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Influence of Icon Design Style on User's Cognition

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ABSTRACT
It aims to study the influence of icon design style on user's cognitive. The visual cognitive process in icon search is obtained by analyzing the visual cognitive mechanism of digital interface. As representatives of skeuomorphism and flat icons, the system icons of iOS6 and iOS7 were selected as the material for the eye tracking experiment. The eye tracking index of subjects were selected and analyzed. The conclusion is that the style of icons has an impact on the accuracy, efficiency and readability of users' cognition. The skeuomorphism design style is better in readability and accuracy of users' cognition, and the flat design style is better in the efficiency of users' cognition.
Keywords: *visual cognitive, style of icon, eye tracking*

1. INTRODUCTION

Icons are graphic symbols with referential meaning. In the digital interface, an icon is a graphic symbol with explicit referential meaning and specific functions, which is a visual command form different from the command in the program language [1]. At present, the icon design style of the digital interface of mobile devices is mainly divided into two types, namely, analogism and flatness. The simulatorialized design style focuses on the authenticity of elements [2], while the flat design style weakens the decoration, highlights the main information and emphasizes the functionality [3]. According to the "mobile industry analysis report of the first quarter of 2018" released by aurora big data, the average number of apps installed on each smartphone is 47, and the average amount of apps installed is still increasing as the performance of the phone continues to improve, which brings huge pressure to the cognition of users.

As the visual carrier of application software, icons play a role in helping users identify. The current icon design style presents a flattening trend [4], but the flattening trend is driven by a variety of factors, and there is still no conclusion on whether flattening is more conducive to users' cognition compared with the quasi-objectification. For example, lu yuan pointed out that flat graphics weaken redundant decoration, highlight the theme, make users more focused on the content itself, and reduce the time and energy people spend when they accept and adapt to the information [5]. Wu tianyu pointed out that too much use of simulacralized icons would reduce the operation efficiency, and too many complex simulacralized elements would make the interface messy when a large amount of information was gathered [6]. However, in contrast, Tom Page[7] pointed out through the survey that the current academic community has different opinions on the trend of flatness, and the design should choose an appropriate style for specific design objects. Christian Stickel et al. [8] also pointed out that although simplifying icons is a very efficient design method, it is not necessary to remove all the objectified elements in the interface.

Cognition is a process of information processing by human brain for signals transmitted by external things [9]. As a form of visual command, the cognitive process of icons is based on visual cognitive mechanism. Taking the visual cognition mechanism as the starting point, the eye movement tracking experiment was conducted to collect the eye movement indexes and task completion of the two styles of icon search in the process of specific task, and analyze the differences between them in readability, significance and cognitive efficiency, so as to provide reference for the icon design of mobile devices.

2. CONTRAST BETWEEN FLAT AND SIMULACRAL STYLE

Through the comparison and analysis of the quasi-objectified icon and the flat icon, it can be found that the quasi-objectified design is to simulate the form of modeling and texture in reality. It reproduces the real object through the superposition of highlights, textures, materials, shadows and other effects. The modeling is three-dimensional and conforms to perspective, and it can also be appropriately deformed and exaggerated. The simulation of real objects enables users to understand their functions and meanings at a glance. Flat design is based on the concept of simplicity as the core, abandon highlights, shadows, perspective and other effects, through the abstract, simplified, symbolic design elements to show. It emphasizes the functionality of the design, extracts the main elements, weakens or even removes the decorative elements to highlight the main information. Big color block, bold and bright-coloured colour and clear layout are flat change the gimmick that design often use. Flat interactions also emphasize highlighting information content, creating a clear hierarchy that highlights the core content through the organization of information priorities. Because its appearance is the representation of real objects,

it conforms to the cognitive basis of users and enables users to quickly understand its connotation. In contrast, flat design requires users to have some experience.

The interaction between people and digital devices is ultimately based on symbolic operations [10], while symbols are metaphorical [11]. The signifier and signifier of a symbol depend on a particular explanatory term. In the design of icons in the digital interface of mobile devices, the mapping between the representation of icons and their functional connotations depends on human interpretation, which is based on human's inherent cognition of the real world. Therefore, by imitating the appearance of real objects, the simulation design enables people to understand the graphic symbols with the cognitive habits of real objects, so as to reduce the generation gap between people and digital interfaces. For example, the camera application icon of iOS6 system, the "camera lens" in the rounded rectangle completely simulates the light and shadow and texture of the camera lens in reality; IOS7's camera app icon, on the other hand, does away with these decorations altogether, leaving the camera in a solid color. In the early days of smart mobile devices, in order to facilitate the understanding of users, most of their icons were designed in an analogue style. However, up to now, smart mobile devices have been born for more than a decade, and users have a certain learning basis for them, and they are no longer unfamiliar with the symbolic expression of digital interface. In the context of the growing number of applications and installations, users' need for icon recognition has shifted from understanding to searching more quickly and efficiently. As a result, the user has to be materialized and flattening of the cognitive differences cannot directly through its forms and the inherent experience to judge, Ren Hong etc based on ERP (eeg) study flattening and cognitive efficiency [12] that will be materialized icon, Joe xin new etc based on eye tracking availability optimization was studied for the flattening interactive elements [13], objective research based on scientific experiments had been carried out.

3. VISUAL COGNITIVE OF ICONS

Visual cognition is a process of information processing by human brain for visual signals transmitted by external things [9]. The visual system is an information processing system with limited resources, which can only process part of the information in the external environment at any time. When browsing the digital interface of mobile devices, the user's visual system continuously acquires a large amount of information. Some information will be noticed and further processed into visual perception, but most of the information will be ignored by the visual processing system. In this process, the factors affecting visual selective attention may be either the stimulus with distinctive features in the visual scene or the individual's current subjective intention or task target. These two situations represent both the bottom-up and top-down cognitive mechanisms. The bottom-up cognitive mechanism is stimulus-driven, while the top-down cognitive mechanism is task-driven.

The cognitive system mainly involves visual module, memory module and target module in the cognitive process of mobile device icon. The visual module is the visual perception of icons, the memory module is the declarative memory of icons in the stage of visual preprocessing, and the target module is the object that matches the visual module. Under the intervention of cognitive mechanism, the three constitute different influence relations and lead to different cognitive results. The process is shown in figure 1. Under the intervention of top-down mechanism, the memory module formed in the pre-processing stage plays a leading role. Under the bottom-up mechanism, the visual module plays a leading role. For example, if a user wants to find a "camera" application, the previous memory module will allow the user to have the image prediction of the "camera". Based on the prediction, the user enters the visual module for top-down cognition and matches the observed object with the target module. In the numerous application icons on the interface, irrelevant information such as "setting" and "weather" does not conform to the memory module and will be ignored; But at the same time, some application icons similar to the icons of "camera" applications, or more prominent application icons in color, shape or volume will also attract users' attention and induce bottom-up cognition.

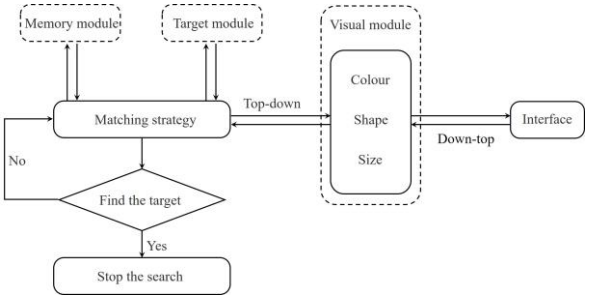

Figure 1 Visual cognitive process

Experimental research was carried out based on this process. Memory module and visual module were used as the factors to induce the cognitive mechanism.

4. EXPERIMENT

4.1. Objective of Experiment

The eye movement comparison experiment was designed to collect the eye movement data of subjects' visual search of the quasi-objectified and flat icons under specific tasks, analyze the recognition efficiency of the icons of the two styles, and then study the impact of the design style of icons of mobile devices on user cognition.

4.2. Methods of Experiment

Construct experiments based on cognitive processes. The subjects were shown a specific icon to stimulate their memory module, and then asked to search for that icon in a set of icons. The search for a set of 16 icons in different styles stimulated the participants' visual modules. In the process of searching for the target, both top-down and bottom-up mechanisms may be involved. The subjects click the target icon with the mouse to represent the completion of the search and automatically enter the next search task. The eye movement data, task completion time and accuracy were calculated.

4.3. Process of Experiment

Experimental equipment includes Tobii x3-120 eye tracker, lenovo Y485P laptop, data analysis software Tobii Studio.A total of 20 undergraduate and graduate students from the school of design art and media of nanjing university of science and technology participated in the experiment, including 10 men and 10 women. The subjects have normal hearing, visual acuity or corrected visual acuity.

The materials of the experiment are two groups of icons with different design styles, as shown in figure 2. In the experimental group, one is the iOS6 system icon, both of which are icons in the simulacra style. Experimental group 2 is iOS7 system icon, are flat style icon. In order to avoid the interference of background, size and other factors, the two sets of icons are all 120px×120px rectangles with rounded corners, and they are all arranged in 4×4 positions. The icons with the same function correspond to each other, and the background is black. In both sets of pictures, specific icons were set as targets, and the subjects searched for the target icons in a set of charts according to the task.

Figure 2 The materials of the experiment

The independent variable of the experiment is the design style of the icon, and the dependent variable is the eye movement data of the subjects, as well as the completion time and accuracy of the task.

The steps are as follows：

(1) On the computer screen is the instruction screen, which says: "hello, welcome to our experiment! Below will display the icon you need to look for, please watch carefully, after 1 second the page will jump, please find the icon as quickly as possible and mouse it under the premise of ensuring accuracy. If you are ready, please click the 'start' button".

(2) After hitting the "start" button in the pilot, the target icon of this search is displayed in the center of the interface for 1000ms.

(3) The target icon disappears, presenting a set of 4×4 layout of the objectified icon.

(4) The subjects searched the target icon and clicked it as quickly and accurately as possible.

(5) If the subject did not click within 10000ms, it was denoted as a response error and the black screen was automatically set at 3000ms to eliminate visual residue.

(6) Bring up the next set of targeticons and repeat.

(7) Convert to flat icons and repeat the above steps.

5. RESULTS

The experimental results are shown in table 1. The target icon fixation time, the number of fixation times before the target icon (the number of fixation times completed before the target icon fixation for the first time), the task completion time (the time from entering the search stage to completing the search) and the task completion accuracy were analyzed. According to the results of data analysis, the skeuomorphism group was superior to the flattening group in the two indexes of target icon fixation time and task completion accuracy. In terms of fixation times before the target icon and task completion time, the flat group was better than the quasi group.

Table 1 Experimental results

Index	Skeuom orphism	Flat	*t*	*F*	*P*
Fixation duration (ms)	846	934	3.109	4.196	0.031
Number of looks	3.15	3.11	-0.279	0.647	0.781
time （ms）	2450	2122	-1.976	3.119	0.038
accuracy （%）	100	98.7	-1.209	0.073	0.049

The task completion time of the flattening group was less than that of the quasi-objectified group, and the difference was significant (P=0.038, P < 0.05). From the perspective of availability, the cognitive efficiency of the flattening group was significantly higher than that of the flattening group. However, combined with the accuracy of task completion, the simulacralization group was significantly superior to the flattening group in terms of cognitive accuracy (P=0.049, P < 0.05). The number of times of gaze before the target icon can reflect the significance among a group of icons to some extent. The number of times of gaze before the flat group is less than that of the skeuomorphic group, indicating that users found the difference between the target icon and other icons by using less comparison in the flat group, but the difference is not significant (P=0.781, P > 0.05). The target icon fixation

time reflects the time required for the user to understand the icon, which can reflect the readability of the icon to a certain extent. The target icon fixation time in the onomatopoeia group is less than that in the flattening group, and the difference is significant ($P=0.031$, $P < 0.05$), indicating that the onomatopoeia icon is more readable.

By combining the fixation time and task completion accuracy of the target icons, it can be concluded that the quasi-stylistic icons are significantly better than the flat stylistic icons in readability and cognitive accuracy. It can be concluded that the flatness style icons are better than the similified icons in significance and cognitive efficiency, but the difference is not significant. The insignificant difference in the number of gazes before the target icon may be caused by the arrangement of the icons themselves. The significance between icons is not only related to the icons themselves, but also to the icons around them. The significance is reflected in the comparison between each other, and the interference of this factor to the results is not considered in the experiment. The fixation time on the target icon is only an objective physiological behavior of the user. The aesthetics of the icon and the user's degree of interest in the icon may affect the fixation time. This index should be analyzed in combination with the time interview, and the conclusion of the difference of the user's ability to understand the icon is subjective to some extent.

6. CONCLUSION

Design style affects the user's perception of icons. Icon-oriented visual cognition consists of three parts: visual module, memory module and target module. The intervention of the three cognitive mechanisms forms different influence relations and leads to different cognitive results. Under the intervention of top-down mechanism, the memory module formed in the pre-processing stage plays a leading role. Under the bottom-up mechanism, the visual module plays a leading role. Based on this process, an experimental study was carried out, in which memory module and visual module were taken as the factors inducing the cognitive mechanism, and the influences of the simulacular style and the flat style on user cognition were compared. The following conclusions are drawn: (1) In terms of readability and cognitive accuracy, the quasi-stylistic icons are better than the flat stylistic icons, with significant differences. (2) Flat style icons are superior to the quasi-style icons in significance and cognitive efficiency, with no significant difference. The conclusion is valuable for the adoption of icon design style.

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