A Study of the Factors Affecting the Usability of Smart Phone Screen Protectors for the Elderly

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Abstract. The issues arising from ageing societies have received worldwide attention. Many studies have pointed out that mobile technology can positively assist the elderly with smartphones being the most prevalent. The low sensitivity of finger touch and the slow response of a smartphone's interface may affect the finger coordination and stability of the elderly on the touch screen interface. A large number of studies suggest that the sense of touch can provide smartphone users to experience richer interaction than audio visual communications alone. Therefore, the reason for using the four different smartphone screen protector materials (Anti-Smudge (AS), Anti-Smudge and Glare (ASG), Blue Light Cut (BLC), and Tempered Glass (TG)) for this experiment on smartphone users aged 50 and above. Each material is scored with a usability evaluation method in order to obtain the superior screen protector in regards to usability for the elderly. The results from the experiments found that TG was the most suitable for elderly, followed by ASG, and then AS. It also showed that the thickness of the smartphone screen protectors do not affect elderly users when manipulating the screen surface. However, smooth surfaced, matte touch material with a translucent visual exterior seems to be the most suitable for elderly smartphone users.

Keywords: Elderly · Smart phone · Screen protectors · Usability

1 Background

The phenomenon of increased living age and ageing population is one that impacts the global society. According to the World Population Ageing 2015 Highlights statistics report from the United Nations, the global number of people aged over sixty has reached nine hundred million, and this number is predicted to increase to fourteen hundred million in 2030 [1]. When the ageing population issue becomes serious, a society is labeled a "Super Aged Society". In an ageing society, the elderly might have physiological deteriorations which can lead to disabilities. These disabilities, which may be associated with their psychological and social adaptation issues, will require new solutions.

J. Zhou and G. Salvendy (Eds.): ITAP 2016, Part I, LNCS 9754, pp. 457–465, 2016.
DOI: 10.1007/978-3-319-39943-0_44

Research indicates that mobile technology not only stimulates the ageing positively, but also provides them with a powerful assistive technology, which can help them to maintain their own independency and self-esteem. In addition, this technology enables the ageing to remain connected to society. Mobile technology has the potential to provide new opportunities to enhance the health and the quality of life of the elderly, especially when they begin suffering from health issues. Many studies have found that as a person ages, their physical functions, including reaction speeds and the ability to receive and assess information, deteriorate and regress. These regressions can negatively impact on their daily lives, and may lead to increased psychological issues [2, 3]. Mobile devices have been integrated with more digitized functions which enable them to exchange and interact with information more efficiently, and as a result, the market share of smartphone have seen a considerable growth. The following chapters will investigate the usability of smartphones for the elderly.

1.1 How Ageing Affects the Use of the Hands

As people age, their muscle fibers decrease and shorten. Muscle contractions weaken, which affects of the elderly by making their movements slower. As a result of this muscle deterioration, it may be difficult for people to press the small icons or buttons as they age and their abilities of control and manipulation decrease [4, 5]. Elderly people may, therefore, struggle to use devices and applications which require small movements. Moreover, slower mental reactions may affect the ability to receive and process information in the brain which could in turn impact the coordination and stability on their movements.

1.2 Receiving Information System

As people receive the information through visual images, ageing increases the difficulty to receive information via the eyes. The eyes may suffer from several impairments, such as lesions, yellowing, cloudy and blurred vision, and poor color sensitivity (especially to the color blue and yellow) [6]. Hyperopia, or farsightedness, is another health issue that may develop as a person ages. This impairment can also result in difficulty when receiving and reacting to visual stimulation [7, 8]. Because of the effects that these numerous health issues resulting in the degradation of vision have on the elderly, fatigue while staring at a small, lit screen is quite a common complaint [9].

Another method of receiving messages is through the tactile sense. The tactile sense conveys information, such as the feeling of pain and temperature, by processing external stimulations through the skin [10]. As skin ages, a rough surface develops. This results in a lower quantity of sensory cells, which in turn decreases the sensitivity of the tactile sense, which often results in the person being able to endure more pain [11, 12]. The tactile sense is important because it not only allows one to react to their environment immediately, but it can also help with psycho-social development to encourage interpersonal relationship communications [10, 13].

1.3 Usability Design

Usability design is a user-base oriented approach to creating the criteria of product designs. The main purpose is to investigate and analyze the positives and negatives of a design to improve the product. In 1980, many designers, scholars, and experts suggested that the "user friendly" concept should be emphasized on product designs with "user-base orientation" to meet the users' demands, as opposed to requiring users to learn the functions of the product [14]. Furthermore, "Quality Attribute" and "Ease of Use" are the required concepts to adjust and improve the simplicity for the users [15]. The Usability Metrics (Errors, Efficiency, Learnability, Memorability, and Satisfaction) are used to ensure that the design processes can meet the users' requirements.

1.4 Investigating Problems and Assessment

Smartphones work through touch and, in most cases, commands are executed by using the fingers to touch and slide across the surface of the screen. However, because of the low sensitivity of the sense of touch and slow reactions to the visuals on the screen, the elderly often have difficulty using smartphones. The literature found that richer interactive experiences can be created by enhancing the tactile sense on the screen while using the smartphone. These experiences can be more rewarding than traditional audio visual communications [16]. Therefore, this research will investigate the effect of different screen protectors on the elderly focusing on the tactile sense. From the findings, this study will make a recommendation for the ideal screen protectors for use by the elderly.

2 Method

2.1 Experimental Setup

As previously discussed, ageing creates problems for people. One study showed that the sensitivity of the sense of touch starts to deteriorate from the age of fifty [17], while another study showed that the clarity of sight begins to weaken as age increases [18].

- Participants: The thirty participants, who were over fifty years old, were recruited from various community centers in Taiwan for this research.
- Material Sample: The four most popular types of screen protectors for smartphones in the current market were selected for the questionnaire (see Table 1).
- Experimental Tool: All participants used the same five-inch screen Android smartphone to maintain a level of experimental accuracy and consistency.
- Conducting Experiment: The experiment was conducted on a one-to-one basis. Before the experiment, the topic and the experiment process were reviewed. Some ground rules were also introduced at the beginning. Next, the participants used the smartphones without screen protectors for five minutes. After these five minutes, the participants used each of the four different screen protectors in order. These screen protectors were scored with a usability evaluation questionnaire. Each section lasted twenty minutes.

Table 1. The experimental subjects

Material Sample	AS (Anti-Smudge)	ASG (Anti-Smudge & Glare)	BLC (Blue Light Cut)	TG (Tempered Glass)
				
Material	PET	PET	PET	Glass
Thickness	0.2mm	0.22mm	0.22mm	0.35mm
Visual characteristics	Glossy	Matte	Glossy with yellow color	Translucent

2.2 Experimental Process

Using the actual smartphone with each of the four different material protectors allowed the participants to be able to define the differences between them precisely. The experimental process was as follows:

- Participants were asked to enter a list of specific number to unlock the screen, and make a phone call using a method familiar to them. This could help to provide an evaluation of the error rate.
- The study found that minimizing, rotating, sliding and enlarge objects on the screen were the most common commands input by touch [19]. However, the methods of minimizing, enlarging, and rotating objects on the screen are more complicated. These commands are associated with the Learnability and memory evaluation.

2.3 Usability Questionnaire

The questionnaire content contained seven Usability Metrics which were: Errors, Efficiency, Learnability, Memorability, Satisfaction, Visual, and Sense of Touch. A Likert Scale was used to evaluate the level of the participants' satisfactions. A lower score represented lower satisfaction, while a higher score represented higher satisfaction.

3 Result

3.1 Comparative Analysis of Each Marital Sample

After compiling all of the statistical data of the four material samples, it was analyzed in ANOVA. The results showed that the different screen protectors had significant

differences in performance (P<0.05) (see Table 2). After this the results of each material sample were compared, and examining the inner factors that influenced each other, to obtain the relative merits for the participants (see Table 3). The results found that the most recommended screen protector for the elderly was the material sample TG, follow by ASG, then AS.

Table 2. Usability statistics results

			Evaluation items						
			Errors	Efficiency	Learnability	Memorability	Visual	Sense of Touch	Overall Satisfaction
Sample	AS	Number	30	30	30	30	30	30	30
		Mean	**2.4**	**2.8**	**2.4**	**2.1**	**3.4**	**2.8**	**3.1**
		S.D.	**0.9**	**1.1**	**1.1**	**0.9**	**1.0**	**1.2**	**1.2**
	ASG	Number	30	30	30	30	30	30	30
		Mean	**2.9**	**3.0**	**2.9**	**2.4**	**2.9**	**3.3**	**3.3**
		S.D.	**1.2**	**1.0**	**1.3**	**1.3**	**1.1**	**1.0**	**1.2**
	BLC	Number	30	30	30	30	30	30	30
		Mean	**2.8**	**2.8**	**3.8**	**3.2**	**3.1**	**2.6**	**3.3**
		S.D.	**1.1**	**1.3**	**1.1**	**1.3**	**1.2**	**1.3**	**1.2**
	TG	Number	30	30	30	30	30	30	30
		Mean	**3.3**	**3.7**	**3.6**	**3.2**	**4.2**	**4.2**	**4.1**
		S.D.	**1.1**	**1.1**	**1.1**	**1.4**	**0.7**	**0.8**	**0.9**
F value			**3.078**	**4.636**	**9.775**	**6.585**	**9.897**	**13.259**	**4.533**
P value (significance)			**0.03**	**0.004**	**0.000**	**0.000**	**0.000**	**0.000**	**0.005**

Moreover, the results indicate that the smooth-surfaced, matte touch, translucent material is probably the most suitable screen protector for elderly smartphone users. One interesting finding was that the thickness of the screen protector seemed to have no difference on the user. The further discussions on the differences of results with the (*) symbol (see Table 3) as follow:

1. TG>AS has significant differences on Errors (p=0.016<0.05)
2. TG>AS, and TG>BLC shows noticeable differences on Efficiency and Sensitivity (Both p=0.009<0.05)

3. BLC>AS shows the most outstanding differences than other comparisons on Learnability (p=0.000<0.05)
4. BLC>AS, and TG>AS both shows great differences on Memorability of hand/finger gestures (p=0.002<0.05)
5. TG shows the highest differences on Overall Satisfaction on the comfort of visual and sense of touch (p<0.05)

Table 3. The usability of analysis of variance on the different smartphone screen protectors

Variable	(I) gesture	(J) gesture	The average difference (I-J)	Standard error	Significance	Comparison result
Errors	AS	ASG	-0.467	0.276	0.334	**TG>ASG>BLC>AS**
		BLC	-0.367	0.276	0.547	
		TG	***-0.833****	***0.276***	***0.016***	
	ASG	AS	0.467	0.276	0.334	
		BLC	0.1	0.276	0.984	
		TG	-0.367	0.276	0.547	
	BLC	AS	0.367	0.276	0.547	
		ASG	-0.1	0.276	0.984	
		TG	-0.467	0.276	0.334	
	TG	***AS***	***0.833****	***0.276***	***0.016***	
		ASG	0.367	0.276	0.547	
		BLC	0.467	0.276	0.334	
Learnability	AS	ASG	-0.467	0.293	0.386	**BLC>TG>ASG>AS**
		BLC	***-1.367****	***0.293***	***0.000***	
		TG	***-1.233****	***0.293***	***0.000***	
	ASG	AS	0.467	0.293	0.386	
		BLC	***-0.9****	***0.293***	***0.014***	
		TG	***-0.767****	***0.293***	***0.048***	
	BLC	***AS***	***1.367****	***0.293***	***0.000***	
		ASG	***0.9****	***0.293***	***0.014***	
		TG	0.133	0.293	0.968	
	TG	***AS***	***1.233****	***0.293***	***0.000***	
		ASG	***0.767****	***0.293***	***0.048***	
		BLC	-0.133	0.293	0.968	

Variable	(I) gesture	(J) gesture	The average difference (I-J)	Standard error	Significance	Comparison result
Efficiency	AS	ASG	-0.233	0.29	0.852	**TG>ASG>BLC,AS**
		BLC	0.000	0.29	1.000	
		TG	***-0.933****	***0.29***	***0.009***	
	ASG	AS	0.233	0.29	0.852	
		BLC	0.233	0.29	0.852	
		TG	-0.700	0.29	0.080	
	BLC	AS	0.000	0.29	1.000	
		ASG	-0.233	0.29	0.852	
		TG	***-0.933****	***0.29***	***0.009***	
	TG	***AS***	***0.933****	***0.29***	***0.009***	
		ASG	0.7	0.29	0.080	
		BLC	***0.933****	***0.29***	***0.009***	
Memorability	AS	ASG	-0.367	0.313	0.647	**BLC,TG>ASG>AS**
		BLC	***-1.133****	***0.313***	***0.002***	
		TG	***-1.133****	***0.313***	***0.002***	
	ASG	AS	0.367	0.313	0.647	
		BLC	-0.767	0.313	0.074	
		TG	-0.767	0.313	0.074	
	BLC	***AS***	***1.133****	***0.313***	***0.002***	
		ASG	0.767	0.313	0.074	
		TG	0.000	0.313	1.000	
	TG	***AS***	***1.133****	***0.313***	***0.002***	
		ASG	0.767	0.313	0.074	
		BLC	0.0	0.313	1.000	

Visual	AS	ASG	0.433	0.263	0.355	**TG>AS>BLC>ASG**
		BLC	0.3	0.263	0.664	
		TG	***-0.867****	***0.263***	***0.007***	
	ASG	AS	-0.433	0.263	0.355	
		BLC	-0.133	0.263	0.957	
		TG	***-1.3****	***0.263***	***0.000***	
	BLC	AS	-0.300	0.263	0.664	
		ASG	0.133	0.263	0.957	
		TG	***-1.167****	***0.263***	***0.000***	
	TG	***AS***	***0.867****	***0.263***	***0.007***	
		ASG	***1.3****	***0.263***	***0.000***	
		BLC	***1.167****	***0.263***	***0.000***	
Sense of Touch	AS	ASG	-0.5	0.286	0.310	**TG>ASG>BLC>AS**
		BLC	0.2	0.326	0.928	
		TG	***-1.433****	***0.267***	***0.000***	
	ASG	AS	0.5	0.286	0.310	
		BLC	0.7	0.298	0.100	
		TG	***-0.933****	***0.232***	***0.001***	
	BLC	AS	-0.2	0.326	0.928	
		ASG	-0.7	0.298	0.100	
		TG	***-1.633****	***0.280***	***0.000***	
	TG	***AS***	***1.433****	***0.267***	***0.000***	
		ASG	***0.933****	***0.232***	***0.001***	
		BLC	***1.633****	***0.280***	***0.000***	
Satis-fac-tion	AS	ASG	-0.2	0.286	0.898	**TG>ASG,BLC>AS**
		BLC	-0.167	0.286	0.937	
		TG	***-0.967****	***0.286***	***0.005***	
	ASG	AS	0.2	0.286	0.898	
		BLC	0.033	0.286	0.999	
		TG	***-0.767****	***0.286***	***0.042***	
	BLC	AS	0.167	0.286	0.937	
		ASG	-0.033	0.286	0.999	
		TG	***-0.80****	***0.286***	***0.031***	
	TG	***AS***	***0.967****	***0.286***	***0.005***	
		ASG	***0.767****	***0.286***	***0.042***	
		BLC	***0.8****	***0.286***	***0.031***	

4 Discussion

Generally, the translucent screen protector seemed to hold more beneficial characteristics to assist the smartphone users. However, the results indicate that the TG material sample was superior to the ASG material, which had different characteristic than others (see Table 1). Moreover, a majority of the participants agreed that the touch and visual differences of the ASG material sample were obvious. These findings are as follow:

1. The characteristic of visual translucent

There was a higher score on the visual translucent characteristic showed for the TG material sample than ASG and BLC. This could imply that the elderly prefer a translucent screen and clean than soften lights.

2. The characteristic of smooth in the feeling of touch

The TG material sample was observed to have the smoothest feeling of all of the material samples. This was followed by ASG, AS, and BLC (see Table 1). However, it is interesting to note that most participants preferred ASG which had a rougher surface.

3. Increasing the sensitivity in sense of touch properly

In this research, most participants agreed that most of the difficulties of using smartphones were from learning new instructions. However, most participants indicated that they felt the responses were more sensitive when using the TG material sample, which seemed to negatively impact on Learnability. Surprisingly, this seemed to increase the level of difficulty when using the smartphone as the participants felt that they had to respond quicker.

5 Conclusion

5.1 Implication

The aim of this study was to discover which material would suit the needs and requirements of elderly smartphone users. The researcher's interpretation of the findings clearly recommend the use of two different materials. The findings suggest that the two most suitable materials were the TG and ASG screen protector material samples. Therefore, by applying the proper screen protector, elderly people could be encouraged use smartphones. The findings of this research could, therefore, be of use to organizations or companies that want to make smartphones more accessible and attractive to the elderly.

5.2 Limitations and Suggestions for Further Study

This study was not without limitations. For one, each experiment demanded much from the participants. Each participant had to use four different material samples and had to feedback on each of the usability metrics. This made each experiment somewhat lengthy. Therefore, a more effective method of data collection, such as through using by metrology equipment, could increase accuracy and decrease the duration of each experiment.

Another limitation could be age group. Different age groups would provide different sensitivities of touch and sight, which could offer a more varied insight into the requirements of the elderly compared to other age groups. A study investigating the preferences of different age groups may provide information for people interested in marketing screen protectors and smartphones for the elderly.

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