A research into the thinking modes in creative design process

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Abstract

The authors made four design experiments to know how student designers create design solutions in translating goal description to its visual form. Firstly, in experiment 1 and 2, several thinking types were found in the sketches of the subjects, and then confirmed that they could sum up to two thinking modes (Metaphor mode and Form-making mode) depending on the difficulty in translating the goal description to its visual form. In experiment 3, it was found that the subjects took varied ways with changing thinking modes to reach final sketches depending on the difficulties of goal descriptions. Lastly, in experiment 4, the subjects were given a very difficult goal description, and the experimenters analyzed the sketches and words written in the sketches. As the result, some hierarchies of meanings of goal description were found in the subjects' thinking processes. The subjects seemed to search clues of translating word to form through low-leveled words. Consequently, the author asserted that to make creative design, designers need to go along a thinking path with repeated changes of the thinking modes.

A research into the thinking modes in creative design process

Introduction

Recently, computer seems to become essential tool of design works. However, designer's creativity is not increased by using computer, but rather seems to be declined. In design education, it is also serious problem. We should pay attention to the human design activity again. In this situation, we focused on the creative thinking process of design.

Finke made famous experiment on the creative cognition, in which they observed how the subjects invent creative things by using given geometrical shaped parts (Finke, Ward and Smith 1992). However, the design process usually started by setting a design goal, and designer has to generate forms fitted to the design goal in his/her thinking process. If the thinking process shown by Finke was a creative thinking, there might be another type of creative thinking in design. Goldschmidt had remarkable study on the designer's thinking process focused on the designer's sketches (Goldschmidt, 1994). Purcell and Gero made effort to sum up the recent studies on the relations of designer's drawings and creative thinking process (Purcell and Gero 1998). Candy and Edmonds presented result of long time survey of certain bicycle designer's thinking process (Candy and Edmonds 1996). Maher, Poon and Boulanger presented a research on the thinking process of design focused on the thinking path (Maher Poon and Boulanger 1996).

Based on those results, we had several experiments to know the relations of designer's drawings and creative thinking process from the view points of thinking mode and thinking path.

Experiments

For the purpose of understanding how creative thinking progresses in design process, we made four experiments focused on drawings as important clues.

Experiment 1

Purpose of the experiment 1
The purpose of this experiment was to know how visual image of a new object is created from verbal goal description (key words).

Procedure of experiment 1

About 80 subjects (first year class students of Chiba University) were assigned a task to design two kinds of paperweights, one of which was to give a sense of 'relaxation' and the other was to give a sense of 'excitement'. This experiment was composed of three steps in the entire process. The first step was made for the purpose of giving training of thinking and drawing to the subjects, because they were still in rudimentary stage in the first year design class.

At first the subjects were assigned two tasks. One was to draw the most favorite plant and the other was to imagine an unknown plant and draw it. After a week from this initial training, the subjects were assigned the second task that was to design a paperweight with which gives a sense of 'relaxation'. After 20 minutes was given for drawing, sketches were gathered and copied for using them to examine subjects' mid term output of thinking process. Then the subjects were instructed to continue drawings. Color pencils were used for drawing this time. After 30 minutes was given for drawing, sketches were gathered and copied again.

After a week from the last task, the subjects were assigned the third task that is to design a paperweight with which gives a sense of 'excitement'. The same process as the second task was taken in this task.

Evaluation of the sketches

Methods of evaluation of sketches were made on the basis of following two ways.
Firstly, two expert design educators evaluated mid term sketches (at 20 minutes after start) in following evaluating items by 5 steps grading (grade 3 was neutral point) on each. We thought that two evaluators were sufficient number because the evaluation items required not so subjective judgment and the results of evaluation would be not so different between the two evaluators. Moreover, the evaluators were experts in design education and they used to evaluate many students works in every days work.

(1) Whether new form was intended to generate or not?
(2) Whether form of ready-made objects were used or not?
(3) What was drawing skill?
(4) Whether a metaphor was used or not?
(5) Whether intended to make aesthetic form or not?
(6) Whether intended to make funny sense or not?
(7) The number of ideas (normalized score 0 to 5).

The results of averaged grades on the evaluation items were analyzed with using the principal component analysis method. From the result of the analysis, the values of the principal components on each sketch were positioned onto two-dimensional distribution maps (Fig.1 and Fig.2).

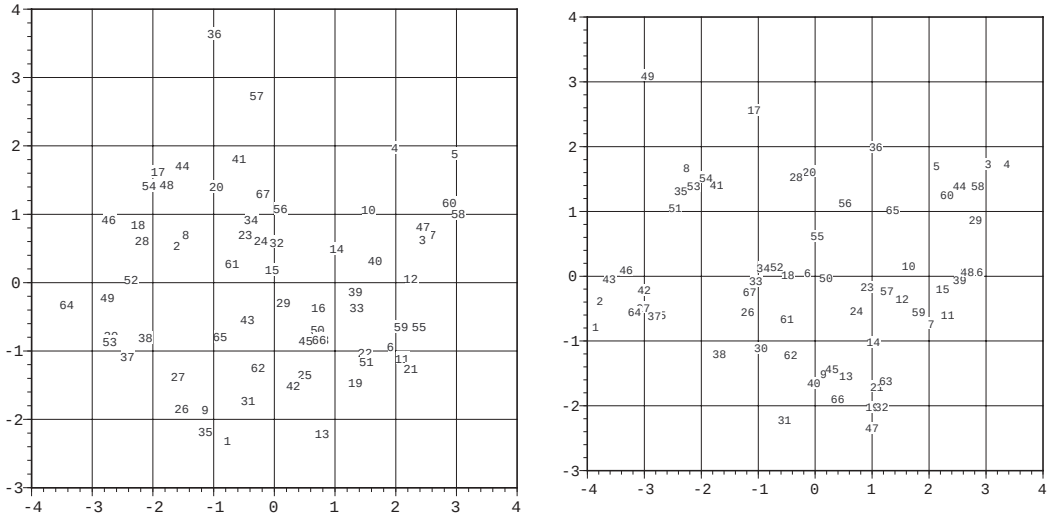

Figure 1: (Scattered graphs of PCA, Left: ‘relaxation’, Right: ‘excitement’)

From the component loading value of each principal component, we recognized as axis X (principal component No.1) represented creativity and axis Y (principal component No.2) represented ability of expression.

Based on the two-dimensional distribution graphs, the first quadrant area implies creative and good expression ability, the second quadrant area implies not creative but good expression ability, the third quadrant area implies not creative and poor expression ability, the fourth quadrant area implies creative but poor expression ability.

Examination of thinking process

In next step, we examined on the difference of two kinds of sketches drawn by the same subject, those were rough sketches drawn in first 20 minutes and colored sketches drawn in next 30 minutes in this experiment. Examination was focused on how did the subjects carry their thinking process from the start to the end of the experiment.

As the results of the examinations, several groups of thinking types were recognized. Those were as follows.

1) Type of subjects who drew sketches in evolving and modifying one sketch to get satisfied one. We named this ‘evolving type’.
2) Type of subjects who drew, at first, as possible many drawings as they could imagine, then selected one of them and refined it. We named this ‘diverging type’.
3) Type of subjects who drew only one or two sketches, but elaborated drawing. We named this ‘Adhering type’.
4) Type of subjects who drew only one or two poor drawings. We named this ‘Poor imagination type’.

Typical examples of sketches by those types are shown in Figure 2.

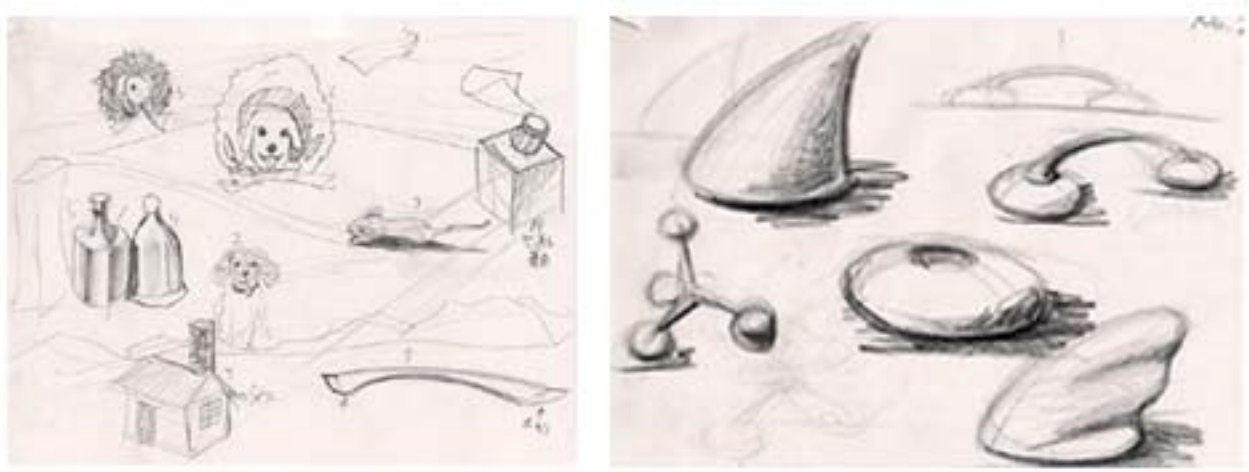

Figure 2: (A pair of sketches of divergent type and evolving type)

Analysis of the results of experiment 1

We looked into the relations between the number of sketches in each quadrant of the principal components spaces and the thinking types mentioned above. Firstly, we counted the number of samples of each thinking type in each quadrant of the principal components space. Then calculated proportions of each thinking type in each quadrant. The results are shown in Table 1.

	Relaxiation					Excitement				
	Quad I	Quad II	Quad III	Quad IV	Total	Quad I	Quad II	Quad III	Quad IV	Total
Evolving type	6 (0.46)	3 (0.15)	0 (0)	2 (0.11)	11	6 (0.4)	1 (0.07)	0 (0)	4 (0.2)	11
Diveging type	1 (0.08)	11 (0.55)	10 (0.67)	9 (0.47)	31	3 (0.2)	12 (0.86)	9 (0.56)	7 (0.35)	31
Adhering type	6 (0.46)	5 (0.25)	1 (0.07)	2 (0.11)	14	5 (0.33)	0 (0)	3 (0.17)	6 (0.3)	14
Poor imagination type	0 (0)	1 (0.05)	4 (0.27)	6 (0.32)	11	1 (0.07)	1 (0.07)	6 (0.28)	3 (0.15)	11
Total	13	20	15	19	67	15	14	18	20	67

Table 1: (The numbers of types in each quadrant)
The result was shown as follows:

1) The evolving type and adhering type were mostly seen in the first quadrant area of both cases (‘Relaxation’ and ‘Excitement’).
2) The diverging type was scattered over the second, third and fourth quadrant areas but scarce in the first quadrant area in both cases.
3) The adhering type was mostly seen in the first and second quadrant areas in case of ‘Relaxation’, but in case of ‘Excitement’, it was mostly seen in the first fourth quadrant areas.
4) The poor imagination type was mostly seen in the third and fourth quadrant areas but scarce in the first and second quadrant areas in both cases.

From these results we found that:

a) ‘Evolving type’ produced the most numbers of creative drawings, and most of their sketches were abstracted forms with drawings of repeated lines.
b) ‘Diverging type’ produced many idea sketches, and most of their sketches were cartoon like drawings of well-known objects.
c) The number of ideas was not correlated to high creativity.
d) There was some difficulty to discriminate the ‘adhering type’ and ‘poor imagination type’.

Confirmation of thinking types by preparatory drawings

As mentioned in precedent section, we assigned two preparatory tasks to the subjects before main experiment was held, those were to draw most favorite plant and then to imagine and draw an unknown plant. We examined and classified the way of the preparatory drawings of each thinking type. The classification viewpoints were as follows.

(1) Elaborative drawing
(2) Cartoon like drawing
(3) Intermediate (Could not categorized into (1) or (2))

As the results, we found that:
The averaged number of sketches in evolving type and diverging type were apparently larger than the other types.

The proportion of elaborated drawings was large in evolving type and adhering type, but was extremely small in poor imagination type, and was intermediate in divergent type.
The proportion of cartoon-like line drawing was large in divergent type and poor imagination type, but was small in evolving type and adhering type.

Those results seemed to support our classification of the thinking types.

Experiment 2

Purpose of experiment 2

The purpose of the experiment 2 was to know how the differences of the words that were hard to associate to form, and the word that was easy to associate to form, appear as the difference of drawings.

Procedure of experiment 2

This experiment was done as a part of a usual practice in first year class students of Chiba University in Oct. 2000. About 80 subjects were assigned a task to design two kinds of flower vase with two different keywords, one of which was ‘give soft image’ and the other was ‘humorous’. 20 minutes was given for each drawing task with a ballpoint pen on a B5 paper, and finally, 74 subjects presented in both tasks.

Method of evaluation

Two expert design educators evaluated each 74 sketches with following evaluation items by 3 steps grading.

(1) Whether the keyword was visualized by using metaphor or not?
(2) Whether the keyword visualized by using form itself or not?
(3) Whether the keyword was successfully expressed in drawing or not?

Analysis on the results of experiment 2

On the basis of those evaluations, the value of rate of success was calculated in each keyword. We found two typical thinking modes from the results, one was that tried to express a keyword by form itself (we named it ‘Thinking mode F’) and the other was that tried to express by using metaphor of the image from the keyword (we named it ‘Thinking mode M’). Then, we examined the results focusing on the thinking modes.

(1) The number of success in expression of form of soft image was 22, and the number of success in expression of form of humorous was 5 (Table 2).
(2) In the group of success in expression form of soft image, the number of the thinking mode M was 1, and the number of the thinking mode F was 14.
(3) In the group of success in expression form of humorous, the number of the thinking mode M was 3, and the number of the thinking mode F was 1.
(4) In the sketches by keyword ‘soft image’, thinking mode F was 20 and thinking mode M was 3 in number.
(5) In the sketches by keyword ‘humorous’, thinking mode M was 36 and thinking mode F was 28 in number.
(6) Most of metaphors related to keyword soft were imaginations from plants, water and so on; those were related with the functions of a vase. However, metaphors related to keyword humorous were based on humorous things or humorous gestures and facial expressions.

	Evaluation items__(Thinking types)	Numbers of subjects	The keyword was successfully expressed in drawing	Rate of success
soft	The keyword was visualized by mainly metaphor (M)	3	1	0.33
	The keyword was visualized by using form itsef (F)	20	7	0.35
	toss-up (evaluation value 2)	51	14	0.27
	Total	74	22	0.3
humorous	The keyword was visualized by mainly metaphor (M)	36	3	0.08
	The keyword was visualized by using form itsef (F)	28	1	0.04
	toss-up (evaluation value 2)	10	1	0.1
	Total	74	5	0.07

Table 2: The rate of success in two keywords

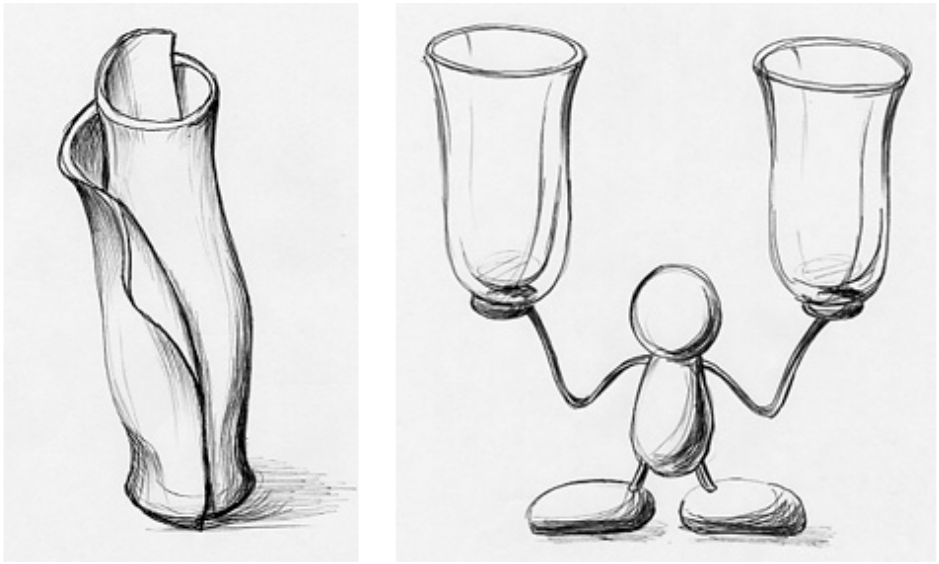

Figure 3: (A pair of sketches of F mode and M mode)

From the results, we supposed that the most of subjects used F mode when they were given keyword ‘soft image’ and used M mode when they were given keyword ‘humorous’. However, in case of the success in expression of from with keyword ‘humorous’, most of the subjects seemed to use F mode, too.

Experiment 3

Purpose of experiment 3

This experiment was held in October 2000 at Chiba University to know how the subjects created different images of design objects from 5 different keywords.

Procedure of experiment 3

The subjects were about 80 students of first year class of Department of Design and Architecture in Chiba University. The class was divided into 5 groups (the number of members of each group was about 15 to 16), and each group was assigned a task to design of streetlight giving different keyword in each: ‘calm’, ‘vigorous’, ‘familiar’, ‘cool’ and ‘elegant’. These keywords were selected

in consideration that they have as different meanings as possible each other. At first, the subjects were given 60 minutes to make idea sketches, then after it, they were given 80 minutes to make a final drawing using color pencils. The mid term sketches were gathered for examining the subjects' mid term thinking process.

Method of evaluations

Two expert design educators evaluated the drawings in each evaluation item (shown below) according to the 3-grade system.

1) Whether was the keyword successfully expressed in drawing or not?
2) Whether was the interpretation of keyword fresh and interesting or not?
3) Whether was the drawing related to other keywords or not?
4) Whether was the keyword visualized in the form by using some metaphors or not?
5) Whether was the keyword visualized in the form by using form itself or not?
6) Whether was it good design or not?

		numbers of high evaluation valued sketches (rate of success)					
Keywords	number of sketches	successfully expressed keyword in drawing	interpretation of keyword was fresh and interesting	drawing was not related to other keywords	visualized by using associations or metaphors	visualized by using form itself	good design
calm	16	3(0.15)	3(0.21)	9(0.19)	4(0.31)	7(0.20)	1(0.09)
vigorous	14	5(0.25)	5(0.36)	11(0.23)	4(0.31)	7(0.20)	1(0.09)
familiar	14	2(0.10)	2(0.14)	5(0.10)	1(0.08)	6(0.17)	1(0.09)
cool	15	6(0.30)	3(0.21)	15(0.31)	1(0.08)	10(0.29)	5(0.45)
elegant	12	4(0.20)	1(0.07)	8(0.17)	3(0.23)	5(0.14)	3(0.27)

Table 3: Results of evaluations of streetlight sketches

Analysis of the results of the experiment 3

Table 3 shows the values of rate of success in each evaluation item. The value of rate of success was calculated by ratio of numbers of high-ranked drawings to all numbers of drawings in each keyword.

(1) In the evaluation item 'successfully expressed keyword in drawing', the group of keyword 'cool' and the group of keyword 'vigorous' were successful.
(2) In the evaluation item 'the interpretation of keyword was fresh and interesting', the group of keyword 'vigorous' was successful.
(3) In the evaluation item 'the drawing was not related to other keywords', the group of keyword 'familiar' seemed to be most related to other keywords. In contrary, the group of keyword 'cool' was seemed to have no relation to other keywords.
(4) In the evaluation item 'the keyword was visualized in the form by using some associations or metaphors', the group of keyword 'vigorous' was in high rank order but the evaluation value was not so high.
(5) In the evaluation item 'it was good design', the group of keyword 'cool' and the group of keyword 'elegant' were successful.

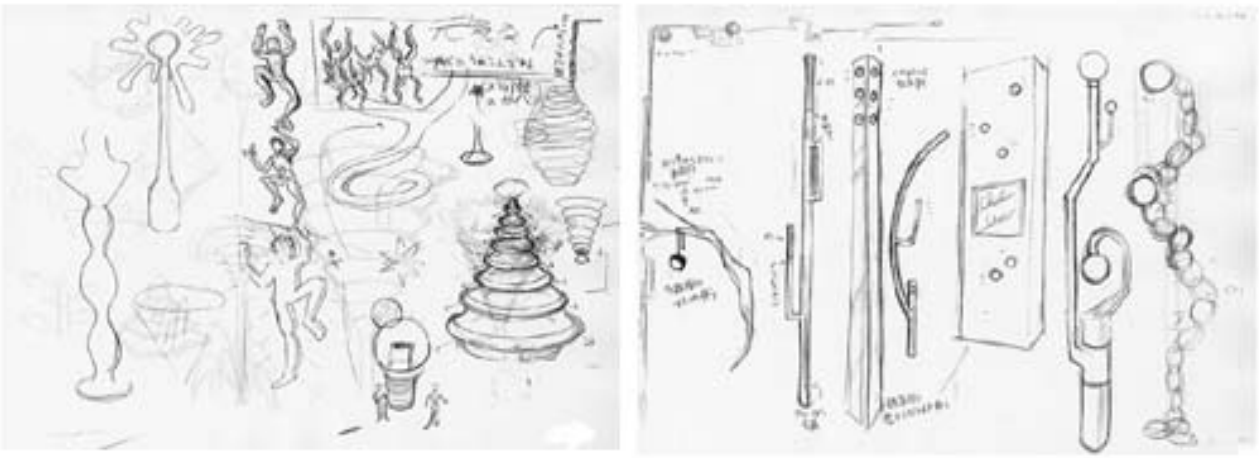

Figure 4: (A pair of sketches of ‘vigorous’ and ‘cool’)

From these results and examined result of mid term sketches, we supposed that the subjects took complicated thinking processes when they were given difficult keywords like ‘vigorous’ or ‘familiar’. There were some precedent researches on the thinking modes. Woo pointed out that L mode and R mode were switched in the thinking process of design (Woo 2001). The L mode and R mode were depended on the categories of physiological function of human brain. However, we thought that there were more complicated relations between the physiological functions and thinking modes. Then we needed to focus on the thinking path in relation with thinking mode when the subject was given ‘difficult’ keyword.

Experiment 4

The purpose of experiment 4
The purpose of experiment 4 was to know how create visual image from goal description that was difficult to relate to form directly.

Procedure of experiment 4

For getting clue of thinking process, we gathered words written in sketches and drawings during the time subjects were thinking under the task. About 80 subjects of first year class students in Chiba University were assigned a task to design ‘a chair that made sad image’. All the subjects developed their ideas on B4 paper with drawings and words appeared during they thought.

Method of evaluation of experiment 4

76 sets of idea sketches and final presentation with comments were collected and evaluated by two expert design educators based on evaluation items shown below.

(1) Whether final form was realized keywords or not?
(2) Whether basic function and structure of chair were realized or not?
(3) Whether the design was fresh or not?
(4) Whether the form was developed in the process or not?
(5) Whether it was divergent thinking or not?
(6) Whether the words were structured or not?

Analysis of the results of the experiment 4

We totalized the results of this experiment as follows.

(1) The largest number of subjects (46) was seen in the item ‘basic function and structure of chair were realized’ and the smallest number was seen in the item ‘it was divergent thinking’.

(2) In correlation values between each item, it was seen correlation between ‘the form realized keyword’ and ‘the design was fresh’ (0.49).

(3) Weak negative correlation was seen between the items ‘basic function and structure of chair were realized’ and the item ‘the design was fresh’ (-0.27).

We picked up all the words written in sketches as clues of understanding the thinking process of subjects. Then we structured the words into hierarchy of concepts (Table 4). From this table, we can guess how the subject draw sketches by using keywords in the hierarchy of concepts: for example, keywords ‘back to back’ ‘stiff’ ‘hang over’ ‘swing’ ‘lacked’ ‘bow’ were made easy to think out the forms. However, if the keyword was in high level of hierarchy and not directly related to form, the subject had to break down the keyword into other keywords in low-level concepts.

In addition, we considered that there was a parting point on the ways of thinking a form of chair in the mid hierarchy in meaning of sadness. For example, ‘back to back’ and ‘face to wall’ were in the under hierarchy of ‘alone’. It could be said that ‘solitude’ was one of general concept to construct the basic meanings of ‘making feel sad’ with ‘anxiety’ and ‘disappointment’. A framework of expression of the form was changed by difference of the keywords in the first class hierarchy. We found through the observations on the sketches that the drawings by keyword ‘pose of sadness’ was clearly different from others those used keywords in third class hierarchy. In case of using metaphor of ‘pose of sadness’, subjects seemed to think the form of chair in imaginations of when they were sad. In contrast, with the keywords ‘instability’ and ‘restricted’ they seemed to think the form of chair based on the rearrangement of their concept on physical situation in meaning of the keywords (Fig5). Therefore the form was tended to be symbolic.

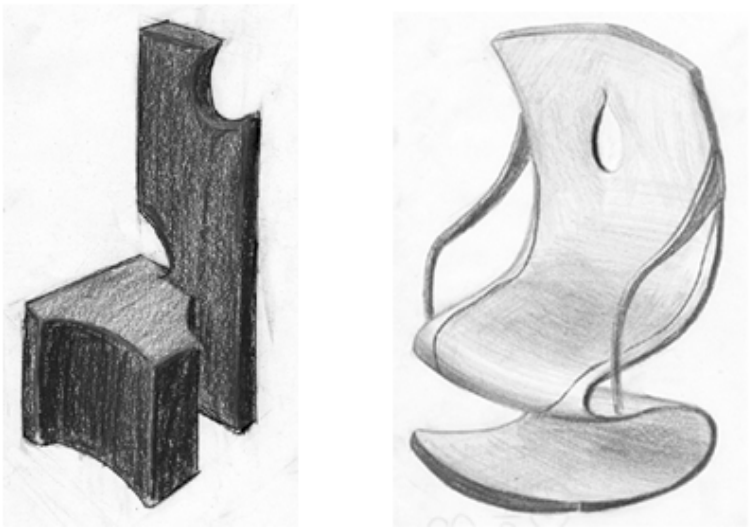

Figure 5: (A pair of sketches of sad chair)

1st class hierachy in meaning of sadness	2nd class hierachy in meaning of sadness	3rd class hierachy in meaning of sadness	words directly related to form
solitude	lonliness	alone	back to back face to wall
	sorrow		
	blockade	restricterd pressured compulsion	stiff narrow twisted distorted hang over
anxiety		instability	weak swing thin tall long left up in th air one legged three legged lacked lost the back make a hole
		protected	enveloped
disappoitment	getting depressed	pose of sadness	bow bent forward hung down low sink ragged thorned
	powerlessness		
uncomforable	agony		
	pain		

directly associated physical atributes from the word sadness	dark
	blue
	heavy
	cold

Table 4: (The hierarchy of meaning of word sadness written in drawings)

Totalized analysis and discussions for all the experiments

From the results of the experiment 1 on the design of paperweight, we came to believe as mentioned below.

In the beginning of design process, designer gets goal description of design object. The goal description can be divided into two parts: one is subjective part and the other is predicative part. We call the predicative part as ‘keyword’ because the predicative part indicates the state of the subjective part that is to be obtained after design thinking. As we saw in the experiment, even if in the simple design process, the keyword was not directly represented its visual image at first. Then, the subjects had to search as possible as many associations and/or metaphors of well-known objects. This stage of thinking process was typically seen in the drawings of the ‘diverging type’. After doing it, they might have to look into common factors in them at high abstracted level of the

imaginations or metaphors. This stage of thinking process was seen in drawings of the ‘evolving type’. It was supposed that most of evolving type could include diverging thinking process in them but not explicitly.

If the keywords of goal description were not directly related to the function (in this case “give a sense of relaxation”) of utility at first, many well-known things associated from the keywords had to be imagined in no consideration of its function of utility. This meant that the predicative part of goal description was thought separately from the subjective part. Then, many associated things and/or events were drawn in this stage of thinking process. The divergent thinking type was supposed to stay in this stage and did not go forth.

However, this process was not creative yet. To make it creative, the well-known images of associated things should be once raised to high-level abstracted thinking for form generation. This process needed trial and error in evolving forms. Only when the abstracted form could be connected to the function of utility, good solution will be carried out. This would be the reason why the evolving type could generate many creative drawings.

Some part of the adhering type could be included in the evolving type, but another part of them supposed to be included in the poor imagination type. We supposed that if most of this type could make explicit their divergent thinking stage, they would make more good results. The poor imagination type was supposed to be in low activated level of thinking.

From the results of the experiment 2 on the design of flower vase, we considered that as follows. Even if it was in the same subject, different thinking modes were found in condition of giving different goal descriptions of design of flower vase. When one gave a keyword as clue of thinking form, if it were easy to relate to form of it, he/she would express it by drawing forms directly. For example, the keyword ‘soft’ was easy to understand to express as a form because we had many imaginations of ‘soft’ things as in a quality of themselves. However, the easy keyword had tendency to become stereotyped in expressing a form associated with it. On the other hand, there was another mode in the creative thinking. In case of giving a keyword of difficult to relate to form, metaphors were used as a clue of expressing form of it. For example, it was difficult to relate the keyword ‘humorous’ to form directly. Therefore most of expressions in form by keyword ‘humorous’ were using metaphors related to states or atmospheres of humorous.

After all, we assert that, in creative thinking, the subject changed thinking mode and took the adequate one in condition of difference of a keyword as a clue of thinking form.

We supposed that the thinking types seen in the former experiment seemed not so depended on subject’s personality but rather depended on the meaning of keyword in the goal description. Then, we call them thinking ‘modes’ that anyone can take them.

From the results of experiment 3 on the design of streetlight, we presented discussions as follows. It seemed that as the keywords ‘cool’ and ‘vigorous’ were not so easy to express as the forms of streetlight, they brought unique forms in terms of being not bound by existing styles. However, only ‘cool’ can reached to good design. The judgment whether good design or not was largely depending on the possibilities of manufacturing and affections to circumstances. From these viewpoints, even if the keyword were successfully expressed in the form, it would not always mean good design and/or fresh design.

As the keyword ‘elegant’ and ‘calm’ were supposed to be easily related to metaphors and/or associations, M mode thinking might be dominated in them. However, some acceptable designs were seen in the group of ‘elegant’.

As the keyword ‘familiar’ was supposed to be not easily related to metaphors and/or associations, moreover it was difficult to image forms directly, both M mode and F mode were not efficient to make images. The ‘familiar’ was supposed to be most difficult keyword in this case. Consequently, we recognized that there were different levels of difficulty in translating keywords to forms of design objects and the subjects changed their thinking modes depended on the difficulties of keywords.

From the results of experiment 4 on the design of sad imaged chair, we presented discussions as follows.

We considered that it was not difficult to realize forms of a chair as an object that has, at least, function as a chair (subjective part of goal description). Also, it was easy to remind some metaphors associated to sad image (predicative part of goal description). However, it was quite difficult to connect ‘form of a chair’ and ‘sad image’. We confirmed it based on the result of the evaluation in which ‘divergent thinking’ was low percentage of success. In spite of the difficulties, if it could successfully connect to the form of chair, it would be a fresh design. On the correlations between final form was realized keywords’ and ‘the words were structured’, we inferred that the subjects would try repeatedly to associate the word ‘sad’ with the form of chair and searched word down hierarchy of meanings to reach a suitable one.

We examined the thinking process of drawing by the concept hierarchy, and found that there were two different thinking paths in this case. Based on the analysis, we presented a model of thinking process in creative design as a translating process from keywords to suitable visual forms of it. One of them was thinking forms by using metaphors of one’s pose in sad feeling. This needed to sink into one’s mind and had to take complicated path to make form of chair. The other was thinking forms by using conceptual metaphors and did not need complicated path. As the result, the former case had more possibilities of success in creating new form of a chair. We discussed the reason of it that the former case needed longer thinking path in searching suitable forms, and had to make repeated drawings under considering good forms.

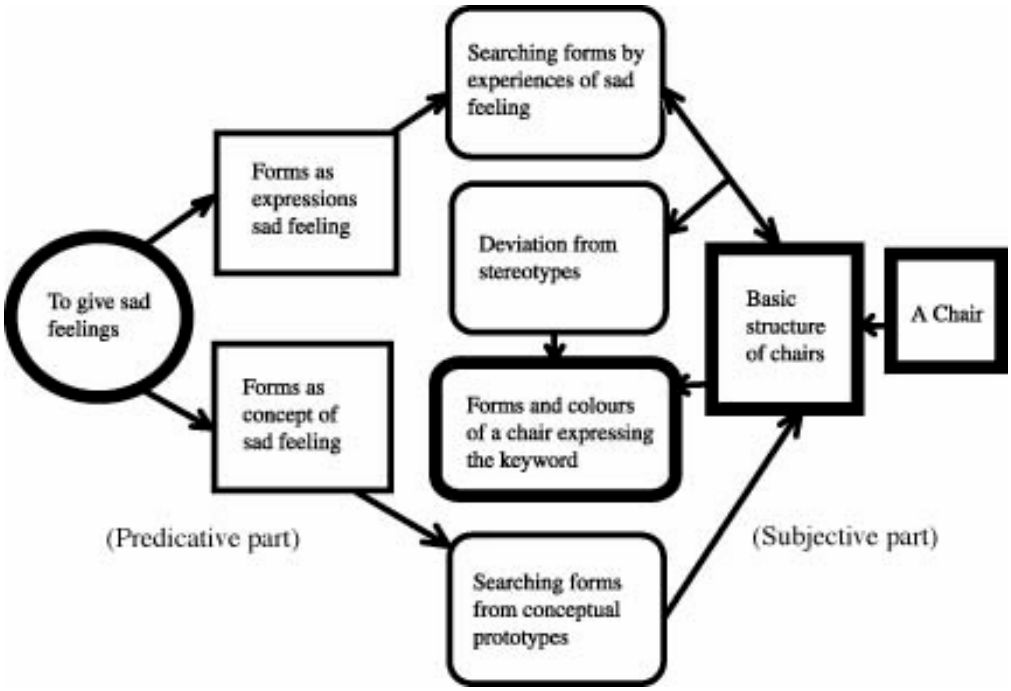

Figure 6 (Thinking path model of sad chair)

Conclusion

We concluded those results of the experiments and analyses as follows. There were several types of the thinking process in design, and they could be recognized from differences of the drawings. The thinking types could be classified into two major thinking modes (we call them 'M-mode' and 'F-mode'). The subjects seemed to change his/her thinking mode depending on the difficulties of translating goal descriptions to the forms fitted to it. If it was difficult (like as 'humorous flower vase' and/or 'vigorous streetlight'), he/she used metaphors to get a clue of thinking form (M-mode). If it was not so difficult (like as 'soft imaged' flower vase and/or 'elegant' streetlight), he/she directly searched forms (F-mode). However, good metaphors did not always result in good design and also sketches from easy keyword did not always result in fresh design. The sketches directly brought from metaphors were characterized as cartoon like and outlined drawing. Most designers who drew this type of sketches did not make effort to generate new forms. On the other hand, most designers who drew elaborated drawings from easy keyword did not make effort of searching metaphors.

From the experiments, we also confirmed that the subjects took separate path of thinking in predicative part and subjective part of goal description until he/she reached to be able to make effort of integration with the form and basic function of the design object.

The most creative form could be generated when the designer found good metaphors associated from the given goal description and kept effort of elaborations to make nicely fitting form to the predicative part of the goal description. Then, we asserted that, to get creative design, designer need to make effort of thinking in long path from goal description to the final form, and he/she needed to change thinking modes several times during the thinking process.

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