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To explore the effect of sub consciousness on Sudden Moments of Inspiration (SMI) in the sketching process of industrial design

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Abstract The purpose of this study is to identify the occurrence of Sudden Moments of Inspiration (SMI) in the sketching process of industrial design through experiments to explain the effect of sub consciousness on SMI. There are a pre-experiment and a formal experiment. In the formal experiment, nine undergraduates majoring in industrial design with same education experience were selected to receive a design task. In the task, nine undergraduates were divided into three groups randomly by lot. While two groups received A or B subliminal suggestions through a slide picture presentation, the other one group was not. The design processes and sketches of the three groups were recorded and analyzed, using concurrent and scientifically experimental methods such as real-time videos and protocol interviews. Comparison of the three experiments provided convincing evidences of the effect of sub consciousness on SMI in the sketching process of industrial design.

Keywords Industrial design · Sketches · Real-time recording · Protocol interview · Sudden Moments of Inspiration

Instruction

The Sudden Moments of Inspiration (SMI) is a burst inspiration or a sudden understanding when solving a problem or doing something, which widely occurs in psychology and daily life. In industrial design, SMI is the moment, which drives the design process and helps designers redirect creative solutions. Most applications and studies of SMI were wide in daily life or limited to psychology. There have been few attempts to identify how SMI occurs and its nature or role in the industrial design process. The study aims to verify the influence of subliminal suggestions on SMI in the industrial design process. The sketching expression is adopted as the object investigated. Through verifying the influence, point of

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views can be put forward. The final result is expected to give a positive influence to the future education in industrial design.

Designing is a complex process of problem solving, problem framing (Gao and Kvan 2004) or even stating (Bijl 1985). Suwa and Tversky (1997) discuss how the designer's attention changes from one aspect of the design to another in what they refer to as a focus shift segment. This study attempted to verify these segments, especially the segments that affect the design, or what could be regarded as the SMI. And the SMI segments were considered to occur with signals such as the 'aha' effect (Akin and Akin 1996), eureka moment (Knoblich and Oellinger 2006) or sudden mental insight (Cross 2001).

Before sketching expression process, different kinds of subliminal suggestions have been given to subjects. The main hypothesis of the study is that since subliminal suggestions have the capacity to alter the cognitive process, they might manifest in the form of SMI and affect the industrial design process (in the experiment, a sketching process was adopted). Specifically, the study examines whether subliminal suggestions affect the frequency and the nature of the occurrence of SMI in the design process.

Sudden Moments of Inspiration

Prior knowledge

The normal understanding of prior is in relative to "experience". It means that prior is before experience but an indispensable part of experience. Prior knowledge is the knowledge before experience. The unique character of prior knowledge is that it obtains knowledge through non-perceptive rationality, such as intuition, pure rationality and reflection instead of originating from the world of the senses. Kant's theory has introduced that prior is obviously relative to experience. Prior knowledge can be a significant and accurate predictor of performance and facilitates new learning (Thompson and Zamboanga 2004). It only provides accidentally universal knowledge or relatively universal knowledge through induction. Experience is the human initial way to obtain knowledge, but it's not the only way.

Sub consciousness

Sub consciousness was proposed by Sigmund Freud (1856–1939). Sub consciousness, a thought relative to "consciousness", refers to a mysterious hidden in the general sense. Sub consciousness is the part that human can't perceive or human haven't perceived. It is the psychological activity, which has occurred but didn't reach the state of consciousness. The main features of sub consciousness are as follows:

1. The energy of sub consciousness is thirty thousand times more than consciousness.
2. Sub consciousness prefers information with emotional coloring.
3. Sub consciousness doesn't distinguish true or false.
4. Sub consciousness is easily stimulated by images.
5. The memory of sub consciousness needs strong stimulation or repeat stimulation.
6. It is easy to get in sub consciousness when people are relaxed.

The concept of Sudden Moments of Inspiration

SMI in psychology means a sudden understanding. Gestalt psychologists pointed out that the process human solve problems is a kind of SMI.

The definition of SMI widely accepted is still the definition that put forward by Gestalt psychologists. SMI is a process of building relationship between corresponding objects inside a thing and the solution through observation and acknowledge of the scene and the way to reach the target. There are six characteristics of SMI.

1. Before solving problem, there's a period of confusion or quiet. In this period, solvers performed as waver in determination with a long-time pause. The pause can be regarded as the "incubation period" for solving problem.
2. The transition from before solving problems to solving problems is not a gradual-change process but a sudden qualitative-change process. The sudden occurrence can be a solution of the problem; it also can be a sudden occurrence of consciousness of the solution.
3. In the solving-problem period, the solving behavior is a fluent and constant process with little mistake behavior.
4. SMI relies on situations. When the relationship between basic parts of the solution and the current situation is easier to recognize, SMI will occur easily.
5. SMI is related with working memory and long-term memory. The solution come from SMI can keep for a long time in memory.
6. The key processing mechanism of SMI is the analogical transfer. A SMI graduated from one situation can transfer to a new situation.

The SMI process is also a process of perception recombination, from an unclear and unorganized status to a clear and organized status. And the perception recombination is the basis of SMI. The perception is a processing that organizes and explain sensory information produced by external objects and things. Perception is the way humans receive outside information, a part of information will form prior knowledge.

Research status of SMI

Nowadays, the influence of sub consciousness has been studied in a lot of fields, such as marketing and education while there are little studies of sub consciousness in design. But results of the influence of sub consciousness and SMI in other fields are great references to this study and the design of the experiment.

Among the research literatures, Mayer (1995) has made a conclusion of the explanations about SMI in Gestalt theory. The conclusion contains five steps, 1. to complete the problem schema 2. to organize the visual information anew 3. to express the problem again 4. to overcome psychological obstacle 5. to find the analogy to the problems. Mayer gave a definition of SMI as the sudden from the status of "don't know how to solve the problem'' to the status of" know how to solve the problem".

Suwa and Tversky have discussed how the designer's attention changes from one aspect of the design to another in what they refer to as a focus shift segment. The segment was similar to a design move proposed by Goldschmidt (1995), in which a move is defined as an act that transforms a design from one status to another. Linkages between different segments helped to identify how segments with SMI relate to the surrounding segments. The emphasis was on the macroscopic scale of the protocol and not on the finer details, which enabled to clearly frame the task of identifying SMI within the protocol. When

identifying SMI, the objective was to investigate the role of subliminal suggestions, which have been studied extensively in fields such as marketing. A subliminal suggestion may be a sign or message embedded within a context, which is designed to pass through normal perception without clear detection. Even though not directly detectable, these messages are received by the sub conscious mind. Studies suggest that subliminal cues may mould the way that a person reacts, which is termed as subliminal persuasion (Dijksterhuis and Smith 2005).

How to identify SMI

SMI was identified through analysis of the concurrent protocol. The retrospective protocol was used to verify the existence of a new idea in each SMI, and the participants were asked for confirmation of ideas that emerged. Retrospective protocol was also used to confirm and supplement the identification of SMI that relate to the subliminal stimuli. It was reasonable to assume that a single-phase chunk would consist of at least one key event/decision. Due to this, every major decision of the design process was initially considered a potential SMI.

Kounios and Beeman (2009) state that a sudden comprehension that solves a problem, reinterprets a situation, explains a joke, or resolves an ambiguous percept is called an insight or an 'Aha' moment.

According to Smith et al. (2011) insight means a deeper understanding of the innermost workings of a problem that may include critical ideas that can solve difficult problems. When such an understanding springs into mind in a sudden realization, it is referred to as an insight experiences, an "aha" experience or a eureka moment.

As a result, the main decisions of each design procedure are regarded as the potential SMI; SMI may occur during the leap from a status to another status; the retrospective protocol identifies SMI through the "aha" experience.

An important content of the retrospective protocol is that subjects described their thought about their sketching process. In the pre-experiment, the method of describing was adopted when sketching. After the experiment, subjects suggested that describing when sketching interrupted their thoughts. What's more, from thinking to speaking out, language was after filtering. So, in the formal experiment and the collection of data, videos were taken when the subjects sketched, and the subjects were required to describe their thought according to the videos after they finished sketching.

The linkage between SMI, prior knowledge and sub consciousness

The earliest person who put forward the linkage between sub consciousness and innovative thought in philosophy is Kant, the German classic philosopher. He suggested that the creative activities of cognition was a process of piecing perceptual material together by one's congenital factors, a prior process. The prior knowledge here means 'before experience', 'before knowledge'. It means that the formation of knowledge is after a creative process and a synthesis process. Kant pointed that the prior process is an unconscious process. What human are aware of is new concepts or knowledge, the result after the unconscious process. As a consequence, Kant regarded the creativeness of thought as "spontaneous". And the "spontaneous" concept contains sub consciousness. The prior knowledge is formed by perception. And the prior process is a process of forming sub consciousness. It can be inferred that SMI is influenced by sub consciousness.

Experiment

The methods and the purposes of the experiment

Purposes of the experiment

It can be inferred from the contact between the concepts mentioned before that SMI is influenced by sub consciousness in some extent. As a result, the experiment aimed to verify whether subliminal suggestions influence the occurrence of SMI or not through identifying SMI of subjects during the experimental process.

Methods

The controlling variable method was adopted in the experiment. The subjects were given the same design task under the control of subliminal suggestions in the shape dimension of Industrial Design. Subjects were asked to express their ideas through sketching, and the whole process was recorded completely through the video. After sketching, they were required to describe their instant thoughts in sketching process with the recorded video before, and these describing processes were recorded by audio. Through the analysis of videos, audios and the final sketches, influences of different subliminal suggestions on design process and sketch can be determined. With the influences, whether subliminal suggestions influence the occurrence of SMI or not through identifying SMI of subjects during the experimental process can be identified.

The given design task was to complete a product design through sketching. The dimensions of product could be divided to three parts: color, shape and material. During the sketch process, color and shape could be expressed directly while material was also expressed through color and finally determined with shape. Besides, the expression of color occurs in the late period of sketch, which meant that the thought of color selection don't run through the entire process. So the experiment was based on sketch, and shape dimension was considered as a variable.

The experiment data and the collecting method

Constitution of design progress

The sketch process in Industrial Design is a process of design, from receiving a design task to conception, to initial ideas, to improvement and finally to form an integrated sketch. Through recording the whole process of the experiment by video, it was expected to have knowledge of the constitution of design process of subjects, to know what parts the sketch process consists of and what modules their thoughts constitute of.

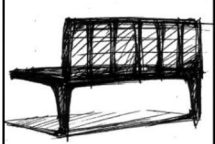
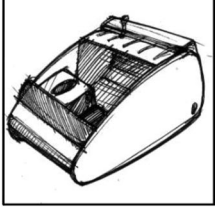
Complexity of sketch

The change of sketch complexity often shows the development of subjects' design thinking, their input level into design and their efficiency in design. The definition of sketch complexity (Table 1) was referred to the study of Rodgerset al (1998). 'Sketch complexity' were used to reject invalid sketches (invalid samples).

Time distribution of each phase

Time distribution of each phase was closely related with design process. The time distribution could reflect how much effort and thought the subjects spend on each phase. And how much effort and thought they have spent often influenced the occurrence of SMI in the whole phase, which was helpful to determine SMI.

Table 1 Concept of complexity of sketch

	Complexity Level One (Least complex) Monochrome line drawing. No shading to suggest 3D form. No text annotations are used no are numerical dimensions. Motion arrows may indicate moving parts. If a single color is used then this also counts as monochrome (eg: a drawing made in blue biro pen)
	Complexity Level Two Monochrome line drawing. There is no shading to suggest 3D form, but there is use of different thicknesses and pressures of line with single medium. One or two brief annotations may appear not more 6 or 7 words each. As in (1) arrows may be allowed.
	Complexity Level Three Monochrome, with rough shading used to give suggestion of form. The drawing may be annotated to describe certain aspects of the idea. Dimensions might be apparent.
	Complexity Level Four Subtle shading is heavily suggestive of 3D form. The drawing will almost certainly be annotated. Color, or gradation of monochrome color may be used to illustrate certain concepts or arrangements, but not to suggest the true colors of parts. NB The example used here is a color illustration.
	Complexity Level Five (Most complex) Color is used to represent the actual colors of parts of the product. There is much use of shading (both highlights and shadows) to suggest 3D form. Annotations will be used to ask questions of the idea or to explain it. Generally a very busy drawing, many lines will be used in its construction. NB The example used here is a color illustration.

The content and procedure of pre-experiment

In the pre-experiment, 3 postgraduate of Industrial Design were selected as subjects. They were divided into three groups to experimentize independently through drawing lots. Group A was under A subliminal suggestions, while Group B was under B subliminal suggestions. Group C was under condition control, with no subliminal suggestions. Images of soft style and industrial style were selected as subliminal suggestions as well as variables. Before receiving the design task, subject A browsed 9 images of soft style (Fig. 1). He was given 5 s to view each image and 30 s to answer a question related to the image. Each of these images was decolorized and had a hidden in the image or prominently displayed. The questions were not related to each image in order to transfer subjects' attention. For example, as shown in Fig. 2, a image showed a u disk. The question was, "What's the structure are there in the head of the doll?"

Subject B was provided with 9 images of industrial style (Fig. 3). Also, subject B was given 5 s to view each image and 30 s to answer a question related to the image. Each of these images was decolorized and had a shape of industrial style hidden in the image or prominently displayed.

Subject C was given no images and no subliminal suggestions.

The design task was to let subjects design shapes of a lamp, without the limitation of function, material and color. The reason why the lamp was chosen as the target task was that lamps were daily products. Subjects' complete prior knowledge was considered to have a less influence in their independent design. In the pro-experiment, every subject was required to describe his or her thought while sketching. The design process was recorded by video.

The pre-experiment completed under exploration, while some problems appeared. What's more, some advices have been received from subjects:

1. The selection of images was not perfect, such as vague and so on.
2. There was no enough time for subjects to conceive their design before the experiment began.
3. Before the beginning of the experiment, subjects should be told about the describing process.
4. To describe while sketch would interrupt subjects' thought.
5. From thinking to describing, the description was the result of thought-filtration.
6. Subjects came from different universities and were under different education background.

Fig. 1 A doll u disk

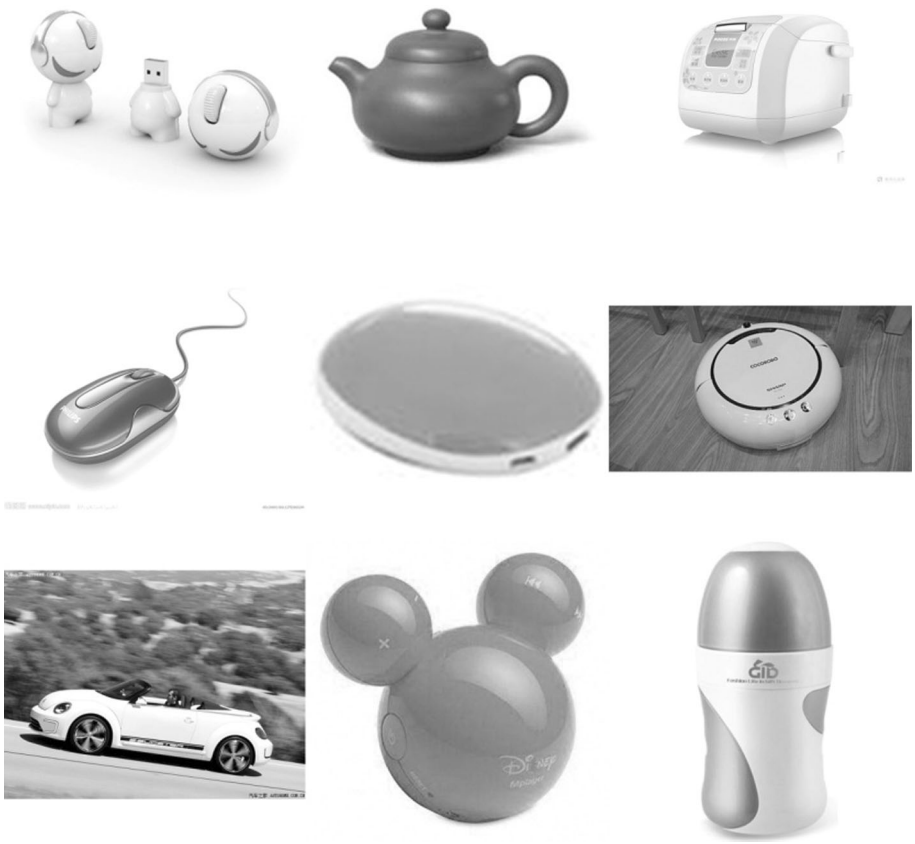


Fig. 2 9 images of soft style

7. The selection of the task still limited the design thought. A wider task should be considered, for example, to protrude function's influence and weaken shape's influence.

The formal experiment

In the formal experiment, nine junior students of Industrial Design from Zhejiang Sci-tech University were selected as subjects. They have received same courses and had education background. They were divided into three groups (three students per group) to experimentize independently through random lot method. Subjects of group A were under A subliminal suggestions, while Group B were under B subliminal suggestions. Group C were under condition control, with no subliminal suggestions. Soft style and industrial style were selected as subliminal suggestions as well as variables. Before receiving the design task, Group A browsed 9 images (images were same with pre-experiment) of industrial style (Fig. 4). They were given 5 s to view each image and 30 s to answer a question related to the image. Each of these images was decolorized and had a shape of soft style hidden in the image or prominently displayed. The questions were similar to those in the pre-experiment.

Group B were provided with 9 images (one image was replaced according to the pre-experiment) of soft style (Fig. 5). Also, Group B were given 5 s to view each image and

Fig. 3 9 images of industrial style

30 s to answer a question which was related to the image. Each of these images was decolorized and had a shape of industrial style hidden in the image or prominently displayed. Group C was given no images and no subliminal suggestions.

Before giving subjects design tasks, they were told to conceive when they receive the task. The sketch process was without limitation of time. When they completed sketching, they could gesture to experimenter. After sketching, they were required to describe their thought according to the video. The design task was to design a lighting device. And the light device focused on function and weakened shape, which could show the effect of subliminal suggestions in the final sketch.

Analysis of data and the conclusion

The analysis method

In the sketching experiment, videos were taken and subjects were required to describe how they thought in the sketching process, and their drawings were collected at last. The collected data before was under analysis of time visualization and analysis. The

Fig. 4 9 images of industrial style

segmentation structure introduced by Suwa and Tversky (1997) was adopted to realize the visualization of the relationship between videos and time (Fig. 6). Each segment is each step of the sketching process. The direct relationship between each segment could help identifying the occurrence of SMI and how they related with the neighboring segmentation.

Analysis of data

Screening of effectiveness data

9 groups of experimental results were collected at the end of the experiment. Each group of data was under analysis of time visualization and analysis in order to identify the association between the occurrence of SMI, sketches and subliminal suggestions. Through analysis of sketch complexity, video integrity, sketch abundance and the interrupt of thought, whether the experimental results were effective or not could be identified. If the result was not effective, the reason should be figured out. Finally, the result of C3 subject was removed due to the incomplete video.

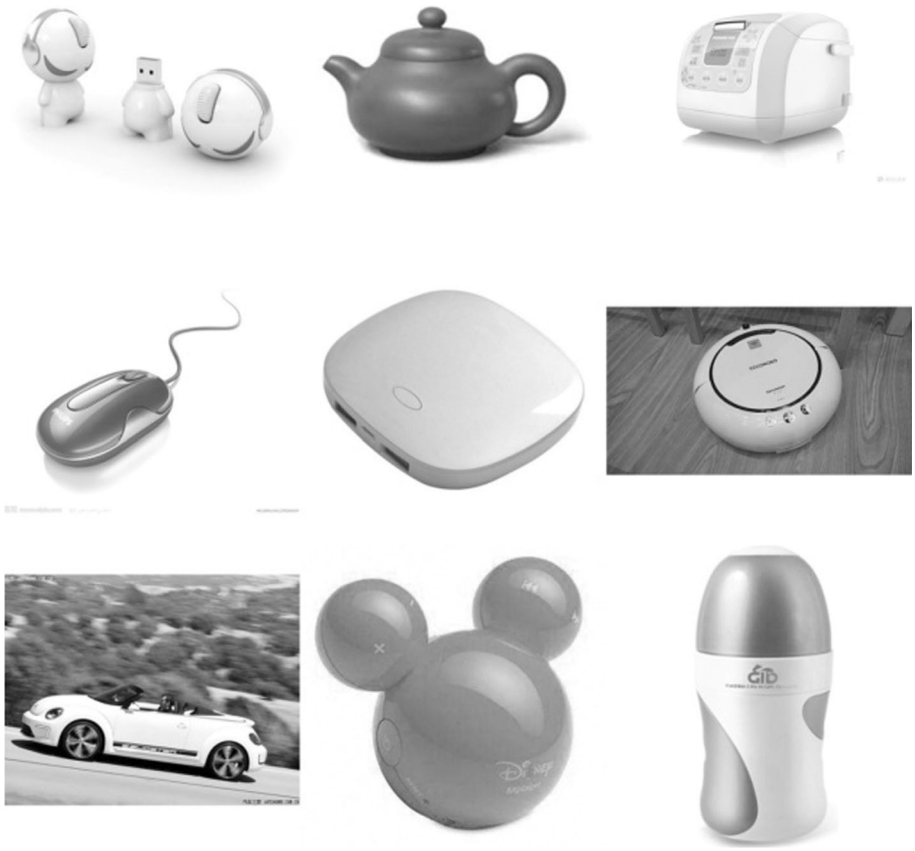


Fig. 5 9 images of soft style

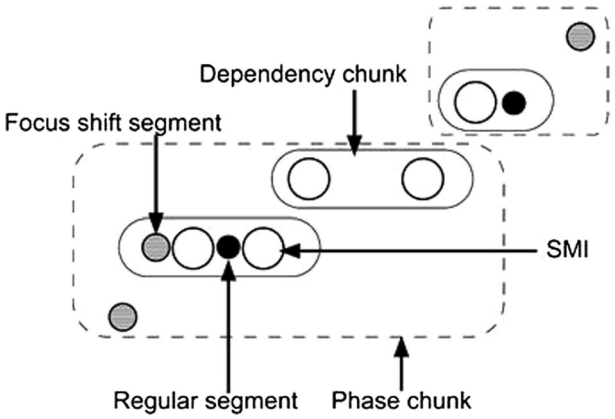


Fig. 6 The segmentation structure

Experimental results and data

Group A was shown images of industrial style.

The sketch of A1 subject shown in Fig. 7 while his time-segmentation chart is as Fig. 8.

There are 7 phase chunks in A1's chart. The division of each chunk was not so clear. In the initial two concept phase chunks, the second concept phase chunk lasted longer as soon as two SMI points occurred. But the two SMI points were not related with subliminal stimulate. The two-phase chunks were considered as the incubation period of the whole design process. In the period, subliminal stimulate began to influence the design process. The main characteristic of this period was a longer time, maybe due to the incubation of SMI. In the later description process, A1 described that he drew some shapes freely in order to expand his thought. To draw a watch as the product was based on the advanced experience he learned before. He wanted to design a watch for the old with functions of lighting their way. In the sketching period, he used sharp chamfers and lines in the present of product modeling in order to convey the precision feeling of the watch. The period consisted the third, fourth and fifth phase chunk, especially in the fifth period (the perfecting phase chunk), SMI points occurred more often. And these SMI points were related with subliminal stimulate directly. At last, in the sketching improvement period (the fifth and the sixth phase chunk), it was shown that obvious correlation existed between the period and subliminal stimulate.

The sketch of A2 subject shown in Fig. 9 while his time-segmentation chart is as Fig. 10.

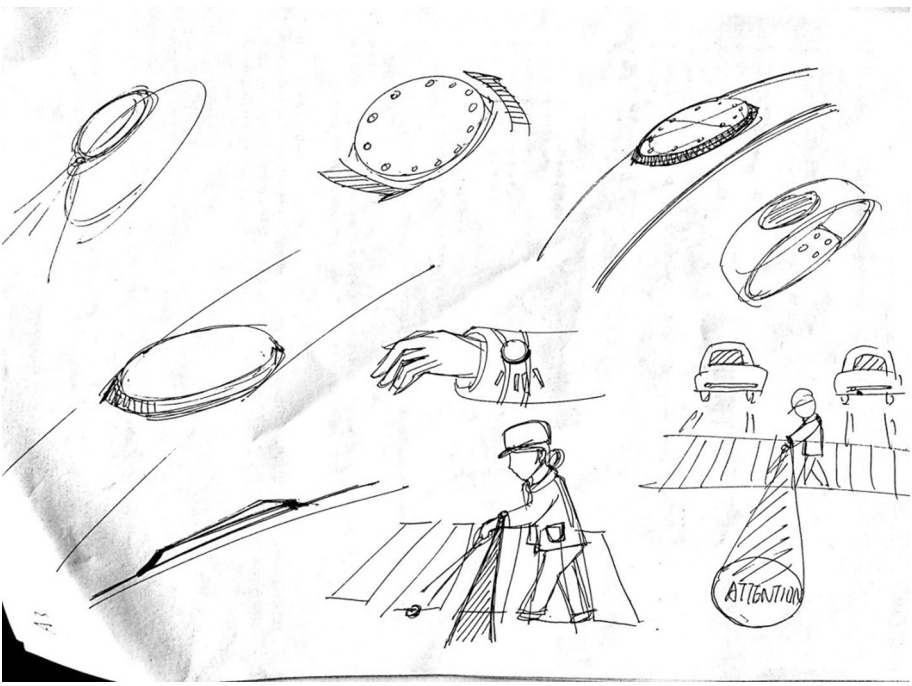


Fig. 7 A1's sketch

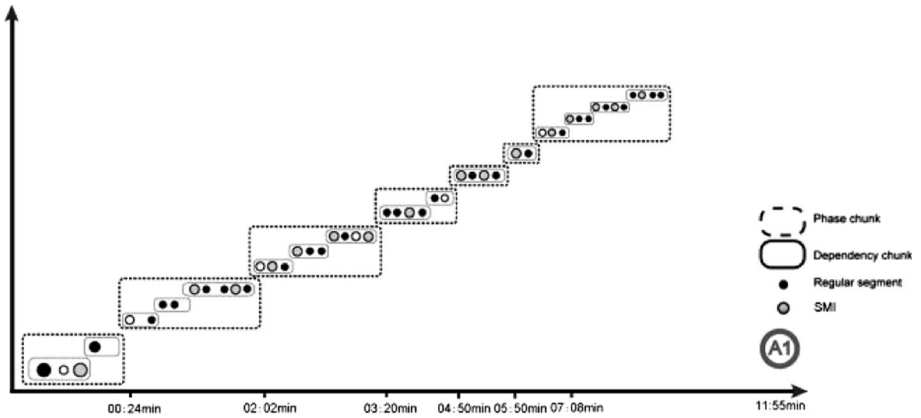


Fig. 8 A1's time-segmentation chart

There are 7 phase chunks in A2's chart. The division of each chunk was clear. He conceived in the first phase chunk while three SMI points occurred but two of them were not related with subliminal stimulate. During describing the thought, A2 pointed out that the quick concept was because of previous competition experience. He wanted to design a lighting installation of tech and cool staff. In the second and the third phase chunk, because the formative line was limited to finger curve, he adopted arc. But he used sharp, angular design to express the light in order to convey a science and technology feeling as he described, which was directly relevant with subliminal stimulate.

The sketch of A3 subject shown in Fig. 11 while his time-segmentation chart is as Fig. 12.

There are 5 phase chunks in A3's chart. He conceived in the first phase chunk and he drew three-pyramid lampshade directly. Three SMI points occurred and they were related with subliminal stimulate. During describing the thought, he pointed out that he wanted to design a modern lightshade and a sharp lighting installation. In the second and the third phase chunk, he adopted a spring structure to improve the installation according to the placement and using way. The reason why he adopted this structure was he had seen some similar floor lamps or pinups before. As a result, these SMI points in the period were not related with subliminal stimulate. And the subject perfected the use scenario in the final three phase chunks.

Group B was shown with images of soft style.

The sketch of B1 subject shown in Fig. 13 while his time-segmentation chart is as Fig. 14.

There are 4 phase chunks in B1's chart. He conceived initially in the first phase chunk and drew models like soft cushion with sporadic openwork ornamentation. Three SMI points occurred and they were related with subliminal stimulate. During describing the thought, he pointed out that the reason why he designed this kind of lampshade was to make the lighting installation soft. And the stars and moons were of his like. SMI points occurred in the former four dependency chunks were related with subliminal stimulate while the SMI points occurred in the latter two dependency chunks originated from his life experience (experience knowledge). The following step was to perfect the whole product and express the use scenario. He wanted to control brightness with gesture sensing which

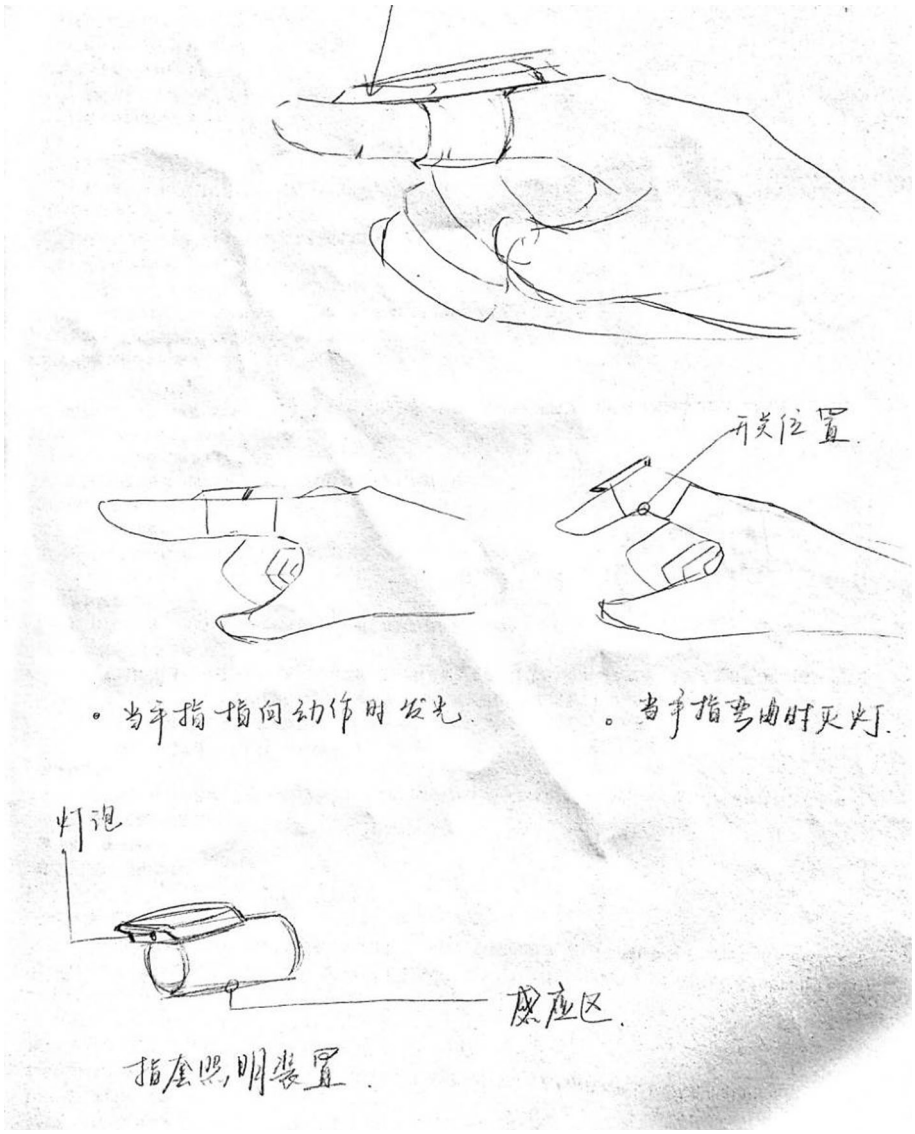


Fig. 9 A2's sketch

looked very high-tech. And SMI points occurred in this dependency chunk also originated from daily classes and the products seen before according to the subject's description.

The sketch of B2 subject shown in Fig. 15 while her time-segmentation chart is as Fig. 16.

There are 5 phase chunks in B2's chart. She conceived initially in the first and second phase chunk and drew models like UFO and ordinary desk lamps. SMI points occurred in the first phase chunk was related with subliminal stimulate. During describing the thought, she pointed out that she was inspired by the robot vacuums to conceive the lamp and felt

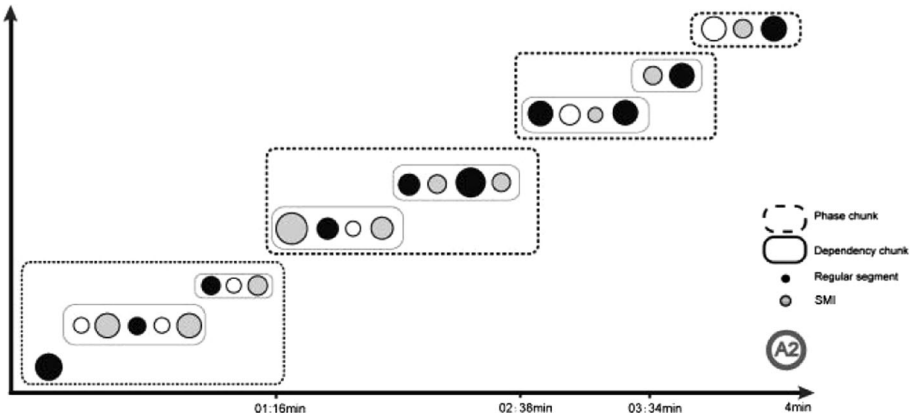


Fig. 10 A2's time-segmentation chart

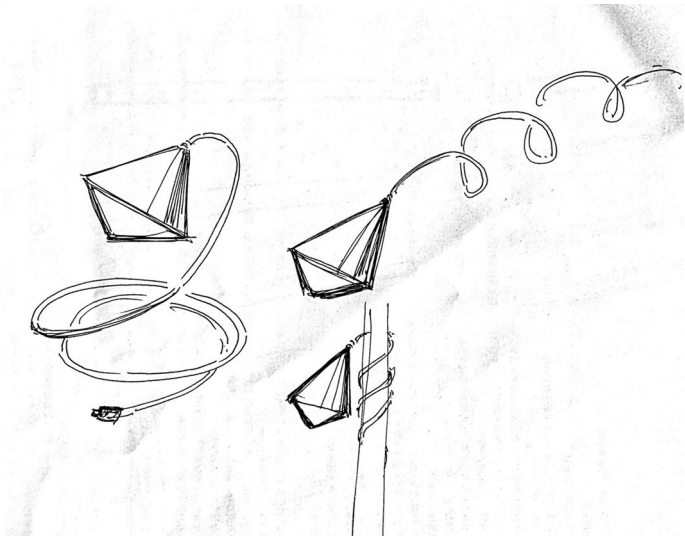


Fig. 11 A3's sketch

difficult to improve the design. And she drew two more schemes which originated from daily life. So SMI points occurred in the second and the third were not related with subliminal stimulate. From the third phase chunk, she began to deepen the UFO scheme. She wanted to be bold innovation to see the result of design.

The sketch of B3 subject shown in Fig. 17 while her time-segmentation chart is as Fig. 18.

There were 11 shapes in her sketch, and 6 phase chunks in B3's chart. And she was in divergent thinking all the design process. As she described, she had no specific ideas about the design task in the whole sketching process, so she wanted to draw some daily products to expand her thought, but finally she couldn't decide which to deepen.

Group C was vacuity contrast group with no images shown to them.

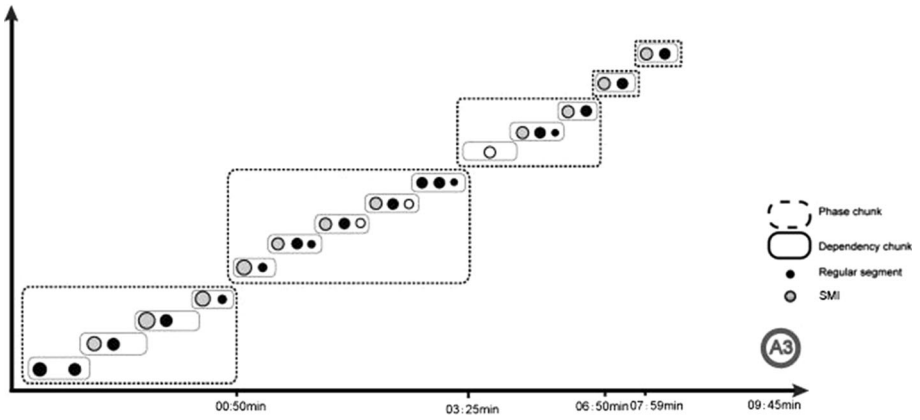


Fig. 12 A2's time-segmentation chart

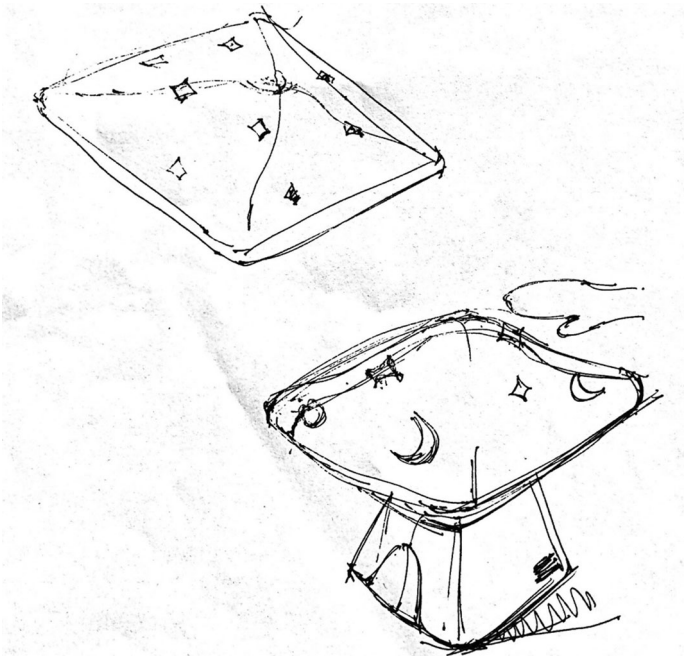


Fig. 13 B1's sketch

The sketch of C1 subject shown in Fig. 19 while his time-segmentation chart is as Fig. 20.

There are 3 phase chunks in C1's chart. After receiving the design task, he drew general modeling in the first phase chunk. And he deepened details and use in the second and the third phase chunk. During describing the thought, he pointed out that his ideas originated from products seen in daily life (experience knowledge).

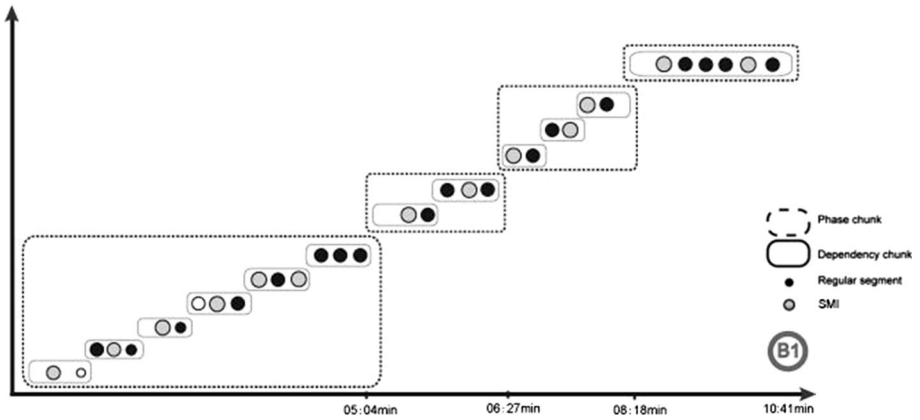


Fig. 14 B1's time-segmentation chart

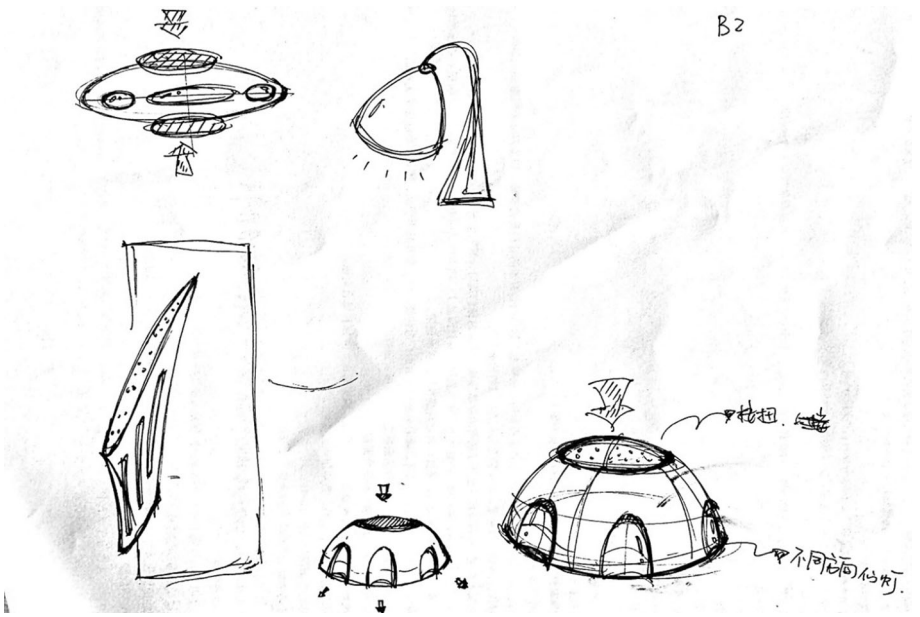


Fig. 15 B2's sketch

The sketch of C2 subject shown in Fig. 21 while her time-segmentation chart is as Fig. 22.

There are 3 phase chunks in C2's chart. After receiving the design task, she drew some fluorescents in the first phase chunk. And she perfected usage mode and usage scenario in the second and the third phase chunk. During describing the thought, she pointed out that her design originated from works scanned in competitions.

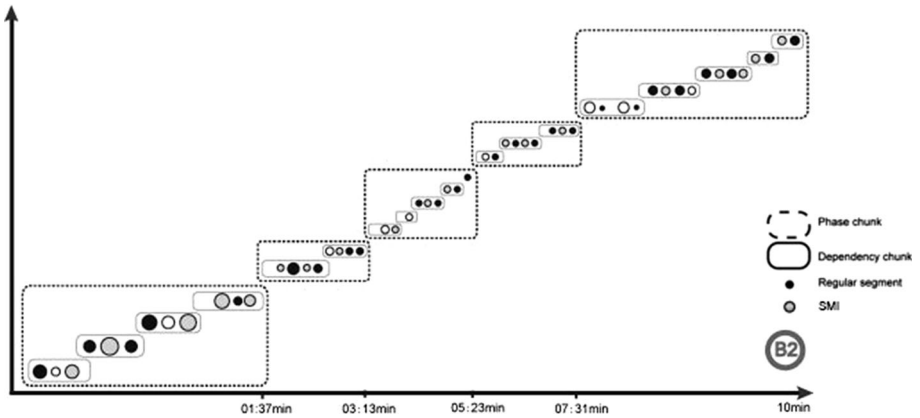


Fig. 16 B2's time-segmentation chart

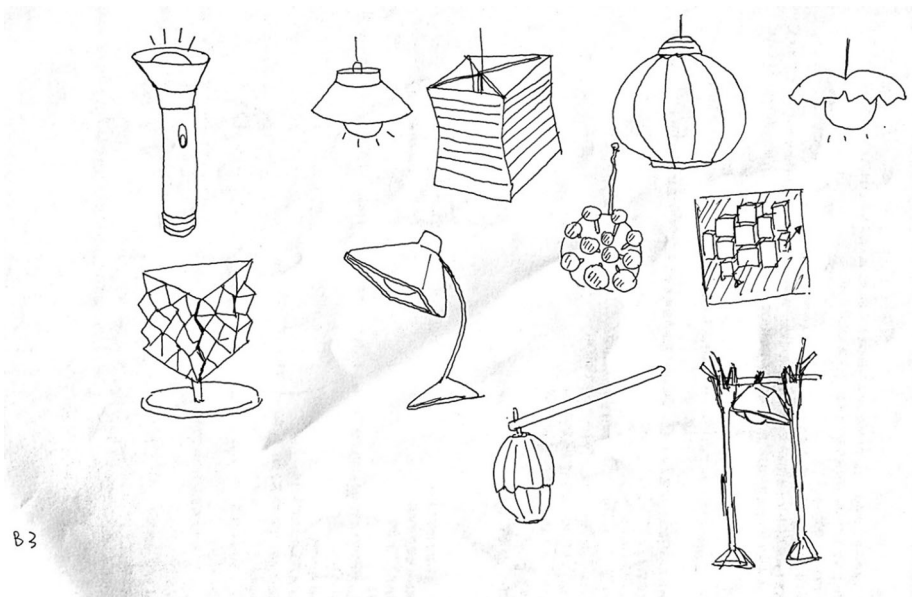


Fig. 17 B3's sketch

Analysis of results and conclusions

Results of the modeling style experiment are as above: sketches and time-segmentation charts. Through comparing sketches and time-segmentation charts, conclusions can be inferred as follows:

1. Subjects under subliminal stimulate generally spent more time in design processes. What's more, segmentations of thought are more careful and abundant.

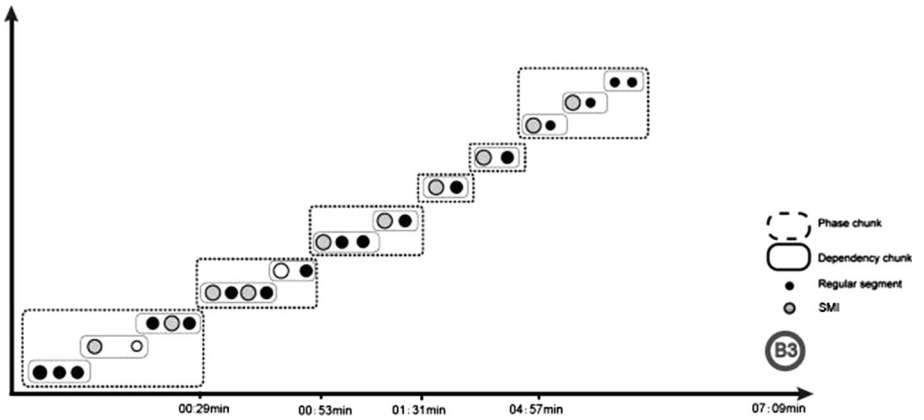


Fig. 18 B3's time-segmentation chart

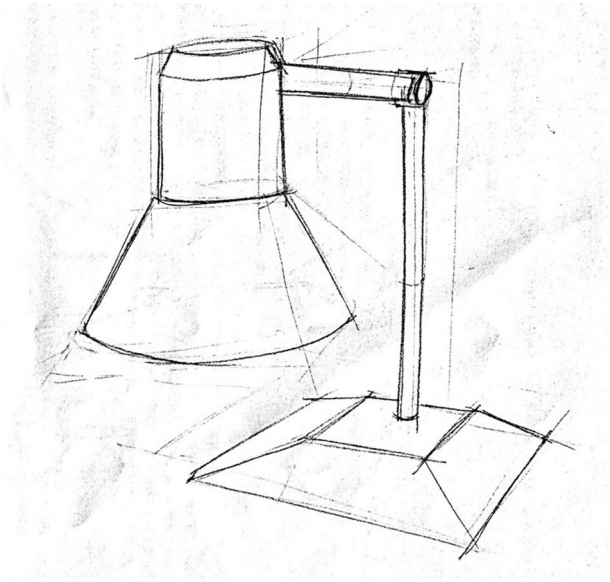


Fig. 19 C1's sketch

2. SMI points occurred more in the design process of subjects who was under subliminal stimulate than in the design process of those who were vacuity contrast group. And the sketches of the control group all contain elements of subliminal stimulate in some aspects.
3. SMI can be divided into SMI initiated by subliminal stimulate and SMI initiated by experience knowledge. In this experiment, the quantity of two kinds of SMI hasn't been compared, but it can be found out directly that SMI can be initiated by subliminal stimulate and can do influence subjects' design.

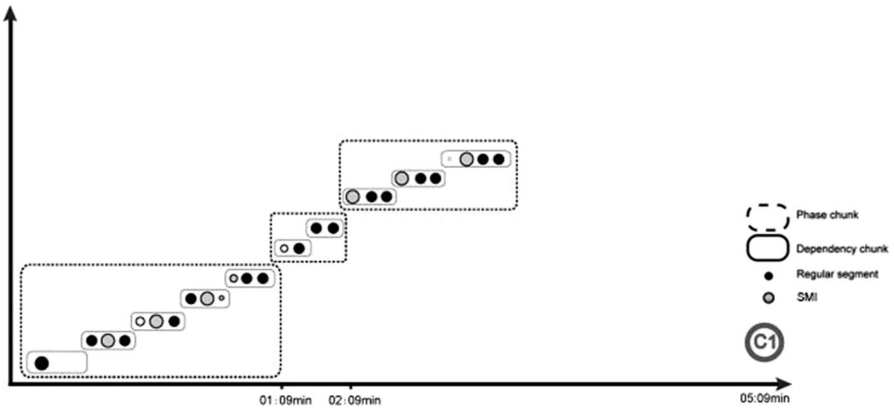


Fig. 20 B3's time-segmentation chart

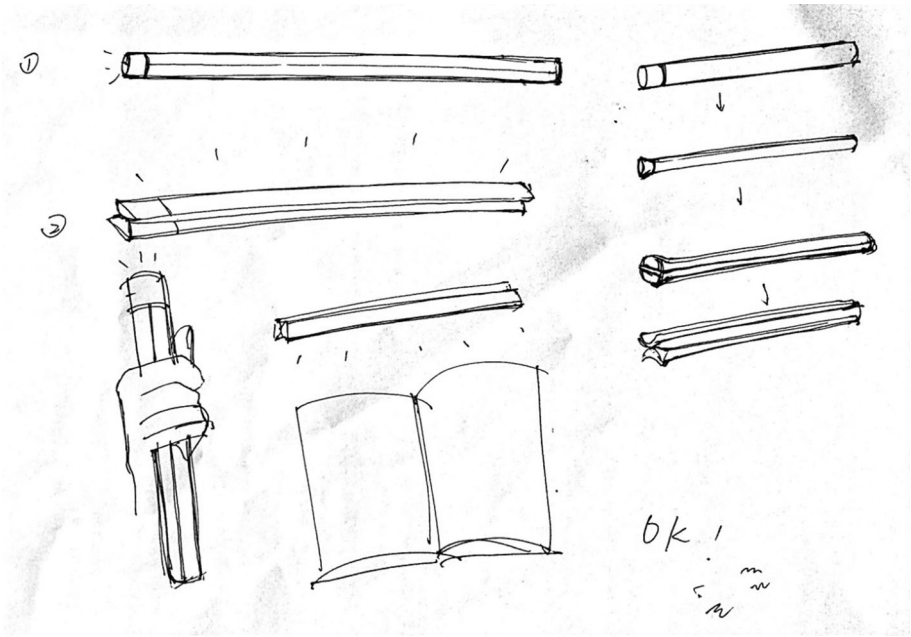


Fig. 21 C2's sketch

4. The difference between SMI initiated by subliminal stimulate and SMI initiated by experience knowledge in the design process is not obvious. It's worth exploring the reasons.
5. The sketches of the control group are obviously influenced by experience knowledge. How the sub consciousness transforms into experience knowledge and the relationship between sub consciousness and SMI are worthy to explore.

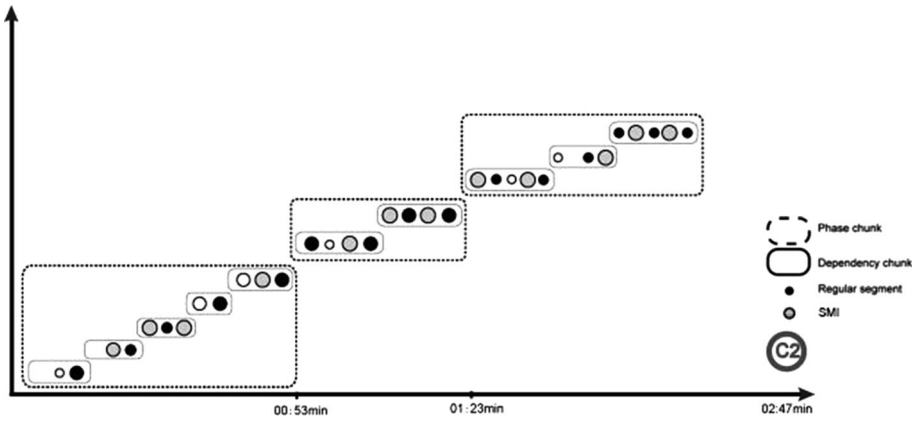


Fig. 22 C2's time-segmentation chart

The limitedness and shortage

The main limitedness in the research is the quantity of subjects and the incomplete analysis of data. As an exploratory experiment, a better comprehension of SMI and the evidence convinced the relationship between the subliminal stimulate in the design process and SMI are concluded. The sketches and time-segmentation charts of eight subjects show the difference of influence to SMI of under subliminal stimulate or not. And it can be concluded from the eight time-segmentation charts that SMI points are the main parts of the design process. The occurrence of SMI points can be found in time-segmentation charts. Generally, there are a short stop/silence or a sudden thought transfer before SMI points occur. The main suppose of this research, SMI points are influenced by subliminal suggestion and SMI points play an important role in the design process is supported by the limitedness of the research.

Although the influence of subliminal stimulate has been widely discussed in some fields (such as marketing and psychology). But there are little evidences to identify the influence in design, especially in industrial design. The evidences of influence of subliminal stimulate are not only implications for studies of industrial design, but also for other different design fields. The ability of initiating SMI points put forward means an ability of changing the design process. In design education, the influence of subliminal stimulate to the construction of students' knowledge hierarchy and mode of thinking is worth exploring because it will influence students the comprehension of SMI points in a design process. This study can be considered as an exploratory research in the direction of SMI in the industrial design. It is needed to explore how to make SMI points occur in design processes reasonably to promote design through the education of the students.

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