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A Research of Tactile Recognition on 2D and 3D Shapes Among Students in Junior and Senior High Schools With Visual Impairment

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Abstract: In the tactile recognition research of people with visual impairment (VIP), there are a lot of researches investigating the impact of tactile shape design towards the performance of identification during the conceptual identification stage. However, the tactile shapes used on the researches above are mostly designed by the stereotype towards objects that people without visual impairment can see. The research randomly sampled 6 subjects, asked them to draw 24 shapes or patterns that they use daily, and then applied the characteristics of the shapes and patterns on tactile shapes for them to perform recognition experiments. The results show that a certain percentage of the blind subjects are able to identify the geometric characteristics on the shapes if using the shapes designed with the drawing characteristics by VIP for identification. Nevertheless, the correct identification rate in their responses to find out the differences in details is still low. As for the vision of angle and the subjects' congenital conditions, the differences in the identification rate are similar with that from other researchers. The correct identification rate in 2D is higher than 3D while those who are late blind are relatively higher than those who are early blind.

Key words: tactile picture recognition; visual impairment; textured picture

JEL code: I0

1. Introduction/Literature Review

Lederman (1990) mentioned in the research related to people with visual impairment (VIP) that there are four stages in tactile recognition, including tactile exploration, converting tactile message into shape, conceptual identification, and naming. In the stage of conceptual identification, a lot of researches explored the tactile shape design due to tactile shapes are more effective compared to other media (Lebaz, Jouffrais & Picard, 2012). The presentation of tactile shape design includes 2D or 3D, and researches reveal the tactile shapes of 2D horizontal view are easier to be identified than 3D perspective view (Lederman & Klatzky, 1990; Lebaz, Jouffrais & Picard, 2012; Bardot, Serrano, Oriola & Jouffrais, 2017). If comparing early blind (EB) with late blind (LB), LB

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possesses obvious advantages in identification due to EB is relatively lack of experience and not familiar with the presentation of tactile shapes (Heller, 1989a; Heller, McCarthy & Clark, 2005). In the stage of naming the item, whether it can be correctly named after conceptual identification is also related to whether VIP can find the corresponded words (Heller et al., 1996). However, the shapes used for VIP to identify in the above identification experimental research are mostly designed according to the existing impression towards the objects that are seen by people without visual impairment. In this research, we tried to use the tactile shapes established according to the drawings done by VIP in the previous research as the design of shapes identified in the tactile shape identification experiment implemented by VIP. We worked with School for the Visually Impaired in Taiwan for the research, and the school mainly recruits VIP at the stages of junior and senior high schools. Through the research program, we exchanged with experts in the schools. Teachers provided some suggestions on the design for tactile shape teaching aids, hoping to make students' learning in identification more effective. Before the implementation of the research, we have passed IRB reviewing and obtained the consent letters from parents. The research takes reference of the research done by Lebaz, Jouffrais, and Picard (2012) and adopts items that are normally used in daily life as items for identification in the experiment. Each item of tactile shape used in the experiment is designed with the reference of the research done by I-Ting Yeh (2008) and the VIP drawing results in the early stage of the research.

2. Methods

2.1 Participants

There are 6 subjects, including junior and senior high school students at School for the Visually Impaired (4 male students and 2 female students). The age profile is between 14 and 18 years old, and they are all blinds; among them, 3 are early blind and 3 are late blind.

2.2 Materials

26 cards of 8K horizontal cardboard tactile card are provided (24 cards are tactile card for items in the daily life and 2 cards are triangular card and circular card respectively for practice purpose). The shape of the card is referred to Gual, Puyuelo & Lloveras (2015) with the application of microencapsulation technology; thermal image device is used to produce embossed linear tactile shape. If the actual size of the item can be operated by hand-hold, such as the method used by Vinter, Bonin & Morgan (2018), the tactile shape will be presented on the A4 size in horizontal (279*210 mm) with the ratio of 1:1. If the actual size of the item is bigger than the handheld size, the shape will be minimized to the size of horizontal A4 size. The width of the tactile line on the shape is referred to the author's research in the past and it is 3 pt (Wu Hsiang-Ping et al., 2016). The whole process of the experiment is carried out on the conference table and two cameras from different angles of vision are installed at the venue for recording (Figure 1).

Figure 1 The Tactile Card Used for the Experiment

2.3 Procedure

2.3.1 Preparation Before Experiment

Before VIP carries out the tactile shape identification of the item, it is suggested that they should have using experience of the item (Mazella, Albaret & Picard, 2016). The researcher has conducted expert interview with director, section chief at teaching equipment, and teachers in School for the Visually Impaired before the experiment to confirm which items are commonly used in the learning environment for students. After determining the items, students with visual impairment in School for Visually Impaired are asked to implement drawing experiment at the early stage as the design reference for tactile shape identification experiment.

2.3.2 Tactile Shape Identification Experiment

There are three procedures in the main experiment. Procedure 1: The researcher will read out the name of the item that is going to be appeared on the tactile card to orally confirm the name of item that VIP is familiar with. If there is any item that they are not familiar with, the researcher will carry out further explanation to make sure VIP understand the words used for naming the item on the card. Procedure 2: The researcher will teach VIP how to identify the tactile shape and make sure VIP can identify the sample cards (triangle and circle). Procedure 3: Tactile cards (24 in total and each subject must complete all of them) will be provided to VIP at random. They will be asked to touch the card by hands and speak out the name of the item on the card. They should answer unrecognized if they cannot to identify it.

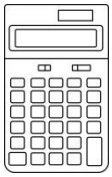
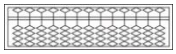
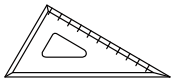
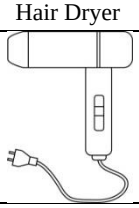
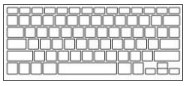
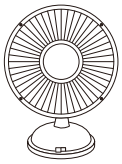
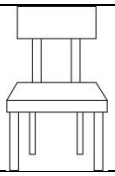
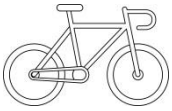
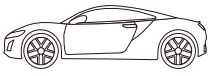
3. Results

3.1 Content of The Tactile Shape

The research takes the reference of experimental shape from the research done by Yeh (2008) and the drawings done by VIP for the design of tactile shape, the content of the 24 shapes used is shown on Table 1. The presentation of the shape is in 2D and in 3D, and the timing for using 2D or 3D is based on the discussion with the experts. For example, 2D dual-oval shapes with a pattern of blade opened up are used to present the item of scissors. For the item of thumbtack, the circle on the head of the thumbtack must be retained as well as the characteristics of lines and it will be easier to present it in 3D. Therefore, the angle of vision in 3D is used to present the top of the thumbtack and the line of the needle at the same time. In Table 1, the images that use 3D

angle of vision include mug, top, trouser, umbrella, fan and chair. The parts on these items that use 3D angle of vision are the circle of the top of the mug that contacts with our mouth, the parts contacting with our body on the top and trouser (collar band and cuff), surface on the umbrella, round base on the bottom of the fan, and the seat on the chair.

Table 1 The Content of 24 Tactile Cards

Thumbtack	Paper clip	Ruler	Key	Fork	Scissors
					
Compass	Magnifying lens	Stapler	Calculator	Comb	Mug
					
Abacus	Set square	Clock	Hair Dryer	Keyboard	Top
					
Trousers	Umbrella	Fan	Chair	Bicycle	Car
					

3.2 Result of Tactile Shape Identification Experiment

The time spent and naming results of the tactile shape identification experiment implemented by subjects are shown on Table 2. Items that are failed to be identified or the named item is with appearance similar to part of the characteristics on the correct item are remarked in italics. The order sequence on the left items is based on the size of actual objects from small to big while the items marked in bold represent the tactile shape is presented by 3D.

Table 2 Result of Tactile Shape Identification Experiment

project	Result of tactile shape identification experiment (The number of seconds spent and the name)					
	early blind			late blind		
	A	B	C	D	E	F
Thumbtack	5 second Thumbtack	11 second Thumbtack	*15 second Key*	14 second Thumbtack	6 second Thumbtack	*13 second Paper clip*
Paper clip	7 second Paper clip	*16 second Key*	18 second Paper clip	3 second Paper clip	*9 second Stapler*	*4 second Ruler*
Ruler	4 second Ruler	*6 second Comb*	*39 second Keyboard*	4 second Ruler	*22 second x*	2 second Ruler
Key	*6 second Compass*	*34 second x*	*17 second x*	5 second Key	*13 second Fork*	*5 second Magnifying lens*

Fork	4 second Fork	14 second Fork	*22 second* *x*	*65 second* *X*	*11 second* *x*	*21 second* *x*
Scissors	1 second Scissors	11 second Scissors	*21 second* *x*	2 second Scissors	16 second Scissors	4 second Scissors
Compass	2 second Compass	*5 second* *Scissors*	*16 second* *Scissors*	9 second Compass	16 second Compass	*18 second* *x*
Magnifying lens	19 second Magnifying lens	*7 second* *Compass*	*20 second* *Hair Dryer*	3 second Magnifying lens	7 second Magnifying lens	7 second Magnifying lens
Stapler	*5 second* *Compass*	*33 second* *Fan*	*27 second* *x*	3 second Stapler	5 second Stapler	*6 second* *x*
Calculator	8 second Calculator	*10 second* *Abacus*	35 second Calculator	3 second Calculator	3 second Calculator	*27 second* *Abacus*
Comb	*23second* *key*	8 second Comb	*15 second* *x*	4 second Comb	4 second Comb	*24 second* *x*
Mug	*40second* *x*	*28 second* *Chair*	*25 second* *x*	4 second Mug	3 second Mug	*18 second* *x*
Abacus	3 second Abacus	8 second Abacus	*21 second* *Keyboard*	*32 second* *Keyboard*	4 second Abacus	12 second Abacus
Set square	2 second Set square	*7 second* *Ruler*	14 second Set square	2 second Set square	5 second Set square	*15 second* *x*
Clock	9 second Clock	8 second Clock	28 second x	15 second Clock	6 second Clock	16 second Clock
Hair Dryer	*17 second* *Fan*	*15 second* *Paper clip*	*41 second* *x*	10 second Hair Dryer	*25 second* *Thumbtack*	*20 second* *x*
Keyboard	7 second Keyboard	15 second Keyboard	*56 second* *Calculator*	6second Keyboard	3 second Keyboard	*11 second* *Calculator*
Top	6 second Top	*14 second* *Stapler*	*23 second* *x*	1 second Top	5 second Top	*14 second* *x*
Trousers	*17second* *Scissors*	*13second* *Umbrella*	*44second* *x*	4 second Trousers	3 second Trousers	*20 second* *Scissors*
Umbrella	7 second Umbrella	*16 second* *Fan*	*25 second* *Hair Dryer*	4 second Umbrella	4 second Umbrella	*9 second* *x*
Fan	4 second Fan	11 second Fan	*25 second* *Clock*	5 second Fan	6 second Fan	*36 second* *Magnifying lens*
Chair	4 second Chair	*8 second* *Hair Dryer*	*34 second* *x*	31 second Chair	*44 second* *Thumbtack*	13 second Chair
Bicycle	12 second Bicycle	*9 second* *Car*	*9 second* *Scissors*	2 second Bicycle	9 second Bicycle	*13 second* *x*
Car	5 second Car	*24 second* *key*	*16 second* *x*	2 second Car	4 second Car	22 second Car

4. Conclusion

First, the result of identification for 2D or 3D shapes reveals that the quantity of the 17 items of 2D shape that the 6 subjects can answer correctly is 55 items and the average correct identification rate is 54% (55/102). Among the 7 items of 3D shape, the quantity of correct identification is 21 items and the average correct identification rate is 50% (21/42). If the subjects are not required to provide correct answer but only the appearance of the item named is with part of characteristics similar to the correct item (such as identifying abacus as keyboard or the two legs of compass as the two blades on scissors), the response rate to the characteristics on 2D shape is 82.4% (84/102) and 80.9% (34/42) on 3D. Although there is not much difference on the identification rate between 2D and 3D tactile shape, the identification rate for 2D in both situations is a little bit higher than that for 3D. The result is similar to the results from other researches (Lederman & Klatzky, 1990; Lebaz, Jouffrais & Picard, 2012; Bardot, Serrano, Oriola & Jouffrais, 2017). We can understand from above that the 2D or 3D tactile shapes produced by thermal image device can be identified by a certain percentage of blind subjects for the

geometrical features on the shape. For example, ruler and comb are both in the shape of rectangle with the texture of scale. When it comes to identify the difference between the two, it will depend on the message provided by the shape is clear and instant. During the process of experiment, some subjects only touched part of the message before they name the item but the answer might not be correct. For instance, when they touched the circle and line on the key, they thought it was part of the tire and edge of the car or when they touched the upper part of fan, they recognized it as a clock immediately. The reason might be related to the mental workload of the subject's. In addition, different subjects are confused by different situations. For instance, magnifying lens and key both include circle and rectangle but it will be confused with thumbtack if the subject believes key consists of circle and line. It will depend on the original impression that the subject holds towards the object.

In term of the size of the item, items above hair dryer on the left side in Table 2 are classified as small items according to the classification done by Vinter (2018) due to they belong to handheld operation, and items listed after keyboard are recognized as big items. The average correct identification rate for small items is 52% (50/96) while it is 54% (26/48) for big items, and there is not much difference between the two. Small items that are with low identification rate (lower than 33%) include key, fork, stapler, mug, and hair dryer while the low identification rate for big items are Trousers and Umbrella. Lastly, let's discuss early blind and late blind. In term of correct identification rate in the correct answer, the performance from those who are late blind is a little better than those who are early blind. The result is similar with the research done by Heller (1989) and Heller et al. (2005). The average time used for identification by subject A, D and E with correct identification rate more than 75% is 6 seconds. The average time used for subject B and F with correct identification rate of around 30% is 10 seconds. Subject C who is with correct identification rate of 12.5% took longer to identify items, and it is 22.3 seconds.

It is suggested that the tactile shape design in the future should explore the process of tactile identification done by the people with visual impairment in depth, including drawing presentation and the production of identification shape as well as use the perspective from people with visual impairment as the accordance of image design. Moreover, it should also be considered to use new technology, such as 3D printing technology, to allow people with visual impairment to touch tactile shapes more intuitively. The possibility and popularity of related teaching aids production should be explored in the future to assist VIP learning more effectively

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