

# THE COMPARISON BETWEEN VISUAL THINKING USING COMPUTER AND CONVENTIONAL MEDIA IN THE CONCEPT GENERATION STAGES OF DESIGN

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**Abstract.** Computer, this new kind of media, has influenced the behavior of design to some degree. Among these years, many researches have appeared for the development of computer-aided design. In recent years, such kind of computer-aided studies about the forefront of design, that is the stage of concept generation, have also started to generate. But most of these researches belonged to the kind of applied studies with the test of computer systems. On the other hand, there were many researches about the visual thinking and cognitive behavior of designers while sketching or drawing in the stage of concept generation. From the synthesis of the fore two disciplines, we can find that there existing a point of deficiency, that is the cognitive research about designers using computers as the sketching media is absent. And that is what I want to study and discuss in this research. The fundamental analytic data of this research is the visual process chronicled from the sketching of subjects, and the assistant analytic data is the verbal data from the questions that the subjects are asked after his/her sketching. These data is analyzed by three coding schema. The cognitive appearance while designers generating concepts with computers or conventional media are propounded and discussed in this research.

## 1. Introduction

Design, this theme has been discussed widely. Jones (1970), Cross (1989) and Goel (1985) all pose that there are several stages as analysis, concept generation, preliminary design and detail design involved in the design process. Concept generation stage, which is so-called the black-box (Jones, 1970; Rowe, 1987) belongs to the fore part of design process, though there are some methodical researches about this aspect been studied, such as the synectics method (Gordon, 1961) and the brainstorming method (Osborn, 1963). Many researchers have posed that the importance of sketching or drawing in the stage of concept generation. Lansdown (1987) claims that drawing is obligate for designers and usually the only modeling way to form their thinking and Goldschmidt (1991) points out that sketching is ubiquity.

Among the researches about sketching, most of all have concerned visual thinking. Archer (1976) clarifies the relation between drawing and thinking, and he points out that drawing is the best and most fast way to visualize the thinking of designers. Mckim (1980) separates visual thinking into three behaviors as

seeing, imaging and drawing. Goldschmidt (1989, 1991, 1992, 1994, 1995) divides the design process into 'moves' and 'arguments', and arguments within moves can be two types – 'seeing as' and 'seeing that'. Besides, Schon and Wiggins (1992) analyze protocols of designers and argue that design is composed of the serial of 'seeing–moving–seeing'.

Such a new theme, computer-aided design has had much impact on traditional design. From now on, these kind of researches have been widely discussed, such as shape grammar (Stiny & Mitchell, 1978; Stiny, 1980; Flemming, 1986), knowledge-based system (Liu, 1991), expert system (Jindo, Hirasago, Nagamachi, 1995) and data-based design system (Muller and Pasman, 1996; Candy and Edmonds, 1996).

The applications of computer-aided design have mainly been restricted within the latter stages of design process within most researches. But in recent years the studies of computer-aided design about concept generation stages have been gradually increasing. Lipson and Shpitalni (1996) poses some technique to alter the inaccurate 2D sketches into 3D model. Van Dijk (1995) develops a kind of shape modeling computer system for industrial designers. Elsas and Vergeest (1998) introduce one interactive computer system for displacement features of shape of products. These researches all break the standpoint which Tovey (1989) poses about computer-aided design cannot match design sketching.

The major backgrounds of this research are two inferior disciplines – computer-aided design and visual thinking while sketching. The stage of concept generation is the problem statement.

The computer system called 'displacement features function' posed by Elsas and Vergeest (1998) is a typical example of the researches about computer-aided design in present time. This system can indeed support industrial designers to design displacement features of sculptured product surface in the stage of concept generation. But the important visual thinking of sketching is hardly concerned in this study. After the positive response of this kind of application researches, the cognitive thinking of designers should be the likewise consequent argument. That is one major source of the problem statement of this research. In addition, in a series of papers, Goldschmidt (1989, 1991, 1992, 1994, 1995) discusses the role of sketching plays within the design process. She divides the design process into two types – 'moves' and 'arguments', and sketching can be directly related to moves. Arguments within moves can be two types – 'seeing that' and 'seeing as' which is directly related to sketching activities. This series of researches really have critical attitude toward visual thinking within designer's sketching. But in present time, when computer-aided design is so flourish, the researches just about sketching with conventional media – pens and papers, seems somewhat deficient. This is the other major source of this article's problem statement.

Based on the absence of discussion about cognition of designers in the field of computer-aided design and the deficiency of that about using computer as sketching media while generation concepts in the field of cognition or visual thinking, the author would like to pose following questions:

The major question of this research is that while designers using computer as the sketching media in the stage of concept generation, will the cognition and visual thinking be the same as which using conventional media? If there will be differences between the behavior while using two kind of media, what kind of differences will be? Besides, the minor question is that while designers using these two kind of media sketching in the concept generation stage, will there be some different ways on the performance of design. Those are what the author would like to study in this research. Based on the question mentioned above, the author would like to understand the phenomena of cognitive visual thinking of designers and representations of designs or drawings while sketching with two kind of media mentioned above in the stage of concept generation.

There are three steps involve in this paper. First part is the hypothesis posed by the author. In second part, two cognitive experiments are conducted. In first experiment, a designer as subject A is asked to generate design concepts using computer. Also, subject B in second experiment is asked to perform the same task as subject A, working with conventional media. The analysis including three coding scheme for the results of second part is discussed in the third part.

## **2. Methodology and Steps**

There are three parts consisted in this research. In the first part, the author hypothesizes that while designers generate concepts using computer or conventional media, their cognitive visual thinking will be different. In the second part, two experiments are involved. One designer as subject A is asked to generate concepts with conventional media, such as pens, rulers and papers. The author would like to know the cognitive visual thinking of designers in the stage of concept generation in traditional way. Likewise, the other designer as subject B is asked to do the same task as subject A using computer as the media. The author would like to understand the same thing as the first experiment in a computer-aided way. After these two experiments, the third part of the method is the analysis of the results from the fore experiments. The major analytical source is the visual data from experiments, and the minor data is form the verbal data of the questions that subjects been asked after the experiments. Before the process of experiments, the warm-up experiments should be accomplished to prove that the choice subjects are suitable for the experiments.

## 2.1. HYPOTHESIS

The major objective of this research is to find out the cognitive phenomena of designers while generating concepts using two different tools as computers and conventional media. The author hypothesizes that when designers uses computer to generate concepts, some visual cycle such as seeing-imaging-drawing will appear more times for the stronger visual feedback of computer.

## 2.2. EXPERIMENTS

### 2.2.1. *Experiment One: Conventional Media*

This experiment is about the behavior that designers generate sketches while using conventional media in the concept generation stage. According to the traditional sketching way, not concerning about computers. The objective is to discuss the cognitive behavior of designers generating concepts in this traditional way.

1. Subject A: one industrial designer who has perfect ability of generating concepts and using conventional media, and has been educated with more than 3 years of industrial design.

2. Topic: the alarm clock, which has simple elements, is easy to handle and has much space to be designed.

3. Tools: papers, pens and rulers.

Goel (1995) mentions that two types of transformations can be identified in the drawing. There are lateral transformation where there is movement from one idea to a different one and vertical transformations where one idea is transformed to a more detailed one. Most lateral transformations occur in the preliminary design phase. Based on this argument of Goel (1995) the subjects are asked to generate lateral ideas during these two experiments.

4. Process: subject A was asked to generate 2-4 lateral idea sketches fitted the demand of the experiment. Besides, each idea should be preliminary shading.

5. Time: half an hour for subject A to generate idea sketches. Before the subject start to generate, the author described the demand of experiment to the subject A and also let him to thinking for fifteen minutes. In the other quarter of an hour after the concept generation phase, the subject A is asked some specific questions about his sketches for the minor data of analysis. The sum is one hour.

6. Recording Process: during the experiment, the subject A is recorded by video among all time. And the author used digital camera to catch visual image per minute. After the experiment, the subject A is asked some specific questions about his sketches.

After experiment one, the author has known the cognitive behavior of designer while using conventional media generating concepts. After the

experiment in the traditional way, the experiment in computer-aided way in the same degree should also be discussed. So there comes experiment two.

### 2.2.2. *Experiment Two: Computer Media*

This experiment is about the behavior that designers generate sketches while using computer media in the concept generation stage. According to the new computer-aided sketching way, not concerning about conventional media. The objective is to discuss the cognitive behavior of designers generating concepts in the computer-aided aspect.

1. Subject B: one industrial designer who has perfect ability of generating concepts and using computer, and has been educated with more than 3 years of industrial design.
2. Topic: the same as experiment one.
3. Tools: Hardware (Pentium II 300 computer, 19 inch monitor, keyboard and mouse), Software (Pro-Engineering)
4. Process: the same as experiment one.
5. Time: the same as experiment one.
6. Recording Process: the same as experiment one.

### 2.3. ANALYSIS

The major analytical data of this research is the visual data recorded from the experiment one and two, and the minor aided data is the specific questions which are asked after the concept generation phase. This is the research dealing with visual process but not with verbal process. The reason why the author chooses visual process for the analytical data is that it is a tough task to ask designer to generate concepts with computer. So if the designer is still asked to think aloud while doing this tough task, the author believes that the result of the experiment will be disturbed. For this reason, the author decides to use visual data as analytical data. Besides, for the unease of getting visual data, the author takes a photo with digital camera per minute. And the total process of experiment is recorded by video in order to prove the total process of visual data.

Additionally, some absent aspects would exist for the only concerning about visual data as analytical source. So the author decides to use verbal data to aid visual data. The verbal data is from the specific questions that are asked by the author after the sketching phase.

The author uses three kind of coding schema (Table 1) to analyze the major visual data and minor verbal data. Two schema comes from the background review, which include the cycle of 'seeing-imaging-drawing' (Mckim, 1980) and the synthesis of 'seeing-moving-seeing' (Schon and Wiggins, 1992) and one type of argument -- 'seeing as' (Goldschmidt, 1989,1991,1992,1994,1995). The

other is the deduction about 'total' and 'detail' of sketches from the author. 'S-I-D' represents 'seeing-imaging-moving', 'S-SA' represents 'seeing-seeing as' while 'T-D' represents 'total-detail'.

TABLE 1. Three Coding Schema

Coding Scheme	Clarification	Source
S-I-D	S: seeing I: Imaging D: Drawing	Mckim (1980)
S-SA	S: seeing SA: seeing as	Schoon and Wihggins (1992) Goldschmidt (1989,1991,1992,1994,1995)
T-D	T: total D: detail	The Author's Deduction

### 3. Cognitive Phenomena of Visual Thinking

This chapter contains both the recording and coding results of two experiments and some sketches of two subjects during the phase of concept generation. The author uses three coding scheme to analyze the major visual data in the sketching process of two subjects. The relation between coding result of two subjects and time can be produced as a table.

Figure 1, 2 and 3 represent the relation between coding result and time of subject A and B who generate concepts with conventional and computer media. The numbers shown on the top of the figure interprets the four sketches drawn by subject A and two sketches by subject B, and number 1 means the first sketch and so forth. From the representation of these three figures, we can clearly see the shifting times and amounts of cognitive behavior of two subjects. According to the convenience of pens and papers, subject A can generate a rough sketch in a short time. Besides, according to the immediate visualized feedback of computer, subject B would generate a more concrete sketch in a longer time.

First, on Figure 1 about the aspect of 'seeing-imaging-drawing', subject A spends more time 'drawing'(Figure1-a) than 'seeing' and 'imaging' when subject B spends more time 'imaging' and 'drawing'(Figure1-b) than 'seeing'.

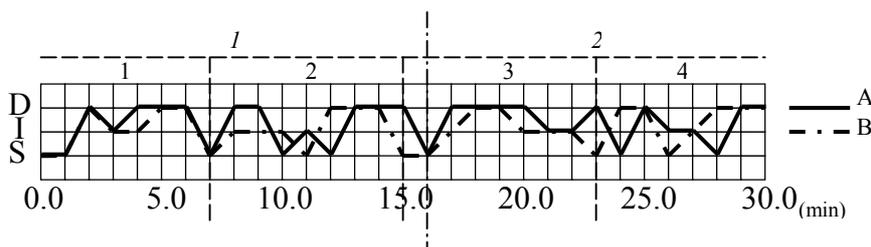


Figure 1. S-I-D Coding Result vs. Time of Subject A and B.



Figure 1-a. 'drawing' by Subject A and Figure 1-b. 'drawing' by Subject B

Second, on Figure 2 about the aspect of 'seeing-seeing as', subject A spends more time 'seeing' than 'seeing as', and the standing time of 'seeing as' is rarely long. But subject B spends almost the same time 'seeing' as 'seeing as', and the standing time of 'seeing as' is longer than that of subject A.

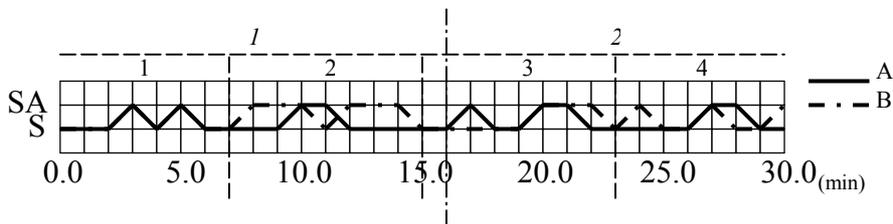


Figure 2. S-SA Coding Result vs. Time of Subject A and B.

Third, on Figure 3 about the aspect of 'total-detail', subject A spends more time on the concentration of 'total' than 'detail', likewise the standing time of attention on 'detail' is usually not long. Besides, subject B spends almost the same time on the concentration of 'total' as 'detail', and the dissimilarity is that the shifting times to 'detail' is more than that of 'total'.

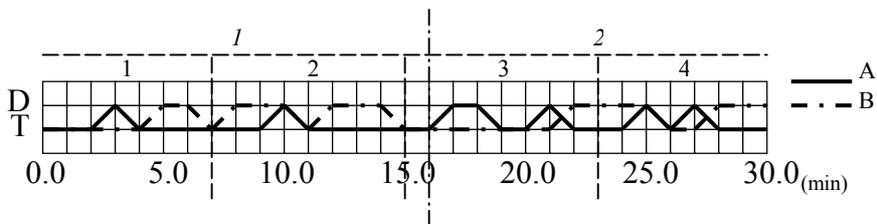


Figure 3. T-D Coding Result vs. Time of Subject A and B.

So the author interprets the visual cognitive behavior of the designer when he/she uses conventional media in the concept generation stage to be a changeable process, and the behavior of seeing and drawing here is more important than imaging. Moreover, the author interprets the visual cognitive

behavior of the designer when he/she uses computer in the concept generation stage to be a more stable process, and the behavior of imaging and seeing as here is more important than other else.

The dissimilarity of visual cognitive behavior of two subjects comes from the different media what they uses to generate concepts. Not only the cognitive behavior would be different, but also the representation of sketches or drawing would have some specific phenomena for the characteristics of two media. The particular description will be discussed in next chapter.

#### **4. Conclusions**

From the result of the analysis of visual and verbal data from experiments, the author derives some cognitive phenomena of designers while he/her generate concepts with computer or conventional media.

When a designer uses conventional media as tools to generate concepts or ideas, his/her cognitive behavior is simpler than who uses computer. First of all, after the designer been told the principles of the design case, he/her begins to generate some ideas in his/her mind. This period of process should be 'stimulus' and then 'thinking'. Then the designer will use pens drawing or sketching on the paper, and this phase is called 'drawing'. During the process while the designer draws, he/she will see the representation of sketches on the paper, and sometimes when the designer concentrate on some specific figural properties of this kind of 'seeing' behavior, he/she will see the image as some thing else. The shift of 'seeing' and 'seeing as' will stimulate the designer to generate some 'imaging' on his/her mind. Sometimes, the focus of the designer will shift from the 'total' to the 'detail' of the sketch, but the shifting time little last long. The cycle of these cognitive behaviors will not stop until the task about generating sketch is well done.

On the other hand, when a designer uses computer media to generate concepts or ideas, his/her cognitive behavior is much more complex than traditional method. First, after the designer been told the principles of the design case, he/her begins to generate some ideas in his/her mind. This period of process should be 'stimulus' and then 'thinking'. The forepart is just the same as traditional way. Then the designer will use the keyboard and mouse to draw or sketch on the monitor, and this phase is called 'drawing'. Among the movements of drawing, the designer will gaze the figural properties of sketches on the monitor, and he/she will easily see the representation as some kind of image for the intensive visualization of computer. The shift of 'seeing' and 'seeing as' will stimulate the designer to generate some 'imaging' on his/her mind in the same way as traditional method, but more stronger and frequent. Likewise, the attention of the designer will shift from the 'total' to the 'detail' of the sketch,

but the shifting time are much more frequent and standing longer than that in the traditional way. The cycle of these cognitive behaviors will also go on until the task about generating sketch is well done.

Besides, from the representation of the visual result of experiments, there are some appearances of sketches or drawings. First, on the aspect for the amount of generating concepts, the designer can generate more concepts when he/she uses conventional media than computer. The reason is the deficiency of present computer systems. Second, on the representation of preliminary sketches or drawings, the stroke representing in traditional way is rough while that in computer-aided way is concrete. That is because of the characteristic of these two different media. Third, on the aspect for shading of sketches or drawings, the designer can easily use the computer system (Pro-Engineering) to generate image with immediate shading, and that's the shortcut of traditional media as pens and papers. For the immediate visualized feedback of computer, the designer can easily been influenced to have some imaging in his/her mind. However, that's the critical point of computer system when the designer uses it as the tool to generate concepts. Besides, the significant point is just the reason why the visual thinking of cognition of the designer will be different while he/she uses computer to generate ideas in the stage of concept generation.

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