The Impact of Color in Phone Software Interfaces on the User Experience of the Elderly

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Abstract. In recent years, China has entered an aging society [1]. As they age, the elderly experience a continuous decline in vision. The decrease in the transmittance of the elderly lens and the size of the pupil leads to a weakened sensitivity to light [2]. In terms of color recognition, due to the degeneration of the visual nerves and the reduction of cone cells in the retina, the elderly's ability to distinguish colors deteriorates [3]. They become very sensitive to intense brightness, their sensitivity to color discrimination decreases, and as a result, their speed of processing visual information slows down [4]. Moreover, with the increase in age, cognitive abilities also decline, and the elderly will take longer than younger individuals to complete a given task [5]. Psychologically, the elderly often experience negative emotions such as anxiety and depression due to the decline in vision [6]. As of June 2023, the proportion of internet users aged 60 and over was 13% [7], and the number of elderly people using smart products has gradually increased. Therefore, in the digital age, the design of interactive interfaces plays a crucial role for the elderly in using social apps. Phone apps are commonly used social apps for the elderly. According to color psychology theory, colors have a regulatory effect on human functions and emotional changes [8]. However, most of the existing phone app interfaces are relatively monochromatic, relying solely on characters and layout to convey information. The functionality of searching, dialing, and connecting is not clear, leading to relatively difficult information recognition for the elderly and a poorer user experience.

Keywords: Seniors · Communication Software · Color Perception · User Experience

1 Introduction

Statistics from the Pew Research Center (Pew Research Center) show that 53% of people over the age of 65 own a smartphone in 2019.

Aging can lead to lesions in the visual system [9]. In the elderly, the retina slowly decreases in size, the cornea grows in diameter, and the vitreous hardens as we age, leading to vision loss [10, 11]. The colour perception of the eye changes with age.

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Eye colour perception changes with age and the ability to distinguish colours decreases significantly [12]. The production of pigmentation from crystals is one of the main causes of diminished colour perception in older adults [4]. In addition to this, colour discrimination is also poor in older adults due to the degeneration of the optic nerve and the reduction of cone cells in the retina [3]. [3] In addition to this, colour recognition is also impaired in the elderly due to degeneration of the optic nerve and reduction of retinal cone cells [3]. In particular, aging decreases pupil function, which reduces sensitivity to light [4]. [4]. In addition, it reduces colour sensitivity in older people, reducing their ability to judge intermediate shades, especially between blue and green [13].

Research has shown that colour influences our lives in different ways. People's reactions to colour are mainly based on physical sensations and psychological experiences [14].

At the same time colour is an important tool for stimulating cognitive motivation and reflexivity levels in older people. Colour increases the legibility of space and helps them to orientate themselves [15]. Finding the desired object even improves their mood and well-being, resulting in a favourable emotional experience. Colour can influence older people's cognitive abilities, which directly affect the way they perceive information, focus their memory, think and understand educational tasks [16].

The use of smartphones by older people has increased and mobile phones have become an important tool for improving the quality of life of older people. Colour combinations make a difference to the discrimination of older people using displays and have been shown to have a significant impact on their daily lives. Therefore, colour is crucial to the design of the screen [17].

Pastoor [18] and Silverstein [19] argue that colour is a major factor in the performance of computer displays and can be effective in increasing the interaction between the user and the computer. Conversely, improper use of colour can also lead to reduced performance [20], and older people may experience difficulty and confusion when viewing colour images on smartphones and tablets. In addition to improving reading performance, research has also found that colour can make user operations less dull, reduce visual fatigue and stress, and even improve visual performance [21]. Today's smartphone application design phase ignores older users and designers do not pay attention to the needs and requirements of older people. Despite the fact that due to the complexity of the interface, older users are willing to adopt technologies that help them to maintain their quality of life, they are unable to take advantage of the benefits of smartphones. Therefore, the causes of different problems are discussed from two different perspectives. Firstly, there are age-related issues, i.e. cognition, physical abilities, memory loss, mental models and sensory functions that make it more difficult for them to interact with new technologies. Then comes soft-ware design; designers do not carefully design applications that address the needs and requirements of older users. In the age of digitalisation, the design of mobile phone interaction interface plays an important role in the use of social software by the elderly. Whereas phone software is a common social software used by the elderly, older people are not familiar with smartphone technology and tend to encounter difficulties when using the device [22].

Therefore, this study takes elderly users as the target group, analyses the effects of different background colours on the attention of the elderly in the telephone software

interface, and deeply analyses the perception of different colours on the psychological emotions of the elderly. It reveals the differences in the emotional experience of the elderly with different colours, and provides insights into the design of interface colour schemes that are more suitable for the elderly. It also provides design guidelines for the interface design of telephony software applications from the perspective of the elderly.

2 Method

2.1 Experimental Design

The overall experiment was divided into two phases: the first phase was a colour selection experiment; the second phase was a software interface colour experiment. The second phase consisted of three parts: the first part was a contact finder test; the second part was an interactive interface colour experiment for answering; and the third part was a dialling experiment as well as an interview and questionnaire on colour perception.

The first stage is colour card selection, where warm colours are usually associated with warmth and cold colours are usually associated with coldness and alienation [8]. The colour cards were divided into warm and cold colour cards see Table 1, and the elderly were asked to select one from each of the warm and cold colour cards, and then to select the three most intimate colours from the selected warm colour cards, and the three more distant colours from the cold colour cards. Finally, the number of times each colour was selected was summed up, and the two most selected colours were chosen among the close and distant colours, respectively.

In the second stage, the two close and two distant colours selected in the first stage were arranged in different combinations, and the closer contacts in the interaction software were marked as close colours, and the stranger contacts were marked as distant colours, with a total of four combinations, which were carried out in two sessions, two groups each time, with a 48h interval between the two experiments, and each group of colour combinations was tested for a variety of interactions respectively in each experiment. Each group of experiments was divided into three parts: the first part measured the reaction time to complete the task by formulating a set task, i.e., to search for contacts with different levels of intimacy in the address book; the second part measured the reaction time to complete the task by having the contacts with different levels of intimacy call the older adults with different colours in the incoming call interface, and the older adults answered or hung up the phone call. In the third part, older adults dialed the phone of contacts with different levels of intimacy, and the communication interface presented different colours. Finally, the colour perception of the older adults was collected through interviews and questionnaires, and then the colour perception was visualised through the questionnaire scoring data (on a scale of 1–5, the higher the score in the close colour the closer the person is, and the higher the score in the distant colour the more distant the person is).

2.2 Participants

This experiment was conducted at the Xiamen Campus of Fuzhou University and introduced to the community, senior activity centre and senior university, covering four life

Table 1. Colour specimens from the first phase of the experiment

warm colours								cool colours							
No.	colour	R	G	B	L	A	B	No.	colour	R	G	B	L	A	B
1		255	0	0	54	81	70	28		0	255	0	88	-79	81
2		255	77	77	60	68	41	29		77	255	77	89	-70	67
3		255	153	153	74	39	17	30		153	255	153	92	-46	39
4		204	0	0	43	68	59	31		0	204	0	72	-67	68
5		204	61	61	48	57	34	32		62	204	62	73	-59	56
6		204	122	122	60	33	14	33		122	204	122	75	-39	33
7		153	0	0	32	55	47	34		0	153	0	55	-54	55
8		153	46	46	36	45	27	35		46	153	46	56	-47	45
9		153	92	92	46	26	11	36		92	153	92	58	-30	26
10		255	126	0	67	46	75	37		0	0	255	30	68	-112
11		255	166	77	76	28	59	38		77	77	255	43	44	-90
12		255	204	153	86	14	33	39		153	153	255	67	19	-51
13		204	102	0	55	38	63	40		0	0	204	23	58	-59
14		204	133	61	62	23	49	41		61	61	204	34	37	-75

(*continued*)

Table 1. (*continued*)

15		204	163	122	70	12	27	42		122	122	204	54	16	-43
16		153	76	0	42	30	51	43		0	0	153	15	47	-77
17		153	99	46	47	19	39	44		46	46	153	25	29	-60
18		153	122	92	54	9	21	45		92	92	153	41	12	-34
19		255	255	0	98	-16	93	46		167	0	255	45	79	-86
20		255	255	77	98	-14	79	47		194	77	255	55	67	-69
21		255	255	153	98	-10	49	48		220	153	255	73	39	-41
22		204	204	0	80	-13	79	49		134	0	204	36	67	-72
23		204	204	62	80	-12	66	50		155	62	204	45	56	-57
24		204	204	122	81	-9	41	51		176	122	204	59	33	-34
25		153	153	0	62	-11	64	52		100	0	153	26	55	-58
26		153	153	162	62	-10	53	53		116	46	153	34	44	-46
27		153	153	92	62	-7	32	54		132	92	153	45	26	-27

scenarios for use by seniors in each scenario, with a total of 40 research samples (20 men and 20 women) seniors over the age of 60 with no visual impairment, no colour weakness or colour blindness, and no cognitive impairment. Among them, 20 (10 men and 10 women) were subjected to the first phase of the colour selection experiment; the remaining 20 (10 men and 10 women) were subjected to the second phase of the

software interface colour experiment, and each elderly person was required to complete the experiment for two different periods of time.

2.3 Experimental Materials

According to the HSB standard, red (H = 0), orange (H = 30), yellow (H = 60), green (H = 120), blue (H = 240), violet (H = 300), three kinds of warm colours, three kinds of cold colours, and each colour in accordance with the brightness (100%, 80%, 60%) and saturation (100%, 70%, 40%) to generate a total of 9 colours, a total of 54 kinds of colors, each colour HSB value was converted to RGB and LAB values, and each color RGB and LAB values were labeled in the color specimen, and the color card was made as in Fig. 1. 54 colours, each colour of the HSB value is converted to RGB and LAB values, each colour of the RGB and LAB values are marked in the colour specimen, and make a colour card in Fig. 1. in the suitable aging colour experiments, through the colour card to select the most representative of the indifference of the two cold colours and the most warm of the two warm colours, the four colours, the four random warm and cold with the combination of the four combinations of four combinations of the four combinations of the four combinations of the four combinations of the four combinations of communication as a communications experimental Colour variables. In the communication APP, these colours are reflected in: the icon in front of the person's name in the address book, and the background colour of the incoming call. Figure 2 (colour random configuration) shows the four system communication in the address book self-designed interface legend, saved in PNG format, the ink knife simulation run as a display, the method resolution of 375 * 812px.Fig. 3, Fig. 4 shows the communication in the incoming call of the self-designed interface legend, saved in PNG format, the method resolution of 375 * 812px. Icons are actual shapes designed by the application icon designer and selected in iPhone 13 min. Image processing software was used to adjust the background colour of the four experimental materials.

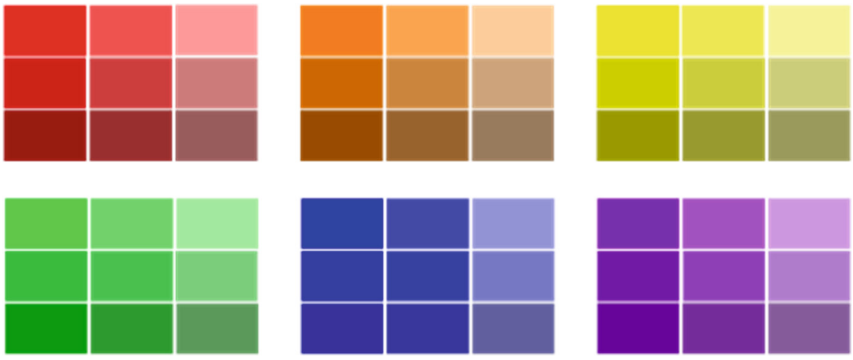

Fig. 1 Test Colour Card Selection.

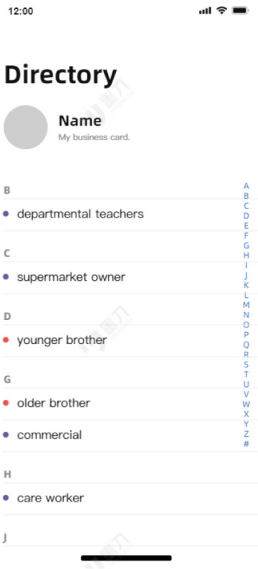

Fig. 2 Directory.

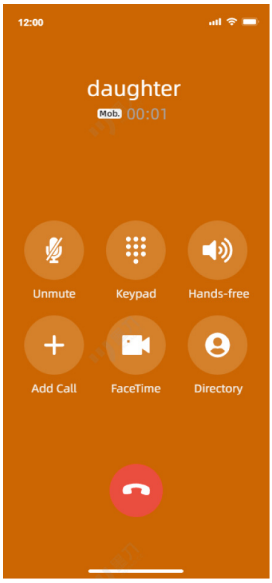

Fig. 3 People Friendly Calling Interface.

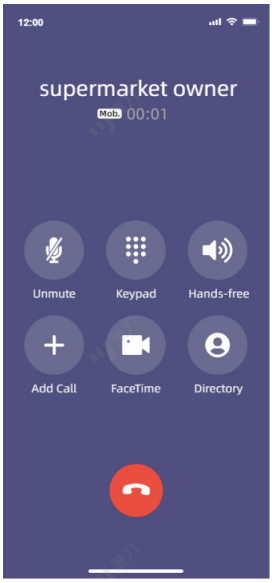

Fig. 4 Stranger call screen.

2.4 Experimental Equipment

The experimental equipment included a laptop (Lenovo SAVIOR) to create the experimental interface, two tablets (2020 iPad pro, ipad2020) for colour swatch selection, two mobile phones (iPhone 12 Pro, iPhone 12) to operate the interface experiments, and a stopwatch to keep track of the time to display the self-designed communication interface on the mobile phone in equal proportions, 1 to 1. A stopwatch was used to record the time, and the self-designed communication interface was displayed on the mobile phone in 1 to 1 ratio.

2.5 Data Analysis

Phase II, Colour Card Selection. The statistical results of the colour card selection interview are shown in Table 1, after the data comparison, it is concluded that in the cold colour No. 45 Blue and No. 53 Purple have the highest number of choices, and more subjects think that these two colours are more likely to make people feel cold, of which No. 45 Blue number is 7, accounting for the total number of votes of cold colours 11.67%, and No. 53 Purple number of choices is 6, accounting for the total number of votes of cold colours 10.00%, and in the Warm colours No. 2 Red and No. 10 Orange had the highest number of choices and more subjects felt that these two colours were more approachable, with No. 2 Red having 8 people or 13.33% of the total votes for the warm colours, and No. 10 Orange having 5 people or 8.33% of the total votes for the warm colours. Finally, the two warm colours and two cool colours obtained were matched with each other to obtain four combinations: No. 10 Orange * No. 53 Purple, No. 10 Orange * No. 45 Blue, No. 2 Red * No. 53 Purple, and No. 2 Red * No. 45 Blue.

Table 2. Note: Votes in the table is the number of people who chose that colour value, 20 in total,with a total of 60 votes each for cool and warm colours.

No.	colour	vote	No.	colour	vote	No.	colour	vote
1		7	19		4	37		1
2		8	20		4	38		1
3		5	21		4	39		2
4		1	22		1	40		2
5		0	23		1	41		1
6		1	24		1	42		2
7		1	25		0	43		2
8		1	26		0	44		4
9		3	27		0	45		7
10		5	28		3	46		1
11		4	29		3	47		2
12		3	30		3	48		1
13		2	31		1	49		0
14		1	32		1	50		1
15		0	33		0	51		1
16		1	34		0	52		5
17		1	35		2	53		6
18		1	36		2	54		4

Phase II, Part I - Finding Tasks Experiments. The specific time statistics are shown in Table 2, after the experimental operation time data analysis: No. 10 orange and No. 45 blue colour matching under the find task completion time is obviously shorter than the other three colour matching under the task completion time, the total value is 114.3 s.

Table 3. Note: Values are the total number of hours spent on the 20-person search experiment.

colour matching	Find (intimate people)	Find (alienate people)	total time
orange × purple	87.40 s	101.51s	188.91s
orange × blue	63.78 s	55.20s	118.98s
red × purple	59.17 s	52.94s	112.11s
red × blue	82.26 s	69.90s	152.16s

Phase II, Part II - Answering Tasks Experiments. The specific time statistics are shown in Table 3, after the experimental operation time data analysis: No. 10 orange and No. 45 blue colour matching under the answer task completion time is significantly shorter than the other three colour matching under the task completion time.

Table 4. Note: Values are total experimental time for the 20-person answering task.

colour matching	answer(intimate people)	answer(alienate people)	total time
orange × purple	48.36 s	52.43 s	100.79 s
orange × blue	41.21 s	41.17 s	82.38 s
red × purple	43.66 s	43.85 s	87.51 s
red × blue	46.99 s	48.12 s	95.11 s

Phase II, Part I III - Dialling Experiments and the Colour Perception Questionnaire. The specific time statistics are shown in Table 4, the subjects were scored on a questionnaire about colour feelings after the find, answer and dial trials, each subject scored 1–5 for each group, for colour combinations 5 points represented the highest colour recognition and 1 point represented the lowest colour recognition, for cool colours (purple/blue) 5 points represented the strongest feelings of alienation and indifference and 1 point represented the weakest feelings of indifference, for warm colours (For warm colours (orange/red) 5 represents the strongest feelings of intimacy and 1 represents the weakest feelings of closeness (Table 5).

Table 5. Note: The values in the table are the sum of the fractions for which this colour combination/colour value was selected.

colour matching	total score value	colour	total score value
orange × purple	60	orange	81
orange × blue	81	red	51
red × purple	42	purple	69
red × blue	71	blue	77

3 Results

This study analyses the impact of interactive interface colours on older adults' use of telephone communication software. For older adults, appropriate colours in the interface of communication software can improve the efficiency and emotional experience of retrieving the address book. Therefore, this study aims to find appropriate interface

colours that can provide a better user experience for older users, reduce their barriers in using telephone software, and enable more equal access to smart communication devices.

From the above analysis, it can be seen that in the first stage of the colour card selection experiment the results showed that among the warm colours, No. 10 Orange and No. 2 Red scored the highest, and among the cool colours, No. 53 Violet and No. 45 Blue scored the highest.

Based on the above experimental data it is stated that warm colours with higher saturation and luminance are the colours that older people feel close to because these colours remind them of warmth and enthusiasm, whereas cool colours with lower saturation and luminance are the colours that older people feel alienated from because these colours remind them of darkness and indifference. Therefore, two cool colours, No. 53 Violet and No. 45 Blue, were used as markers for distant contacts and two warm colours, No. 10 Orange and No. 2 Red, were used as markers for close contacts.

The second phase of the experiment was an interface manipulation experiment with a sample of 20 individual elderly people.

In the first part of the contact finding task, the No. 53 Purple No. 2 Red combination took the shortest time out of the four groups, with the red colour having the fastest reaction time, suggesting that the colour red is very noticeable in the finding task.

In the second part of the connected call test, the No. 45 Blue No. 10 Orange combination takes the shortest time among the four groups. When a call comes in, the colour sensation from the background colour of the caller ID page will help the elderly to make a quicker judgement, and the use of blue and orange to represent close and distant contacts will enable the elderly to identify the proximity of the contact more quickly.

In the third part of the dialing experiment, the questionnaire data shows that most of the elderly people think that No. 10 Orange, as the background colour of the interface of dialing close contacts, can feel more warm and evoke some good memories. On the other hand, No. 45 Blue as the background colour of the interface of dialing distant contacts can feel more strange and distant.

This was also confirmed in the final colour combination questionnaire, where the No. 45 Blue No. 10 Orange combination scored the highest, with more seniors believing that the blue-orange combination is the pair that best represents close and distant contacts in telephony software.

4 Conclusions

Taken together, the results of the experiments in this study show that the colour of the interactive interface of telephone software has a significant impact on the experience of older people. Different colour combinations do affect the reading speed and accuracy of older people. At the same time different colour tones have different feelings and experiences on the emotional experience of the elderly.

The main conclusions of this study are:

1. Although the red-violet combination was more rapid in the look-up experiment, it did not score as well in the longer response time in the answer experiment and in the final questionnaire, because the colour red gives a strong visual stimulus and a feeling of

alertness [15] This is because red colour gives people a strong visual stimulus and alertness [15], so the red-violet combination does not bring a good experience to the elderly, and the reaction time and final score of the four groups are combined to conclude that the blue-orange combination is more suitable for the elderly.
2. Red is the most striking colour when controlling saturation and brightness23, The colour red can be used in interface design to attract the user's attention to specific interface elements and information, and to be more prominent and conspicuous in the use of the interface.
3. No. 10 Orange is the colour that the elderly consider the closest to them, while No. 45 Blue is the most distant. In the interface design, orange is chosen as the mark of close contacts and blue is chosen as the mark of distant contacts, which is more conducive to the recognition of close and distant relationships and improves the operation efficiency of the elderly.
4. The combination of No. 45 Blue and No. 10 Orange significantly improves the attention and concentration of the elderly when they use the telephone software, and the combination of blue and orange creates a balanced and compelling interface atmosphere. In the interactive interface of the telephone software, the use of vibrant orange and stable blue can be considered to optimise the experience of the elderly in using the interface, and to guide the elderly to use the telephone software more conveniently and attentively.
5. In terms of brightness and saturation, warmer colours with higher saturation and brightness will give the elderly a feeling of closeness and comfort, and can stimulate more positive emotions, making the elderly feel closer and creating a warmer and more pleasurable atmosphere for the elderly. Low saturation and brightness of the cool colours will give the elderly strange and distant feelings, triggering a more calm and peaceful emotional experience.

Also this Study has Some Limitations. Due to financial as well as practical constraints, we only used the Xiamen campus of Fuzhou University as well as nearby communities, senior activity centres, and senior colleges, which made the representativeness of the sample somewhat limited. Future studies need to expand the scope of the survey to include a wider range of older adults and older adults in different regions to obtain more comprehensive findings.

We only used a total of six colour shades of warm and cold tones in our experimental research, and this simplified design may not fully reflect the experience of older adults with different variations of colours in the telephone software interface. Future research could consider introducing more variation conditions to delve into the combined effects of these factors on older adults' user experience.

These limitations are not only present in the research design, but may also have some impact on the generalisation and interpretation of the results. Therefore, in order to gain a more comprehensive and accurate understanding of older adults' user experiences in communication applications, future research should aim to address these limitations by adopting more diverse samples and more complex experimental designs, which will help to improve the scientific validity and practicality of the study.

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