

A STUDY ON TWO-POINT DISCRIMINATION TACTILE SENSORY FOR RECITING QURAN BRAILLE DOTS

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Abstract:

Al-Quran is the holy book for Muslims consists of wonderful word of Allah. It is learned and memorized by Muslims including visually impaired persons. Therefore, to recite the braille Quran, learning braille code using their finger is a must where each person has their own sensitivity during touching the braille dots. Hence, the aim of this study was to investigate the effects of age, sex and test side of fingers using two-point discrimination (TPD) test. TPD test was conducted towards test subjects at different age. Each test subject was tested on their different fingers with initial test point of 10 mm. The points applied randomly using different test points to study each test subject's most sensitive test point. Subsequently, age, gender and test points effects of an individual test subject was investigated to obtain individual most sensitive finger. At the end, the results obtained were used to develop a 3D printed tape-like Braille dots casing which was used as a teaching aids specifically for visually impaired children. The distance between the Braille dots were varied based on finger sensitivity. Eventually, this engaging teaching aids is a wonderful tool for visually impaired children learning Quran in a practical way.

Keywords: 3D printing; Braille code; Finger test; Integration Naqli and Aqli (INAQ); Visually Impaired

Introduction

Globally, visual impairment and blindness are one of the health issues happened with the estimated of 285 million visual impaired people including 39 million are blind (Awad et al., 2020; Bettelani et al., 2020; Qu et al., 2020). Blindness is the inability to see anything, including light which serve as one of the dominants disabling societal affecting the visually impaired people and people in their surroundings (Qu et al., 2020). This group of society faced many challenges in their daily routine and in learning and reading as shown by sighted people. Despite their challengers, they can mainly depend on tactile sensory and hearing to gather encircling information (Qu et al., 2020).

The sense of sight is one of the most important senses of human beings. People without the sense of sight may have difficulty interacting with other people and with their environment as compared to those who have it. However, the advantages for the visually impaired is they are given other sensory for help them in reading. A reading is not a typical input for the visually impaired. That is the reason why the researcher asserted that the effective methods for visually impaired perceive an information requires strong auditory skills and strong language ability (Thi Minh, 2020).

The Two-point discrimination (TPD) is one of the most used neurosensory tests to assess mechanoperception in the clinical setting. Clinical neurosensory testing is performed to evaluate sensory abnormalities. There are three level routine conducted of test for the assessment of altered sensation, i.e, spatiotemporal perception, contact detection and nociception of temperature (Won et al., 2017). The TPD test is a classical test of the capacity to discriminate the distance between compass points, which is to feel two contacts. This method has been used to measure the recognition capability of tactile touch with two stimulation points to identify if two points are separated or not (Ray F. Lin & Allan D. Rugama, 2015).

Al-Quran is the holy book for Muslims consists of wonderful word of Allah. It is a wahy or divine guidance and direction to the mankind. Inasmuch as its prestige, it is learned and memorized by millions of Muslims worldwide in the same form as it was revealed. Reciting and acculturation in the study of al-Quran play an important role in developing the Muslim ummah (Tengku Puji et al., 2015). Therefore, an urgent need to improve the Muslim's interest in study Quran will be a crucial decision especially for the young generation Muslim since they will be the one who continue the Muslim ummah in the future. Hence, al-Quran studies need to be given exceptional deliberation attention and focus on national education development to ensure the best impact on the process of building the Ummah (Tengku Puji et al., 2015). Essentially, reciting, memorizing, and understanding the content of al-Quran are required in the study of al-Quran.

However, not all Muslim are given with the advantage of learning Quran in a considerable manner. There are problems encountered by the disabled people especially those who are visually impaired to learn and memorize al-Quran (Tengku Puji et al., 2015). Barely, they unable to use their sense of sight properly in overcoming the encountered learning difficulties. Such special needs people may only hear the holy verses recited before committing them to memory (Tengku Puji et al., 2015). Through many initiatives and assessment has been done in developing Braille Quran, still, the learning process without the teaching aid facing unsettled. Thus, the use of Braille code is a perfect solution to help them to overcome their learning problems due to the easily available sensory for them. (Awad et al., 2020; Bettelani et al., 2020; Mohd Noor & Mujani, 2016). The difficulty level in understanding the Braille code as the basic principle in learning Braille Quran even at the beginning of their study has demotivated the children in pursuing on learning Braille Quran due to the lack facility in learning Braille code. Meanwhile, the adaptation of al-Quran in Braille eventually be the significant to Muslims in enhancing and facilitate of visually impaired in learning the words of Allah (Tengku Puji et al., 2015).

Therefore, this study aims to investigate the effects of age, gender and test side of fingers using two-point discrimination (TPD) test. Analysis was conducted to determine relationship of age and gender towards the most sensitivity fingers. At the end the study, the results were used to develop a tool suitable for visually impaired children in reciting Al-quran based on their finger sensitivity.

Methodology

Development of survey questions

A set of survey questions was established which classified into Two Point Discrimination test and level of finger sensitivity among test fingers of Left Index Finger, Left Middle Finger, Right Index Finger and Right Middle Finger. The test conducted at the fingertip area for each finger. Before test was performed, the test subjects were identified by their gender and age. Meanwhile, during the test, the test subjects were asking questions as stated in Table 1 though google form sheet.

Table 1: The survey questions in Google form

No	Survey Questions
1	Have you heard about Two Point Discrimination (TPD) test?
2	The most sensitive test point at Right Middle Finger (2mm, 3mm, 4mm, 5mm & 6mm)
3	The most sensitive test point at Right Index Finger (2mm, 3mm, 4mm, 5mm & 6mm)
4	The most sensitive test point at Left Middle Finger (2mm,

	3mm, 4mm, 5mm & 6mm)
5	The most sensitive test point at Left Index Finger (2mm, 3mm, 4mm, 5mm & 6mm)
6	Pressure applied: <ul style="list-style-type: none"> - Too low - In the middle - Too strong
7	Over all functions of the fingers, which is more sensitive: - <ul style="list-style-type: none"> • Right Middle Finger • Right Index Finger • Left Middle Finger • Left Index Finger

Applying TPD test on students

Thirty-seven students of Kolej GENIUS Insan and eight random people were participated as the test subjects in finger sensitivity test. All the forty-five subjects were categorized into gender and age. The test subject's details were summarized in Table 2.

Table 2: Details of test subjects

Age Range	Gender	
	Male	Female
Below 13 years old	2	3
Between 16-18 years old	10	27
Above 18 years old	-	3

Finger sensitivity test was implemented by using baseline two-point discriminator (TPD) as a tool to determine finger sensitivity or tactile sensation. As shown in Figure 1, the maximum distance between the compass points of TPD is 20 mm and the minimum distance is 2 mm. The larger the distance between the two adjacent points indicate the finger has less sensitivity. The TPD test is a classical test of the capacity to discriminate the distance between compass points, which is to feel two contacts. This method has been used to measure the recognition capability of tactile touch with two stimulation points to identify if two points are separated or not (Dane et al., 2017; F. Lin et al., 2015).



Figure 1: Baseline two-point Discriminator

The test was carried out by an investigator in a quiet room at room temperature due to the sensory of finger which also affected by surrounding temperature (Won et al., 2017). The subjects were seated in a comfortable and parallel position with the investigator. It is important to make sure there is no obstacles on the finger. The subjects were asked to keep their eyes closed throughout the test procedure.

The test was performed by applying the two tips of the device to the test site. The stimulus intensity was chosen to be that which the subject could perceive as constant touching or moving without the perception of discomfort or pain. The contact time was approximately 2 s with the inter-stimulus interval was approximately 5 s as can be seen in Figure 2. The first distance of the tips, which was large enough for the subject to clearly perceive correctly, was determined at the preliminary testing. The initial TPD test distance was 10 mm followed by, 5,4,3 and 2 mm. If the subject could not correctly perceive the initial distance, a longer distance was set for the initial distance. A threshold was determined using a descending stimulus magnitude and one point was inserted intermittently during the descending series to avoid the subject's expectation of the continuous decrease in distance between the two points. If the subject answered correctly in response to these changes, the distance decreased in intervals of 1 mm. This testing pattern was continued until the subject answered incorrectly, and the experimenter returned to the next longer distance. The series was terminated when a correct answer for the next longer distance was followed by two incorrect answers on two subsequently shorter distances. This final correct answer was chosen as the endpoint for the TPD test. However, when the subjects continuously had inconsistent responses with the repeated measure of the TPD tests at the given test site, the subjects were excluded from the corresponding test. This testing series was continued until the subjects answered incorrectly. Let say the subjects answer "one" for 3 mm, then investigator move to 4 mm and the answer is "two". The test was terminated when a correct answer performs, and it will be recorded as a result. The same procedure was implemented to all fingers involved. Consequently, at the end of the test, subjects were asked about the pressure applied whether too low, in the middle or too strong (Won et al., 2017; Dane et al., 2017).



Figure 2: Applying Finger Test using TPD

Analysis of the TPD findings

Statistical analysis was carried out with SPSS software version 26. Table 3 shows the descriptive statistics that were calculated for data on means and frequencies of the subjects to describe main aspects or categories of the data including gender, age, and most sensitive finger.

Development of Tape-Like Braille Dots Casing

3D printed tape-like casing was designed for its 3D model followed the conventional tape design. The 3D model was design using TinkerCAD and the 3D design in the form of .stl file was sliced and converted into g-code and finally printed using 3D printer. Meanwhile, a roll of Kraft paper was used to produce the braille dots. In this study, the dots were presented by Hijaiyyah braille dot and formed into Al-Fatihah verse braille dots. The dots were formed manually using “reglet” on the Kraft paper of 120 gsm. The distance between the dots were varies according to the result and analysed after TPD test which were 2mm, 3mm, 4mm & 6mm. The imprinted Braille dots paper was then incorporated into the tape-like casing to form a 3D printed tape for reciting braille Quran.

Results and Discussion

Implementation of TPD Test

TPD test was implemented towards all the test subjects. Figure 3 shows flow process on how the test was carried out with their eyes closed at different age and gender. The test subjects were gathered in a room and the finger testing was carried out for each individual test subject for four different fingers with different test subjects. Each test subject was mentioned on the pressure applied during the testing. The mean value for the most sensitive finger was 2.7 and the standard deviation was 1.091. Meanwhile, the

categories with lowest mean value was “gender” with 1.73 and the standard deviation was 0.447.

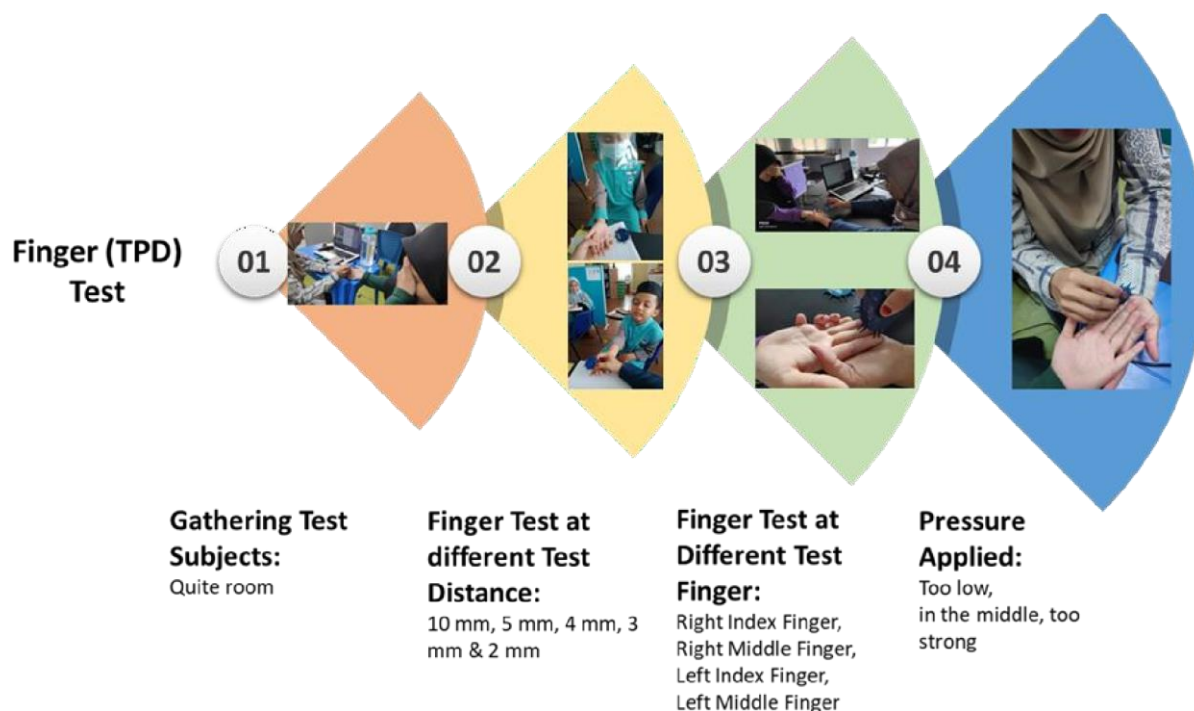


Figure 3: Flow Process on Finger (TPD) Test

Table 3: Mean and frequencies of the subjects

Categories	Descriptive Statistic				
	N	Minimum	Maximum	Mean	Std. deviation
Gender	45	1	2	1.73	0.434
Age	45	1	3	1.98	0.400
Most sensitive finger	45	1	4	2.7	1.091

Effect of Gender

Figure 4 shows the analysis of the most sensitive finger from all fingers tested, i.e; right middle finger (RMF), right index finger (RIF), left middle finger (LMF) and left index finger (LIF) based on gender. The findings revealed that index fingers for both right and left for female were dominant and most sensitive fingers compared to their middle finger. The percentage of most sensitive fingers for both RIF and LIF were 58.4 % and 57.4 %, respectively. Meanwhile, male test subjects show that their left fingers (index and middle fingers) were dominant as compared to their right fingers. In comparison

based on age, female shows better finger sensitivity for all tested fingers (Alemdar et al., 2014). A correlation between finger size by gender and their finger sensitivity. The differences of gender in somatosensory sensitivity perhaps due to characteristic in tissue conformation and thickness, mechanoreceptor densities, skin hydration or temperature. Naturally, female and male skin may vary regarding biophysical properties. In additional, hormonal changes during the menstrual cycle may lead to gender differences. It has been marked that female skin show to have a higher elasticity and extensibility (Wang et al., 2017). Moreover, female possess smaller finger size than male, statistically, they have better perception on their finger (Abdouni et al., 2018; Wang et al., 2017; Won et al., 2017). Hence, it can be hypothesized that finger sensitivity for female than male based on TPD test conducted (Won et al, 2017).

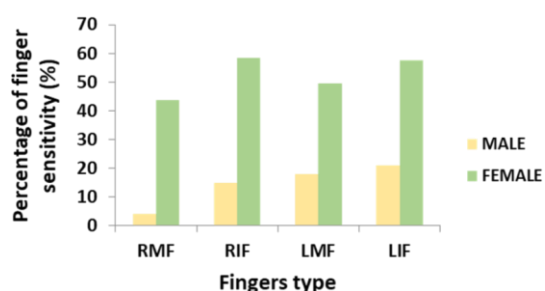


Figure 4: The percentage of finger sensitivity on the tested fingers

Effect of Age

The effect of age was analysed for all tested fingers. Figure 5 summarised that the test subjects based on age ranging from below 15 up to above 18 years old. The results shows that LIF was the most sensitive fingers for test subjects at the age of between 16-18 and above 18 with the percentage of 31.7 % and 42.9 %, respectively. However, test subjects below 15 years old showed that their most sensitive finger was RIF with percentage of 33.3 %. It can be analysed that the increase of age influences the sensitive fingers on LIF. Index finger is one of the globous skins including the tongue tip and both lips was more sensitive area compared to hairy skin such as the forehead, cheek and mentum was less sensitive (Won et al., 2017). The thickness or hardness skin influence tactile sense which is it is more sensitive than thin skin (Noh et al., 2015). Therefore, it can be concluded that test subject age below 15 years old were still young (teenage) and they were less exposed to daily living activities of which using hand compared to adult.

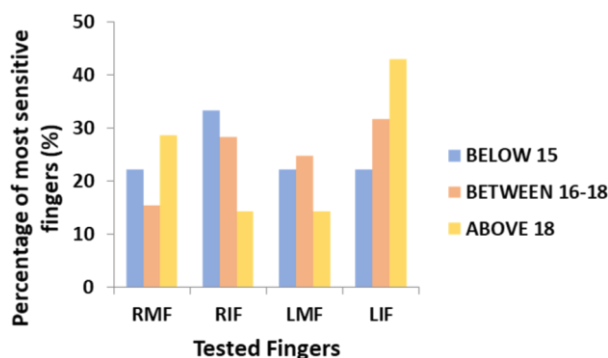


Figure 5: The percentage of most sensitive finger among categories of age

Trend of Most Sensitive Finger

The values of the most sensitive finger for all tested fingers were presented in Figure 6. It shows LIF was the most sensitive finger among all the tested fingers with highest percentage of 32 %. The trend was followed by RIF, LMF and RMF with percentage of 27 %, 24 % and 17 %, respectively. This is due to the LIF is one of nondominant fingers (Alsaeed et al., 2014; Dane et al., 2017). Therefore, it is suggested that discriminatory sensation focused on nondominant fingers. It has been reported that heavy callus over the skin influence the result value where skin texture had also a defect role. Furthermore, all daily living activities of hand was considered to gain best result (Alsaeed et al., 2014; Vijusha & P. Ponmathi, 2018). Hence, most of the test subjects were dominant hand in all daily living activities and the have trend on nondominant hand in sensitivity fingers.

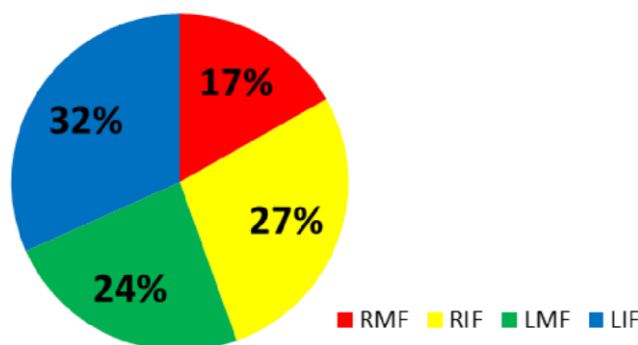


Figure 6: The percentage of the most sensitive fingers

Pressure Applied

Figure 7 presented the percentage of responses on the pressure applied during the TPD test. Most of the test subject responded that the pressure applied was in the middle (88%) which was not too weak or too strong and only few subjects' response that the

pressure applied was too strong (12 %). This shows that the investigator should be more careful to control their pressure applied during the test. This may affect in identifying the very first blanching of the skin (Won et al., 2017). As an affirmation, many researchers and clinicians were pointed that the uncontrolled force in the TPD test would affects its outcome (Jung et al., 2019; Won et al., 2017).

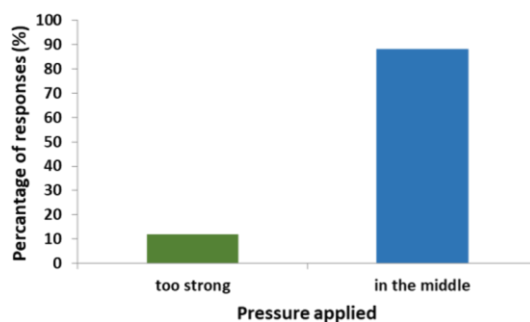


Figure 7: Percentage of responses on pressure applied during TPD test

Test Points

The different test points were analysed for all the test subjects as shown in Figure 8. It shows that the highest percentage with 48.8 % for the test point was 2 mm which means that most of the test subjects have sensitive finger. Followed by test point 3 mm (37.7 %), 4 mm (11.1 %), 6 mm (2.2 %) and there was no record for 5 mm among subjects. As can be seen, the test point 2 mm come from various age and gender. It is due to fingertips was the most sensitive part than palm of hand or other part (Alsaeed et al., 2014; Thube et al., 2020). Finger is crucial for completing activities of daily living which typically require precise hand-object interaction (Blanquero et al., 2020). Moreover, finger is one of the body parts that use to touch and recognise an object. So that, it is accordance with the results in figure 8 that have been mentioned before which most of the test subjects have sensitive finger. Meanwhile, for test point of 6 mm, it is come from a female subject in category age between 16-18. Based on the result, it can be assumed that may be a person with 6 mm test point have a problem with the fingers that obstruct the sense of touch such as the hardness of skin. The hardness of skin could be existing from skin disease such as eczema. Furthermore, the less of finger sensitivity might be occur when lack of expose to activity daily living that focus on using fingers such as planting, cooking, housekeeping, laundry and so on. Hence, the tendency of less finger sensitivity was higher.

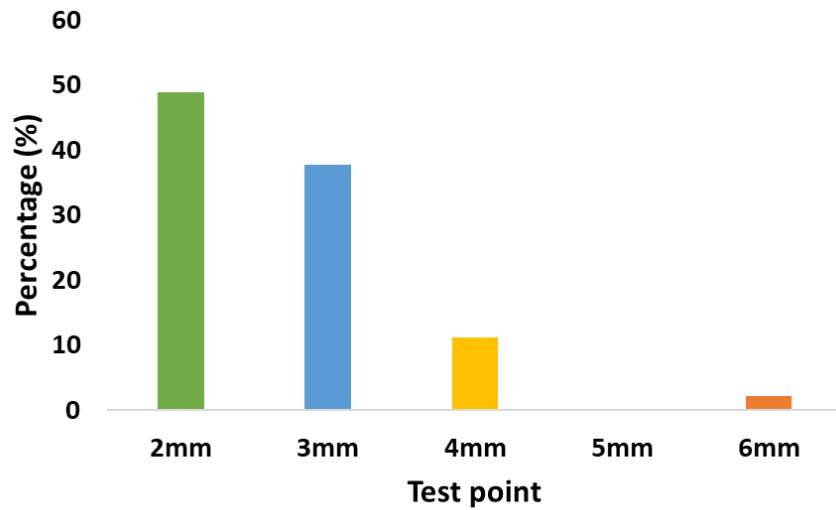
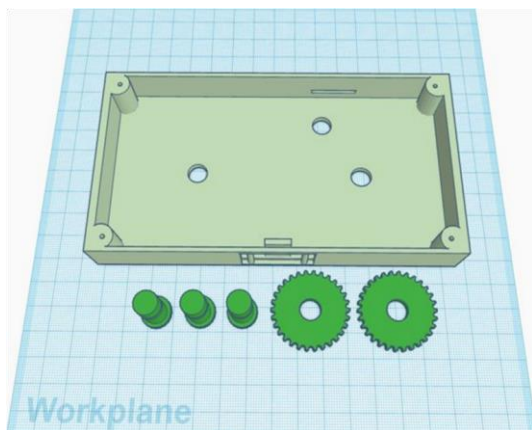


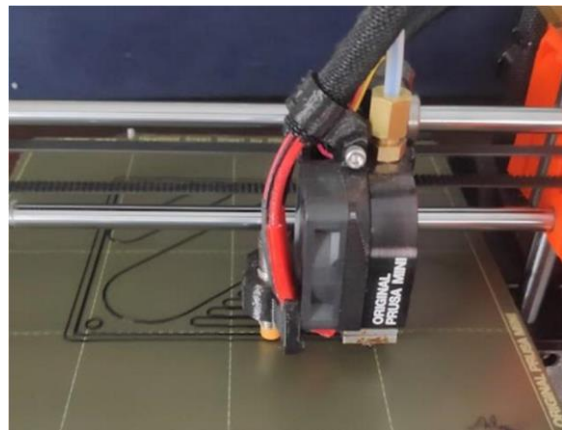
Figure 8: Percentage of the most sensitive test point among subjects

The Tape-Like Braille Dots Casing

Figure 9(a) shows the 3D model of tape-like casing was that was 3D designed using TinkerCAD. The tape was then converted into .stl file and was sliced using Prusa slicer software to convert the .stl file to g-code file. Consequently, the g-code file was used for the 3D process (Figure 9(b)) to print the 3D model. The 3D printed tape-like model as shown in Figure 9(c) consists of gears that were used to rotate the imprinted Hijaiyyah Braille dots on a paper roll which was manually inserted into the 3D model (Figure 9(d)).



(a)



(b)

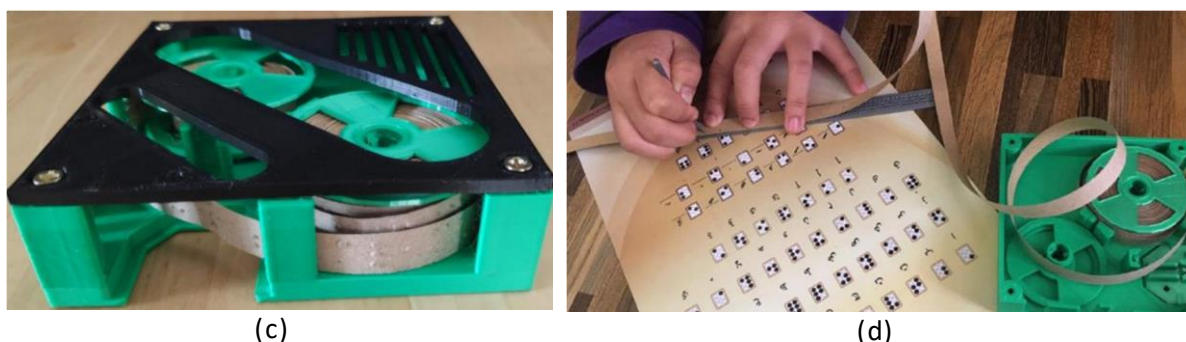


Figure 9: (a) The 3D model designed (b) 3D printing process (c) 3D printed tape and (d) manually imprinted paper roll

Meanwhile, Figure 10 shows the imprinted paper with different distance of the braille dots of 2 mm, 3 mm 5 mm and 6 mm. The distances were chosen after the finger sensitivity test results were analysed as in Figures 4,5, 6 and 8. The different test points were than inserted into the 3D printed tape and further used towards the visually impaired children as it serves as mobile tool with low-cost production compliment with a fun learning approach.

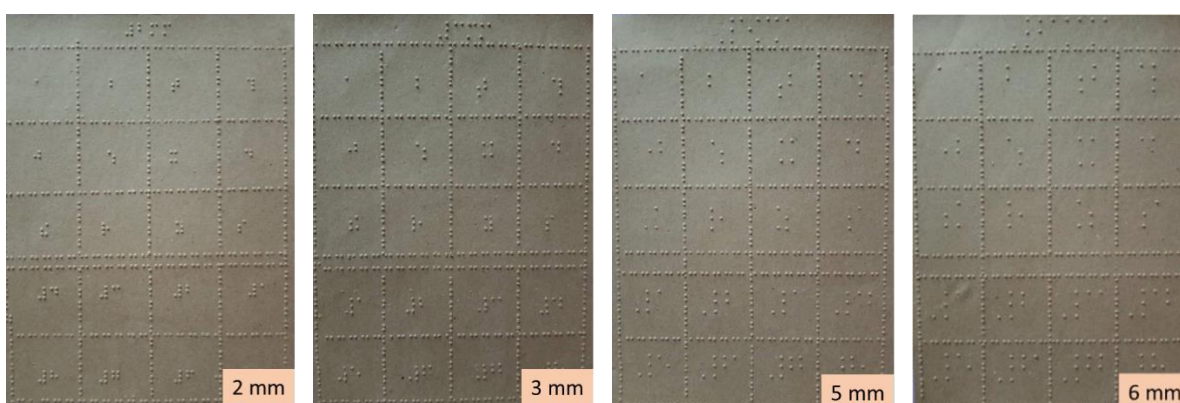


Figure 10 Imprinted braille dots at different test points

Conclusion

Eventually, the finger tactile sensitivity tests can be used as a guidance to determine the most sensitivity finger specifically for visually impaired. From this study, it was found that female possessed better finger sensitivity for all the tested fingers as compared to male. However, age shows various findings where, each range of age has their own sensitivity. Generally, almost 50% of the tested fingers has the most sensitive finger with 2 mm test points which represent that the test subjects have sensitive finger. Therefore, the findings were used in developing 3D printed tape that will be used as a teaching aids for visually impaired children in learning al-Quran recitation. The different in learning approach may give a different perspective towards visually impaired in learning Quran and shifts the paradigm to overcome the challenges of the visually impaired Muslim. Hence, with tactile and braille, this engaging tool is perfect for blind and sighted to enjoy and consequently for Quran recitation with the addition of braille

strip 3D printed cassette for Braille Quran for bringing users interest in learning al-Quran which was produced for easy touch and memorize at low cost.

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