Design activities and cognitive processes of visual communication designers

- Through verbal and visual protocol analyses of the thinking processes -

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Abstract

Researches on design activity and cognitive process of different design disciplines have been explored on the foundation of design thinking theories through various research methods. This paper calls to the attention of visual communication designers' thinking processes with research goals of proposing a research method for the analysis of visual communication designer's thinking process and conducting experiments on visual communication designers to analyze design activities and cognitive processes from problem structuring phase to detailing phase. After a comprehensive review on research methods for the analysis of design thinking process, experiment appropriate for examining design activities and cognitive processes of visual communication designers is designed. Two visual communication designers participated in the experiment and the verbal and visual data collected are analyzed through two separate coding schemes. Results from the experiments indicate that visual communication designers perform various activity modes such as thinking, examining, writing, sketching, and working with computer throughout the process of designing. They structure ill-defined design problem by multi-modal activities of thinking and examining and generate either a design concept or a visual concept by writing and sketching. They refine visual design by working with computer. The simultaneity and the modal shifts of the activities have shown to make novel design decisions. Visual communication designers diverge their thoughts during problem structuring phase to preliminary design and again, during design refinement to detailing for visual exploration . Convergence of visual concept is done rapidly after examining their writings. Convergence of visual execution is done by the designer's level of satisficing design work through computer iterations.

1. Introduction

Researches on design activity and cognitive process have been explored on the foundation of theories on design thinking process using various research methods such as protocol analysis, interview, and observation. Numerous studies in different design disciplines of engineering design, architectural design, and industrial design have explored and investigated designer's thinking process yet relatively little attention is paid to the field of visual communication design.

The goals of this study is to propose a research method for the analysis of visual communication designer's thinking process and to conduct experiments on visual communication designers to analyze design activities and cognitive processes from problem structuring to detailing of design phases.

The designed experiment is conducted to obtain data for an objective and systematic analysis of visual communication design activities and different cognitive processes in regards to the symbol systems employed during comprehensive design phases. The research questions follow:

1. What modes of activities are performed during the comprehensive visual communication design process?

2. What cognitive processes are unfolded during the design activity? And to what relations do they interact with symbol systems and design phases?

3. What are the characteristics of visual communication designer's cognitive processes that differ from other design disciplines?

The method of this research is;

1) to review literatures on the analysis methods in design thinking researches and design an experiment appropriate for the analysis of visual communication designers' thinking processes,

2) to conduct the designed experiments on two visual communication designers,

3) to analyze the data through coding schemes of activity-based design modes and cognitive processes in relations to design phases.

2. Background

2.1. Design thinking process

Design thinking process is what describes the process of structuring ill-defined problem and providing a satisficing solution (Simon, 1979, p3). Researches on design thinking process have relatively a short history and there are two dominating theories regarding the issue: Simon's rational problem solving theory (Simon, 1981) and Schön's reflection in action theory (Schön, 1983). Dorst and Dijkhuis (1995, pp262-263) have made comprehensive arguments and observations on comparing these paradigms:

"The problem solving approach means looking at design as a search process, in which the scope of the steps taken towards a solution is limited by the information processing capacity of the acting subject... Schön proposes an alternative epistemology of practice based on a constructionist view of human perception and thought processes. He sees design as a 'reflective conversation with the situation'. Problems are actively set or "framed" by designers, who take action improving the current situation."

Although these theories are considered to be dichotomic in their approaches to solving design problems (Dorst et al., 1995; Meng, 2008), recent studies have been making attempts to incorporate the theories in close relations to the other, implying the possibility of them co-existing during the process of designing (Cross, 2001; Kwak, 2008).

2.2. Analysis methods for design thinking researches

According to Cross (1999, p26), various methods have been taken to explore designers' thinking processes. The methods include observation, protocol analysis, self-reporting, project reports, and interviews. When interviewing, the designers being interviewed are mostly ones with well-structured design processes which they are renowned for. The interviewer may need a good reputation as a design researcher to draw out sincere and useful answers during an unstructured interview (Lawson, 1994; Cross et al., 1995). Another method consists

of conducting case studies of design projects in which particular projects are observed and studied (Galle, 1996; Valkenburg and Dorst, 1998). The advantages of this method are that the design project can be as real as it can get and longitudinal observations and evaluations can be conducted. One of the disadvantages is that, though the design process is thoroughly examined during the observation procedure, its generalization into theoretical knowledge is difficult (Dorst et al., 1995). Using a different approach, protocol analysis takes "think-aloud" method to identify cognitive thinking associated with the design actions while carrying out artificial projects in experimental environments (Lloyd and Scott, 1994; Cross et al., 1996). In protocol studies, it is difficult to involve large number of participants due to its in-depth analysis nature. Another rare approach is for theorists to observe and rationalize their reflections on design thinking into theories (Simon, 1981; Schön, 1983). There only have been two major theories concerning the design thinking process. In recent studies, simulation trials using artificial intelligence techniques have been conducted by AI researchers to explore human behavioral thinking in design (Gero and Sudweeks, 1998).

2.2.1. Verbal protocol analysis

Among the methods mentioned above, the most frequently used method for analyzing design thinking process is protocol analysis due to its capability of revealing the contents as well as the process of design decisions. The method itself has its validity as it has been developed and applied to numerous researches in design thinking for over some decades.

Protocol analysis uses think-aloud method where designers verbalize what they are thinking while designing. While it has its advantage of designer's verbalized thoughts being recorded and analyzed in timely manner, the verbalized thoughts cannot always represent what designers are thinking.

With protocol analysis, a design task is given to the designers. The characteristics of the task are focused on the reality and the appropriateness. A realistic, challenging, and feasible task with prototypical design problem is given within an experiment time. Most of the protocol studies have examined the conceptual stage of the design process and the time limitation for the task is around two hours. (Akin, 2002; Dorst and Cross, 2001; Kruger and Cross, 2006). The experimental setting is usually a controlled laboratory situation (Eisentraut, 1999; Kruger et al., 2006) although recently, with possible influences of the unnatural settings for designing, researchers try to set up the environment as natural as possible (Kim, 2009). Concurrent verbal data through think-aloud method are often supplemented with retrospective interviews for the insights of the thinking process.

2.2.2. Visual protocol analysis

With verbal protocol analysis, whether concurrent or retrospective, verbal transcripts are collected and analyzed to reveal specific issues on design thinking processes. More recently, visual protocol such as sketches is cross-referenced to verbal protocol to provide better understanding of the thinking processes. The importance of visual protocol is being stressed for revealing the contents of the design thinking. In recent studies in design thinking processes, especially of design disciplines with more dependency on the visualization of the design concept, visual data are being used centrally for the analysis.

Among various forms of visual protocol, sketch has been most frequently used. According to Goldschmidt (1991), sketches not only represent the images held in designer's mind on paper but also show a dialectic process. Sketches are tangible visual concepts related to the design arguments (Arnheim, 1993, p15) and they stop to tell the designer of the current work and direct the designer to proceed with the work. Sketches also utilize the invisible activity of the mind in the creative process of designing. They organize the minds of the designers who deal with the world of physical matter with vital concern with visual perception. For those reasons, sketches are be used as practical data for exploring design thinking processes.

3. Experiment

3.1. Overview of the experiment

For the study, verbal analysis of concurrent reporting, retrospective interview and visual analysis of sketches and computer iterations are being utilized to conduct the experiment for the analysis visual communication designers' activities and cognitive processes. Concurrent reporting can be useful in sequentializing the activities and visual analysis of sketches and computer iterations can be cross-referenced to the activities providing the contents of design activities.

[Table 1] Overview of the experiment

	design field	analysis method	design Phase
	visual communication design	verbal & visual data analysis	problem structuring to detailing
participants	2 sophomores majoring in visual communication design with sufficient software knowledge		
design task	visual communication design task suggested and selected by 4 expert designers/ appropriate to be coded and evaluated by the researcher		
coding method	single coder, 1-week interval, 2 times		
coding scheme	temporal activity cross-referenced with visual transformation		

The experiment is concentrated on the field of visual communication design [Table 1]. The inspected design phases are from problem structuring to detailing. Participants of the experiment are two sophomore students majoring in visual communication design with sufficient software knowledge. The design task which meets the need of its appropriateness to be coded and evaluated by the researcher is suggested and selected by four expert designers. Coding method is single-coder coding twice with one-week interval. Coding scheme is based upon temporal activity cross-referenced with visual transformation .

For the research, two separate experiments were conducted [Table 2]. Both Experiment 1 and 2 were held on October 9th, 2010. Two major differences between the Experiment 1 and 2 were experiment setting and time limitation. Experiment 1 took place in a laboratory of a university with time limitation of 5 hours. Experiment 2 took place in participant's home and had limited time of one day. Although the time limitation differed, Participant 1 took task-time duration of 4hrs 38mins and Participant 2 of 5hrs 46mins to finish the task.

[Table 2] Summary of Experiment 1 & 2

	Experiment 1	Experiment 2
experiment setting	experimental laboratory setting	natural work-place environment
time limitation	5 hrs	1 day
design project title	a poster design for an annual conference of Korean Psychological Association	
participants	a sophomore majoring in Visual Information Design without professional design experience (gender=f.)	
experiment date and time	12:30pm ~ 5:08pm, Sat. 10/09/2010	12:30pm, Sat. 10/09/2010 ~ 12:03pm, Sun. 10/10/2010
task duration	4 hrs 38 mins	5 hrs 46 mins
task location	Rm. 714 Samsunggwan, Yonsei University	Rm. 714 Samsunggwan, Yonsei University and participant's home
experiment procedure	▪ training exercise ▪ design task ▪ retrospective interview	
data collection	participant ▪ verbal: note taking on timesheet ▪ visual: sketches and drafts on timesheet, computer iterations (saved every substantial progress), final design researcher ▪ note taking during observation	participant ▪ verbal: note taking on timesheet ▪ visual: sketches and drafts on timesheet, computer iterations (saved every substantial progress), final design
design result	final design in a digital format (Adobe Illustrator, A3 size)	

3.1.1. Participants

The participants, two sophomores majoring in visual information design, were exposed to design courses such as basic information design, basic digital design, and editorial design during their prior year. They were compatible with graphic software such as Adobe Illustrator and Adobe Photoshop. They had no professional design experiences.

3.1.2. Design task and required outcome

The design task was selected with consideration of what constitutes the functions of visual communication design. The task of visual communication design can vary from poster design, editorial design, to corporate identity design. The task for the experiment must meet the following needs;

a) a task for a single visual communication designer,

b) a task that can result in a concrete design outcome, yet, simple enough to be completed in five hours,

c) a task that visual communication designers are likely to have perform,

d) a task that can be considered as a typical visual communication design work.

Four expert visual communication designers in research and in practice with more than 15 years of design experience made suggestions for the design task appropriate for the experiment. The list of tasks were from poster design, leaflet design, to B.I. and signage design.

After careful consideration, a poster design was selected as the design task appropriate for the experiment. Poster design meets the needs for the experiment as it is relatively a small project that can be done by a single designer whereas digital design project such as a web design usually takes a team of different disciplines such as interface designers, information architects, and developers. A poster design is relatively a short-term project compared to other print designs such as brochures and annual reports. A poster design can show the final design result in a form of a poster and it can contain various visual design elements such as photographic images, illustrations, and typographic elements for the designers to consider. A poster design is rather a low-maintenance design task that does not need high-tech software or higher level of design knowledge. Any designer with knowledge on basic typography and basic graphic software tools such as Adobe Illustrator and Adobe Photoshop can produce a poster. Poster design falls under the category of visual communication design,

as it is part of the design history produced from Arts and Crafts Movement, blossomed during Art Nouveau, and continuously considered as a popular medium of visual communication design.

For the research, participants were informed to design an A3 sized poster. The poster design was to include typographic elements and/or various graphic elements such as photographic image and illustration. The title of the design task was 'a poster design for an annual conference of Korean Psychological Association'. The theme, the schedule, and the location of the conference were described in the design brief.

3.1.3. Experiment setting and procedure

Two participants started the experiment by having a brief introduction from the researcher, followed by a training exercise. They were instructed to fill in the timesheet during the whole design process. For Experiment 1, the researcher observed and took notes on the participant's activity. For both experiment, retrospective interviews were conducted separately after the tasks [Fig. 1].

[Fig. 1] Experiment procedure

Most of the previous experiments conducted to analyze design activity were concentrated on the conceptual stage, taking experiment time from 1.5 hours to 3 hours. For this experiment, two different time limitations were given to find the work patterns of visual communication designers. For Experiment 1, which took place in a laboratory setting, time limitation of five hours was given to finish up a design assignment. Experiment 2 was a take-home assignment, handed with same design brief as Experiment 1, but was given time limitation of a day to finish the assignment. This way, the better working environment and the better time duration can be in a hold of, making better use of the data being collected.

The in-lab experiment (Experiment 1) was held in a multimedia laboratory in a university building.

The participant was provided with a large table to do sketches and an iMac computer (Windows XP Bootcamped) to do the computer work. The participant had an internet access to do research and image searches. As the participant proceeded with the assignment, the researcher took notes of the activities of the participant according to time.

The take-home experiment (Experiment 2) had the liberty to take the whole day to think about the design assignment and do the assignment in the comfort of home. The participant used her own computer (with Windows XP) with internet access. For Experiment 2, the researcher's observation was not included due to the location and the relatively long period of time limitation.

3.2. Data collection

After the experiments, timesheets and digital files made by participants were collected as well as the notes by the researcher. Timesheets filled by the participants with information on a) time and duration of the activity, b) description of the thinking and of the activity, and c) referred codes with writings, sketches and annotation of the sketches on the bottom part of the timesheet were handed in along with digital files of their computer iterations and final design.

For Experiment 1, the researcher's observation in a note-taking form was also added to the data to be cross-referenced [Table 3]. Retrospective interviews were mainly concerned with the method of the experiments.

[Table 3] Data collection

	participant	researcher
verbal	note taking on timesheet	note taking during observation
	writings on timesheet	
visual	sketches on timesheet	visual remarks during the observation
	computer iterations saved every substantial progress (digital file)	
	final design (digital file)	

3.3. Coding scheme

The coding scheme for design thinking research may vary according to the specific issues to be examined. Dorst's coding scheme was according to the different design thinking theories of Simon and Schön (Dorst et al., 1995). Some researchers generate their own matrix system to analyze and visualize the thinking process (Han, 2000; Kim, 2006).

For this study, the data collected were analyzed through two different coding schemes. One is to examine various activity modes visual communication designers perform while designing. The other is to analyze visual data to explore symbol systems and cognitive processes of visual communication designers.

### 3.3.1. Activity-based design modes

Activity-based design modes are how Akin and Lin analyzed the design activities of industrial designers to explore the relationship between visual data processing and novel design ideas (Akin and Lin, 1995, p214). In their study, they categorized all activities observed in the protocols. The activities designers performed during the experiment were drawing, thinking, examining, talking, writing, and listening. Activity-based design modes were found to be effective analysis of design thinking process and researchers have repeated this analysis for different research purposes (Han, 2000).

For this study, the purpose of the activity mode analysis was to visualize the activity pattern of visual communication designers during the examined design phases. The activities performed during the experiment were thinking, examining, writing, sketching, and working with computer.

3.3.2. Cognitive processes in design phases

In Sketches of Thought, Goel presented a coding scheme for sketch analysis. The sketch data were laid out by the transformation types which indicated how the episode came about [Fig. 2]. The transformation types were new generation, lateral transformation, vertical transformation, and duplication. New generation was results in new drawings unrelated to previous drawings. Lateral transformation modified a drawing into another, related but distinctly different drawing. Vertical transformation reiterated and reinforced an existing drawing through explication

and detailing. Duplication was a drawing moving to a type-identical drawing (Goel, 1995, p207).
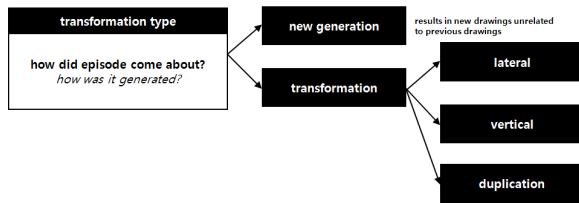
[Fig. 2] Coding scheme for sketching study (Goel, 1995)

For this research, visual data collection of sketches and computer iterations were analyzed according to Goel's coding scheme. Sketches and computer iterations were laid out according to the relations to the prior one, with the identification of either a lateral or vertical transformation.

4. Results

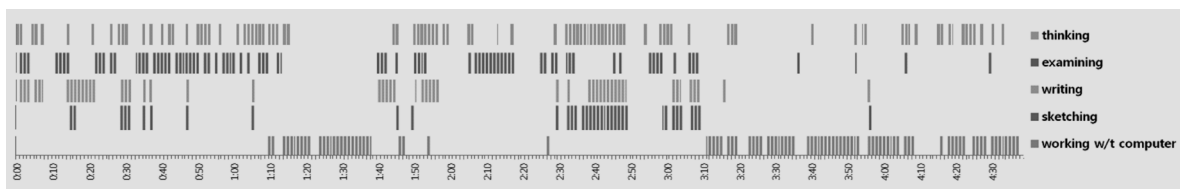### 4.1. Activity modes of visual communication designers

As seen from [Fig. 3] and [Fig. 4], both designers show similar patterns in activities performed during the design tasks. The thinking activity is consistently performed during the entire design process. The examining, writing, and sketching activities are clustered in the beginning phases of the process. The activity of working with computer is in the mid to the end phases of the process. Also, when activities are in multi-mode, significant decision makings were involved such as concept visualization, design elements to be used, and judgment call on the final design. Both visual communication designers made writings and sketches in between working with computer for design refinement as they needed to explore novel visual ideas as well as to confirm the visual decisions they made while refining.

Comprehensive analysis of the entire design phases is apposite for analyzing design thinking process of visual communication designers as they have gone through thinking activity throughout the process of designing, from problem structuring to detailing.

4.2. Symbol systems and cognitive processes of visual communication designers

Goel (1995) proposed correlation of symbol systems and cognitive processes of designers. According to Goel, designer uses natural language and sketching during the problem structuring and preliminary design phase. During these phases, cognitive process is undergoing a lateral transformation. When drafting and restricted subset of natural language are used for the final output, designer's cognitive process undergoes vertical transformation. This indicates how designer's thinking expands with ideas first and then diverges into a single solution. [Fig. 5] describes how different symbol systems correlate with different cognitive processes during the design phases.

[Fig. 3] Activity modes of visual communication designer-1
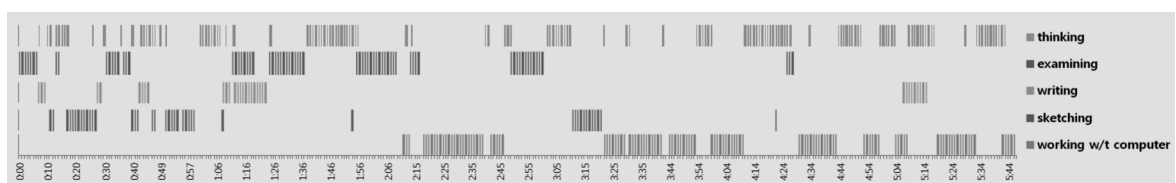
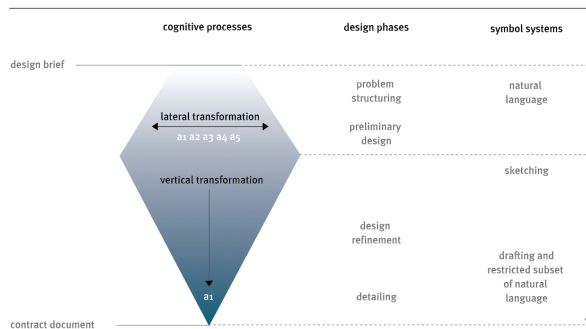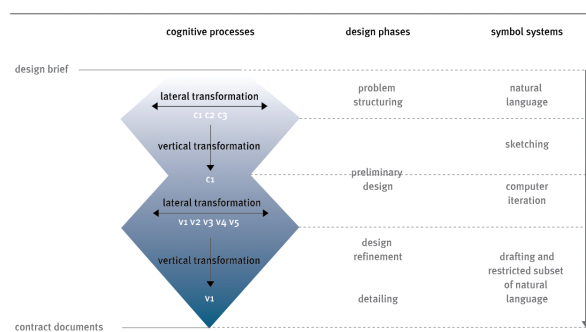[Fig. 4] Activity modes of visual communication designer-2

Fig. 5 Symbol systems and cognitive processes of designer (Goel, 1995)

[Fig. 6] illustrates how visual communication designers repeat the pattern of diverging and converging. The second lateral transformation is due to the utilization of computer software as designers can easily produce related but different iterations using graphic design softwares such as Adobe Illustrator or Adobe InDesign. This finding is significant as designers had difficult time diverging as well as converging especially during the design refinement phase using computer tools. One relied too much on the computer software making rather inappropriate visual decisions during design refinement phase and the other had trouble coming up with specific visual decision makings on typefaces, type sizes, and type colors during detailing phase.

[Fig. 6] Symbol systems and cognitive processes of visual communication designer

5. Conclusion

The aim of the study is to identify activity-based design modes that visual communication designers perform during the design process and to explore the correlation between the cognitive processes and the symbol systems in accordance to different design phases.

Visual communication designers perform various activity modes such as thinking, examining, writing, sketching, and working with computer throughout the process of designing. They structure the ill-defined design problem by multi-modes of thinking and examining, and generate either a design concept or a visual concept by writing and sketching. They refined the visual design by working with computer. When visual exploration is not sufficient through sketching, they explored further using graphic software. The multi-modal and the simultaneity of the activities, and the modal shifts of the activities have shown to make novel design decisions which are also supported by Akin's study on the industrial designer's design activity.

In relations to modal shifts, visual communication designers diverge their thoughts during problem structuring phase to preliminary design using symbols systems of natural language and sketching, and again, diverge through visual exploration during design refinement to detailing by generating computer iterations. Convergence of visual concept is done rather rapidly after the examination of their writings and sketches. Convergence of visual execution is done by the designer's standard of the satisficing level of design work of their computer iterations.

This study provides basis to design thinking research in the field of visual communication design. Through the identification of the activity-based design modes of visual communication designers and their cognitive processes, appropriate design activities can be suggested for each design phases in relations to the cognitive processes of divergence and convergence for concept visualization and for visual execution of the design solution.

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