



Development of More Concept Words Leads to the Generation of More Idea Sketches

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Abstract. In this study, we evaluated the performance of designers' idea development using the IDEATOR app as the designers' ideation tool and investigated whether there were differences in behavior linkages and idea sketches among designers from three design fields. The results were as follows: 1. According to our analysis of the video data recorded by designers using IDEATOR, their behaviors included nine behavioral codes separated into three behavior modes (GI, GA, TH) and an error action code; 2. The designers used IDEATOR for ideation and most frequently engaged in GI behavior, especially those in the fields of graphic and product design; 3. The designers who used IDEATOR for ideation had a tendency to frequently develop concept words. In particular, graphic designers were highly dependent on word-type data to perform the ideation process; and 4. The more input concept words on the interface of the IDEATOR mind map employed by the designers, the more idea sketches the designers drew. As they input additional concept words, the designers also produced sketches that fit into multiple lateral thinking categories.

Keywords: Developing HCI expertise and capability worldwide · Design thinking · Ideation

1 Introduction

Many researchers have explored the influences that design support systems have on designers' working process through examination of their design characteristics. For example, Sun, Xiang, Chai, Wang, and Huang [1] proposed the creative segment theory, which postulates that creative segments include inspiration generation, inspiration expression, and visual feedback. They observed that the theory accurately describes the sketching process and developed a sketch-assist system that can structure creative segments. Ozkaya and Akin [2] proposed a requirement design coupling approach that can provide a connection mechanism for requirement-driven design. They modeled a continuous and interactive design process for integrating problem formulation and form exploration to facilitate the architectural design thinking process and enable designers to understand the entire design process from the initial design stage to the stages of construction, maintenance, and completion. Segers, de Vries, and Achten [3] constructed an idea space system to facilitate architectural design thinking. The designers

were inspired by the system's word-image connection to think creatively and consider more perspectives, thus enhancing their work efficiency.

Siangliulue, Chan, Gajos, and Dow [4] conducted an online experiment to explore two mechanisms that offer examples at the appropriate moment. Their results indicated that examples provided on demand can assist designers in developing novel ideas, whereas examples delivered at the wrong time can suppress their idea generation. Golembewski and Selby [5] invented Ideation Decks, a card-based design ideation tool that helps designers effectively examine specific problems by aiding in iterative design explorations. When engaging creatively with each Instance Card, designers critically reflect on the depicted concept in isolation, exploring and gaining insight regarding their internal conceptual models in that instance. Cruz and Gaudron [6] also described an "open-ended objects tool" for use in brainstorming; this tool stimulated participants to reflect on emotions and desires and to establish a participatory atmosphere among themselves.

Ahmed [7] enhanced the reuse of design knowledge by developing index knowledge in the field of engineering design. He observed engineering designers and determined that 24% of them spent most of their time searching for information. Therefore, he asserted that information searches are vital to the design process and accordingly developed a method that enables designers to index design knowledge. Westerman and Kaur [8] examined the retrieval of inspirational images from computer databases, proposing that creative design tasks require the support of information systems for both convergent and divergent processes. Our previous research [9] assumption was that designers are accustomed to looking for resources online by using keywords as a result of Internet technology development. Words have since become recognized as a critical component for researchers in the field of design cognition to understand how designers transform their design concepts. The present study focused on the relevant connection between keyword thinking and design concepts and suggested that the search for resources using keywords should be regarded as a component of "seeing."

As designers decide which keywords to use for their "seeing," they must identify words related to the design task to begin the retrieval process, by which they can find the needed resources and the proper materials, a step known as "thinking first." With the advent and explosion of Internet resources in particular, designers' approaches to finding these resources have dramatically changed. Today, designers can be inspired by the substantial amount of Internet resources available, which is a notable change from designers in the past, who used books as references.

1.1 Creative Idea Generating App IDEATOR

Our preliminary research proposed four modes of association based on designer behavior during ideation [10, 11]. We then developed a creative idea generation tool, IDEATOR [9], to support designers during ideation. The main functions of IDEATOR (Fig. 1) are developed from designers' behavioral modes and resource searching needs during ideation, supporting a designer's formulation of concepts by integrating image searches, and stimulating design actions by displaying all of the images on an image board. Unlike other design thinking support systems, IDEATOR emphasizes recording a designer's word-thinking paths and processes (Function A in Fig. 1). It assists designers with the repeated input, access, and storage of information. Our preliminary research results

indicated that IDEATOR enables designers to add their own ideation sketches and brief descriptions while recording each concept, which makes the results of their idea maps similar to a designer's self-reports. During the process, keywords, ideation sketches, and images serve as a stimulus or as the object of “seeing” in the “seeing–moving–seeing” model [12].



Fig. 1. Three main functions of IDEATOR (Screenshot sequences from left to right indicate the functions for ‘idea developing–mind map’, ‘image searching’, and ‘image comparing’).

IDEATOR provides designers with copious visual stimulation during idea development (Functions B and C in Fig. 1), which is in accordance with research demonstrating that a designer's mental imagery can be triggered by an abundance of visual stimuli [12–18]. Such mental imagery aids designers in generating new ideas.

However, most research on design support tools has focused on studying designers from a specific design field rather than comparing designer characteristics among various fields. Therefore, the present study investigated and compared the influence of IDEATOR on the idea development of designers in the fields of graphic design, product design, and interior design. Specifically, we examined the differences in behavior linkages and idea sketches among designers from these fields.

2 Research Method

We explored how designers in different fields develop ideas with IDEATOR and the effects that the app has on ideation. We collected data using IDEATOR. Specifically, IDEATOR was adapted to record the designers' idea maps, index reference content, concept words of association, and sketch development. Further details of the research methods are provided in the following sections.

2.1 Design Task, Process and Participants

To ensure consistency, the designers performed a design task assigned by us. Regardless of their field, all of designers had an assigned task for the same café place. Specifically, graphic designers were required to design a logo, product designers were required to design a chair, and interior designers were required to design a bar for a coffee shop named “at Café.”

Before the design task was executed, task instructions, pieces of A4 paper for sketching, and an iPad Mini with the IDEATOR app were provided to each designer. Designers were taught how to use IDEATOR and were informed that their behavioral data would be collected and analyzed. The designers were given freedom regarding their working environment and Internet usage.

The designers had 1 week to finish the task and were allowed to finish early. In addition, upon completion, the designers were required to turn off the screen-recording app (Shou.TV mobile game streaming 0.7.13) on their iPad and write down the drawing completion time point for each sketch on the paper (see Fig. 2).

A total of 15 designers (10 male and 5 female) with an average of 3 years of experience were invited to participate. Of them, five were graphic designers, five were product designers, and five were interior designers.

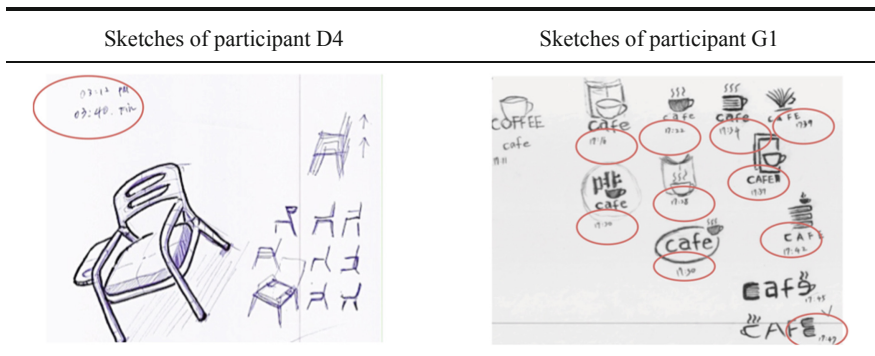


Fig. 2. Idea sketches of designers D4 and G1. Red circles indicate completion time points (Color figure online)

2.2 Data Analysis

For data analysis, each designer's IDEATOR data from the mobile device, screen capture recordings, and developed idea sketches were collected. Video and protocol data analysis was conducted by the researcher and two coders, and the internal consistency of the coding results was tested.

The study used behavior-recording software, The Observer XT was used to collect and analyze video data. First, the researcher and two coders individually marked the change points of the videotaped behavior of the designers according to the behavioral definitions and coding scheme from our previous study [9]. Subsequently, the two coders listed clips that could not be categorized under any behavioral code. Thereafter, the researcher and two coders discussed possible revisions to the behavioral definitions and coding scheme.

The designers' recorded video data using IDEATOR to record their self-ideation process. Their operational behavior did not perfectly match the behavioral codes used in the previous study because of the app's revised interface and functions. For example, for

sketching behavior, the behavioral coding in the preliminary study comprised “Creating new sketches” and “Continuing to sketch.” Although the research data was provided by the designers, the mobile screen-recording app (Shou.TV mobile game streaming 0.7.13) was unable to record the designers’ sketching process, which was done on paper. Therefore, the sketching behavior in this study was classified under the behavioral codes “Sketching on paper (SOP)” and “Drawing on sketch pad (DOSP).”

Our modified behavioral coding scheme is presented in Table 1. There are three behavioral modes. The “Gathering information (GA)” mode includes the three behaviors of “Retrieving information (RI),” “Referring to relevant information (RRI),” and “Referring to the saved data (RSD).” The “Generating ideas (GI)” mode includes the three behaviors of SOP (Sketching on paper), DOSP (Drawing on sketch pad), and “Adding a new branch idea (ANI).” Finally, the “Thinking (TH)” mode includes “Revising a branch idea (RBI),” “Highlighting a branch idea (HBI),” and “Purposeless action (PA).” In addition, because the designers were unfamiliar with IDEATOR, they may have performed an “Error action (EA),” an action that belongs to none of the three modes.

3 Results and Discussion

To explore whether the effect of IDEATOR on the design process differed by a designer’s field, the data collected from the graphic, product, and interior designers were denoted G1–G5, D1–D5, and I1–I5, respectively. Each designer had a complete set of data comprising screen capture data, hand-drawn sketches, and IDEATOR data.

3.1 Analysis and Comparison of the IDEATOR Operation Records Segment Encoding in Three Design Domains

According to our analysis using Observer XT, the mean duration of each designer’s ideation was 1873 s (or 31 min). Video data on the designers’ interface operations were divided into 767 segments according to the behavioral coding scheme (Table 1), and the coding results of all the segments are detailed in Table 2. During ideation, the product designers had the greatest number of IDEATOR segments ($M = 75$), whereas graphic designers had the fewest IDEATOR segments ($M = 33$).

ANI (Adding a new branch idea) had the most segments ($M = 288$, 37.5%) coded under it, followed by PA (Purposeless action, $M = 127$, 16.6%) and RI (Retrieving information, $M = 85$, 11.1%). The least prevalent type of behavior was DOSP ($M = 12$, 1.6%), followed by SOP (Sketching on paper) ($M = 17$, 2.2%). For the interior designers in particular, the RSD (Referring to the saved data) behavioral segment was more prevalent, even more so than PA (Purposeless action) and RI (Retrieving information); DOSP was also more common than SOP (Sketching on paper). Interestingly, the designers in all three fields seemed not to use IDEATOR’s built-in sketch pad to sketch (DOSP), and the graphic designers used this function the least. The interior designers were the group most likely to use a sketch pad to draw sketches; only one interior designer did not use this tool. The remaining four used the sketch pad to sketch (DOSP) with higher frequency and duration than those of designers sketching on paper (SOP).

Table 1. Behavioral coding scheme (revised from the behavior codes of [9])

Behavior mode	Behavior (code)	Definition
Gathering information (GA)	Retrieving information (RI)	Retrieving information on-line for capturing ideas, sketching or drawing; saving the retrieved information in the hard disc to be the reference later.
	Referring to relevant information (RRI)	Referring to the information they have retrieved on-line in advance. Retrieving action is not included in the behavior.
	Referring to the saved data (RSD)	Referring to some saved data that have been retrieved on-line by them in advance.
Generating ideas (GI)	Sketching on paper (SOP)	Creating the new shapes, labels or lines.
	Drawing on sketch pad (DOSP)	Drawing the new shapes, labels or lines on sketch pad.
	Adding a new branch idea (ANI)	Adding an idea in the mind map area of IDEATOR as the new branch to be used or further thinking later.
Thinking (TH)	Revising a branch idea (RBI)	Revising the idea, fixing the words of an idea, adjusting the level of an idea in the mind map area of IDEATOR.
	Highlighting a branch idea (HBI)	Applying different color to a branch idea for highlighting its important or using several colors to those ideas for separating them from each other.
	Purposeless action (PA)	Making a move purposively, such as touching and moving working area back and forth.
None	Error action (EA)	Making a move incorrectly or not accordance with the operational rules of IDEATOR.

When referring to the three modes (GA, GI, and TH), the designers' behavior segments corresponding to the GI mode (Generating ideas, including codes SOP, DOSP, and ANI) occupied 41.3% of the behavioral segments, which was higher than the frequency of behavior segments corresponding to the GA mode (Gathering information, including codes RI, RRI, and RSD) occupied 21.5%. This finding indicates that the frequency of the designers' GI behavior occupied more than two-thirds of all of the behavior segments; that is, the designers most frequently performed GI behaviors during the ideation process.

However, regarding differences among designers of different fields, GI behavior was observed more frequently in the graphic and product designers than were the other two types of behaviors. In particular, the graphic designers' GI behavior accounted for more than half of the total number of behavior occurrences, whereas the product designers' GI behavior accounted for more than 40% of the total number of behavior occurrences. Additionally, among the graphic designers, GA (Gathering information) behavior occurred the least frequently of the three modes, whereas among the interior designers, GA (Gathering information) behavior occurred the most frequently of the three modes.

3.2 Behavioral Relationship Among the Three Design Domains in Ideation

All of the before–after behavior linkages with the designers' sketching behaviors (including SOP and DOSP in IDEATOR) and data referred to before sketching are presented in Table 3. The second column shows the designers' DOSP before–after behavior, with “-” indicating no action after drawing. The third column indicates the type of data that the designers referred to before sketching. For example, designer G1 appears to have engaged in PA (Purposeless action) before drawing the sketch, followed by no other

Table 2. Encoding of designers' behavior segments in three fields

B-mode	GA			GI			TH			None	Total
B-Code	RI	RRI	RSD	SOP	DOSP	ANI	RBI	HBI	PA	EA	Segs.
G1				1		15		3	2		21
G2				1		12		2	3	2	20
G3	1			1		29	11		14	1	57
G4				1		11	1	3	2		18
G5	4		3	1		20	3		10	7	48
Total	5	0	3	5	0	87	15	8	31	10	164
D1	12		4	3		4	2			2	27
D2	14	5	6	1	2	49	7		38	7	129
D3	14	1	10	1		13	4		2	6	51
D4	2	4		1		50	7	11	16	20	111
D5	7	6		1		31	2		5	5	57
Total	49	16	20	7	2	147	22	11	61	40	375
I1	14	2	14	1	2	2	2		14	2	53
I2			10	1		15	10	7	2	1	46
I3	4	2	3	1	1	12	2	5	13	11	54
I4	6		2	1	1	5			3		18
I5	7	1	7	1	6	20		7	3	5	57
Total	31	5	36	5	10	54	14	19	35	19	228
Segs.	85	21	59	17	12	288	51	38	127	71	767
Pct.(%)	11.1	2.7	7.7	2.2	1.6	37.5	6.6	5.0	16.6	9.0	100
Order	3	8	5	9	10	1	6	7	2	4	

behavior after the sketch was completed. G1 reported searching for a word reference before sketching. Among all of the designers, only designer D1 engaged in three periods of sketching behavior when using IDEATOR v.2 to proceed with ideation; the other designers sketched until they were satisfied with the drawing and then exhibited no further behavior. Thus, only the first and second sketches of D1 followed the behaviors of RBI (Revising a branch idea) and RI (Retrieving information).

The most common behavior among the designers before sketching was PA (Purposeless action), followed by RI (Retrieving information); RSD (Referring to the saved data), HBI (Highlighting a branch idea), ANI (Adding a new branch idea), EA (Error action), and RRI (Referring to relevant information) behavior also appeared once. Among these behaviors, PA (Purposeless action) occurred before the graphic designers began sketching, with only designer G2 also engaging in HBI (Highlighting a branch idea) before drawing. The product designers' behavior was different: before beginning to sketch, designers D1 and D5 engaged in RSD (Referring to the saved data), RI (Retrieving information), and RRI (Referring to relevant information); designers D2 and D4 engaged in PA (Purposeless action) and EA (Error action); and designer D3 engaged in ANI (Adding a new branch idea). Among the interior designers, designers I1, I4, and I5 engaged in RI (Retrieving information) and RSD (Referring to the saved data) and designers I2 and I3 engaged in PA (Purposeless action).

Regarding the type of data referenced before beginning their sketches, nine designers (G1–G5, D2, D3, I2, and I3) looked at words and six designers (D1, D4, D5, I1, I4, and I5) looked at pictures. This pattern suggests that product and interior designers tend to refer to words or pictures before sketching, whereas graphic designers tend to refer solely to words before sketching.

By comparing the behavior of the designers with their preferred data reference type, we discovered that the graphic designers usually engaged in PA (Purposeless action) and looked at the words on the mind map before sketching. PA (Purposeless action) was less common among the product designers and interior designers, who usually began their sketches after engaging in RI (Retrieving information), RSD (Referring to the saved data), and RRI (Referring to relevant information) and looking at either the words or the pictures on the mind map. The results of the video data analysis indicated that compared with the traditional behavior adopted by designers of relying on image data for reference before proceeding with the ideation process, the graphic designers in the present study were the most dependent on word references to perform the ideation process.

Table 3. Behavior linkages of before–after drawing sketches and reference data type before drawing

Participant	G1		G2		G3		G4		G5	
	Before	After	Before	After	Before	After	Before	After	Before	After
1st Sketch	PA	--	HBI	--	PA	--	PA	--	PA	--
Reference Type	words		words		words		words		words	
Participant	D1		D2		D3		D4		D5	
	Before	After	Before	After	Before	After	Before	After	Before	After
1st Sketch	RSD	RBI	PA	--	ANI	--	EA	--	RRI	--
Reference Type	images		words		words		images		images	
2nd Sketch	RI	RI								
Reference Type	images									
3rd Sketch	RI	--								
Reference Type	images									
Participant	I1		I2		I3		I4		I5	
	Before	After	Before	After	Before	After	Before	After	Before	After
1st Sketch	RI	--	PA	--	PA	--	RI	--	RSD	--
Reference Type	images		words		words		images		images	

3.3 Designers’ Sketches, Referenced Pictures, and Lateral Thinking Categories

The researcher and two coders analyzed the sketches, reference content, and concept words drawn by all the designers during the ideation process. The results revealed that all together, the designers drew a total of 121 idea sketches, saved 100 reference pictures, and input 284 concept words. The categorization of designer G1’s sketches and of designer I1’s picture references is shown in Fig. 3, and the classification of all of the designers’ idea sketches, reference pictures, and concept words is presented in Table 4.

The five graphic, product, and interior designers drew a total of 67, 48, and 6 sketches, respectively. On average, each graphic designer produced 13.4 sketches, each product designer produced 9.6 sketches, and each interior designer produced 1.2 sketches.

Regarding lateral thinking classification, designer G3 demonstrated the highest rate of lateral thinking among the graphic designers, with sketches separated into seven categories. By contrast, designer G1 demonstrated the lowest rate of lateral thinking in the graphic design field, with sketches only separated into three categories. Furthermore, the logo sketches drawn by the graphic designers were mostly variations of the “coffee cup + word” concept, followed by the “type design” concept and the “coffee beans + word” concept. Designer D3 demonstrated the highest rate of lateral thinking among the product designers, with sketches separated into five categories; D2, D4, and D5 demonstrated the lowest rate of lateral thinking among the product designers, with sketches separated into only two categories. In addition, most of the product designers’ coffee shop chair sketches were variations of “arc” sketches and “simple line” sketches, followed by the “plant shape” and “coffee bean shape.” Among the interior designers, designer I5 had sketches that were separated into two categories of lateral thinking, and all of the other interior designers’ sketches were placed in one category of lateral thinking. Most of the coffee shop bar design sketches made by the interior designers were categorized as a “space layout” design.

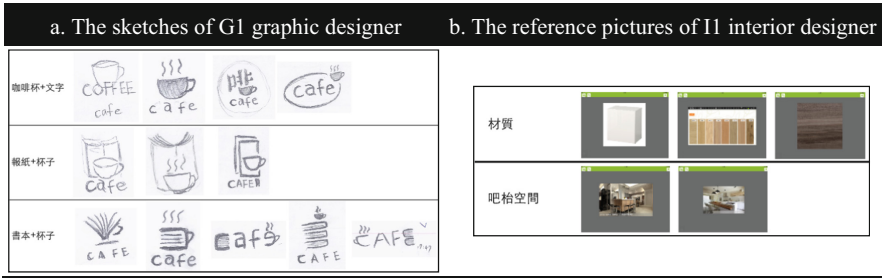


Fig. 3. Sketches of designer G1 and the reference pictures of designer I1

A closer examination of the reference picture analysis results revealed that the five graphic designers had only saved three reference pictures. The average number of pictures saved by each graphic designer was 0.4, which was the smallest average among the three design fields. Only designer G5 saved three pictures that were grouped into two categories. By contrast, the five product designers saved 59 reference pictures in total. The average number of pictures saved by each product designer was 4.2, which was the highest average among the three design fields. Their reference pictures were mostly classified as “arc chair design,” followed by “coffee shop space.” Finally, the interior designers saved 38 reference pictures altogether. The average number of pictures saved by each interior designer was 3.6, and their reference pictures were mostly classified as “coffee shop space,” followed by “material.”

In addition, the five graphic designers input a total of 78 concept words for concept word analysis. Among these designers, the average number of input concept words was 17.8 per designer. Most of their concept words were classified as “style,” followed by “objects” and then “feeling.” The five product designers input a total of 192 concept words. The average number of input concept words was 41.4 per designer, constituting the highest rate of input across the three design fields. Most of their concept words

Table 4. Number of designers' idea sketches, reference pictures, concept words and category in three design fields

Idea Sketches																
Group	Graphic Design					Product Design					Interior Design					Ave.
Participant	G1	G2	G3	G4	G5	D1	D2	D3	D4	D5	I1	I2	I3	I4	I5	
Amount	12	18	16	10	11	8	4	15	11	10	1	1	1	1	2	8.07
Average	13.4					9.6					1.2					
Categories	3	4	7	5	4	3	2	5	2	2	1	2	1	1	1	2.87
Average	4.6					2.8					1.2					
Reference Pictures																
Group	Graphic Design					Product Design					Interior Design					Ave.
Participant	G1	G2	G3	G4	G5	D1	D2	D3	D4	D5	I1	I2	I3	I4	I5	
Amount	0	0	0	0	3	9	22	7	8	13	5	13	4	6	10	6.67
Average	0.6					11.8					7.6					
Categories	0	0	0	0	2	1	7	3	2	8	2	4	3	4	5	2.73
Average	0.4					4.2					3.6					
Mind map Ideas																
Group	Graphic Design					Product Design					Interior Design					Ave.
Participant	G1	G2	G3	G4	G5	D1	D2	D3	D4	D5	I1	I2	I3	I4	I5	
Amount	17	17	26	9	20	5	104	22	48	28	5	13	11	5	25	23.67
Average	17.8					41.4					11.8					
Categories	7	6	5	4	7	3	5	5	7	5	1	4	3	2	5	5.0
Average	5.8					5.0					3.0					

were classified as “requirement and restriction,” followed by “style” and then “feeling.” Finally, the interior designers input a total of 56 concept words. The average number of input concept words per designer was 11.8, constituting the lowest rate of input across the three design fields. Most of their concept words were classified as “style,” followed by “objects” and then “requirement and restriction.”

In order to understand whether a correlation existed among the designers' idea sketches, reference pictures, and concept words, all of the designers' idea sketches, sketch categories, reference pictures, reference picture categories, concept words, and concept word categories were subjected to a correlation coefficient test (Table 5). The statistical results revealed that positive correlations between the number of idea sketches and “idea sketch” categories; the number of idea sketches, concept words, and “concept word” categories; the number of “idea sketch” categories and “concept word” categories; the number of reference pictures and “reference picture” categories; and the number of concept words and “concept word” categories for six types of double variables. Negative correlations were also observed among the number of idea sketches, reference pictures, and “reference picture” categories and among the number of “idea sketch” categories, reference pictures, and “reference picture” categories for four types of double variables.

In terms of the results of the correlation coefficient test, we observed a positive correlation between quantity and category among the designers' idea sketches, reference pictures, and concept words. Our most notable finding was that the greater the number of concept words that the designers input on the mental map interface of IDEATOR v.2, the greater the number of idea sketches they drew. With respect to negative correlations, the more reference pictures and categories saved by the designers, the fewer idea sketches they drew. In particular, the more "reference picture" categories they referred to, the fewer sketches they produced, which led to the emergence of fewer "idea sketch" categories. In accordance with this discussion of the relationships between the designers' idea sketches, reference pictures, and concept words, we argue that the designers' concept words may increase idea sketch quantity and expand lateral thinking compared with reference pictures. The results reinforce the importance that word-to-word association has for designers' ideation: when they input more concept keywords, their sketches span across more categories. We will verify these results and increase the number of designers studied in future research.

Table 5. Results of the correlation coefficient test between designers' idea sketches, reference pictures, concept words and category

Item		Sketches	Sketch Category	Picture	Picture Category	Word	Word Category
Sketches	r	1.000					
	p	--					
Sketch Category	r	.826**	1.000				
	p	.000	--				
Pictures	r	-.488*	-.487	1.000			
	p	.034	.033	--			
Picture Category	r	-.570*	-.624**	.850**	1.000		
	p	.013	.006	.000	--		
Word	r	.446*	.187	.319	.309	1.000	
	p	.048	.252	.123	.131	--	
Word Category	r	.746**	.443*	-.172	-.205	.704**	1.000
	p	.001	.049	.270	.232	.002	--

* means $P < .05$, ** means $P < .01$

4 Conclusion and Recommendations

In this study, we evaluated the performance of designers' idea development using the IDEATOR app as the designers' ideation tool and investigated whether there were differences in behavior linkages and idea sketches among designers from three design fields. The results were as follows:

1. According to our analysis of the video data recorded by designers using IDEATOR, their interface operation behaviors included nine behavioral codes separated into three behavior modes (GI, GA, TH) and an error action code;

2. The designers used IDEATOR for ideation and most frequently engaged in GI behavior, especially those in the fields of graphic and product design;
3. The designers who used IDEATOR for ideation had a tendency to frequently develop concept words. In particular, graphic designers were highly dependent on word-type data to perform the ideation process; and
4. The more input concept words on the interface of the IDEATOR mind map employed by the designers, the more idea sketches the designers drew. As they input additional concept words, the designers also produced sketches that fit into multiple lateral thinking categories.

This research achieved the expected results in line with the innovative results of the previous preliminary study. In addition, this study provides an effective recording tool for use in future ideation process research. Furthermore, on the basis of the relationships among idea sketches, reference pictures, and concept words, we argue that concept words have a greater impact on idea sketch quantity and lateral thinking than do reference pictures. This assertion will be verified with further research and a larger pool of participants.

Acknowledgement. The author gratefully acknowledges the support provided by the Ministry of Science and Technology under Grant No. MOST 109-2410-H-004-036. Additional gratitude goes to the 15 designers who participated in this study and the two coders, Nian-Chen Cai and Tsai-Ping Chang, who participated in the analysis.

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