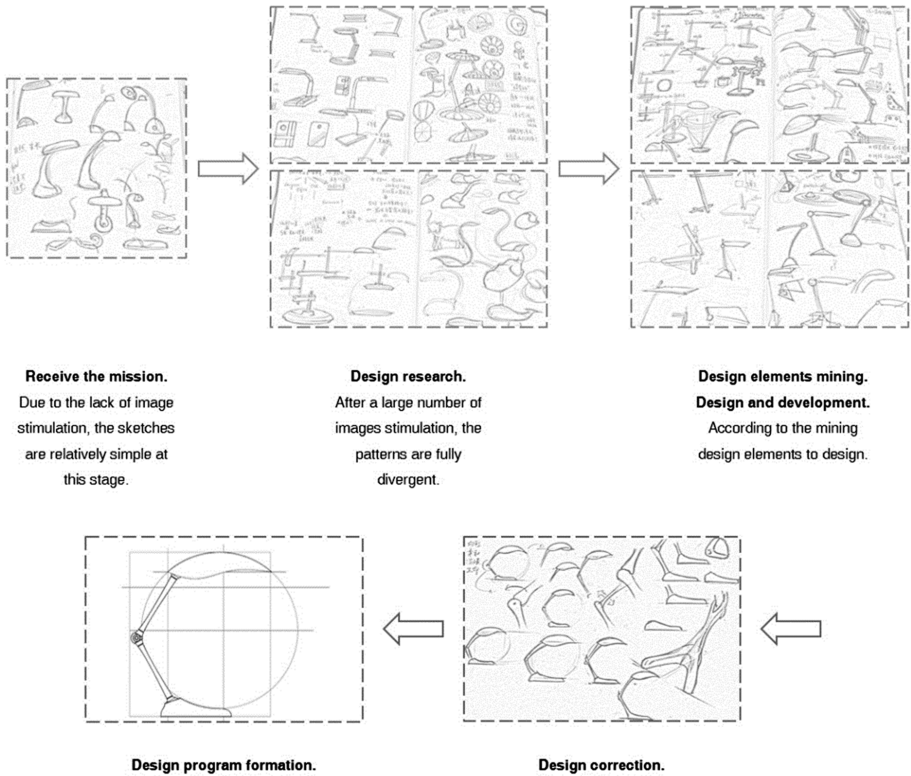


Fig. 4. Classify the sketches as the design stage

### 3.2 Stage 2: Study of Initial Idea Stage of Design

By setting up a couple of control experiment groups, that is, with or without stimulation, different stages of stimulation, study the creativity stimulation at initial idea stage of design. Evaluate the stimulation effect through self-evaluation and experts' evaluation.

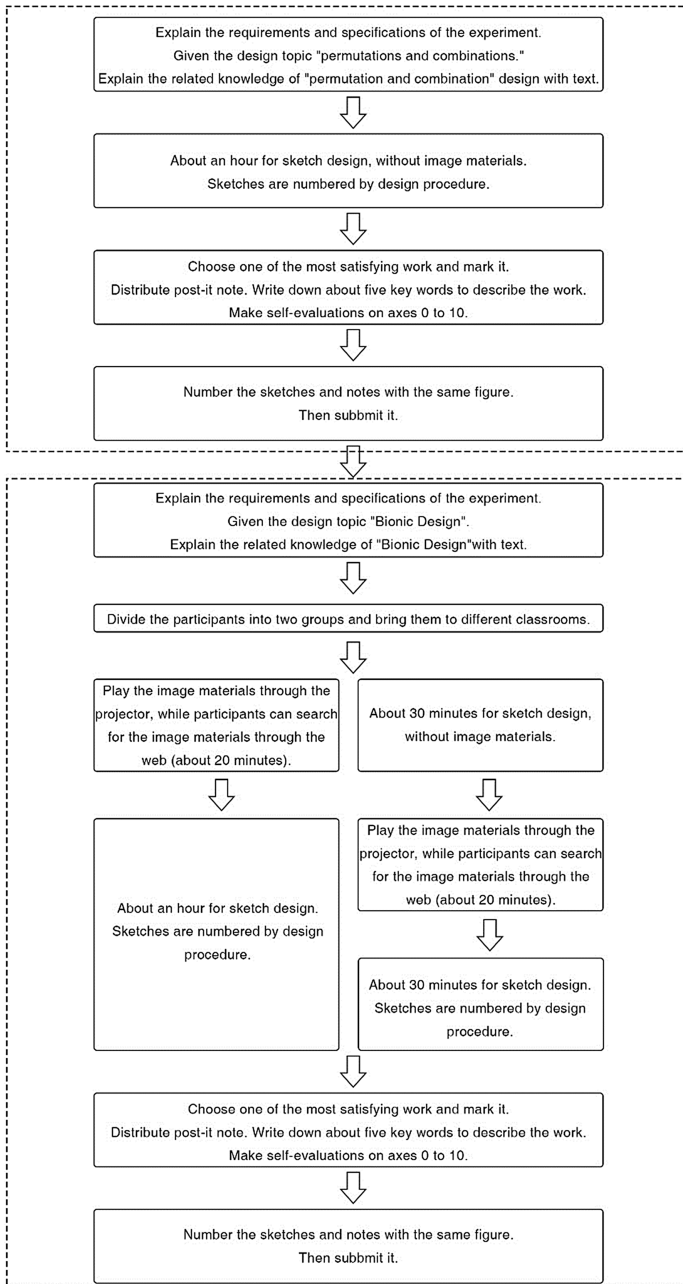
#### 3.2.1 Participants

There are 28 industrial design students voluntarily participated in this study. They were all undergraduates from the same class, with 1–3 years' industrial design learning experience. There were 16 female and 12 male participants, with most being in the 18–22 year age range.

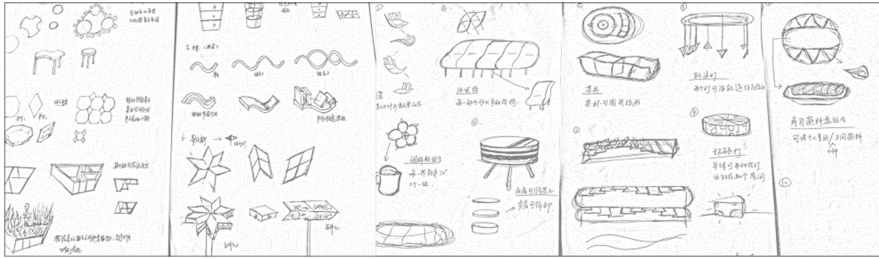
#### 3.2.2 Experiment Process

All sessions were conducted within design classrooms that featured a video camera, bare walls, and the projector to provide visual stimuli (Fig. 5). Participants worked on a bare desk using A4 drawing paper and a variety of pencils to sketch with.

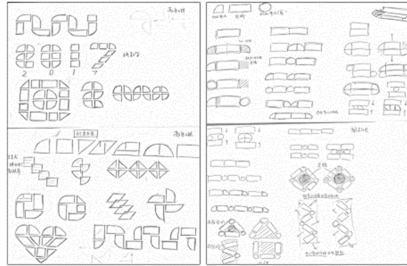




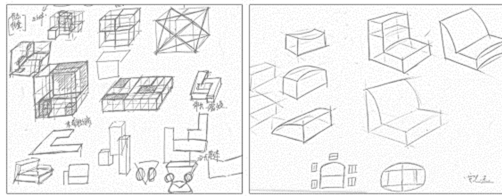
**Fig. 5.** Study session



1. starting from the shape



2. starting from the product



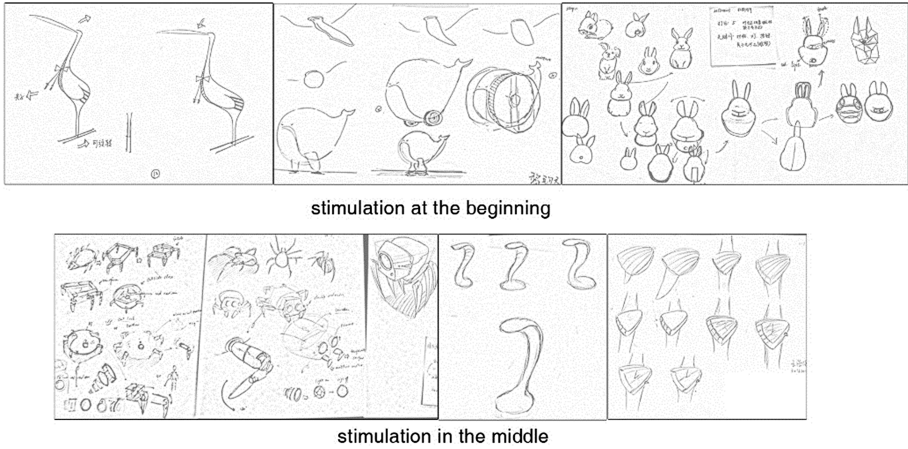
3. starting from the theory

**Fig. 6.** Three kinds of sketch thinking

### 3.2.3 Sketch Data Analysis

As can be seen from the sketch of the first set of experiments, the participants’ design thinking for a given topic can be broadly divided into three types. First, associating the possible shapes from the perceptual words, in the analysis of the shape, confirming the possible combination methods and applicable design products; the second is, starting from the product, determine the product to be designed, and then divergent possible both shapes and combinations; the third is, starting from the theory, analyze the concept of permutation and combination, then diverge scheme from the cutting of the basic form.

As can be seen from the sketches of the second experiment group, the group that received the image stimulus at the beginning has the accurate shape and smooth line. However, due to the limitation caused by the image stimulus, the design concept is rather single and the divergence is not strong. The group receiving image stimulus in the middle was slightly deficient in styling and sketching, but the diverging effect was better, the shape was more varied and paying more attention to the expression of function and emotion at the same time (Fig. 7).



**Fig. 7.** Stimulation in different points

## 4 Evaluation Result of Stimulate Effect of Image Material

Our data collected from the study took a variety of forms: sound recordings of the participants' vocal thinking, notes taken by the observing researcher, participants' design outputs, participants' post-task self-ratings and commentary and experts' ratings on the criteria measured. Statistical analysis of the ratings provided by the study participants and expert judges carried out to identify any perceived differences in the study sessions. The results of these analyses are given below. This is followed by the findings from the analysis of the interviews and commentary provided by the study participants.

### 4.1 Statistical Analysis of Self-ratings and Experts' Ratings

**Self-ratings.** The same group of participants in given image material case and no image materials cases, whose self-evaluation of design results in the table below.

We collected 28 effective scores in the experiment without image materials and 27 effective scores in the experiments with image materials. As can be seen from the table, with the design of the image material, the participants are more satisfied with the design process and the work, meanwhile, the creative effect is better. Due to the different design topics of the two experiments, it may disturb the scorers. We did not conduct expert scoring on this control group. So the result of this analysis is based on the designer's perspective (Table 1).

**Table 1.** Statistical analysis of self-rating

	M	SD
Without stimulation	6.1786	1.6789
Stimulation	6.6111	1.3253

**Experts' Ratings.** We invited two industrial design teachers and three industrial design graduate students, composed an expert scoring team. They will rate the results of the second design task in study on the initial idea stage of design. Before scoring, we selected 27 effective sketches from the two sets of sketches, mixed and relabeled. The expert scoring team rated the designs using the grading sheet. The evaluation criteria are as follows (Fig. 8).

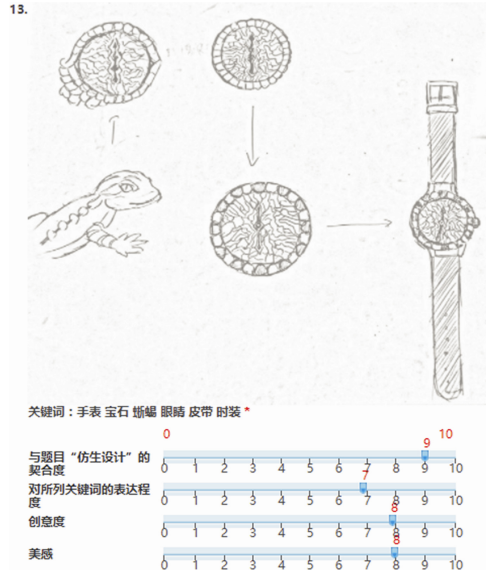


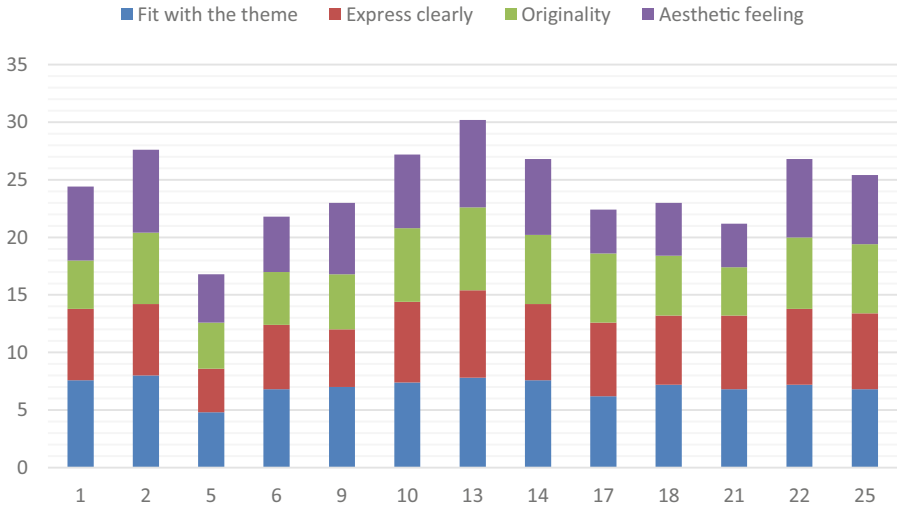
Fig. 8. Sample of the grading sheet

- Fit with the design theme (Bionic Design) or not.
- Express clearly or not (corresponding to the given keywords).
- Originality.
- Aesthetic feeling.

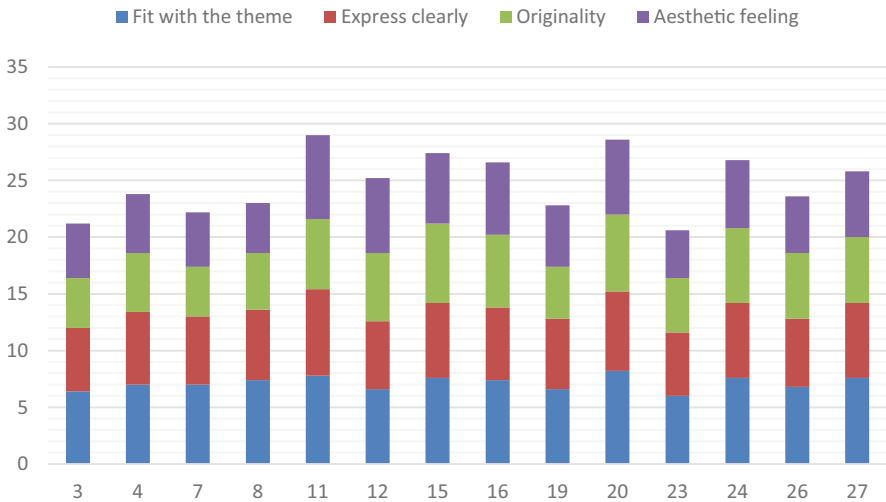
According to the numbers before scoring, the sketches that were stimulated at the beginning, were labeled as 1, 2, 5, 6, 9, 10, 13, 14, 17, 18, 21, 22 and 25; while, the sketches that were stimulated in the middle, were labeled as 3, 4, 7, 8, 11, 12, 15, 16, 19, 20, 23, 24, 26 and 27. Their average score of experts' rating are as follows.

From the Figs. 9 and 10, we can see that the group with the stimulating in the middle has the higher score in total, and the score distribution is relatively stable. Further, we calculated the average score of each group for comparative analysis in the table below. As we can see in the table, in the initial stages of generating ideas, applying image stimuli to different points can have different effects. The group with the stimulating in the middle fit with the theme better ( $M = 7.1429$  vs.  $M = 7.0154$ ), because it had better understanding in the design theme. In addition, this group is superior to the other in terms of expression ( $M = 6.3429$  vs.  $M = 6.1538$ ) and originality ( $M = 5.6429$  vs.  $M = 5.4615$ ). On the contrary, has more smooth lines and more

beautiful shape ( $M = 5.7231$  vs.  $M = 5.6286$ ). The average total score of the group with the stimulating in the middle is 24.7571 (full score is 40), higher than that of the group with the stimulating at the beginning (24.3538).



**Fig. 9.** Experts' rating for stimulation at the beginning



**Fig. 10.** Experts' rating for stimulation in the middle

Therefore, based on these analyses, thought there are some different effects when stimulate to different points, the difference is not very significant, applying stimulation in the middle of the process is slightly better (Table 2).

**Table 2.** Statistical analysis of experts' rating

	Fit with the theme	Express clearly	Originality	Aesthetic feeling	Total score
Stimulation at the beginning	7.0154	6.1538	5.4615	5.7231	24.3538
Stimulation in the middle	7.1429	6.3429	5.6429	5.6286	24.7571

## 4.2 Analysis of the Interviews and Commentary

In order to try and capture the participants' perspective on the design process, as well as their design output, short interviews were carried out with them at the conclusion of the first and second experiments during each study session.

After the first task, we choose three participants with three kinds of sketch thinking as interviewee, to find out how they think when sketching, what problems have they met and satisfied with their work or not. During the interview, comments were sought through open-ended questions, so that we can catch more valuable information. During the interview, we found that interviewees expressed their dissatisfaction with the design process and design work because of the lack of image materials. Some participants hope provided materials before designing, while, more participants expect shown the materials after giving them some time to think.

As with the first interview, once the participants had concluded their second design task, they were again invited to comment on the task they had just completed. They were also asked to review the effect of the image materials. During the interview, participants from stimulation in the middle stimuli group analyzed the image material more deeply.

From the interview result, we can also find that the creative design thinking can be divided into intuitive design thinking and logical design thinking. These two ways of thinking appear alternately in the design process. By analyzing the interviews and commentary of the first set of experiments, we got three kinds of the participants' design thinking (Fig. 6). We classify the thinking of starting from the shape as intuitive thinking, and classify the thinking of starting from the product and theory as logical thinking. Under the no stimulation situation, participants in intuitive thinking can design based on the accumulation of life, so their demand for image stimulation is not as strong as that of logical thinking. Besides, participants in both way of thinking said that the design process without image stimulation make their ideas dry up.

Design is a choice, and there are two space can offer for creativity. One is when we make a list of drastically different design drafts for selection, the other is when we definite the guidelines [13]. This is the thinking of divergence and convergence, each design phase is the process of divergence and convergence phases alternating [16]. By analyzing the initial idea stage of design, we find that two image stimuli act on the divergence and convergence stages of the design, respectively. So it led to the difference of divergence and convergence between the two groups of participants. The group that stimulated in the convergence phase had a higher evaluation of the effect of the image material and a lower evaluation of their work, and the group that stimulated in divergence phase was exactly the opposite.

## 5 Conclusions

In this paper we have described a study we conducted to better understand the influence of images on design creative stimulation. Although there are some limitations with our study, such as the small sample size ( $n = 28$ ), and the fact that our participants were industrial design students rather than professional practitioners, nevertheless the study has provided us with a number of useful findings.

- At stage 1, by tracking designer's total design flow and in-depth interviews, we find that initial idea stage is a phase where a lot of ideas are generated. This phase demands image stimulus to stimulate creativity urgently.
- At stage 2, by analyzing the sketching patterns and the interviews of participants, we find that their thinking model can be divided into two types, i.e., intuitive design thinking and logical design thinking. Under different thinking model, the participants, however, report positive benefits from the availability of image stimulus during creative idea generated in different levels, and express higher satisfaction to the image-stimulating work as well. Besides, participants of logical thinking demand more for image stimulation. Although the actual effect is not as obvious as their subjective feelings.
- Further analysis on stage 2, we find that applying the stimulus in the middle stage of the sketch design, which is the convergent stage of thinking, can stimulate creativity more effectively and avoid the limitations of thinking from insufficient stimulus to some extent.

We are now in a better position to know more about where is the applicable point that image stimulus should be set and how to evaluate the effect of image stimuli. The next important step would be using eye movement, EEG and other method to choose creative stimulation images materials. This research can help us to establish the image material-driven creative design theory and method. Then lay the foundation for the iterative evolution and innovation of intelligent design that leads from creative thinking.

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