공학석사 학위논문

Mitigating Design Fixation during Idea Generation with Situation Awareness Support System

상황인지보조시스템을 통한 디자인 픽세이션의 완화

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산업공학과 인간공학 전공

최 병 현

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이 논문을 공학석사 학위논문으로 제출함

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Abstract

Mitigating Design Fixation during Idea Generation with Situation Awareness Support System

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The objective of this master's thesis research was to develop a new display system that helps the designer perceive the occurrence of design fixation during ideation and empirically evaluate its effectiveness in reducing design fixation. In the early stage of the creative design process, designers commonly seek external stimuli with the aim of framing and solving the problems they are engaged with. Although multiple analogies and design heuristics may help alleviate design fixation by providing the designer with different directions for thinking, it is possible that design fixation still occur while utilizing them. That is, the designer may not consider all of the available stimuli but rather repeatedly utilize a small subset of them. We developed Situation Awareness Support System for solving the problem and empirically demonstrated its effectiveness.

Keywords: Design Fixation, Situation Awareness, Ideation, Creativity
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Chapter 1

Introduction

In the early stage of the creative design process, designers commonly seek external stimuli with the aim of framing and solving the problems they are engaged with [1, 2]. External stimuli can vary in type and form. In terms of representation modalities, stimuli can be pictorial, verbal/textual or three-dimensional, among others [3]. In terms of relatedness, closely related stimuli refer to entities found within a domain, for instance, existing solutions within the domain or ideas generated by others for the same design problem [4]. Conversely, distantly related stimuli are sources found in different domains, or outside the scope of the problem [5].

A number of research studies have investigated the impact of external stimuli on the generation of creative ideas and have shown their positive impacts on ideation performance. Fiol [6] strongly argued that the potential of designers to generate innovative ideation outcomes is dependent on the degree of exposure to external stimuli. An external stimulus can provoke a stream of thought that could lead to one or more ideas, help focus attention on the problem to solve, and, even by itself, suggest some possible solutions [7]. In the absence of any stimulus, on the other hand, there may be little momentum for creative thought and ideas generated may revolve around the prevailing paradigm [7]. Previous studies on design heuristics for ideation empirically demonstrated that using design aids (external stimuli) can enhance the outcome of ideation [8, 9, 10].

Despite their positive impacts, however, there is an unexpected effect that external stimuli may bring about when generating creative ideas. It is design fixation. In this thesis, we consider the design fixation problem that occurs during ideation using external stimuli. We start by describing the problem in Section 1.1.

1.1 Design Fixation

Although various definitions of design fixation can be found in literature, Crilly [11] provided one of the widely used definitions of design fixation, which goes as follows: "design fixation is a state in which someone engaged in a design task undertakes a restricted exploration of the design space due to an unconscious bias resulting from prior experiences, knowledge or assumptions". Design fixation can be seen as a cognitive error because areas of the design space are inadvertently left unexplored. Reducing/eliminating design fixation would likely help generate creative products, since the presence of unexplored design space may hinder finding novel and useful inventions [12].

Although the cause of design fixation has not yet been clearly understood, several factors contributing to design fixation have been suggested: expertise [12], unfamiliarity with principles of a discipline or domain knowledge [13], personality types [14], a lack of awareness of technological advances [15], and weak or ill-defined problem and example solutions [16].

To tackle the design fixation problem, a number of methods have been developed. Chrysikou and Weisberg [17] found that informing designers of the notion of design fixation and its effects could mitigate the fixating effects of external stimuli during ideation. Abstract formulation of a problem is proposed to promote divergent thinking processes and generation of original ideas [18]. Dugosh & Paulus [18] suggested utilizing audio recorded examples to foster retrieval of long-term memory concepts and concepts distantly associated. Smith & Linsey [19] provided analogies, which assist in restructuring a problem and triggering design improvements during product development. Design heuristics were found to promote divergent thinking by providing multiple sequential and/or systematic ways to approach a problem and generate novel and original solutions [10, 20].

Although multiple analogies and design heuristics may help alleviate design fixation by providing the designer with different directions for thinking, it is possible that design fixation still occur while utilizing them. That is, the designer may not consider all of the available stimuli (analogies or design heuristics) but rather repeatedly utilize a small subset of them [21]. This behavior may occur because focusing on a small subset reduces the mental burden or cognitive loads during idea generation. Some of the available stimuli may be more easily related to the given ideation problem or may be more easily integrated to the internal knowledge of the designer. Also, switching between different external stimuli would incur mental set-up costs for inhibiting the previously considered stimulus and loading the new one onto the working memory [28]. Thus, repeatedly utilizing them would reduce the mental processing costs. Focusing on a small subset of the available stimuli may likely cause design fixation in that it would hamper fully exploring the design/solution space. Despite the possibility of design fixation during ideation based on multiple external stimuli, little attention has been paid to the understanding and mitigation of such human behavior.

1.2 Research Motivation and Contribution

In an effort to help address design fixation during ideation using external stimuli and thereby contribute to design ideation research, the objective of this master's thesis research was to develop a new display system that helps the designer perceive the occurrence of design fixation during ideation and empirically evaluate its effectiveness in reducing design fixation.

The new display system keeps track of the stimuli use history and visualizes it in an easily understandable format with the aim of assisting the designer in noticing the occurrence of design fixation in real-time. If the designer is aware of what stimuli he has used, how many times each stimulus has been used, and how much time is left at a given time point during ideation, he could easily notice the possible occurrence of design fixation, and, if necessary, redirect the attention focus to be able to recognize the potential value of the unused stimuli. Such control of attention would otherwise be dependent on pure chance. The display system seeks to enhance the designer's situation awareness during ideation, and, thus, can be considered as a display for improving situation awareness. Therefore, the display system is termed the Situation Awareness Support System (SASS).

Two hypotheses were entertained in this study:

H1) The SASS would help designers reduce design fixation during ideation using external stimuli, and

H2) The SASS would help designers improve the ideation outcome during ideation using external stimuli.

To test the above hypotheses, an example SASS was created and its effectiveness in reducing design fixation and improving design ideation outcome was empirically evaluated.

1.3 Organization of thesis

Thesis is composed of four chapters. In Chapter 2, we review the literature related to the research problem. In Chapter 3, we propose the concept of SASS, develop an illustrative example of SASS, and demonstrate its effectiveness by an experimental evaluation. Finally, in Chapter 4, we make concluding remarks and present possible future research directions.

Chapter 2

Literature Review

2.1 Mechanism of Design Fixation

Many studies have shown that design fixation can occur when solutions already discovered are presented to participants [22, 23]. Jansson and Smith [31] first applied an experimental approach to study design fixation. They confirmed that a given example solution could limit the range of design space generated by a designer. Following Jansson and Smith [31], other researchers have investigated further the issue of design fixation by conducting a number of empirical experiments [13, 17]. These studies, as a whole, demonstrated that introducing examples (external stimuli) could cause design fixation, resulting in less creativity during ideation.

One of the reasons why design fixation is difficult to overcome is because designers typically cannot detect its occurrence [12]. Ward and colleagues [22, 23, 24] have discovered that designers did not consciously try to produce design solutions similar to given external stimuli but rather their mental operations were subconsciously affected by them. In their studies, two groups of designers were provided with the same sets of external stimuli and were instructed to generate ideas. One group was instructed to avoid generating ideas similar to the given stimuli while the other was not provided with any instructions. The two participant groups did not show any significant differences in the similarity between the external stimuli and the generated ideas. These results suggest that designers are unaware that they are being influenced by example solutions or previously generated solutions during ideation [22, 23, 24].

2.2 Situation Awareness

Endsley [25] defined situation awareness (SA) as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future". The SA breaks down into three separate levels: perception of the elements in the environment (Level 1 SA), comprehension of the current situation (Level 2 SA), and projection of future status (Level 3 SA).

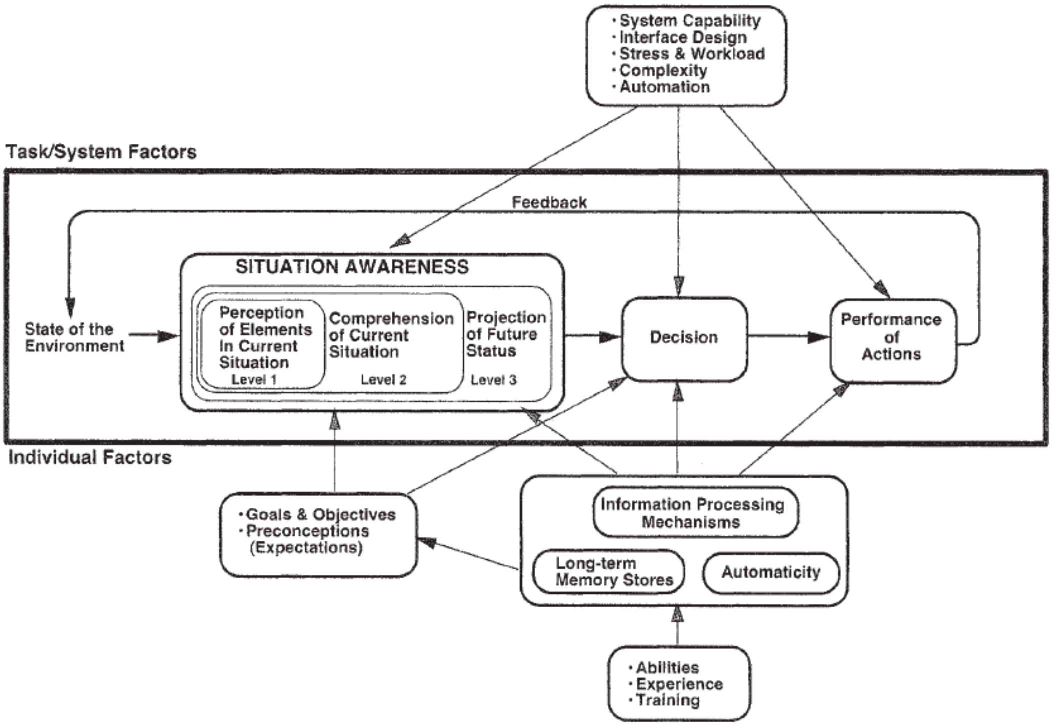


Figure 2.1. Model of situation awareness in dynamic decision making [25]

The first step in achieving SA (Level 1 SA) is to perceive the status, attributes, and dynamics of relevant elements in the environment. The second step in achieving good SA is understanding what the data perceived mean in relation to relevant goals and objectives. Comprehension (Level 2 SA) is based on a synthesis of disjointed elements, and a comparison of that information to one's goals. Once the person knows what the elements are and what they mean in relation to the current goal, it is the ability to predict what those elements will do in the future (at least in the short term) that constitutes Level 3 SA. These definitions stress that the likelihood of attaining productive awareness of a situation depends on the ability not merely to notice or attend to the various signals, symptoms, and information sources in one's environment but also to determine their relevance and implications in a timely and appropriate manner.

Acquiring and maintaining SA involve significant cognitive resources [26] and they must be appreciated as an integral part of the user's mental workload [25]. Although it has been long acknowledged that clear understanding of one's situation is undoubtedly the critical trigger that allows the creativity [25, 27], it has not been studied from the perspective of mitigating design fixation.

Chapter 3

Development and evaluation of a SASS for reducing design fixation during ideation with external stimuli

3.1 The Concept of SASS

Situation Awareness Support System (SASS) is a kind of information acquisition automation, which includes methods for helping notice the occurrence of design fixation and delivering information on whether the user is navigating the solution space properly within a given time duration.

SASS is basically designed assuming an ideation activity with a time limit that uses countable external stimuli. SASS displays all available external stimuli in a list, and, if one of the stimuli is selected by the user (the designer), it presents detailed information about the stimulus. As ideation proceeds, SASS will automatically record the number of ideas that have resulted from each stimulus and display the numbers to the user in real-time. SASS also displays the elapsed time. By providing these information, SASS intends to help the user perceive, understand, and predict the likelihood of occurrence of design fixation.

3.2 Development of a SASS: ideating with a design heuristics set for X

A SASS was developed to help designers ideate with a design heuristics set for X (DHSfX).

A DHSfX is a collection of design heuristics that are likely to help assistive product designers produce solution concepts successfully meeting a particular design goal X. The DHSfX considered in this study was one developed to inform creating product concepts for one-handed individuals [10]. The DHSfX consisted of 13 design heuristics (see Table 3.1). Figure 3.1 visually presents the user interface of the SASS created for the DHSfX. The timer and percentage bar in the interface help the user easily recognize the elapsed time in relation to the given time limit. The percentage bar uses a color coding scheme: green if the elapsed time is less than 50% of the time limit, yellow if the elapsed time is between 50% and 90%, and red if the elapse time exceeds 90% of the time limit. Thus, the percentage bar serves as an alerting display. Below the percentage bar, the 13 design heuristics are shown (Table 3.1).

Table 3.1: Thirteen DHs for creating for one-handed people [10]

No.	*Design heuristics*	*Description*
1	Attach the product to a body part(s)	A product can be manipulated with one hand by attaching the product to a body part(s) using additional components (i.e., straps, holders, etc.).
2	Design the product operable with one hand and a non-hand body part	A product can be manipulated using one hand with the help of a non-hand body part.
3	Fix the product using a holding or support aid	A product can be manipulated with one hand by fixing the product to a certain position.
4	Integrate one-hand gesture control to the product	A product can be manipulated with one hand by integrating one-hand gesture control to the product.
5	Merge two products into one	A product can be manipulated with one hand by integrating multiple functions originally accomplished by separate products into the product.
6	Offer an attachable accessory for the product	A product can be manipulated with one hand by offering an attachable accessory for the product.
7	Permanently integrate hand/finger rings into the product	A product can be manipulated with one hand by integrating hand/finger rings into the product.
8	Place controls/grips of the product within the hand's functional range	A product can be manipulated with one hand by placing controls or grips within the hand's functional range.
9	Provide a mechanical extension along with the product	A product can be manipulated with one hand by providing a mechanical extension (i.e., a reacher grabber, a button hook, etc.) to extend the user's hand reach and manipulation abilities.
10	Provide a shape maintaining aid along with the product	A product can be manipulated with one hand using a shape maintaining aid (i.e., a shell, a frame, etc.).
11	Replace bi-manual motions with a single hand's gripping/squeezing	A product can be manipulated with one hand by replacing a bi-manual motion with a single hand's gripping/squeezing.
12	Replace bi-manual motions with a single hand's pressing/pushing	A product can be manipulated with one hand by replacing a bi-manual motion with a single hand's pressing/pushing.
13	Turn the product into a motion-activated one	A product can be manipulated with one hand if its operation is fully or partially automated with sensors and actuators.

The SASS interface allows the user to freely select some of the 13 design heuristics as an inspiration for solving a creative design ideation problem. The user clicks the design heuristic that he wants to use; then, the SASS updates the screen with detailed information concerning the design heuristic (see Fig 3.2 for an example). The user studies the design heuristic and tries to generate solution ideas for the design ideation problem at hand. If the user succeeds in generating an idea, he records it (verbal and/or pictorial description) and then clicks the Use button. Clicking the Use button increases the number of ideas generated from using the design heuristic. If the user wants to return to the main screen (Fig 3.1), he clicks the Back button. In the main screen, tally marks are displayed next to each design heuristic; the number of tally marks represent the number of ideas resulting from utilizing the corresponding design heuristic. Also, first five tally marks are displayed in green, the next five, in yellow and the ones that follow, in red. Also, the design heuristics that have not been visited by the designer are displayed in red – this alerts the designer of the fact that the design information contained in the design heuristics have not been exploited. The design heuristics that have been visited by the designer are presented in blue. The main screen (Fig 3.1) enables rapidly gaining situation awareness concerning the on-going ideation activity.

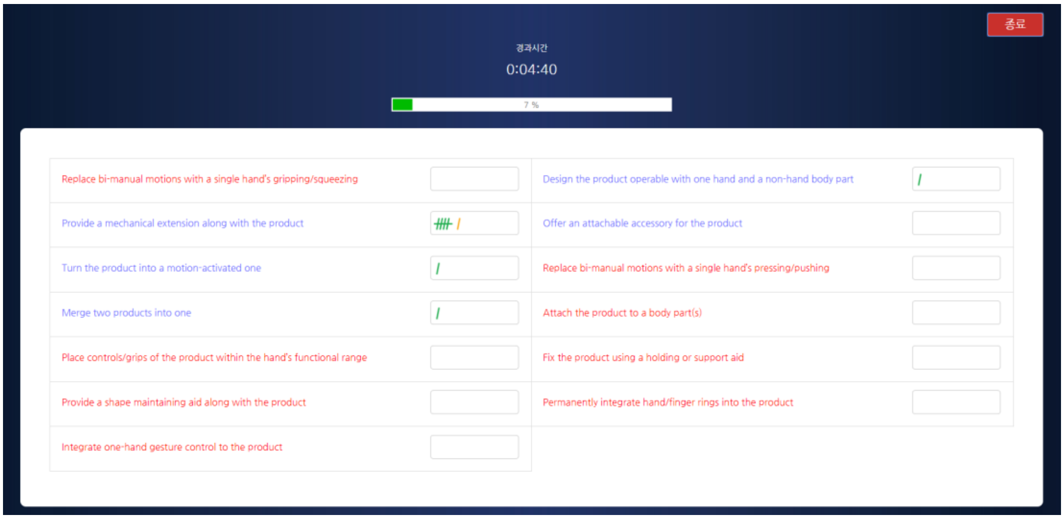


Figure 3.1: The user interface of the SASS (the main screen)

Figure 3.2: Detailed information about a design heuristic selected by the user (illustrative)

3.3 Empirical evaluation of the SASS

3.3.1 Study participants

The participants of this study were comprised of 40 Seoul National University undergraduate students majoring in engineering fields. A short lecture on the external stimuli (the 13 DHSfX) to be used in the experiment was provided along with a 30 minute ideation practice session prior to the experiment. The participants were randomly divided into two groups of twenty: the “Control” and “SASS” groups.

The participants in the Control Group were provided with a paper booklet describing the 13 design heuristics (Fig 3.3), and did not have access to the SASS or any other information. They were also not aware of the existence of the SASS.

Figure 3.3: Ideation with booklets (The Control Group)

The participants in the SASS group were instructed to use the SASS freely at any point during ideation as they like (see Fig 3.4).

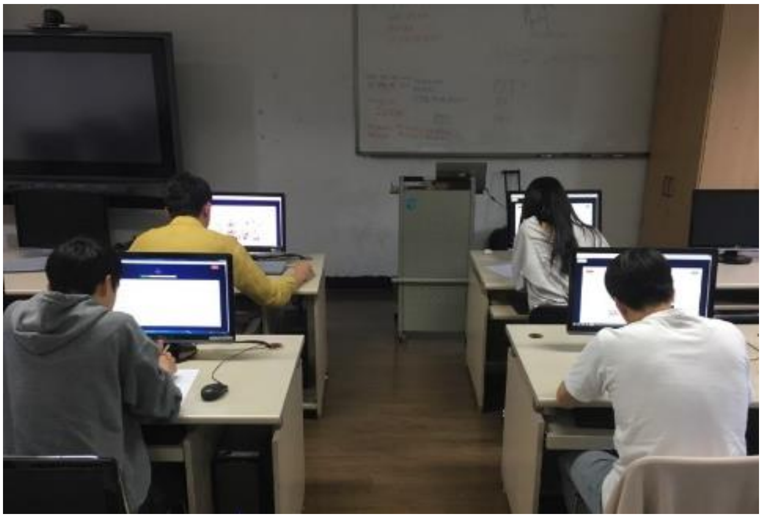


Figure 3.4: Ideation with SASS (The SASS group)

3.3.2. Design Problem

All participants were provided with the same design problem. The new product concept design problem was to redesign the Rubik's cube for one-handed users. An excerpt from the problem statement used is as follows: 'Currently, one-handed users find it difficult to play with the Rubik's cube. Develop new Rubik's cube concepts (as many as possible) that allow one-handed users to easily and efficiently play the game of Rubik's cube. The new design concepts do not have to resemble the original Rubik's cube in the mechanism design and/or other aspects as long as they realize the original game of Rubik's cube.'

3.3.3. Experiment protocol

The total time of idea generation was 60 minutes and no extra time was given. All participants were told that the goal of the experiment was to generate as many solutions to the design problem as possible and were instructed to use sketches and/or written words to clearly describe their ideas. For each participant group, the ideas (new Rubik's cube product concepts) generated individually by its members were collated. For each group, the authors examined all the ideas and classified the ideas into bins which are categories of ideas that share similarities in order to identify unique sets of solutions.

The evaluation of ideation outcome was conducted employing three evaluation criteria. They were: novelty, quality and quantity. Novelty refers to how unusual or unexpected an idea is as compared to other ideas. Quality pertains to the feasibility of an idea and how close it comes to meeting the intended design goal. The novelty and quality metrics pertained to a single idea. An idea's novelty and quality were quantified through two expert judges' subjective ratings. Both judges had a bachelor's degree in engineering specializing in a product design related discipline; they also had conducted numerous product development activities, including multiple assistive product design and universal design projects. The judges used 7-point rating scales (one: extremely low, seven: extremely high) to subjectively determine the novelty and quality scores for each idea. For each metric, the average of the ratings of the two judges was computed and was used in the subsequent analysis. With raters considered to be in agreement when their ratings differed by no more than one point [29], the two raters agreed in 86.28% of the novelty ratings and 85.06% of the quality ratings. Both the percentages of absolute agreement reached the acceptable level of agreement [30, 31]. They were both blind to the conditions of the experiment and the hypotheses.

As for quantity, three indexes were defined: quantity of total ideas generated (Q_{total}); quantity of repeated ideas (Q_R), where a repeated idea occurs when it is classified as an already existing bin; and quantity of non-repeated ideas (Q_{NR}), which corresponds to the remaining number of Q_{total} once repeated ideas have been removed. These metrics pertained to a single participant. Q_{total} can be expressed as the sum of Q_R and Q_{NR} as shown in Equation 1 below.

$$Q_{total} = \sum all\ \ ideas\ \ generated\ \ = \ Q_R + \ Q_{NR} \quad (1)$$

The evaluation of design fixation was conducted for each participant utilizing the metric created by Linsey [12]. The metric is computed as the proportion of the non-repeated ideas within the total idea set (Equation 2).

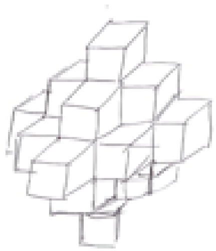
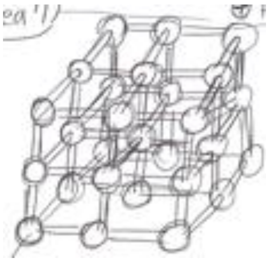
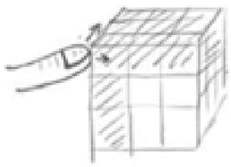
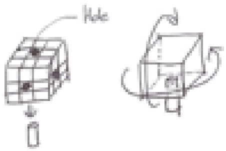
$$\text{Fixation} = \frac{Q_R}{Q_{Total}} \quad (2)$$

The two participant groups were compared with each other in each of the metrics described above. A series of t-tests were conducted to statistically compare the means of the two participant groups in the following metrics: the novelty score, the quality score, the two quantity scores, and the fixation score. IBM SPSS 25 statistical analysis software was used to perform the Levene's test for unequal variances at significance level $\alpha = 0.05$. The unit of analysis for the novelty and quality score comparisons was an "idea" while that for the quantity was a participant.

3.2.4. Results

For illustration purpose, Table 3.2 provides some example ideas (new Rubik's cube product concepts) generated from the ideation experiment. The four examples were produced by participants in the SASS group.

Table 3.2: Example ideas

Idea sketch	*Text descirption*
	Change the game so that instead of rotating, the player needs to push the faces of the cube up or down to match their colors.
	Change the game so that the player needs to match the colors of the balls instead of the faces.
	Make faces of the cube using touch screens that can change colors. The cube itself does not rotate; instead, colors of the faces change through touch or gesture.
	Drill a hole in the center of each side of the cube. The player can put a bar through the hole and rotate the cube using the bar.

For each group, all the ideas were classified into bins which are categories of ideas that share similarities in order to identify unique sets of solutions (Tables 3.3 and 3.4).

Table 3.3: Idea bins of the Control Group

name of bins	the number of ideas	name of bins	the number of ideas
Fix the cube	24	Bump	3
Assistive device with other part of body	18	Use spring	3
Make Button	16	Use magnetic force	3
Touch device	14	force on face	3
Use Frame only	13	More cubes	2
Remote control	13	Make Detachable	2
Transform to 3D game	9	Cube inflatable	2
Change shape	9	Cube material	2
Reduce size	8	Pupil recognition	1
Attach grip	6	Different each of cubic shape	1
Use Light	4	smooth rotate	1
Make holes in the cube	4	use gravity	1
Touch control	4	Use Buoyancy	1
Stick through hole	3	insert sphere	1
Saw-toothed surface	3	Transform to 2D game	1
Add force with motor system	3	Use friction	1
magnet control	3		

Table 3.4: Idea bins of the The SASS group

name of bins	the number of ideas	name of bins	the number of ideas
Fix the cube	10	Use Buoyancy	5
Assistive device Other part of body	10	Add force with motor system	4
Make Button	9	magnet control	4
Touch device	9	Use friction	3
Use Frame only	9	Bump	3
Remote control	9	Use spring	2
Change shape	8	Use magnetic force	2
Reduce size	8	Make Detachable	2
Touch control	7	Cube material	2
Attach grip	7	Change rule	1
Use Light	7	smooth rotate	1
Make holes in the cube	6	insert sphere	1
Transform to 3D game	6	use gravity	1
Stick through hole	6	Transform to 2D game	1
Saw-toothed surface	5		

The results of the t-tests conducted to compare the two participant groups in the novelty, quality, quantity (Q_{total}, Q_{NR}), and severity of fixation are summarized in Table 3.5.

Table 3.5: Results of Levene's tests for unequal variances (α = 0.05)

	Group	N	mean	SD	t	p
Novelty	Control	181	3.95	1.37	1.428	0.154
	SASS	147	3.75	1.1		
Quality	Control	181	3.79	0.74	-1.755	0.080
	SASS	147	3.93	0.65		
Q_{total}	Control	20	9.1	3.14	2.128	*0.041
	SASS	20	7.3	2.11		
Q_{NR}	Control	20	7.1	1.68	0.080	0.936
	SASS	20	7.05	2.21		
Fixation	Control	20	0.183	0.144	4.017	*0.000
	SASS	20	0.036	0.077		

The t-test for the design fixation metric showed that on average, the participants in the Control Group (Mean = 0.183, SD = 0.144) had a larger mean value of the design fixation metric than those in the The SASS group (Mean = 0.036, SD = 0.077) t_{38} = 4.017, p = *0.000 (Figure 3.5).

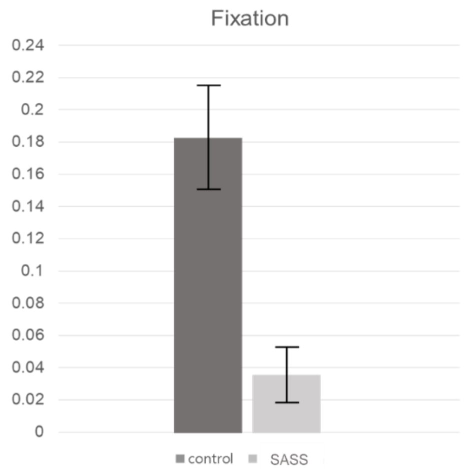


Figure 3.5: Comparison of Fixation score between two groups

The Control Group generated an idea set consisting of 181 ideas. The The SASS group, on the other hand, produced 147 ideas. The t-test results showed that on average, the participants in The Control Group (Mean = 9.1, SD = 3.14) individually generated more ideas than those in The SASS group (Mean = 7.3, SD = 2.11) t_{38} = 2.128, p = *0.041 (Figure 3.6), but the t-test for the average Q_{NR} did not reveal any statistically significant difference between the Control Group (Mean = 7.1, SD = 1.68) and the SASS group (Mean = 7.05, SD = 2.21), t_{38} = 0.080, p = 0.936.

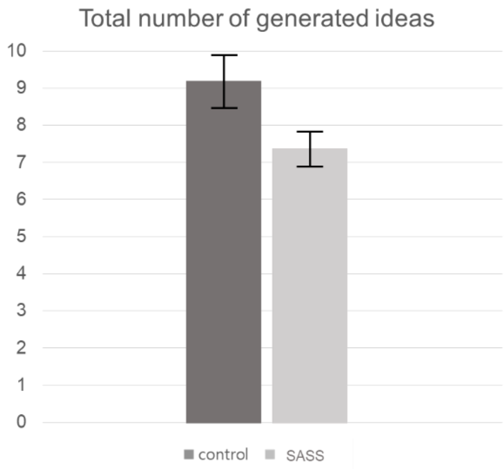


Figure 3.5: Comparison of Q_{total} between two groups

The t-test for mean novelty did not reveal any statistically significant difference between the Control Group (Mean = 3.95, SD = 1.37) and the SASS group (Mean = 3.75, SD = 1.1), t_{326} = 1.428, p = 0.154. The t-test for mean quality also did not reveal any statistically significant difference between the Control Group (Mean = 3.79, SD = 0.74) and the SASS group (Mean = 3.93, SD = 0.65), t_{326} = -1.755, p = 0.080. The t-test for mean quality did not also reveal any statistically significant difference between the Control Group (Mean = 3.79, SD = 0.74) and the SASS group (Mean = 3.93, SD = 0.65), t_{326} = -1.755, p = 0.080.

Chapter 4

Discussion

We found SASS was able to mitigate the degree of design fixation. However, when referring to the number of ideas, novelty, and quality, it was difficult to establish that the mitigation of design fixation has a positive impact on ideation performance. In fact, when developing SASS, we anticipated that it would show better ideation outcomes due to the mitigation of design fixation, which has been known to interfere with generating creative ideas [12].

4.1 Possible reasons for the observed mitigation of design fixation resulting from the use of SASS

The SASS was found to significantly reduce design fixation (Table 3.5, Figure 3.5). This is thought to be because the SASS allowed the designer to easily determine/detect whether design fixation had occurred or not. The SASS enables easy perception of design fixation. The usage frequencies of the stimuli were displayed in a single screen, and, thus, the designers were able to recognize his/her stimuli usage pattern at a glance. The color coding scheme used for displaying the stimulus usage frequencies helped the designer easily notice the possibility of design fixation. Also, the elapsed time was always displayed and was easily recognized. Therefore, Level 1 SA of design fixation occurrence was improved.

The SASS also helped improve comprehension. To determine the occurrence of design fixation, the user must compare the usage frequencies of the stimuli, and combine the information with the time he/she has used for the ideation. The SASS provides these different pieces of information in a format conducive to easy integration, it helps the designer gain Level 2 SA.

Because the designers had been informed of the effects of design fixation on ideation performance in advance, during the ideation sessions, they were able to predict how the design fixation detected/anticipated would influence their ideation outcomes. Thus, such prediction contributed to Level 3 SA. Maintaining good SA in each level would help the designer take appropriate stimulus usage strategy and it would have led to the mitigation of design fixation.

4.2 Possible reasons for the lack of positive effects on ideation outcome measures

It was found that the SASS did not result in significant improvements in the ideation outcome measures. Such lack of positive effects may be attributed to the following: first, the SASS could have hampered effectively utilizing some useful DHs for creative ideation although it provided information relevant to design fixation mitigation. Repeated use of certain stimuli may induce reduction of the solution space, which may lead to design fixation, but it could encourage designers to get many high-quality ideas in a short time if the stimuli were useful. In such situation, repeated use of certain stimuli could be interpreted as positive concentration or immersion that helps creativity. The executive control over the use of available stimuli triggered by the SASS may have resulted in impeding such concentration/immersion on some useful stimuli. By using the SASS, the designer would likely consider more stimuli, which include irrelevant or unfamiliar ones. Such irrelevant/unfamiliar stimuli may not positively affect time efficiency or effectiveness of ideation.

Second, interacting with SASS may have increased the user's mental workload. In performing ideation with external stimuli, most designers, especially novices, would not mentally keep track of their stimulus usage history [33]. The SASS provides information (elapsed time and stimulus usage frequencies) on the stimulus usage history, which is useful for mitigating design fixation; however, this additional information provided by the SASS needs to be processed, and, therefore, incurs cognitive costs and increase mental workload during the ideation task. Such cognitive costs and increased mental workload would have hindered the task of creative ideation as less mental resources would be available. The effectiveness of an SA support system depends on the availability of a display system that can easily achieve SA without any special cognitive effort [25]. Ergonomically better display interfaces of the SASS would have led to reduction of mental workload on the acquisition of information and have improved focusing on creative thinking.

4.3 Future Directions

This study investigated only one piece of the design fixation puzzle. Some ideas for possible follow-up studies are provided here:

First, the empirical validation study considered a situation in which only a small set of external stimuli (13 DHs) was used for design ideation. It may be worth investigating how the size of the external stimuli set affects the effectiveness of the SASS in design fixation mitigation. To do so, a larger set of external stimuli, for example, the 40 design principles of TRIZ [8] or the 77 design heuristics [20], could be employed in new empirical studies.

Second, future studies may investigate improving the display component of the SASS. For example, an improved version of the SASS may be designed to display the time spent on each available stimulus or the number of visits to each stimulus rather than the stimulus usage frequency. Such design changes may result in better ideation outcomes in addition to mitigation of design fixation. Also, such improved SASS may display the total number of generated ideas in real time so as to help the designer adopt a productive ideation strategy/behavior.

Third, the current study focused only on the ideation situation in which a finite set of countable external stimuli has been prepared in advance. The empirical validation of the effectiveness of the SASS in mitigating design fixation is limited to such situation. The SASS concept may be utilized in ideation situations not considered in this thesis study. In the age of the Internet as a solid and dominant information platform, we need to consider how the SASS can be utilized in combination with Internet search engines. For example, a SASS search engine that displays the user's search record and the number of visits to each search result would better support ideation than the existing Internet search engines.

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국문초록

본 석사학위논문 연구의 목적은 여러 외부 정보를 활용하여 아이디에이션 과정에서 디자이너가 겪는 설계 고정 문제를 해결하는 것이다. 창의력이 필요한 디자인 과정의 초기 단계에서, 디자이너들은 일반적으로 아무것도 없이 고민하는 대신에, 그들이 겪고있는 문제를 해결할 목적으로 외부 자극을 찾는다. 아이디에이션 과정 중 이런 외부 정보를 활용할 때, 여러 가지 유추 및 설계 휴리스틱이 설계자에게 사고 방식을 다르게 하여 설계 고정 현상을 완화하는 데 도움이 될 수 있지만, 이런 정보들을 활용함에도 설계 고정 현상이 계속 발생할 수 있다. 즉, 설계자는 사용 가능한 모든 정보를 고려하지 않고 반복적으로 작은 부분 집합을 활용할 수 있고 이런 문제는 설계 고정 현상의 원인이 되는데, 해당 연구는 이런 문제를 해결하기 위하여 상황인지보조시스템을 개발했으며, 그 효과를 실험적으로 입증하였다.

주요어: Design Fixation, Situation Awareness, Ideation, Creativity

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