iaSDR07
INTERNATIONAL ASSOCIATION OF SOCIETIES OF DESIGN RESEARCH THE HONG KONG POLYTECHNIC UNIVERSITY 12TH TO 15TH NOVEMBER 2007

A STUDY ON PROFESSIONAL DESIGNERS' INITIAL PERCEPTIONS OF DESIGN BRIEFS: SOME REFLECTIONS ON DESIGN PROBLEM FORMULATIONS

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ABSTRACT:

This study investigates how designers' initial perceptions of given design tasks formulated at different levels of abstraction are affected by their expertise. Our working hypothesis is that design problem formulations affect performance. These initial perceptions can subsequently influence designers' strategies and information-seeking behaviours. Using four case studies of card-sorting experiments, we were able to elicit the knowledge structure of professional designers. Verbal protocols of the experiments were analyzed, and the results indicated that both novice and expert designers focus and attend to different features of the design task descriptions. The sorting rules used by the designers were summarized into four criteria including information, abstractions, surface elements and application domains. Some guidelines are proposed to take these criteria into consideration when formulating design briefs.

1. INTRODUCTION

Gagne (1959) stated over 45 years ago that problem-solving begins with a stimulus situation. This statement still echoes to the current understanding of the basic design cycle (analysis, synthesis, and evaluation) proposed by Roozenburg and Eekels (1995) and a more iterative and reflective design process described by Schön (1983). In the two descriptive models of a design process (Fig. 1), a stimulus situation can be interpreted as a designer's initial perception and understanding of a design problem initiated by a given design brief. However, in design research, the criteria to study problem formulation are quite different from the ones used in rational problem-solving. Performance is often defined not only by efficiency or problem-solving time, but also by evaluation criteria such as creativity, usability and functionality in design solutions which are presented in the forms of preliminary sketches. Varying design briefs have been showed to affect designer's initial perceptions and subsequently influence designers' strategies and information-seeking behaviours toward a design problem (Lau 2007; Restrepo 2004). Design researchers also noticed that problem formulations using object keywords tend to lead to attachment to existing concepts and familiar solutions. These results seem to confirm the suspicion that "different wordings (abstraction levels) of briefs bring in different assumptions and lead one's thinking in different directions [...] the answers one gets depend on the questions one asks (Von Oech 1992)." Dominowski (1995, p82) also observes that "the first impression of a problem is the result of automatic encoding of information filled with our preconception of objects and experience. These tendencies cannot easily be overcome by writing guidance on the problem statement." However, little is known in the design research literature about how design expertise affects designers' initial perceptions of design briefs formulated at different levels of abstraction. In other words, what elements in a design brief will attract designers' attentions or what elements are ignored by designers. This study aims to reveal the dominating factors that influence designers' understanding of a given brief and the results are expected to help design brief writers to formulate more effective design briefs.

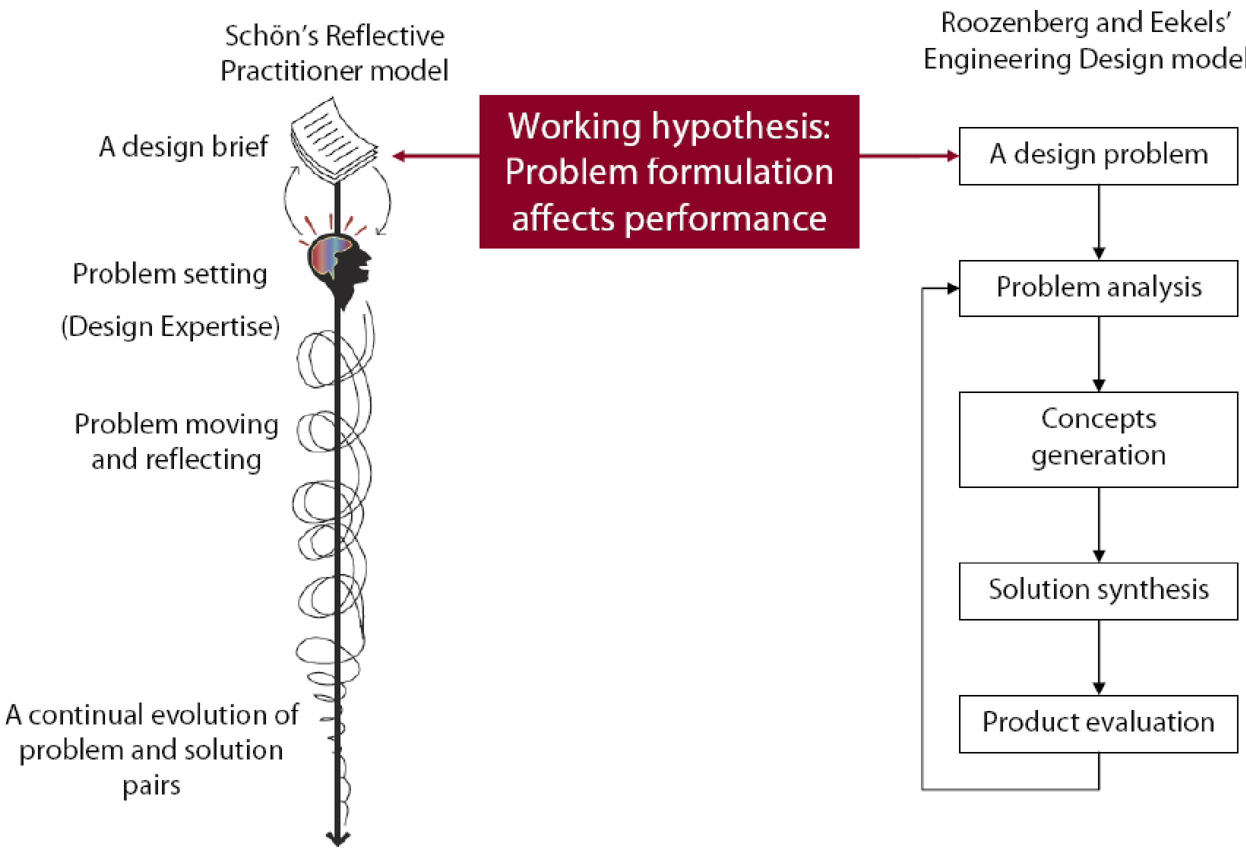

Figure 1: Two descriptive models of the design process.

2. BACKGROUND

Design expertise is often associated with a judicial choice of design strategies leading to superior design performance. Expert designers tend to form abstract conceptualizations of the original problem statement, while novices focus more on surface features of the problem (Adelson & Soloway 1988; Cross 2004; Holyoak 1991). One common finding is that experts and novices have specific preferred mental sets (representations) when solving problems. Experts are reported to tend to form abstract representations (what something does) while novices form concrete representations (how something is done) of given problems (Adelson 1984; Chi, et al 1988). Adelson's study (1984) in the computer programming domain showed that expert's analytical problem solving skills may suffer if the problem formulation does not match with the designers' preferred abstract representation. Adelson pointed out that even expert designers who are skilled at problem solving may be affected by the format of information presented to them. So, an essential factor that seems to affect designers' perception is the abstraction levels of a design brief.

Varying design problem formulation has previously been examined in the form of a heuristics method to promote creativity in design outcome (Goldschmidt 1996, Fung 2005). Two general formulations often used to categorise design briefs are “open-ended vs. close-ended” and “precise vs. imprecise”. These formulations are shown to influence designers’ performance in terms of creativity and perceived information completeness. A previous study conducted by Fricke (1996) showed that designers who were presented with a precisely formulated (and hence concrete) design brief asked fewer questions and accepted the problem requirements without critical appraisal. “The designers subsequently did not discover several requirements that could have supported the design process (Fricke 1996).” Nonetheless, these earlier efforts still relies mainly on individual brief writer’s experience that there is not yet a formal study to focus investigation on design brief perceptions. In varying the design problem formulations using abstractions, this exploratory study aims to reveal designer’s initial perceptions of a design brief which can subsequently affect design performance.

3. RESEARCH METHODS

In order to investigate designers’ initial perceptions of given design tasks, it is necessary to understand their knowledge structures. In this study, card-sorting has been shown to be a more efficient knowledge elicitation technique than structured interviews, protocol analysis and laddered grid (Burton, Shadbolt, Rugg and Hedgecock 1990), was utilized to elicit the design professionals’ knowledge structure. Card-sorting focuses on identifying key concepts that are generated by the subjects as they perform the task. This technique requires the subjects to think aloud when making their sorting decisions and to give reasons for their choices afterwards. Both concurrent and retrospective verbalizations are recorded, transcribed and coded for further analysis. The design tasks used in these card-sorting experiments were formulated by a previously validated abstraction instrument (Lau 2007). The instrument incorporated three types of abstraction, based on Rasmussen’s (1986) *abstraction hierarchy* (AH), Rosch’s (1976) *linguistic taxonomy* (LT) and *scenario-based* (SB) *design* as described by Carroll (1995), Guindon (1990) et al. These three concepts are closely related to problem-solving, preconceptions of everyday objects as well as design expertise. Abstraction hierarchy is developed to systematically analyze and solve complex problems by examining the problems from both the designer’s and end-user’s point of view (functions vs. physical structures). Linguistic taxonomy, however, suggests that there is a natural abstraction of physical objects (e.g. table) in mental representation. Any words above this level of abstraction are called superordinate (e.g. furniture) while the ones below are called subordinate (e.g. kitchen table). For expert designers, scenario-based design is applied to effectively uncover hidden design requirements and to identify potential constraints when solving design problems.

In summary, 24 design tasks were taken from an earlier study of educational design brief formulations involving design students, and also from a product design textbook (Roozenburg & Eekels 1995). These tasks were written on individual 5.5' x 4' sized postcards and were formulated based on different levels of abstraction: superordinate(abstract), subordinate(concrete), functions(abstract), structures(concrete), specification(abstract), and scenarios(concrete). One way of categorizing the cards is by the proposed abstraction levels. The cards can also be categorized by the corresponding formats (point-form, single statement, short composition), application domains, principles, design disciplines and other surface features such as keywords. Some of the design tasks used in the experiment are shown in Table 1.

Identifier (not shown on card)	Card descriptions	Proposed Abstraction	Presenting format
coffee maker	To design a coffee maker with -10 cups capacity -removable filter basket -auto start/stop	specifications	point-form
margarine storage device	To design a storage device which can -store margarine that also can be reused -a measurable amount (e.g. 20g) of margarine can be taken out every time -try to avoid greasy fingers when using the margarine	functions	point-form
beverage vending machine	To design a beverage vending machine which is consisted of a selection window and panel, a payment receiver, a beverage collection box, a refrigerator and a compressor.	structures	short composition
window cleaner	To design a window cleaner that is used to wash and dry windows which has an extendable arms for cleaning higher windows, with multiple changeable cleaning brushes and an ergonomic handle to reduce fatigue.	specifications	short composition
garden chair	To design a garden chair which is made up of -stainless steel or cast aluminum -using a modular design -required easy assembly	structures	point-form
coin-operated payphone	To design a coin-operated payphone	subordinates	single statement
diamond watch	To design a diamond watch	subordinates	single statement
trash can	In front of a busy restaurant, there are a lot of cigarette light buds on the	scenarios	short

Identifier (not shown on card)	Card descriptions	Proposed Abstraction	Presenting format
	ground since the smoking ban, can you design a trash can to improve the existing condition.		composition
revolving door	To design an automatic revolving door	subordinates	single statement
card game	To design a new card game that friends and family can enjoy playing together. The card game should let players cooperate or play against one another The card game should be interesting and challenging.	functions	short composition

Table 1: Sample design tasks formulations on the cards.

3.1 DATA COLLECTION

Four design professionals with various levels of experience were invited to participate in the card-sorting experiments. Subjects I, J and K are product designers with 3-6 years of professional experience. Subjects I and J have bachelor's degrees in industrial design while Subject K has a master's degree in interaction design. Subject L has more than 10 years of experience and is currently working as a design manager. The different backgrounds of the subjects provided four diverse cases which were appropriate for the exploratory nature of this study.

3.2 PROCEDURE

Before the actual experiment, all the subjects were required to practice with the "think-aloud" exercises (Ericsson & Simon 1984) which aim to uncover the subject's knowledge structure through concurrent and retrospective verbalization. After the subjects were familiar with the process, they also needed to read the card-sorting instructions to categorize the cards into stacks that are meaningful according to their knowledge structures. The stacks were not to be either too large or too small, but they also did not need to be equal. The session began by asking the subjects to read aloud the design tasks given on the cards and lay out all the cards on a table. They then followed the think-aloud procedure throughout the sorting session. When there was a long period of silence, the subjects were reminded to continue verbalizing. The sorting time for the first trial was recorded, and a resort was performed until a stable result was reached. These experiments were videotaped, and the verbalizations were transcribed into written data. The data for all the sessions were then analyzed by a qualitative content analysis.

4. RESULTS

All the subjects achieved a stable sort result within the first two trials, which is consistent with earlier findings(), and this result indicates that each subject had a stable knowledge representation. The time required to finish the first sort and the underlying rules used by the subjects are presented in Table 2. The verbal data transcribed suggested that there are essentially four major types of rules that govern the subjects' sorting result. The information rule indicates that the sorting was based on the amount of information (no. of words) given on the card and the presenting format on the card. Abstraction rules include the abstraction elements proposed by the above-mentioned instrument, the design principles, and the scale of the design tasks, while the domain rule is linked to the application domains. The last rule is called "surface elements" which are related to specific words used in the design tasks. Analyses of individual sorting results are presented below.

Subject	1st sorting time (mins)	Underlying sorting rules
I	14	Information + Abstraction
J	14	Surface elements + Domain
K	37	Abstraction + Information
L	7	Information

Table 2: All the subjects' sorting results.

Group name	Definitive (8 tasks)	"Out of the blue" (8 tasks)	Problem-solving (8 tasks)
Dominating features of the grouped tasks	Point-form	Single statement	Short composition
Reasons for grouping	- tasks have specific design requirements -those requirements are perceived to be given by authoritative sources -tasks have detailed information to support the following design work	- no requirements - supervisor may only have a vague idea of the project	- task descriptions are only used to provide information for the current situation - game design as a sub-category
Subject's assessments of the given tasks	- can start the design process immediately -simpler tasks	- tasks too open-ended - induce frustration in the designer who may perceive the tasks as never-ending	- the given tasks are only tentative solutions to the current situation - multiple solutions possible to the given situation
Subject's design strategies	- should follow the given requirements - no need to challenge the obvious	- need to seek more information from other	-should consider relevant information and possible

	requirements	sources - need to start from scratch and understand the task from a macro perspective - need to perform a lot of background research	solutions together with the situation - negotiate with the clients for better solutions than the given task

Table 3: A summary of Subject I's sorting results.

Originally, Subject I started to identify the stack according to the number of words presented on a given card. However, he quickly reflected on his approach and argued for a more meaningful way to arrange the tasks. He then recognized the need to use multiple design strategies to handle the different design tasks, and used this as a rule for his final sorting. A content analysis was performed on the subject's transcripts and a summary of the reasons for the grouping and design strategies is shown in Table 3. Subject I was able to develop some kinds of production rules to determine the design strategies associated with a given stack of cards. From the labels of the groups, it is noted that the three groups are categorized mainly according to formats. The first group he labeled is described as being "very definitive". Most of the tasks are in point-form and in the functions, specifications and structures abstraction. His explanation stated that this group does not require further information and that is reasonable to start the design process with the given information. He further justified his decision by stating that the requirements are well understood and could not be argued with, unlike those in the problem-solving group. The problem-solving group essentially consisted of the short-composition format and the scenarios abstraction. He stated that these tasks descriptions presented a symptom of a phenomenon: the task is merely suggesting one particular solution and many possible solutions are still open for consideration.

It should be noted that one specification and one structure task that were written in a short composition format were also placed in this group. Subject I seemed to notice this abnormality in his second sort, and defended his choice by stating that these requirements could be argued as negotiable. This observation revealed that the presenting format may have had a strong influence on his initial representation of the design task and led him to argue instead of modifying his initial judgment of the task. Since his reason did not agree with his earlier assessments of the tasks, this result may indicate some kind of reluctance to change course once a decision has been made and some kind of automatic encoding is happening with presenting formats. Previous findings report similar results, i.e. surface features such as objects and format on the cards compete for the attention of novices while experts mainly focus on the more abstract principles. For the last group, even though Subject I was familiar with some of the tasks, such as designing a diamond watch, he was uncomfortable with a single task statement and considered that he had insufficient information for the task and labeled the group as "out of the blue" for that reason. From the sorting result, Subject I can be regarded as an advanced novice, because his design strategies were affected by both the information and the abstraction rules.

Group name	**Household (4 tasks)**	**Family (2 tasks)**	**Kitchen (3 tasks)**	
Dominating features of the grouped tasks	Objects	Surface keywords	Surface keywords	
Reasons for grouping	- objects used at home	- self-imposed family-related theme	-self-imposed kitchen-related theme	
Group name	**Personal fashion (3 tasks)**	**Personal healthcare (2 tasks)**	**Personal timepiece (2 tasks)**	
Dominating features of the grouped tasks	Objects	Application domain	Objects	
Reasons for grouping	- wearable objects	- health-care related objects	- self-imposed similarity	
Group name	**Chinese restaurant (2 tasks)**	**Vending machine (2 tasks)**	**Car interior (2 tasks)**	**Restaurant interior (2 tasks)**
Dominating features of the grouped tasks	Surface keywords	Principles	Surface keywords	Surface keywords
Reasons for grouping	- self-imposed similarity	- similar operating principles	- self-imposed similarity	- self-imposed similarity

Table 4: A summary of Subject J's sorting results.

Subject J was primarily concerned with physical objects, he categorized the tasks based on the objects described in them and he created the largest number of stacks (10 groups). Subject J also focused on surface features, including vocabulary used for describing the design tasks, and the grouped tasks did not have meaningful specific relationships. For instance, a coffee mug was grouped with a dashboard for a car because both tasks had 'car' in the card description. Some groups had a weak relationship in the relevant application domains, which were quickly identified. However, when the rest of the tasks did not fit into any other groups, idiosyncratic relationships were created, grouping a trash can in a restaurant with an automatic door, and stating that a restaurant may also need a door. Some aspects of abstracting from principles were presented when he grouped a vending machine with a payphone task. The sort results (Table 4) were quite superficial and were affected by the vocabulary (irrelevant tasks were grouped together because of the existence of familiar vocabulary such as children and family, or having the same word 'car'). Another unexpected observation was his failure to seek further information. Subject J was the only one in the study who did not seem to attend to the information provided in the design tasks which is reported to affect design performance. All tasks seemed to be treated as equal on the information level and Subject J did not mention any variations in design strategy, which lead us to suspect that the subject employed a single generic approach to tackle all design tasks. His sorting rationales could severely limit his analogical transfer of previous experience of many routine design problems in seemingly unrelated application domains.

<table>
<tr><th>Group name</th><th>Health and well-being (2 tasks)</th><th>Wearable pretty things (5 tasks)</th><th colspan="2">Standalone devices for a better living (5 tasks)</th></tr>
<tr><td>Dominating features of the grouped tasks</td><td>Application domain</td><td>Single statement</td><td colspan="2">Project scale</td></tr>
<tr><td>Reasons for grouping</td><td>health-related</td><td>wearable objects</td><td colspan="2">standalone devices</td></tr>
<tr><td>Subject's assessments to the given tasks</td><td>- require ergonomics specialists
- require fashionable designs</td><td>- need to seek out more information for the tasks
- assume the tasks are related to beauty</td><td colspan="2">- improve certain parts of life but not a whole system</td></tr>
<tr><th>Group name</th><th>Process-oriented (2 tasks)</th><th>System / environment consideration (3 tasks)</th><th colspan="2">Home-setting (3 tasks)</th></tr>
<tr><td>Dominating features of the grouped tasks</td><td>Principles</td><td>Project scale</td><td colspan="2">Application domain</td></tr>
<tr><td>Reasons for grouping</td><td>- related to human machine interaction</td><td>- require system design</td><td colspan="2">- home-related</td></tr>
<tr><td>Subject's assessments to the given tasks</td><td>- insert money for a service</td><td>- design of a cooking system</td><td colspan="2">- need observational study to understand the user habits</td></tr>
<tr><th>Group name</th><th>Complicated display (1 task)</th><th>Fun (1 task)</th><th>Art (1 task)</th><th>Part (1 task)</th></tr>
<tr><td>Dominating features of the grouped tasks</td><td>Principles</td><td>Principles</td><td>Principles</td><td>Principles</td></tr>
<tr><td>Reasons for grouping</td><td>- dashboard design
- is a typical human factors-related design</td><td>- game design
- very different from the rest of the tasks</td><td>- aesthetics</td><td>- part of an infrastructure</td></tr>
<tr><td>Subject's assessments to the given tasks</td><td>- requires designers to have a well-developed concepts of display and control</td><td>- a very difficult branch of design discipline
-need to find factors that amuse players</td><td>- not related to usefulness nor functions</td><td>-can generate many related ideas</td></tr>
</table>

Table 5: A summary of Subject K's sorting results.

Subject K demonstrated many behaviors which are characteristic of expert designers, especially she exhibited a significant cognitive ability to extract from the surface features of the design tasks. Even though she took the most time in her first sorting, she was the only subject to recognize the scale of the design tasks, and labeled one of the groups as standalone products (including a coffee maker, a window cleaner, a coffee mug, a margarine storage device and a can opener). She also named another group under a system design perspective. This recognition of scale is likely to assist overall project schedule and management, which are important criteria when determining the necessary time to develop a product.

Subject K identified the remaining groups using keywords from design disciplines, theoretical concepts and principles (such as ergonomics, users research, human-machine-interaction, game design and interface design). For instance, she was again the only subject to categorize a flower vase task under “aesthetics”. She possessed the cognitive ability to zoom out from the given tasks using a more abstract perspective, and often questioned specific design requirements that were provided under the structure and specification formulations. Subject K acknowledged the interdisciplinary nature of many given tasks and did not attempt to tackle the tasks individually. She recommended tackling the tasks collaboratively with specialists from various disciplines, which perhaps reflect her teamwork experience. Therefore, Subject K did not provide any individual design strategies for the tasks except that she was concerned with the lack of information in the single statement tasks and she would seek out additional information regarding these tasks. Details are shown in Table 5.

Group name	**Design tasks in point form (8 tasks)**	**Design task statement (7 tasks)**	**Design tasks with background information provided (9 tasks)**
Dominating features of the grouped tasks	Point-form	Single statement	Short composition
Reasons for grouping	- clear and explicitly requirements	- ambiguous tasks	- background information is given
Subject’s assessments to the given tasks	- help designers to answer and keep track of all the points given in the tasks - no need to ask further questions - can proceed to the following design work	- need to seek out more information from the clients - leave designers more rooms to design	- background information can make the designers feel more confident and secure about the tasks

Table 6: A summary of Subject L’s sorting results.

The last subject, L, was working as a design manager and was not participating in the daily design activities. She described her primary responsibility as being to brief junior designers with the materials she obtained from clients. She did not pay much attention to the actual design tasks but focus only on the available amount of information given on the cards, and took the least time to finish the sorting. All single statement tasks were grouped together as ambiguous tasks. She said that these tasks would require further discussion with the clients and that is a common case where the clients are unclear about the objectives of the project. She made a similar comment as Subject I about the tasks given in point-form being very definitive. For that group of tasks, she would give a go ahead to junior designers to start the design process without searching for more information because she perceived that the point-form tasks were specific and could act as checkpoints for junior designers to follow. The last group, consisting of tasks written in short composition, was labeled as design tasks with background information. She considered these tasks were in the middle between the two extreme groups and background information would make designers feel more confident and secure about the design tasks. As a design manager, she would rather reinterpret the background information into point-form before briefing her junior designers. The sort results (Table 6) are highly similar to those of Subject I which was unexpected because of the difference in their professional experience and position. In this case, Subject L appeared to be an information facilitator, often working with clients and in the position of briefing her junior designers of the actual design task. A plausible explanation is that Subject L had a more abstract knowledge structure, which is automated as in an expert case. However, since she acted as a middleperson between clients and junior designers, she needed to proceed to sort the cards according to the ways perceived by junior designers. Subject L also reiterated that briefs given to junior designers were interpreted versions of the ones received from clients.

5. DISCUSSION AND CONCLUSION

The results obtained from the sorting experiments generally agree with earlier findings in other domains (Chi and et. al. 1981; Chi, Glaser and Farr 1988) where experts are more likely to abstract from task descriptions and novices are frequently influenced by surface features. The dominating surface features for novice designers are vocabulary, presenting format, and physical objects in the task descriptions, while expert designers mostly focus on design principles, design disciplines and the project scale. These factors also affect the information seeking behaviors and design strategies of the designers which are repeatedly linked to design performance. The point-form formulations using specifications and structures seem to provide novice designers with a false sense of security and concreteness concerning the design tasks. Subsequently, novice designers mainly attend to the presented requirements and reason that these existing requirements are derived from authoritative sources. This interesting observation about the initial perception of novice designers could be useful when formulating design briefs to expedite a project or to create small improvements in existing products. Using a short composition and scenario formulations seem to promote novice designers to search for relevant information and to treat the design task only as a tentative solution. In this case, the information-seeking activities are more directed to towards addressing a given situation or context, which will often lead designers to discover hidden requirements or constraints, as reported by Caroll (1995). With regard to the single statement design tasks, both novice and expert designers defined the tasks as being highly ambiguous even when they were asked to design very concrete objects. The designers then tried to elicit additional information by asking many questions about the tasks. They also tried to use brainstorming and analogical thinking to further define the task requirements which are essential for new ideas and innovations. The results also confirm that information is the most significant factor for designers in assessing the given design briefs, regardless of expertise. An unexpected result came from Subject L who was a design manager. Her sorting results suggest that our findings should be limited to the immediate brief given to "front-end" designers. A few limitations of this study should be noted. Firstly, English is the second language of most of the participants in the study. During the experiment, some subjects did express uncertainty about several English words such as margarine, ventilation, and ECG. In order to alleviate this potential obstacle, Chinese translations (Hornby 2002) in equivalent abstractions were provided if requested by the subject. Secondly, we made an implicit assumption that the Sapir-Whorf hypothesis, which states that the nature of a language influences thought, had a minimal effect on the results of this study (Heider 1972). Thirdly, some subjects considered the think-aloud protocol rather unnatural and it took a few practices before they were used to the process. In this study, the different educational backgrounds and experience of the subjects can serve as an exploratory study to identity the knowledge structure of professional designers with different levels of expertise. The findings are expected to help design brief writers to take various sorting rules used by the designers into consideration when establishing appropriate design brief formulations to challenge designer's dispositions and to meet the projects' objectives.

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