Research on the Influence of Multidimensional Display for Users' Concerns

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Abstract. The purpose of the Display Design is to present more information about a product which can help users to understand more about the product, so that get more and more feedback from users to improve the products to meet users' needs.

With the development of multimedia technology, the presentation dimension of modern exhibition design is becoming increasingly diverse. This article bases on the analysis of users' visual attention of different information point under the different dimensions display, to explore the influence of different dimension product shows for user's visual attention. Thus we can provide more accurate and specific application methods for product Display Design, to guide users to know the relevant information of products efficiently. First of all, this article classifies display's dimensional modes of existing Display Design by research. Then, we use smart home coffee machine as the subjects, use 25 to 35 years people as the subjects crowd to carry out this control variable experiment of user's understanding level of the information in different dimensions display. Then, we use the method of mathematical statistics to analyze our experimental data to conclude the effect of user's visual attention for different product information in different dimensions display. We hope It could provide the basis for the targeted application of product Display Design, so that we can use different dimension to give the visitors a better display experience in the future, to improve the effect of Display Design's information delivery.

Keywords: Display Design · User's focus · Character of dimensions
Virtual reality

1 Introduction

With the development of multimedia technology, the presentation of Display Design is becoming more and more diversified. From plane to stereo, from static to dynamic, and from material to non-material, more and more display designers begin to pay more attention to the presentation of interaction's efficiency. The Display Design has aroused a burst of virtual heat, especially in recent years with the maturity of virtual reality technology. Many exhibitions have used 3D simulation technology to replace some

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traditional plane information display [1]. But whether 3D visual stimulation is really better than 2D, whether all visual information can be presented by 3D display effectively is still a question which present display designer should consider.

2 The Application of Display Design and It's Current Situation

2.1 The Development Current Situation of Display Design

The opening of the London World Exposition in 1851 opens the history of our world exhibition design develops officially, at the same time, developed countries' research of the theory for Display Design really began. Since then, various types of Display Designs have flourished around the world [2]. With the development of technology and the change of people's consumption concept, the presentation of Display Design is changing constantly. In recent years, with the maturity of multimedia technology and the constantly enrichment of design concept and it's theory, Display Design breaks through the traditional concept of exhibition space fundamentally, and translates it's development mode to consumers as the center of experiential interactive direction [3]. It visual presentation mode also shows a trend that develops from the traditional 2D display to the 3D simulation, from the material to the non-material and from the static to the dynamic.

With the development of Virtual Reality, many enterprises have used 3D simulation display to replace the traditional visual plane to attract consumers' eyeballs. In a sense, the traditional 2D presentation seems to be showing some signs of decline. But because of the visual information of 3D display at present is still in the stage of development, whether it can completely substitute for graphic display status in Display Design is still don't known [4]. So the product's mainly visual information display is still in an integrated use of way, like text display, silhouette display 2D, 2D image display, 3D holographic projection and the physical model display, etc.

2.2 The Application Status of Different Dimension in Display Design

Before the maturity of digital media and modern model making technology, because of the limitation of technology, the Display Design is mainly in 2D way. With the rapid development of multimedia technology, the presentation of design is becoming more and more diversified. From the view of spatial dimension to define the standard point, the current visual information Display Design includes 2D display based on text and 2D silhouette images, 2.5D display based on planar images, and 3D display based on holographic projection and physical object.

(1) Traditional 2D display

The traditional 2D visual information display is a flat display method which completely uses flat frame or text to describe information. It develops for a long time, after the perfection of time it have formed a complete symbol system, and users has a strong recognition for it, so it still has an indispensable status in modern product

display. 2D Display Design today is mainly applied in product dimensional specification display, necessary function attribute prompt and so on.

(2) 2.5D display

2.5D display is a visual information display which between traditional 2D display and 3D display. On the visual display, 2.5D is a display way which has the 3D sense but still use plane image to show information. Today, 2.5D display is mainly applied to the display of large area posters, product operation description and so on. Some of the display scenarios that are not provided with physical or virtual simulation also use 2.5D to present description of the product information, such as most current electric business platform mainly use 2.5D graphic to display their products.

(3) 3D display

3D display is a 360° way of display. 3D display can express product information vividly, it provides a richer meaning for the visualization of product information, that will help users to understand the product's visual information carefully [5].

With the development of virtual reality technology, 3D display has begun to replace the physical model with some virtual display now.

3 Dimension and It's Characteristics

Dimension is the number of independent parameters in mathematics. In the field of physics and philosophy, it means the number of independent space-time coordinates. 0 dimension means a point in the world, it don't have length. One dimension usually means a line, it only have length, two dimensions is a plane way, which is formed by length and width (or curve), and three dimensions is a form which 2D form plus height. The environment in which we live is mainly composed of 2D and 3D [6].

Based on the number of different coordinate direction, different dimension shows different level of information, the communication of information of how many there will be differences. In general, the spatial dimension of visual information has the following features:

(1) The larger the dimension base, the information it presents is more and comprehensive.
(2) According to the increase of dimension base, the number of visual information is exponentially increasing.
(3) With the increase of the dimension base, the information it transmits becomes more complex, and users will have greater the psychological and cognitive pressure when they receiving the information.

In addition, because people have different understandings of different dimensions, the application of dimensions in different fields will also be different. In the display of visual information, 2D is the form of conveying information by plane silhouette image which means the pure line and color block or text form in the plane image. And 2.5D is an approximate form which between 2D and 3D, it just like fake 3D, which is actually a kind of 2D in the traditional sense, it is a plane image with three-dimensional sense.

3D is a stereoscopic form, which can show things by a form which with 360 Angle [7]. In this paper, we base on the spatial dimension and the visual presentation in dimension standard, and through user grasp of the visual information quantity and accuracy of the analysis, to explore the influence of user's attention for product's visual information in multi-dimensional display.

4 Experiment on the Degree of the Influence of User's Concerns on Different Dimensions

4.1 Purpose

Because different dimension forms convey different amounts of information when they present different visual information, and they have different advantages and disadvantages when display different types of visual information, so, when we want to show different types of information points, users visual concern extent for different information often occupies an important place. Using different dimension to display different product information in reasonable and guiding users to obtain relevant information efficiently will help Display Design to improve the efficiency of information transmission. In this paper, we explore the influence of different dimensions on users' attention by studying the experiment on the information and accuracy of users in different dimensional products. We hope our experiment could help display designers to find an efficient way which provides users a visual experience with an all-round, multi-angle and efficient visual information display today.

4.2 Subject

Through the investigation and analysis of the current Display Design product category, we found that the products currently displayed are mainly smart home appliances, and the most frequent content of visual information in product display is the product's appearance, material, size and their operation. After analyzing the information of user's usage and the information of these four attributes of design, we select the household coffee machine to be the experimental object. Compared with other household electrical appliances, household coffee machine in the shape, material, size and its operation has relatively more change in the form, so it is easier to sample display information extraction.

By compare the different brands of coffee machine visual information, we decided to choose morphological differences Pitticaffe's next coffee machine, DOLCE GUSTO's EDG466 coffee machine coffee machine, C - pot's CRM2008-1 as the experiment of three dimensions object extraction experiment sample of products form display which in different dimensions. In the product dimensional display in different dimensions, we decided to select the sample extraction of Pitticaffe - next coffee machine, NESPRESSO's INISSIA C40 coffee machine and NESPRESSO's pixie C60 coffee machine as the experimental object. And in the presentation of product materials in different dimensions, we select NESPRESSO's pixie C60 coffee machine, NESPRESSO's INISSIA C40 coffee machine and c-pot crm2008-1 coffee mechanism

for three groups of experimental samples. Finally, when performing the operation of the product, we will select the Pitticaffe's next coffee machine, NESPRESSO's INISSIA C40 coffee machine and NESPRESSO's pixie C60 coffee machine as the sample extraction object (Fig. 1).

Fig. 1. Experiment object

Because a product in a same display has a great difference for the information, to some extent, we do these can reduce the influence of the experimental results which because of users' memory of the subjects.

4.3 Positioning of the Subjects Crowd

In order to ensure the objectivity of our experimental data, the subjects in this experiment should meet the following points: (1) They should be between 25 and 35 years old. (2) They should have the cultural foundation above high school. (3) They should have common sense of home appliances. (4) They should have some spatial imagination. (5) They should have a certain understanding of weights and measures, and also have some understanding of materials. (6) They should have some experience in virtual reality.

Through these conditions, the selection of 20 participants in this experiment is mainly the young teachers and students of a university in Nanjing. In order to reduce the difference in the spatial imagination ability of men and women, the ratio of males and females in this experiment was 1:1.

4.4 Methods and Contents

We based on the experimental psychology theory, divide the experiment three steps' qualitative extraction, classification experiment, and statistics and analysis of experimental samples. The specific experimental steps are shown in Fig. 2.

In the stage of qualitative experiment sample extraction, we mainly use research methods to classify the types of electrical appliances product at the percent. And then, we compare the appearance, size, material and performance of these electrical appliances in this category to selects the experimental subjects (the coffee machine), which has comprehensive differences for the highest percentage. After these, we will use Adobe Illustrator to make the 2D silhouette experimental object, and use camera to make the 2D image production experimental object, and make the two into the same size display board. In order to avoid the influence of the sample size on the user's understanding, the size in multi-dimensional displays is the actual product size. At the

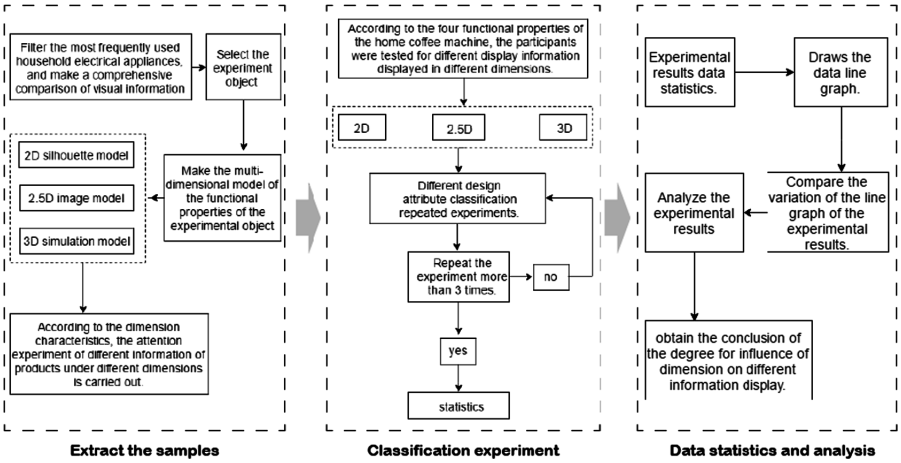

Fig. 2. Experimental procedure

same time, we use 3D software to model the object and use the holographic projection equipment to project the 3D projections. The experimental samples were extracted and produced before the experiment. In order to ensure the subjective interference caused by repeated viewing, different subjects were selected to extract the three dimension samples of this experiment (Figs. 3, 4, 5 and 6).

Fig. 3. Multi-dimensional visual display experimental samples of dimensional products

In the stage of "classification experiment", this experiment uses the control variable method to carry out different dimensional visual display experiments on four product design attributes. We will repeat the experiment to observe the user's attention to different dimensions in different lengths of time, and test the accuracy of the user's understanding of information. According to the principle of ergonomics, human memory can be divided into long-term memory and short-term memory. Short-term memory is the behavior which within 60 s, and the information obtained by users is

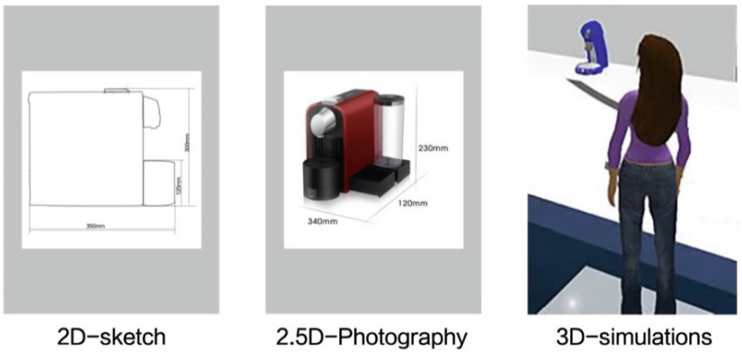

Fig. 4. Multi-dimensional product morphological visual display experiment samples

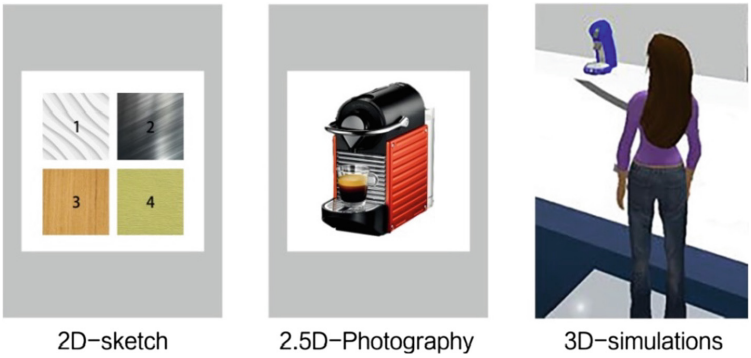

Fig. 5. Multi-dimensional product materials display experimental samples

Fig. 6. Multi-dimensional product execution operation visual display experiment sample

mostly extensive reading information, more than 60 s is the long time memory, the information acquired by the user is the information after deep learning [8]. Because of it, the two observation times of this experiment were respected 60 s and 120 s (the time used in 120 s include the previous observation).

In the stage of "statistical analysis", we will take the users' accuracy of information acquisition as the evaluation index in the experiment, to calculate the influence of the dimensional visual display on user's attention by demonstrate the statistics of users' accuracy of information acquisition in a certain dimension. In this experiment, we will draw a line chart to analyze the influence of product information in three dimensional visual display for the users' attention and the effect of length of observation time for it.

4.5 Process

The experiment is divided into three basic steps. We will conduct repeated experiments on four product design attributes separately to test the attention of users to a design property at different time in different dimensions. Because this experiment has many steps in fact, so in this paper, we only describe the visual display experiment of product form in three dimensions, the experimental steps of the other three design properties are similar to the following experimental steps. The specific experimental steps are as follows:

Step 1: we ask the experimental participants stood away from the panel (the panel is 1.5 m above the ground) of 0.8 m to observe the 2D samples 60 s, and then, select the product type according to the instruction and select all the basic forms that constitute the product. In order to ensure the accuracy of the experimental results, the experimental subjects were composed of the same number of geometric shapes. When the subjects submitted the test answer, we will ask them to enter the exhibition area, and to observe the 60 s and repeated the above questions again. After these, the first step is completed and we will start the second step.

Step 2: we ask the experimental participants stood away from the panel (the panel is 1.5 m above the ground) of 0.8 m to observe the 2.5D samples 60 s, and then, select the product type according to the instruction and select all the basic forms that constitute the product. After they complete the first answer, they should observe the samples again and repeat to answer the question according to the principle of step 1 (Figs. 7, 8, 9 and 10).

Step 3: we ask the experimental participants stood away from the panel (projection is 1 m above ground) of 0.5 m to observe the 3D samples 60 s, and then, select the product type according to the instruction and select all the basic forms that constitute the product. After they complete the first answer, they should observe samples again and repeat to answer the question according to the principle of step 1.

4.6 Data Statistics

In this experiment, we count the test results obtained from the four design attributes of the family coffee machine in three dimensions. Finally, we obtain 40 user's choice of product attribute perceptions about product form in a variety of dimensional visual display, 137 user's choice of morphological cognition about product form in a variety of dimensional visual display, 40 user's choice of size cognition about product size in a variety of dimensional visual display, 40 user's choice of material cognition about product material in a variety of dimensional visual display, 40 user's choice of execution operation cognition about product execution operation in a variety of

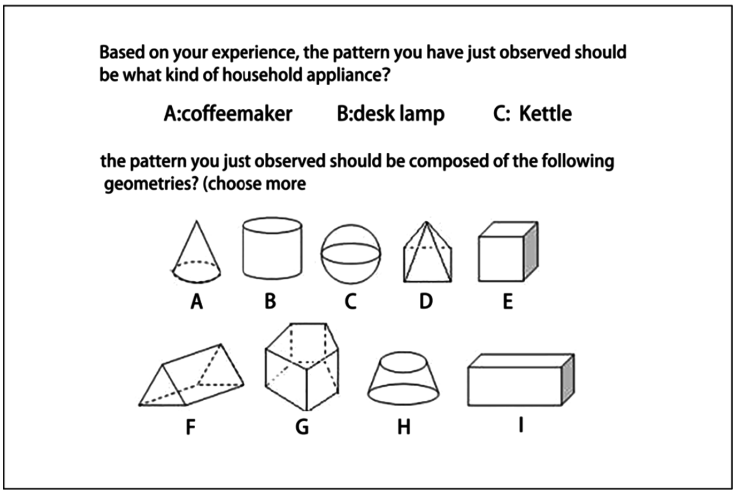

Fig. 7. User's attention test of multi-dimensional product form visual display

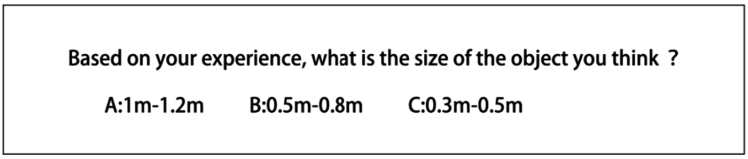

Fig. 8. User's attention test of dimensional product size visual display

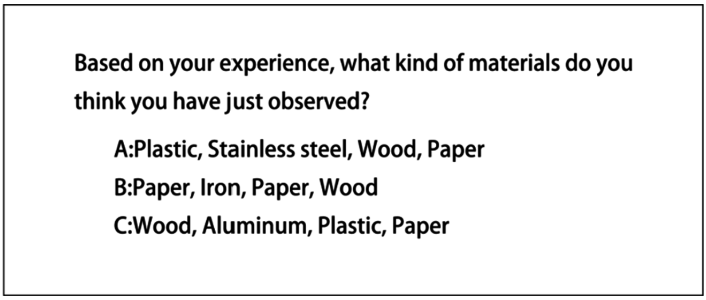

Fig. 9. User's attention test of multi-dimensional product material visual display

dimensional visual display. Because of the paper's limited space, we do not elaborate on the test results of the subjects.

Because the experimental results are not conducive to analyze the user's attention of different design attributes indifferent dimensional visual display. So, we will use the number of results which matched with the actual answer in 20 subjects as the evaluation index of information accuracy. According to the statistics of the correct number of

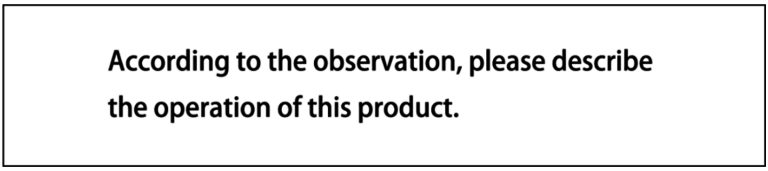

Fig. 10. User's attention test of multi-dimensional product execution operation visual display

information which displayed in different dimensions in these two experiments to get its influence on user's attention. In the product morphological experiment, we will calculate the percentage of product morphological cognitive selection results first, and then calculate the number of people who has more than two right choices and the right choices make up more than 60% of the total. In the experiment of product execution, we will only count the experimental results that were able to operate correctly. In order to observe user's attention to different design attributes of the product is displayed in different dimensions better, we will calculate the mean of the two experimental results, and compare it with the two experimental results. The results of this experiment are shown in Table 1.

Table 1. The number of product information obtained by users accurately in different dimensional display.

dimension test	User's attribute recognition for product form of multiple dimensions display			User's form recognition for product form of multiple dimensions display			User's size recognition for product size of multiple dimensions display			User's material recognition for product material of multiple dimensions display			User's operation for product operation of multiple dimensions display		
correct / dimension / time	2D	2.5D	3D	2D	2.5D	3D	2D	2.5D	3D	2D	2.5D	3D	2D	2.5D	3D
60s	7	12	19	14	10	9	16	17	16	6	9	11	10	15	17
120s	9	15	19	16	13	12	17	17	18	8	11	13	13	15	18
mean value	8	13.5	19	15	11.5	10.5	16.5	17	17	7	10	12	11.5	15	17.5

4.7 Analysis of Experimental Results

In order to make it easier to observe the impact of different dimension on user's attention, we will draw a line drawing of the above data in this experiment. The results of the user's attention experiment result of the four product design attributes in different dimensions are shown in the Figs. 11, 12, 13, 14 and 15.

After observing the line graph of the experimental results, we can see that the length of time has a little influence on the user's understanding of the visual information in different dimensions. The most affected by time change is the user's attention of visual information for the operation process under 2D silhouette. So we can see that, Compared with other presentations, 2D silhouettes have a low level of attention when it comes to displaying visual information about users' performing operations, so users may need more time to pay attention to this information during presentation.

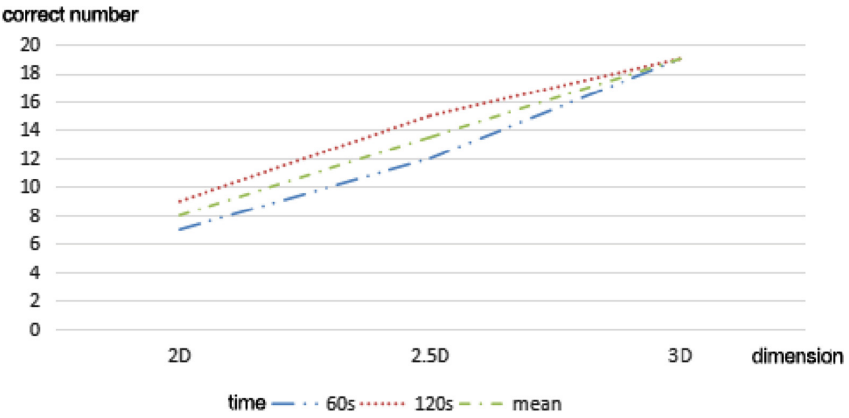

Fig. 11. User's attribute recognition for product form of multiple dimensional display

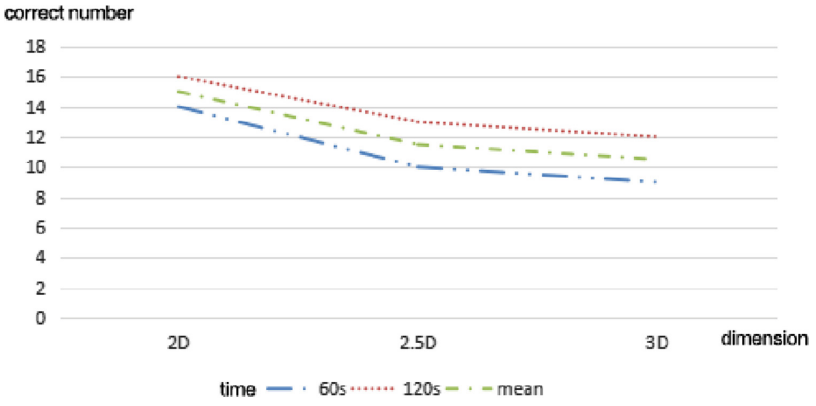

Fig. 12. User's form recognition for product form of multiple dimensional display

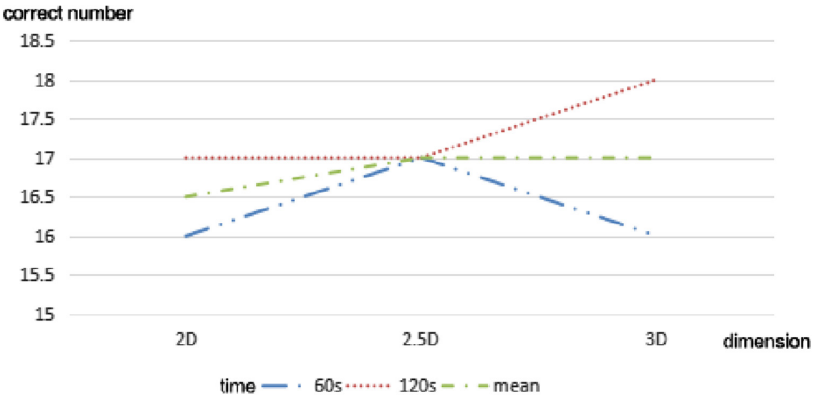

Fig. 13. User's size recognition for product size of multiple dimensional display

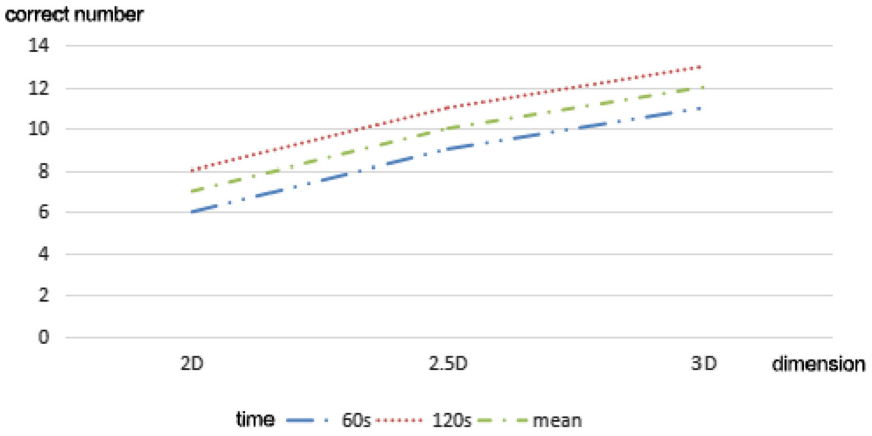

Fig. 14. User's material recognition for product material of multiple dimensional display

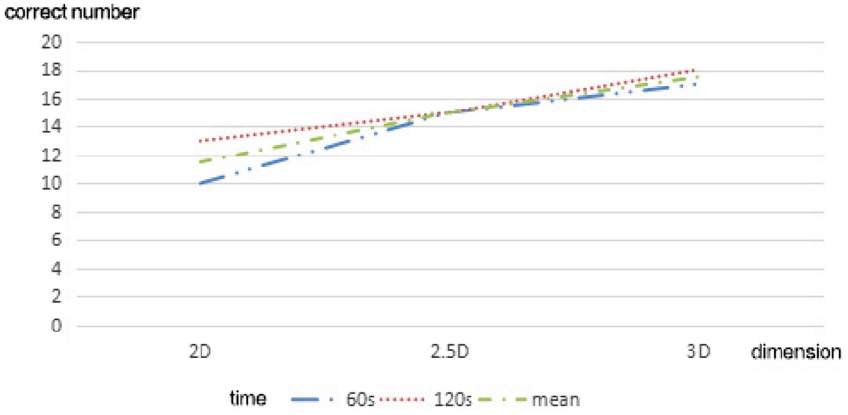

Fig. 15. User's operation for product operation of multiple dimensional display

At the same time, by looking at the mean line graph of the above two experimental results, we can see that, in the terms of product properties display, 3D simulation is easier to present product information to users clearly, 2D silhouette and 2.5D image display have no advantage for it. But in terms of product form display, 2D silhouette images are more likely to show users the basic outline of the product. After comparing these three displays, 2D silhouette shows less disturbing information than the other two dimensions, and users will be more likely to focus on the product profile. In terms of product size display, the display of these three dimensions has no significant influence on the user's attention to the size of the experiment object. In terms of product material display, 3D simulation has a slight advantage over the other two dimensions. By comparison we found that the 3D simulation can show the surface texture of the

material more easily, so it is also easier for users to understand this information. In terms of product operation display, the 3D simulation demonstration also has great advantages for it.

5 Conclusion

With the maturity of multimedia technology, the ways of cross-application of various dimensions will be more and more applied in the visual information display of modern products. But how to convey visual information accurately and efficiently to users by using multiple dimensions to increase the user's attention of product and to guide users to obtain relevant information of products accurately and quickly will be a question which the display designers should consider. In this paper, we use the experiment of users' attention on the visual display of some product information in different dimensions to sort out the role of different dimensions in product visual display. We hope these could provide some insight into the design of the future.

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