The Research on Elderly-Adaptive Interface Design Based on Choice-Oriented Attention Theory

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Abstract. Visual selective attention is a way of cognition processing which makes the limited mental resources focus on the most significant information during a specific period of time. The visual selection is introduced to the interface design research for the elderly in order to analyze the elderly's mental cognitive process and establish the relationship between the two from the perspective of selective attention. Two experimental methods are used: No.One, to compare and research the elderly group and the young one's visual preference through the extraction of interface's visual elements. No. Two, eye tracking experiment. Calculate the elderly group and young group's average fixation time and average fixation points, then validate the calculation data. Through coding the visual elements which are obtained from the two experiments, the visual element code sets are determined, which conforms to the elderly's visual selective attention on the interface, so as to guide the interface design practice for the elderly.

Keywords: Selective attention · Suitable for the elderly · Visual code set · Interface interaction

1 Introduction

As we known, China is the only country which has an aging population of more than 100 million. The elderly over the age of 60 usually regard the newspapers as the medium of "first contact". But the new medias like the internet have more and more information because of the arrival of information age. It is a huge challenge for them to transcend the traditional media and use the new media. The interaction interface of the new medias which are mainly made up of rich information has become complicated.

It is more difficult for older users to search for and find the information they need than young users. The old people will have some heavy psychological burden if the design form of the information can't attract their enough attention. And they can't use the new medias better.

It will become a very important part to introduce the visual selective attention to the interface interaction design for the elderly. On one hand, human's visual system is the most developed sensory systems and is also an important channel for the communication between human and electronic interface. On the other hand, the physical and

A. Marcus (Ed.): DUXU 2016, Part I, LNCS 9746, pp. 293–303, 2016.
DOI: 10.1007/978-3-319-40409-7_28

cognitive abilities of the elderly began to show different degrees of recession. They have the stronger requirement for the design for the elderly. Therefore the emphasis of our study is to explore how to use the new design standards to promote the elderly to interact with the interface of the new medias.

1.1 The Interface Interaction's Visual Elements

Humans have unusual prominent data screening ability. people always can quickly detect the important information which is closely related with them and respond in time. This selective and initiative psychological activity is known as attention mechanism. In humans' visual information processing, they always select a few significant objects to prioritize quickly, and ignore or abandon other non-significant objects, in order to improve greatly the work efficiency of information processing. The process is called visual attention.

The significant objects in the image information is called visual Focus (the Focus of Attention, short for FOA) [1]. Visual focus is likely to be a certain range humans are interested in, or a characteristic value of the interest. (As shown in Fig. 1), the stage model of Treisman's visual attention. At first, some basic properties of the visual scene (color, direction, size, and distance) are encoded in separate and parallel pathways, and generated into the characteristics map, then these maps are integrated into the images. After that, the focus of attention (FOA) extracts information from the images in order to get the detailed analysis about the related characteristics of the selected area in the graphics.

Psychology research found that those image areas which can produce the extraneous and stronger stimulus, and the stimulation that people expect are easy to attract the attention of the observers. Accordingly, the attention can be divided into two types: one is based on the primary visual sense, which is the attention from the bottom up driven by data, namely passive attention; Another is based on high-level vision, which is the top-down attention related to mission and knowledge and so on. It is called active attention.

To explore the factors of the visual selection in the elderly, this article extracts the layout, colors, shapes, materials of the interface interaction to do experiments. First of all, the means of the interface layout affect directly the convenience which the customers use interface information, reasonable interactive layout will help the users quickly find

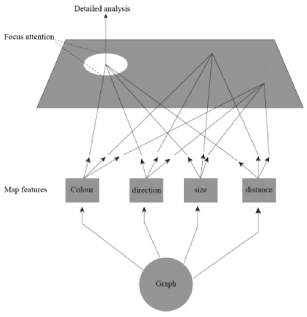

Fig. 1. The stage models of the visual attention

the core content and services. Second, in the interactive interface, colors are the first ones which users can feel, they can leave impression in your mind through the retina, and affect our mental activities and experience in the subconscious, the demand for color becomes the person's potential mental set. So colors of the interface suggest the users the direction and meaning that interface represents. Third, the main way the users recognize objects is through the silhouette of the objects, icon shape or framework used in the interface. They affect the property and definition defined by the users. Fourth, the materials themselves have the unique language, ideas and feelings. Different materials and textures can bring people different impressions and aesthetic feelings. In the interactive interface design, the use of the materials should be fully considered. Therefore, the above four interactive interface visual elements should be extracted in preparation for the experiments.

1.2 Psychological Effect and Factor Extraction

Psychological cognition includes the perception process how to accept and understand the information from the environment through visual, auditory sense and so on, and the processes of memory, thinking, logic reasoning etc., through the humans' brains. According to five stage models about psychological cognition proposed by Edward·K·-strong in 1925, respectively, the first step: to attract and maintain the attention, the second step: to show an interest in, the third step: to strengthen the understanding, the fourth step: to strengthen the memory, the fifth step: the willingness of action. Therefore, the effect of visual elements to psychological effect should be studied from the five aspects.

1.3 Establish the Relations Between Visual Information and Psychological Cognition

The important visual evaluation factors in the four interfaces like the layout, colors, shapes, materials can be got through the research of the interactive interface visual

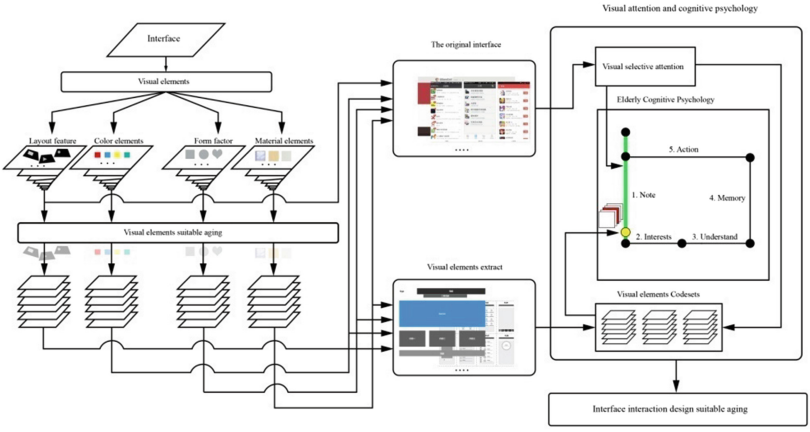

Fig. 2. The interface interaction evaluation models for the elderly

elements. and characteristics of these elements are obtained by the users through visual selective attention mechanism, and the psychological cognition is formed [2]. The interface interaction evaluation models (As shown in Fig. 2 for the elderly used in this article's study are set up, combining Treisman's stage models of visual attention and five stage models of psychological cognition proposed by Edward·K· strong.

2 Methods

Study was conducted on the basis of the data collection. 40 people are invited to participate two ways of experiments. They include subjective visual preference and objective tests, namely perceptual evaluation of visual elements and the analysis of eye tracking experiment.

They give some quantity analysis about the old people's attention, interest, understanding, memory and action, through the extraction testing experiment about the layout, colors, shapes, materials of the interactive interface, then compare with young people in all kinds of data, in order to extract visual selective attention preference elements of the elderly and the codes of the various visual elements. They will sum up the principles which can be regarded as a reference for the interface interaction design for the elderly.

VET. (visual elements test). VET is tested through a series of interactive interface visual elements, as shown in Fig. 3, the adaptability of the physiological function in the elderly are decaying, such as difficulty in vision, slow response, inattention, confusion, forgetfulness, getting tired easily etc. Therefore the number of tests should be minimized, in order to maximize the test stimulus and enable participants to recognize and understand easily, and make a choice in 15 min [3]. In this study, four kinds of visual elements are selected to collect the elderly and young people's subjective visual preference data. As shown in Fig. 3.

ET. (eye tracking experiment), Tobii Glasses eye movement device is used in this study in order to collect the elderly group and young group's eye movement data with it. Stimulation Settings is consistent with VET, but only combination images of visual elements are displayed. Each test category is displayed on the screen for 5 s to collect eye moving data index. As shown in Fig. 4.

Fig. 3. Comparison test about group visual elements

Fig. 4. Comparison experiment of group eye tracking

3 Primary Studies

In order to explore the visual elements of the interface interaction for the elderly, in the process of study, the subjects were divided into the elderly group and young group. The two groups are used to do the comparison experiments. The elderly group is made up of 20 people (10 men and 10 women, 60-80 years old), the total of the young group is 20 people (10 men and 10 women, between 18 to 25 years old).

The test methods of visual elements can be divided into two, one is the test method of combination images, The research objects give the marks according to the scales of their love on each test project, “very good” is “5 “ points, and “good” is “4”, “general” is “3”, “not good” is “2”, and “very not good-looking” is “1”. In the process, the test objects can put forward some perceptual words to describe the reasons they make a choice [4].

The other is the test method of a single image. When a single visual element is decomposed to test, the pictures which are used to test a single visual element will be made into slides, a tester ask the subjects, the other tester is responsible for recording the answers. The time is set within 5 s while they are played. the main questions involved in the test are: 1 what is the characteristic of the layout shown in the picture? 2 what color is shown in the picture? 3 what is the graphic shown in the pictures? 4 What material is shown in the picture? the top three of the single visual elements chosen are used to make answers from five dimensions, 1. attracting the visual attention, 2. showing interest, 3. easy to understand, 4. leaving deep Impression, 5. having the willingness to take action. Also the five-level Likert Scale is used to give scores, “strongly agree” is “5” points, “agree” is “4”, “general” is “3”, “do not agree with” is “2”, and “strongly disagree” is “1” [5].

3.1 The Composition of the Test Set

The Method of the Automatic Generation of the Test Set. Because older people tend to some problems such as inattention and being tired easily, so the quantity and time of their test must be controlled. therefore we need to typify the test set. The so-called typical processing means to classify test sets which had the numerous test objects before,

and extract the most representative of the test object in each type to form the new test set in order to simplify the test sets and not to lose their characteristics. Traditional typical operations for the test sets about layout, color, texture and shape are depended on experts. It means that we should invite a number of experts in related fields to classify and extract the test objects in the appropriate test sets. The operation method is involved in much subjective human trace, and tends to have a lot of uncertainty and replication. Therefore, this article adopts intelligent algorithm to give the automatic typical processing to the test sets. The advantages which the man-made operation practice is completely abandoned is not only to save a lot of manpower and time, but also to make each typical operating of the test set more objective and repeatable.

X - means algorithm [6] is the improved version of K-means [7], the famous clustering algorithm. K – means is one of the most widely used clustering algorithm. Its idea is to initialize K clusters heart randomly, to assign each sample which will be classified later to every cluster according to the most proximate principles, then redistribute repeatedly the classified samples by repeating calculation automatically and moving the heart of each cluster in order to get the largest similarity among the objects which are divided into the same cluster, and the minimal similarity among different clusters. X - means is regarded as the enhanced version of the K - means algorithm. Its biggest advantage is that it doesn't need to be specified by human the partition type or number K, and can automatically work out the clustering number which is the most suitable for the whole test sample set. That is to say, it can achieve full automation.

X - means algorithm process can be described like this :

1. Initialization: $K = K1$.
2. Random initialization cluster centers $c_i^{'}$, and generate K cluster C_i according to the K - means algorithm $1 \le i \le K$.
3. Do the following operations for each cluster Ci:
   ① calculate C_i about its Bayesian Information Criterion (BIC) [3]:

$$BIC(k{=}1) = -\frac{n_i \cdot d}{2}\log(2\pi) - \frac{n_i}{2}\log\sigma_i - \frac{n_i - 1}{2} - \frac{1}{2}\log n_i \tag{1}$$

   n_i is the size of the cluster C_i, variables σ_i is calculated with the following formula:

$$\sigma_i = \frac{1}{n_i - 1}\sum_{t=1}^{n_i} ||x_t - c_i^{'}||^2 \tag{2}$$

   ② Cluster Ci is divided into two subclasses Cij (j = 1,2) according to 2 - means algorithm, and calculate the new BIC :

$$BIC(k{=}2) = \sum_{j=1}^{2}[n_j \log n_j - n_j \log n_i - \frac{n_j \cdot d}{2}\log(2\pi) - \frac{n_j}{2}\log\sigma_j - \frac{n_j - 2}{2}] - \log n_i \tag{3}$$

   ③ If BIC(k = 1) > BIC(k = 2), the cluster Ci remains unchanged; Otherwise, Ci will be divided into two subclasses.
4. record BIC got in Step 3.

5. If there is no cluster needed to be divided into in Step 3, we will output the current clustering model; Or judge whether K is greater than K2, namely when K > K2, the output will have the largest cluster model; When K < K2, K = K + 1, and jump to Step 2.

Among them, (K1, K2) is the possible scope of the cluster number. In the test set which is calculated by X-means clustering algorithm, the center of each cluster in every class is the typical sample of each class.

3.2 The Encoding of the Test Set

When using the X - means algorithm to do the typification processing automatically for the test set, the input data can't be the original shape sample, or the color sample. We must do the coding operation firstly on the shape, color, material texture, layout accordingly. Each kind of shape (color, texture, layout) corresponds to a kind of coding. The coding is used as the input of X – means to do the clustering operation.

Shape Coding and Clustering Results. This article selects 1000 shapes which are commonly used in the current page design. After coding the 1000 shape, we input X - means algorithm for automatic clustering. Through the iteration, the algorithm will divide the 1000 shapes into 14 classes. Each type is shown in Fig. 5 respectively.

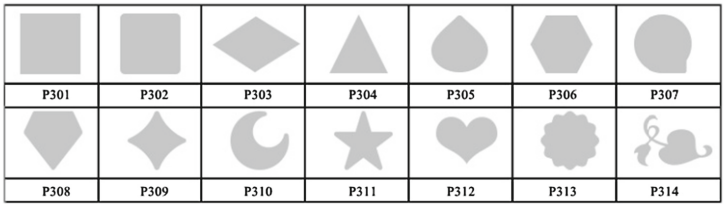

Fig. 5. Typical shapes worked out with X - means algorithm

Color Coding and Clustering Results. The method of color coding is simple. This article uses RGB, the color classification model. It inputs X - means algorithm with the (R, G, B) values of each color as the input values to do automatic clustering. After the iterations, we will get 12 types. They are shown respectively in Fig. 6. The 12 colors will be the last ones to be used in the visual elements test.

Material Texture Coding and Clustering Results. With material texture encoding, we select 100 material texture used commonly to do the clustering. As a result, 8 kinds of typical texture are worked out. As shown in Fig. 7.

Fig. 6. Typical colors worked out with X - means algorithm

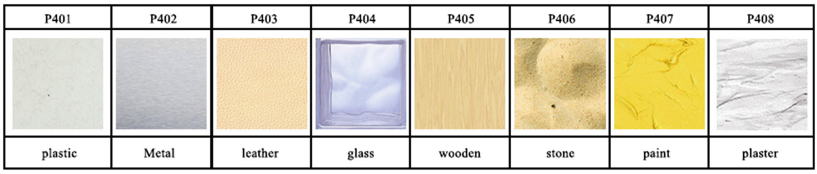

Fig. 7. Eight typical material texture worked out with X - means algorithm

Fig. 8. Six typical layouts worked out with X - means algorithm

Because the code of the page layout is relatively complex, this article takes the related technologies about the eye movement identification to code. We select 69 interactive interface layouts used commonly, and work out 6 types of layouts with X - means algorithm at last. As shown in Fig. 8. Their own typical layouts are also in them.

4 Results and Discussions

We quantify every visual element, compare the descriptive statistics between the two groups of subjects, use as frequency processing with spss17.0, get their mean value, standard deviation, coefficient of skewness and kurtosis coefficient respectively, then analyze them. We will further determine the corresponding relationship between the elderly group's visual preference elements and psychological effect, and have some correlation analysis on the visual element evaluation and psychological effect to get the Pearson correlation coefficient.

According to the data, there are significant differences between the elderly group's visual preference and the young group's. The maximum of the scores' standard deviation about the elderly group's visual element choice is 1.09, the minimum is 0.92. They are not too small or too large, it proves that the evaluation of the objects is relatively concentrated and shows a strong identity. and the highest average value of the visual elements in each group were 3.94, 3.90, 3.59 and 3.68. The evaluation was relatively high. It proves that the visual elements selected were typical.

From the related data about the elderly group's visual elements and psychological cognition, they have the greater influence on the evaluation of the visual attention in the group of the layout elements. The top three attention evaluation of the highest selection frequency were 0.246, 0.415, 0.483. The correlation is very significant and shows that the layout elements chosen can attract their attention. In the shape factors, all the correlation is high on the evaluation of various psychological effect, and the correlation about attracting their attention is the highest, and the maximum of correlation coefficient

was 0.622. In the group of material elements, the correlation of the psychological effect evaluation on material is lower than that of other visual elements. It shows the elderly pay more attention to the layout, colors, shapes than materials significantly. And the visual elements of colors and shapes and the correlation coefficient about the evaluation of strengthening memory are higher, they are 0.472 and 0.466, respectively. It shows the correct use of colors and shapes can evoke memories of the elderly.

Most subjects can have profound memory within 5 s according to the reaction of the tester and the effect of answering the questions in the decomposition test for single visual elements. It shows that the visual elements which are extracted have obvious characteristic memory for the elderly, and can attract visual attention in a short period of time. Especially color elements, 100 % of subjects could remember red correctly in the testing time, but the memory accuracy of blue, purple and orange were 98.72 %, 95.7 % and 94.35 %. In addition, the test results found that the differences of age have influence on the layout, colors, shapes and materials. There is a certain gap between old people and the young in cognitive time. For old people, the closer shapes and contours get to the specific objects, the faster the elderly have feedback.

They use the eye movement experiment to test the above testing results of visual elements. Each group of visual elements which are extracted in the visual testing experiment are made in a experiment picture. The purpose of this experiment is to reflect that the visual elements of the interaction interface have effect on the attention effects of the elderly through the eye movement experiment data index. In every group of visual elements, the two groups of subjects, the elderly and the young are regarded as independent variables, and the eye movement experiment index which gets the attention of the subjects is regarded as the dependent variable. keep the single variable and get the information of attention points and eye tracking data, compare and analyze respectively all the visual elements in view of the data index from the elderly group and young group, in order to get the average fixation time and the average fixation point which the two groups pay attention to the visual elements. As shown in Fig. 9.

		Elderly group				Youth group	
		Average Fixation (ms)	Fixation count (n)			Average Fixation (ms)	Fixation count (n)
Layout feature	P106	220	7	Layout feature	P102	231	9
	P102	215	5		P101	227	7
	P101	201	2		P105	213	5
Color Elements	P205	225	13	Color Elements	P202	198	11
	P207	217	11		P210	191	9
	P209	209	9		P211	183	5
Form factor	P312	246	9	Form factor	P312	250	5
	P311	243	7		P311	243	3
	P310	230	5		P310	231	2
Material elements	P403	235	3	Material elements	P403	232	4
	P407	210	2		P407	225	4
	P406	197	1		P406	214	2

Fig. 9. The statistics about the fixation time and the fixation point of the subjects on each visual element

5 Conclusion and Recommendations

The old people's visual selective attention preferences can be get according to the comparing data of eye movement experiment and visual elements test. (As shown in Fig. 10). The design should meet the cognitive demand of the elderly on layout, colors, shapes and materials. otherwise visual coding will be imperfect and some memory will be lost, then the learning burden and anxiety will be produced, to form a vicious cycle of low visual cognitive efficiency.

- Layout Code. The elderly like No. P106 pop-up layout, No. P102 the layout without frames, and No. P101 the layout which the big frames encase the small ones. To a certain extent, it shows the elderly have visual preference about the traditional rules and symmetrical layout. The way of information architecture should be used, which has simple feature set, easy operation and takes short time. And the information which has fewer hierarchical levels and the smooth process should be used in the design of interface, combining with the behavior characteristic of older users.
- Color Coding. Red is the old people's favourite color according to the experimental results, purple and blue are also popular. The following principles of color design should be followed in the interface design: 1 using colors for visual reminder. The colors with high degree of attention and recognition should be used more in the interface design in order to have visual reminder on key content and area, and guide the elderly do manipulation and reading with targets. 2 making full use of the emotional attributes of colors. The emotional attributes of colours can produce psychological effects, such as associating, thinking and memorizing etc. It includes the transfer of color, associating of colors, the symbols of the colors and color preferences. Interface colors should evoke memories of old people, let them have a positive happy associating and explore common beautiful things in the old people's memory.
- Shape Coding. The shape coding encodes the message, based on geometry codes. The following principles of designing the interactive interface shape for the elderly are proposed according to the shape coding features: 1 using shapes which have better emotional attributes. From the shape and visual elements testing experiment in this article, the old people show some visual preference on No. P312 heart-shape, No. P311 pentagram. For the elderly, they have a lot of life experiences. The shapes which can conform to their living habits, have common memories and come from the real life have stronger emotional attributes. Each shape has different coding meaning and has a certain emotional color. So the emotional design should be considered when choosing the shapes. 2 choose the shape with high plumpness. The old people like the shapes with full outline, but the sharp structure can be easier to cause visual sensitivity of the elderly.
- The Material Coding. The elderly show the visual preference on No. P403 wood, No. P407 paint, No. P406 sand. Most of the feelings about different materials and crafts are directly from different visual stimulations which a variety of materials give people, and the skin texture effects of the materials' appearance, (such as sparse and dense, smooth and rough, soft and hard, random and neatly, etc.) impact the user's psychology through vision. The soft materials make the elderly relaxed,

comfortable and peaceful. They can be combined with mild colours in order to create quiet and comfortable atmosphere. The design of interface materials should follow this principle.

These Suggestions help further improve the interactive interface design for the elderly to a certain extent, and provide some valuable reference.

Codeset	legend	description
Layout coding		The traditional rule, symmetrical layout
Color coding		Stimulate strong, warm colors
Shape coding		Full structure contains sharp
Material coding		Delicate texture, texture soft and comfortable material

Fig. 10. Visual coding set

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