INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN
ICED 05 MELBOURNE, AUGUST 15-18, 2005

DESIGN SPACE BLENDING-A KEY FOR CREATIVE DESIGN

Toshiharu Taura, Yukari Nagai and Shinji Tanaka

Keywords: Similarity, Creativity, Conceptual design, Design Space Blending

1 Introduction

In this paper, a method for conceptual synthesis in design is proposed. Conceptual synthesis is useful for creative design; however, the possibilities for selecting two different concepts to synthesize may be unlimited. The problem of conceptual synthesis stems from the difficulty in selecting two different concepts that are appropriate for creative design. In this study, the authors attempt to determine the conditions for successful conceptual synthesis, focusing on the dissimilarity (distance) between the two selected concepts. A design experiment was performed in order to inspect the results of creativity, which depend on the dissimilarity between the two given concepts. From the results of the design experiment, we found that higher creativity could be obtained in the case based on two concepts of high dissimilarity compared with the case based on those of low dissimilarity.

1.1 Background

"Where do concepts come from? " is a perennial question in design [1]. It has been pointed out that conceptual synthesis is a key answer to this question, particularly for steering design toward creativity. This has been reported in both empirical example and scientific research result.

Empirically, the invention of the art knife –the first snap-off blade cutter– is a good example. The inspiration for this incredible idea came from breaking off segments of chocolate bars and analyzing the sharp edges of broken glass [2].

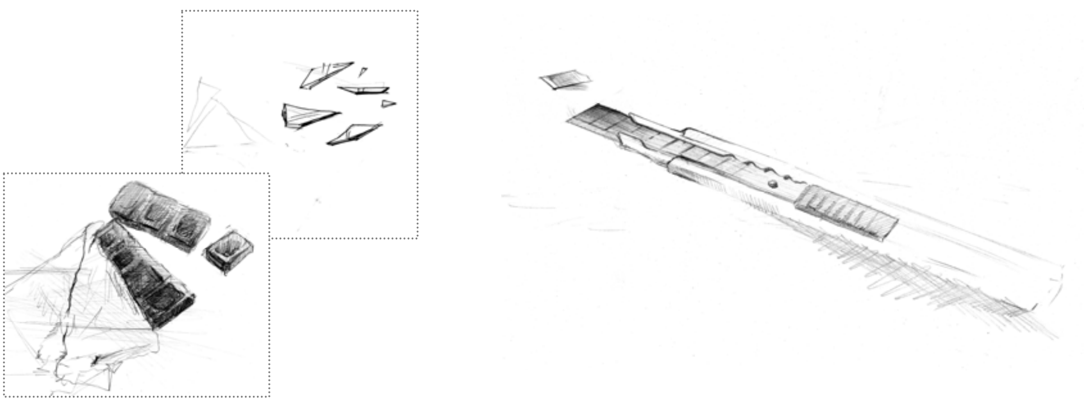


Figure 1. Example of invention from synthesizing concepts

It can be interpreted that this invention was realized by synthesizing a concept (function) abstracted from existing things.

Conceptual synthesis also has been studied in the field of cognitive science. Finke et al.[3] described conceptual synthesis as an efficient means of developing creative insights into new inventions, and carried out experiments on creative concepts by imagery synthesis in mind.

Kokotovich and Purcell [4] investigated various issues related to mental synthesis and creativity in design and compared the features of creativity in 2D designers, 3D designers and non-designers.

Yoshida et al.[5] are conducting a living thing generation experiment, which combines two or more parts prepared beforehand. They have reported that unexpectedness and creativity have a positive correlation.

Thus, conceptual synthesis is closely associated with creativity in design.

However, the following problems remain to be solved.

- Compared with the situation in actual designs, such as the case of the cutter knife, the experiments of Finke et al., which allowed only a few operations, such as expansion, reduction and rotation, were much more restricted than real design work. It is more realistic to ease restrictions by saying, "As long as it has inherited a certain feature, the original form may change," from the viewpoint of creativity. Therefore, it is necessary to conduct an experiment that imitates real design work.
- Although it is clear that a new creative concept can be generated by synthesizing two different base concepts, it is still unknown what type of base concept is valid for realizing high creativity. From the viewpoint of supporting creative design, it is necessary to clarify what type of relationship between the base concepts is effective in promoting highly creative designs.

In this research, our goal is to elucidate the mechanism of conceptual synthesis. From the viewpoint of creativity, we are interested in the design space blending, because not only the concepts but also design spaces which are constructed by abstracting the concepts seem to be blended in the process of more real-world creative design work.

Fauconnier and Turner [6] have focused on the construction process of meaning in ordinary discourse. They have analyzed how conceptual integration creates mental products and how to deploy systems of mapping and blending between mental spaces. From the viewpoint of mental space theory, they have shown that conceptual integration operates on two input mental spaces to yield a third space which is called the blend. That blended space inherits a partial structure from the input spaces and has an emergent structure of its own.

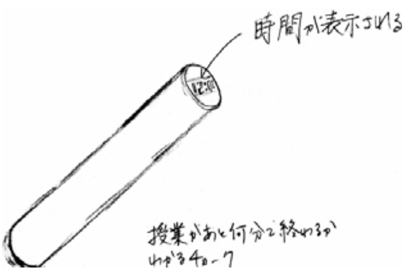
We consider that in the case of designing, the blended design space has more schematic and abstract information than the input spaces of two concepts. Therefore, design space blending produces a specifically emergent structure to create a novel design concept.

This research focuses on the following two processes: a process that abstracts a concept, and another process that show the dissimilarity between concepts. The reason for focusing on the former is that in design space blending, an abstract concept seems to be more closely associated with a high-creativity design rather than a concrete concept, such as form. The reason for focusing on the latter is that we can infer that the dissimilarity between the entities used as the basis of the design source is associated with the creativity of the design result.

1.2 Assumption

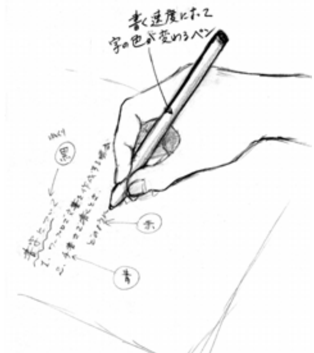
The assumption in this study is that for blending the design spaces in the process of composing, the concept abstracted from existing entities by a designer affects the design results. Figure 2 shows the difference between the two design processes, one that was performed at the form generation level and the other at the conceptual generation level. In this case, the two base entities were a ‘chalk’ and a ‘clock’. The idea for ‘chalk with a clock’ (left) is an outcome of the form generation level of the design process and the ‘color-changing pen’ (right) is an outcome of the conceptual generation level of the design process. The latter is an innovative idea for a new type of pen, the colors of which change with writing speed. It is inferred that the latter idea needs a higher abstract level of thinking in the design process and shows a higher creativity than the former.

This chalk has a clock to show time.



‘chalk with a clock’

Ink color changes with writing speed.



‘color-changing pen’

Figure 2. Difference between design process

Although a good result, to some extent, is also obtained in the case of shape creation by the form generation level as shown in Figure 2, ‘color changing pen’ actually indicates more feasibility in the direction of functional creation by abstract thinking at the conceptual generation level, which leads to higher creativity in the design outcome.

On the other hand, we propose in this research that there may be a relationship between the dissimilarity between base entities and the creativity of a design result. In the case of low dissimilarity between two base entities, although concept generation is easy, the creativity of the result is not high. On the other hand, when there is high dissimilarity between two entities, concept generation is difficult, but the result show high creativity. This is because the designer must construct more abstract design spaces in order to blend them.

2. Aims and hypotheses

2.1 Aims

In this research, we aim to clarify the relationship between design space blending and creativity in design by focusing on the dissimilarity between the base concepts.

2.2 Design spaces and hypothesis

Analysis progresses by paying attention to the conceptual distance between two entities for synthesis. According to the research of Yoshida et al., the distance between concepts is described as unexpectedness. Generally, the distance between concepts is indicative of the degree of similarity between two entities, or their dissimilarity [7] [8]. In this research, the term 'dissimilarity' is used because it is the difference between the entities that is significant for conceptual synthesis. The conceptual dissimilarity between entities has an individual difference, and it is measured for every subject at the beginning of an experiment. In this research, it is inferred that there is a relationship between the dissimilarity among the base entities synthesized and the creativity in the design outcome, which will be described as follows.

Table 1. Relationship among distance between entities, difficulty of design and abstract level

Dissimilarity between entities	Difficulty of design	Abstract level of design space	Creativity of designed object
Low	Low	Low	Low
High	High	High	High

In this research, the following hypotheses are proposed regarding the dissimilarity between entities, the degree of abstract level of a designer's thinking, and the creativity in the design outcome.

- HYPOTHESIS 1

In design creation which has been carried out by synthesizing two entities, the abstract level of design spaces increases proportionally to the dissimilarity between the base entities.

- HYPOTHESIS 2

The design result generated from base entities which are more dissimilar shows higher creativity.

3. Methods

3.1 Outline of experiments

One of the design experiments, which focused on the image creation of artificial objects by synthesizing existing knowledge, was carried out by Finke et al [9]. In this experimental study, which aimed to draw some general principles of creative cognition, the subjects were given stimulus sets – formed by fifteen basic object parts, to create an invention. The subjects were asked to combine three basic object parts in their mind to invent a new object that might be useful, name it, and represent it in an illustration. Under the conditions of Finke's research, the subjects were allowed to vary the size, position, or orientation of any part but they were not allowed to bend or deform most of the basic object parts.

As mentioned above, our research differs from the experiment of Finke et al. in the following points.

- The base object is not a simple form but an entity

- Regarding generation, the new entity is required to inherit at least a certain feature of the base entities but its form can be changed

3.2 Evaluation of creativity

The design results are evaluated based on Finke et al.'s method, which evaluates them from the viewpoint of 'practicality' and 'creativity', on a five-point scale.

4. Experiment procedure

4.1 Investigation of subjects' concept space

At the start of the experiments, the subjects were required to arrange nine objects: a plastic bottle, charcoal, a fish, a bird, a star, a flower, a thermometer, scissors and wind according to their dissimilarity in function and form, from a glass, which was the standard entity in this experiment. The nine objects were divided into three groups by their dissimilarity with respect to function and form: low-dissimilarity, intermediate-dissimilarity, and high-dissimilarity groups. Given this result, the base entities that were used in the design session were determined as follows. The three base entities for each subject were selected from the three groups respectively so that each entity belonged to the group of the same dissimilarity level from the viewpoint of both function and form.

4.2 Design session

Before the design session, a preliminary experiment (10 min) was carried out. The task involved designing a new entity by synthesizing two different entities, namely, a car and a dolphin. After the preliminary experiment, three design tasks (10 min each) were assigned to each subject in turn. To explain how to synthesize the entities correctly, the subjects were told they could abstract the entities as long as the final result inherited a certain feature from each.

Figure 3 shows examples of the sketches produced during the design session by two subjects.

During these design sessions, the subjects were required to verbalize their thoughts. These three tasks were designed as follows.

- 1st design session (10 min)

  Task: design a new object by synthesizing the glass and an entity selected from the low-dissimilarity group

- 2nd design session (10 min)

  Task: design a new object by synthesizing the glass and an entity selected from the intermediate- dissimilarity group

- 3rd design session (10 min)

  Task: design a new object by synthesizing the glass and an entity selected from the high-dissimilarity group

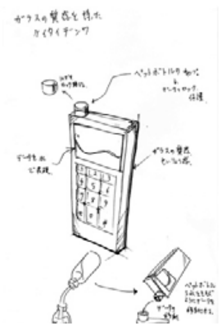
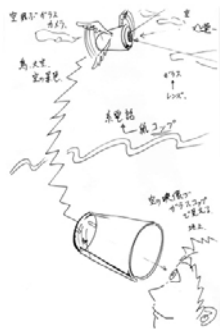
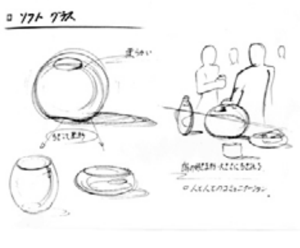
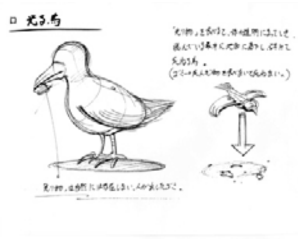
Low dissimilarity	Intermediate dissimilarity	High dissimilarity
 S1 : a glass and a plastic bottle ‘glass type mobile phone’	 S2: a glass and charcoal ‘wind-bell makes negative ion’	 S3: a glass and a bird ‘flying camera’
 F1 : a glass and a plastic bottle ‘joint-ball bottle’	 F2 : a glass and a fish ‘soft glass’	 F3 : a glass and a bird ‘shiny bird’

Figure 3. Sketches from the design session

4.3 Evaluation of design results

The design results were evaluated by 10 people along two dimensions; ‘practicality’ and ‘creativity’, using a five-point scale for each.

5. Results of experiments

Table 2 shows the result for each subject’s concept space. Given this result, the experimenter selected ‘a plastic bottle’ for its low dissimilarity with a glass and ‘a bird’ for high dissimilarity, which are the same choices made by the two subjects. The entity of intermediate dissimilarity was different between the two subjects, and the experimenter selected ‘charcoal’ and ‘fish’ for each. Therefore, the idea from the synthesis of a glass and a plastic bottle was the case of low dissimilarity and that of a glass and a bird was the case of high dissimilarity. Figure 4 shows six sketches drawn by the two subjects. Each sketch represented a new idea for the designed object. For example, S3 is called ‘the flying glass camera’ and it can fly up to the sky to send us pictures from above.

Table 2. Dissimilarity from a glass on two viewpoints

Dissimilarity from ‘Glass’				
Subject	viewpoint	Low	Intermediate	High
S	Form	**Plastic bottle**	Star	Fish
		Flower	Wind	**Bird**
		Thermometer	**Charcoal**	Scissors
	Function	**Plastic bottle**	Star	Fish
		Flower	**Charcoal**	Scissors
		Wind	Thermometer	**Bird**
F	Form	Flower	**Fish**	Charcoal
		Plastic bottle	Thermometer	Scissors
		Star	Wind	**Bird**
	Function	**Plastic bottle**	**Fish**	**Bird**
		Flower	Scissors	Scissors
		Thermometer	Star	Charcoal

Table 3. Results of evaluations

	S1		S2		S3		F1		F2		F3	
name	Mobile phone		Wind bell		Flying camera		Joint bottle		Soft glass		Shiny bird	
entity	Plastic bottle		Charcoal		Bird		Plastic bottle		fish		bird	
dissimilarity	low		middle		high		low		middle		high	
items	practicality	creativity	practicality	creativity	practicality	creativity	practicality	creativity	practicality	creativity	practicality	creativity
rate	3.3	3.5	3.2	1.8	3.2	4	2.7	3.5	3.5	3.5	1.7	4.3

Table 3 shows the average rating for each sketch. The highest rate of ‘practicality’ is shown in F2 (3.5), which is synthesis of a glass and a fish. The highest rate of ‘creativity’ is shown in F3 (4.3), which is the result of a synthesis between a glass and a bird. The lowest rate of ‘practicality’ is also shown in F3 (1.7). The lowest rate of ‘creativity’ is shown in S3 (1.8), the synthesis of a glass and charcoal. The highest creativity was realized by both subjects during the third design session.

The results revealed that the highest creativity is obtained in the case of conceptual synthesis from two base entities of high dissimilarity.

6. Conclusion

In this study, the highest creativity was obtained in the case of synthesizing two base entities of high dissimilarity. This result shows that probably we can determine the conditions for successful conceptual synthesis. That is, to obtain a highly creative synthesis more dissimilar entities should be selected. It also shows the blend of design spaces which, structured by the integration of two highly dissimilar input design spaces, have an emergence structure with the features of a highly abstract notion and highly creative situations. This investigation develops the study on relationships between the design knowledge to select the original input concepts and the dissimilarity of two input concepts, which yields a design space blending that, is rich in creativity. However, to determine the validity of the hypothesis proposed in this study, we must analyze our data more closely and perform further studies. Currently, we are analyzing the relationships between the high abstract conceptual level in the creative design process and design space blending.

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Toshiharu Taura
Kobe University
Graduate School of Science and Technology
1-1 Rokkodai, Nada, Kobe
Japan
Phone: 81.78.803.6503
Fax: 81.78.803.6503
E-mail:taura@mech.kobe-u.ac.jp

Yukari Nagai
Japan Advanced Institute of Science and Technology
School of Knowledge Science
1-1 Asahidai, Nomi, Ishikawa
Japan
Phone: 81.761.51.1706
Fax: 81.761.51.1149
E-mail:ynagai@jaist.ac.jp

Shinji Tanaka
Kobe University
Graduate School of Science and Technology
1-1 Rokkodai, Nada, Kobe
Japan
Phone: 81.78.803. 6503
Fax: 81.78.803. 6503
E-mail: s-tanaka@mi-5.scitec.kobe-u.ac.jp