A Study on Haptic Feedback Awareness of Senior Citizens

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Abstract. The global population is moving toward an ageing population. Many countries are improving their technology to create smart cities suitable for the elderly. With the development of smart devices, people can make their life more convenient and can use phone APP to help the older with medical or health management. With the degeneration of their body, their sense of touch decreases, which in turn affects their feelings of haptic feedback for smart devices. Therefore, the study is aim to measure haptic feedback differences between elderly and young people, and to provide the manufacturers of mobile devices development as a basis for elderly have a good haptic feedback experience and improve the quality of use. The study was divided into two phases, a total of 58 participants recruited, of whom 27 people were 18 to 50 years old and 31 people over the age of 50, and through comparing haptic vibration feedback intensity by different vibration frequency and vibration time of mobile devices to explore whether there is any feeling difference between two ages.

Keywords: Elderly · Physiological function · Tactile · Haptic feedback

1 Introduction

As the world enters a society with more senior citizens, more and more elderly people embrace technological products (such as smartphone, computer, etc.) and use them to contact other people and learn new things. The frequency of use of high technology device by elderly people is not necessary less than that of young people. In addition, the design of smart devices can be combined with the software in medical related purposes which may help the elderly to have better connection with medical team to track their health condition and diet habits. It could provide an easier way to help the elderly to achieve their health management and improve their quality of lives [1–3].

Alongside the progress of science and technology, man-machine interaction provides people with richer experience, especially giving people a rich sensory experience in the side of visual, tactile, and auditory senses. In the daily life, it can be observed that the screen meets the visual needs and the speaker meets the auditory part. The current trend shows that science and technology is oriented towards the development of haptic feedback. The process of virtual reality and wearable devices reduces the size into the finger-grounded skin deformation device from the larger devices originally. The size

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miniaturization provides the users an improved tactile experiences by using the three freedom dimensions of kinesthetic and skin tactile interaction to the fingertips [4, 5]. Taptic Engine developed by Apple assumes the responsibility for tactile sensation. Currently, sensory dimension is the haptic feedback mechanism that Apple is committed to developing [6]. The tactile vibration feedback from human senses is the earliest measurement and the most common-use tactile haptic feedback. The tactile perception is able to obtain many diversified information by sending different tactile form messages to the brain through touching on the different sizes of objects, shapes, materials, roughness, and temperature, and so on [7, 8].

The smart devices can be applied in the haptic feedback development to assist the visually impaired. The researchers creates the braille pattern on the touch screen with different frequencies and different length of vibrations to test if the visually impaired people is able to discriminate the differences [9]. The haptic feedback technology can be categorized into three major applications: confirmation, immersion, and enriched communication. 1. Confirmation: for example, making the users to be able to have an actual feeling on their fingers when they press the virtual keyboard which may avoid the over pressing problems. 2. Immersion: it can provide the users more actual experiences by integrating the Confirmation technology with the environment into the smart devices. 3. Enriched communication: the meaning of communication is included the hearing, vision, and tactile communications. Inputting the tactile vibration feedback can create live experiences to the users [10].

Although many senior citizens enjoy learning new technologies, during the learning process, they still feel some inadequacy. The reasons for this maybe (1) they are not familiar with the operation of a new technological product due to the complicated design of its hardware and software which is too complex and difficult to understand; (2) they have limited experience of using computer products and cannot use past experience to operate the device; (3) the deterioration of their body function (such as vision, tactile sense, hearing, etc.) makes them unable to successfully complete an action [11–13]. The skin is the largest organ of the body. The sense of touch can replace auditory and visual senses. Hence, although the elderly's physical functions are degrading, smartphones can enhance their tactile experience and make up for their weakened hearing and vision [14]. In terms of tactile sense, neurostimulation, such as light, sound, current, vibration, action, and thought, can be used as a way to stimulate the brain [15]. Most people undergo deterioration of sight at the age 40 to 50 [16]. Therefore, if haptic feedback can be enhanced, the elderly would be able to have a better smart phone experience. However, the sense for haptic feedback of the elderly people differs from general users due to the deterioration of their physiological function due to aging. In general, smart phone haptic feedback research is rarely done on the older generation. Therefore, this study focuses on the haptic feedback of the elderly and compares it with users of different ages so as to understand the differences in the haptic feedback between the elderly and other age groups in order to give senior citizens a satisfactory experience of smart devices.

2 Method

The aim of this study was to explore the differences in the haptic feedback between the elderly and the different age groups. Experiments were conducted with different haptic feedback samples accompanied. This study is divided into two experiments, and the individual recruitment of the older and the younger groups of participants were compared. The descriptions of Experiments are as follows:

- Experiment 1: The main purpose is to explore the intensity perception of different vibration frequencies under fixed vibration time. Participants should be based on personal perception of the same vibration time to compare different vibration frequency samples, and provide the feedback of which vibration strength is the greatest.
- Experiment 2: The main purpose is to explore the intensity perception of different vibration time under fixed vibration frequencies. Participants should be based on personal perception of the same vibration time to compare different vibration frequency samples, and asked them which vibration strength is the greatest as experiment 1.

2.1 Experimental Sample

Experiment 1
Three different vibration frequencies (80 Hz, 160 Hz, 200 Hz) were compared among three different vibration times (100 ms, 300 ms, 500 ms), as shown in Table 1.

Table 1. Experiment 1 sample.

Vibration time	100 ms	300 ms	500 ms
Vibration frequency	80 Hz	80 Hz	80 Hz
	160 Hz	160 Hz	160 Hz
	200 Hz	200 Hz	200 Hz

Experiment 2
Three different vibration times (300 ms, 500 ms, 1000 ms) were compared among three different vibration frequencies (160 Hz, 180 Hz, 220 Hz), as shown in Table 2.

Table 2. Experiment 2 sample.

Vibration frequency	160 Hz	180 Hz	220 Hz
Vibration time	300 ms	300 ms	300 ms
	500 ms	500 ms	500 ms
	1000 ms	1000 ms	1000 ms

2.2 Experimental Setup

- Participants: Two experiments were recruited the middle-aged or older and the young groups. In experiment 1, 22 participants were recruited (10 young people and 12 middle aged people). In the second experiment 2, 36 people were recruited (17 young people, middle-aged and older people 19 people).
- Apparatus: In experiment 1, two different devices were used to perform the experiments, 5.5 in. phone panel and 9.7 in. tab panel. The main idea is to know whether the two sizes have different effects on the participants. According to the results of the first experiment, we discover that perception of the participants on the tab panel is better than that the phone panel. Therefore, in the experiment 2, the experiment will be conducted only on the tab panel device. Two experimental motors are based on the most common type of tactile vibration motor which is model 301-101.945 of mobile devices.

2.3 Conducting Experiment

The apparatus as shown in Fig. 1. The motor was placed in the four corners of the sample. Then, the sample was placed on a stationary table to reduce the external factors caused by the hand. In addition, a noise pad was laid between the sample and the table to reduce the resonance or sound interference when the device was put on the table. The order of sensitivity of the hand is as follows: the most sensitive are the fingertips, followed by the knuckles, then the palms [17]. Therefore, this test allowed the subject to place the index finger of the dominant hand on the center of the screen sample (Fig. 2).

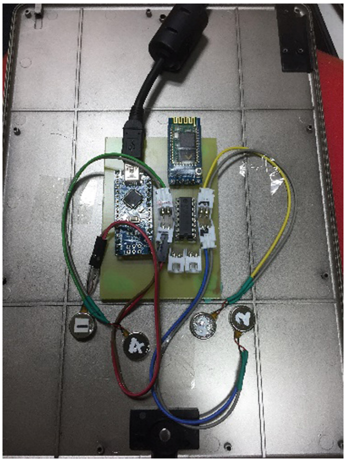

Fig. 1. Experimental devices

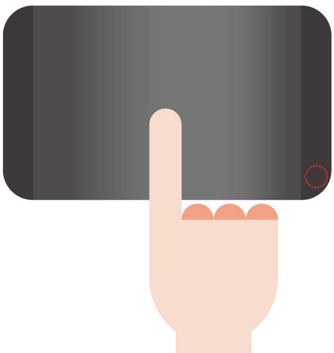

Fig. 2. Illustration of the experiment

2.4 Experimental Process

This study has two phases of experiments, below are process details based on the experimental sample settings.

Experimental 1 Process
The Sample see Table 1. In this experiment, to explore the effect of vibration frequency on intensity perception under the fixed vibration time. Participants will be in a fixed time vibration samples to compare the different vibration frequency of the intensity feelings for 9 times. For example, under 100 ms vibration time, the participants will experience the vibration frequencies of 80 Hz, 160 Hz and 200 Hz in random, and then ask them to sort the intensity of the vibration sample they feel. Using the answer of participants to compare with the experimental vibration frequency in sequence which is correct answer, as correct rate. Seeing sample in Table 1.

Experimental 2 Process
In experiment 2, different vibration times will be compared at the same vibration frequency, with a total of 9 comparisons per participant (see Table 2 for the sample). For example, under the vibration frequency of 160 Hz, the participants experience three groups of vibration which are 300 ms and 500 ms, 300 ms and 1000 ms, 500 ms and 1000 ms in sequence, and compare which feeling of vibration time is more intensive within each group. Using the answer of participants to compare with the experimental vibration time in sequence which we set the answer is that 500 ms is more intensive than 300 ms, 1000 ms is more intensive than 300 ms and so on, as consistency rate.

3 Result

3.1 Experiment 1

The participants were divided into the elderly group (total 12, the average age of 58.2 years) and the young group (total 10 people, the average age of 22.6 years). Those with related experiences (9 males and 13 females) in using smartphones or tablets were divided. The results showed that the elderly group had better tactile vibration feedback on the tablet than the smartphone. The results of the experiment 1 is shown on Table 3; the compliance rate of 40 Hz difference on smartphone is shown on Fig. 3; the compliance rate of 40 Hz difference on tablet is shown on Fig. 4.

Table 3. Experiment 1 results

	Phone	Pad
The young group rate	77.78%	80%
The elderly group rate	65.74%	81.48%
F rate	70.09%	76.92%
M rate	72.84%	86.42%
Compliance rate	71.21%	80.81%

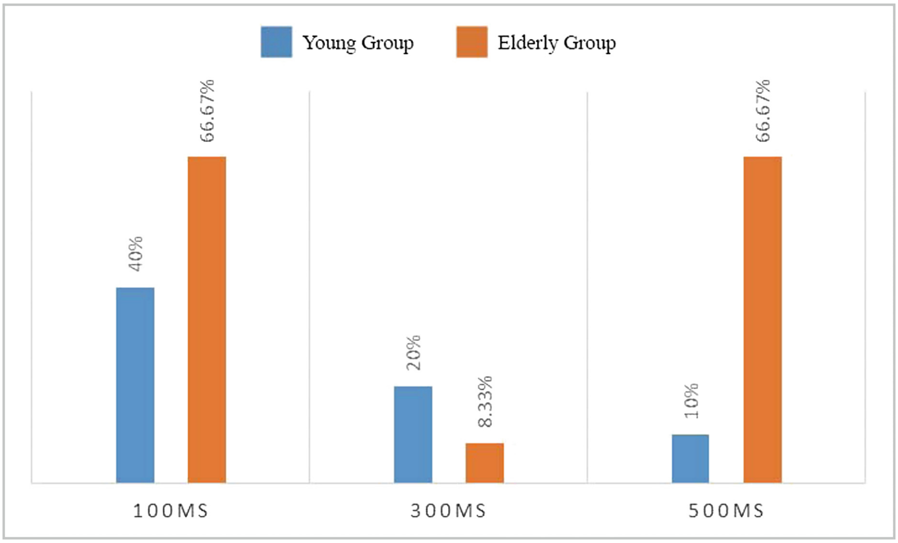

Fig. 3. Error rate at 40 Hz difference-phone

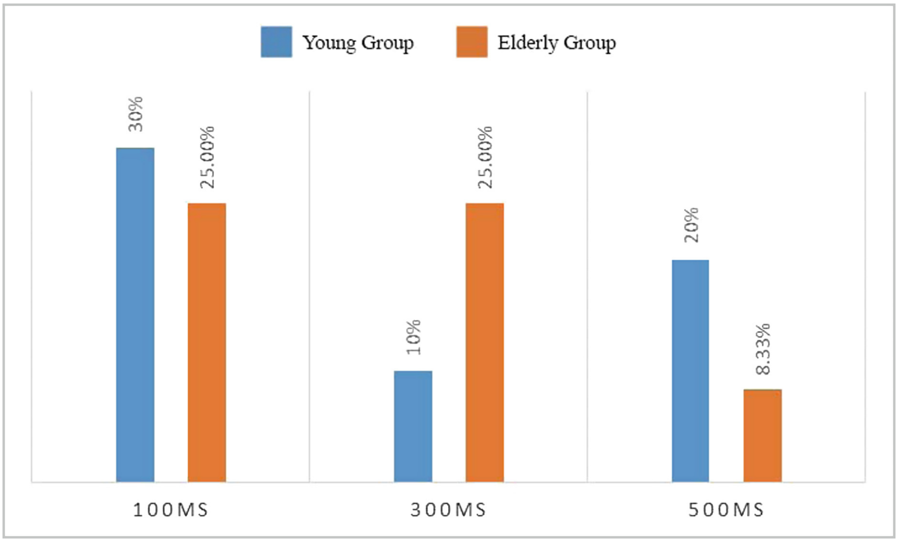

Fig. 4. Error rate at 40 Hz difference-pad

3.2 Experiment 2

The respondents from experiment 2 were recruited 36 people in total. There were 19 people in the elderly group (average age of 67 years old) and 17 people in the young group (the average age of 23 years old). The purpose of this experiment is to investigate if the users are be able to distinguish the differences the different time length of vibrations at the same vibration frequency condition from the mobile devices. Moreover, this experiment discussed about if the users will have stronger feeling from the longer time length of vibrations by calculating the consistency from each vibration samples of the respondents' perception of the strength and the differences of vibrating durations.

As shown in Fig. 5, when the vibration frequency was fixed under 160 Hz, 77.5% respondents from the young group and 71.9% respondents from the elderly group found that the longer duration of the vibration provided them stronger feeling ($\alpha = 0.1$, p value = 0.209). When the vibration frequency was fixed under 180 Hz, 77.5% respondents from the young group and 71.1% respondents from the elderly group found that the longer duration of the vibration provided them stronger feeling ($\alpha = 0.1$, p value = 0.138). When the vibration frequency was fixed under 220 Hz, 72.5% respondents from the young group and 63.2% respondents from the elderly group found that the longer duration of the vibration provided them stronger feeling ($\alpha = 0.1$, p value = 0.132).

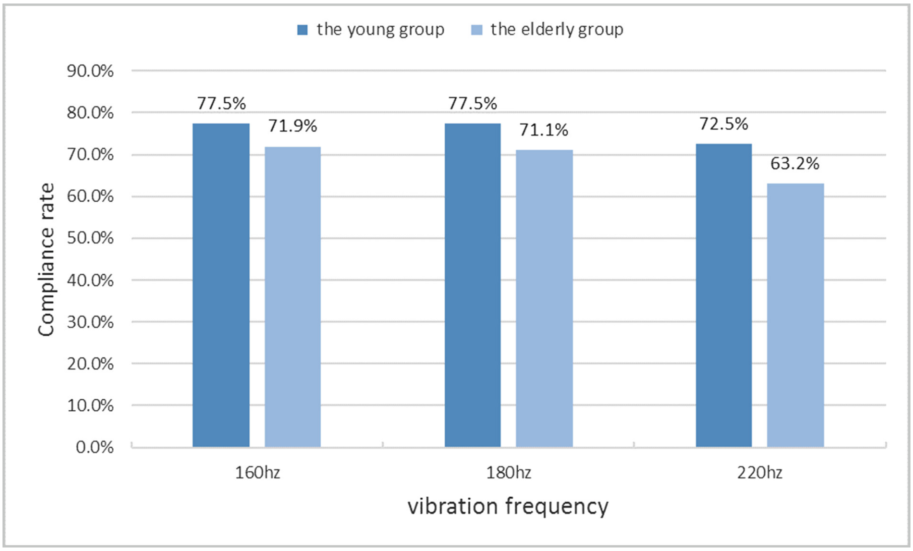

Fig. 5. Compliance rate based on different vibration frequency

Figure 6 is shown the results by using the duration as standard to compare. Taking 300 ms as the standard to compare with other durations, 76.5% respondents from the young group and 65.2% respondents from the elderly group were able to distinguish it clearly with others ($\alpha = 0.1$, p value = 0.07). Taking 500 ms as the standard to compare with other durations, 75.5% respondents from the young group and 61.4% respondents from the elderly group were able to distinguish it clearly with others ($\alpha = 0.05$, p value = 0.016). Taking 1000 ms as the standard to compare with other durations, 72.5% respondents from the young group and 78.3% respondents from the elderly group were able to distinguish it clearly with others ($\alpha = 0.1$, p value = 0.27).

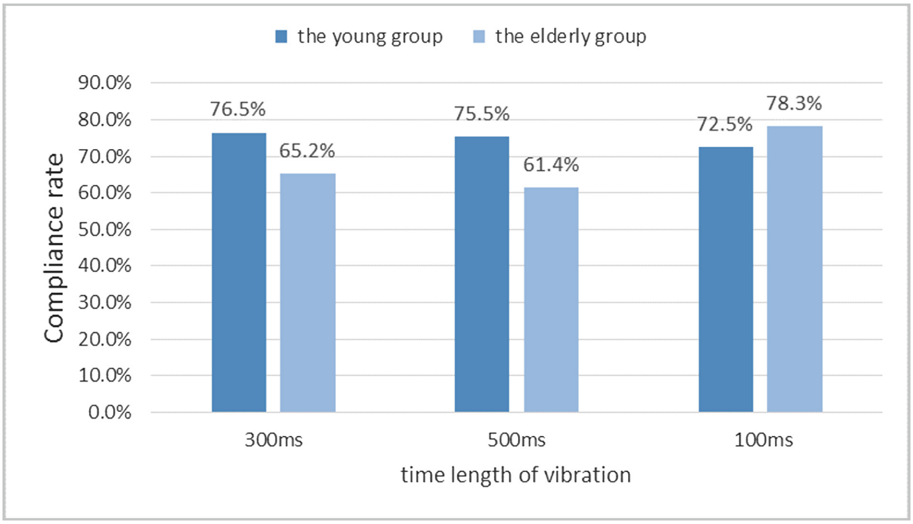

Fig. 6. Compliance rate based on different vibration time

The result of the differences of haptic feedback from the rest group and the control group is the perception of haptic feedback from the test group was generally lower. However, the perception of haptic feedback from the elderly was higher than the young group when using 1000 ms as the standard (Figs. 5 and 6).

4 Discussion and Conclusion

The response rate for smartphone haptic feedback was 71.2% and for tablets 80.8%, showing a difference of 9.6%. Perhaps the rate of vibration transmission is affected by the size of the panel. For those who are 20 to 50 years old, the correct answer rate is 77.7%; for those 50 years of age and older, the correct answer rate is 65.7%. From these data, the deterioration of the tactile sense of the elderly can be clearly compared. Their rate of haptic response differs from those below 50 years old by 12%. For tablets, the correct answer rate of 20 to 50 years old is 80%, while the correct answer rate of those 50 years of age or more is 81.4%. From these data, it can be observed that the elderly has a better sense for the haptic response for samples with larger area. 86% of the respondents like phones with a vibration mode. 81.82% of the respondents preferred the smart devices with vibration mode. This shows that most users like to have actual haptic feedback experience when using smart phones.

In addition, the study found that respondents had difficulty in distinguishing frequencies with a difference of 40 Hz (as shown in Figs. 3 and 4). Therefore, for future development of device with haptic feedback, it is necessary to put into consideration that the elderly might not feel the slight drop in haptic feedback due to tactile deterioration. On the tablet test, the elderly's the correct answer rate is nearly 20% higher than on the phone test. This maybe because the larger area of a tablet enables the elderly to distinguish the vibration better. Therefore, in future studies on the increase in haptic feedback experience, a larger sized tablet could be considered.

In experiment 2, when using 300 ms and 500 ms vibrating time as standards to compare with other durations, the elderly group's the compliance rate of perception of the vibration intensity and duration was lower than young group. It may imply that when the single vibration duration is low, the elderly may have more obvious feeling on the vibration intensity than the duration, which may make them easier to feel fatigue.

In experiment 2, the data showed the differences in haptic feedback perception among the elderly group and the young group. The young group had better perception than elderly group from the frequency of haptic feedback. However, the elderly group had better respond in 1000 ms test. For further discussion, from the data at 1000 ms which is under 180 Hz test, the tactile perception of the elderly group was almost 3% better than the young group. In the interview from the experiment 2, most respondents from the elderly group had more sensibility to the longer vibration feedback, and they also could feel the differences vibration feedback at the very first and second time at the same millisecond and the same frequency. Furthermore, the result of perception of haptic feedback of 1000 ms under 160 Hz was 6% higher than other frequencies and the perception feedback of 300 ms was higher than other frequencies under 180 Hz, which provide an opportunity to discuss the differences for the future study.

Most of the tactile experience on smartphones available on the market are not designed for the elderly. In the future, this study will add users of different ages in the research on haptic feedback and focus on the haptic feedback sensed by the elderly. To make products meet the needs of the senior citizens, there is a need for more experiments and samples to verify the frequency of vibration for the elderly's haptic feedback experience. This would make it easier for them to identify and learn to use smart devices. This study also provides future mobile device developers a reference on haptic feedback in order to give senior citizens a good user experience.

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