Evaluation of Recognizing Tactile Pictures in Different Size Display in Sighted and Blind People

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Abstract: The real world is always impact the blind people with objects they hardly known. Owing to the defective vision of the blind people, all of the shape of man-made things can only be detected by the tactile sensation. Within the major essences of product design: shape, size, scale, texture, position, and color, the blind people can reach all of the information except color by their tactile sensation.

Base on our earlier research of relative works, few works mentioned about the way of how to integrate those essences of product design into objects for the blind people to use properly. This research focused on some of the factors of design: shape, size, and scale, trying to find out the effects of using the different shape / size / scale of tactile pictures in sighted and blind people. The result showed there were no significant differential on the recognition time and the rate of accuracy between the blindfolded people and blind people on recognizing all of the tactile pictures. There were some interesting findings on the rate of accuracy on recognizing true-size tactile pictures. All of the subjects had better performance on recognizing the true-size tactile pictures than 2 times or 1/2 times pictures, by the 76% against 61% of accuracy rate, in significant differential. This illustrated the shape of object we used on tactile picture should be about size of the real world. In the conclusion, some suggestions had been made on the design of tactile pictures for some further applications such as tactile product manual, tactile map, tactile graph card for teaching, and tactile brand card.

Key words: blind people , blindfolded sighted people, tactile picture.

1. Introduction

Blind people are curious to know what the world may look like. Because of their visual impairment, they can only construct the spatial map of the product simply using their hands, this is the main way they can feel the shape and texture of products. Within the major essences of product design: shape, size, scale, texture, position, color, the blind people can reach those information except color by their tactile sensation. Base on our earlier research on this topic of relative works, few works mentioned about the way of how to integrate those essences of design into objects for the blind people to use properly.

As the result of our earlier work for the National Science Council on 2001 (NSC 90–2218–E036–004) [13] showed, the blind children (born with blindness) could hardly have the accurate space perception about a product (such as shape, size, scale), if we chosen wrong combination of the design factors. Also amblyopic people can

only gather some of the information about the shape and texture. We found products for those people with lower vision should be enhanced on the cues of operation, cues of position and cues for leading the tactile sensation to recognize the shape of objects. So we figured out this research to find out the effect of shape, size, and scale of tactile pictures for the blind people. The result could lead us towards some design guidelines of tactile manual of teaching aids for blind children, tactile brand of products, tactile maps, and tactile graph cards.

2. Paper review

In the past years, most of the studies focus on the better pattern recognition and the category of tactile pictures, and only few discussed about the size, scale, angle, and texture of product. Shimizu et al in 1993 [10] introduced a relief pattern consisting of a 3D presentation in which the tactor pins formed a surface analogous to the original object. They showed that the relief presentation was superior to the line drawing presentation in accuracy of recognition and the tactile graphic display can help blind people to use in computer-related jobs, and the relief mode is effective presenting maps or is useful in transmitting scientific illustrations.

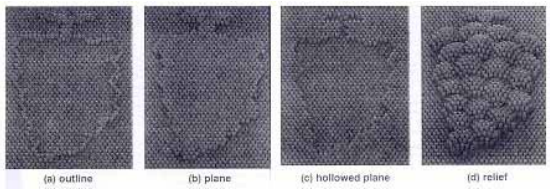


Fig.1 Illustration of a bunch of grapes in the outline mode(a), the plane mode(b), the hollowed-plane mode(c), and the relief mode(d) (Shimizu, Masami Shinohara et al, 2000)

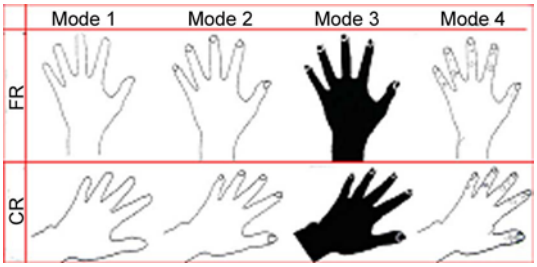


Fig.2 Different view angle and representation type of 2D tactile pictures Wan-Xiu Chen (2002) [12]

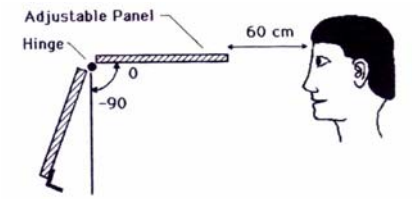


Fig.3 A side view of the apparatus used in the experiments（Heller，1996）

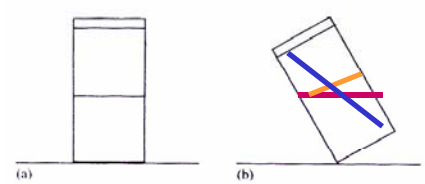


Fig.4 Piagent's water level task（Heller, 2001）

Further more, they categorized the pattern of Tactile-pins into 4 modes (outline, plane, hollowed pane, relief), Shimizu [11] recommended the relief mode was the better type.(Fig. 1)

Wan-Xiu Chen (2002) [12] concluded the represent styles of hot print transfer paper into four types: the outer contour, the outer contour with simple details, the contour plane, the outer contour with rich details. It showed the contour plane was the better way of representing physical objects. Also, when the contour plane adds some outline description of the object on the surfaces, the performance of tactile will be the best among them. (Fig. 2)

In the recent years, some works focus on the space perception of products. Heller et al (1995) [3] studied how blind persons thought about pictures of different angle; the next year he conducted a work to explore the perception of a 2D angle on the air, they had some achievement.

Till recent years, few researches started to focus on the spatial perception of product, Heller et al (1995) [3] researched production and interpretation of the foreshortened-perspective views and one bird's-eye view; also Heller (1996b) [5] exposed the subjects to a board on a hinge, both in horizontal position, and at various angles. Subsequently the blind subjects were able to perform as well as the blindfolded sighted subjects. (Fig.3) They apparently learned something about foreshortened representations.

In Heller (2002) [8] Piagent's water level task taps into subjects understanding what water level stays horizontal, even if a container is titled; also to know how the water level would look in the real world (Fig.4). He

found a few of the low vision subjects were capable of judging the general outline of a very large form, such as building. It was interesting that the very low vision individuals had near-errorless performance on this task, and even outperformed sighted subjects who could see the pictures of jars.

Therefore, among these researches above, they were not actually discussed the real shape of spatial perception of productions (including shape, size, scale, rotation, position, etc.). With much attaching importance to the product design for blind people, there are more and more companies have involved in studying relative researches.

3. Method

The samples were divided into two groups, one was blind group, the other one was blindfolded group. They were given some tactile pictures with different shape, size, scale, then were asked to tell the kind of that object once at a time. The respond time and the accuracy were recorded. This research investigated the suitable size of tactile pictures for blind people to recognize, and discussed the difference between them.

3.1 Subject selection

The experiment was conducted at the TMSB (Taipei Municipal School for the Blindness), ten volunteers at the schools and ten blindfold students from other school were random sampled, 13-16 years old and all of them were at 8th year.

3.2 Tactile pictures

Table1：Illustration of pictures within the categories (fruits, stationery, daily things).

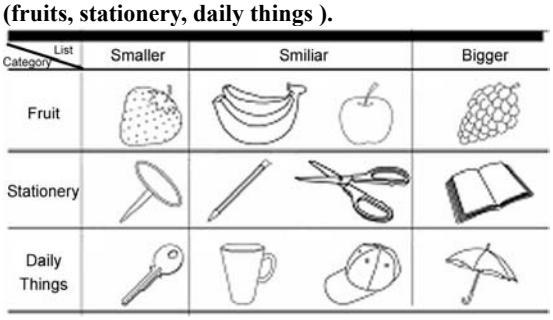
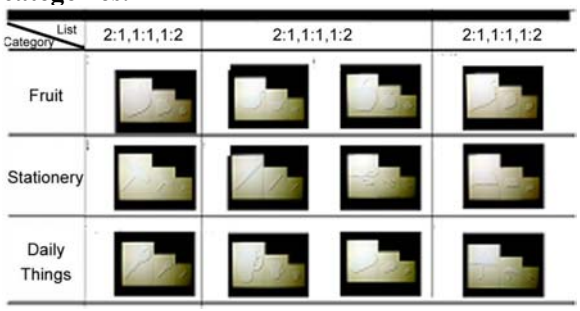


Table2：Three size of tactile pictures within categories.



The tactile pictures were rectangle cards with different tactile pictures on the top surface. All of the cards were divided into 3 levels, 2/1, 1/1, and 1/2. The standard size of 1/1 was 181.42 X 89.079 (mm), the average size of palm of 8th year student in Taiwan (Jun-Mao Wang, 2002) [9]. The shape of the pictures picked from the reference material of the TMSB(Taipei Municipal School for the Blindness), in order to ensure those blind children could understand the meaning of the objects. We picked 12 kinds of object (see Table 1), the representation method of the shape referenced from Wan-Xiu Chen (2002) [12], for they were frequently noted in the daily school life of those students. The drawings were made by computer graphics, and the cards were engraving by laser (see Table 2).

3.3 Procedure

Before the test, the subjects were told that those pictures, they were asked to touch, were within 3 kinds of object: fruits, stationery, daily things, and they needed to recognize what they were as soon as possible. Each of

the subjects were asked to draw the order of those cards, touching the cards one at a time with no other hits by the researcher, then told the researcher what kind of picture it was. The observer recorded the respond time and the accuracy of their answer. The picture was put at a hole of a desk to prevent the vibration of touching. The observer changed the cards after one card was recognized, and help to move the hands of the subject on the standard position. The researcher recorded any action abnormal, or any comment from the subject. If there was one card cannot be recognized within 90 seconds, the subject need to response by guessing in order to end a cycle of a card test.

4. Result and analysis

4.1 Comparison of the three sizes on blind children / blindfolded children

Blind children spent the least time in responding the small size and performed more accurately in middle size, shown in Table 3. The results of ANOVA analysis, the response time and accuracy with the three sizes of tactile pictures for blind children, are no significance differences, shown in Table 4 and Table 5.

Table 3 Response time and accuracy on blind children

blind	Response time (s)			Response accuracy (%)		
	S	M	L	S	M	L
Strawberry	15.88	13.34	12.06	60%	40%	50%
Banana	7.41	14.40	16.18	60%	70%	50%
Apple	8.66	13.34	8.23	70%	90%	70%
Grapes	9.16	9.26	14.33	60%	70%	60%
Nail	9.56	8.29	6.50	80%	70%	80%
Scissors	5.61	6.97	4.63	90%	90%	90%
Pencil	6.60	6.99	9.41	70%	90%	50%
Book	12.78	113.98	11.38	40%	50%	60%
Key	7.63	7.27	9.75	90%	80%	60%
Cup	15.50	8.59	13.74	70%	80%	70%
Cap	11.98	13.08	16.41	0%	40%	10%
Umbrella	7.67	4.60	7.41	90%	90%	90%
平均數	9.87	10.02	10.84	65%	72%	62%

Table 4 ANOVA analysis of Response Time on blind children

ANOVA-Response Time

Source of Variation	SS	degrees of freedom	M.S	F	P-Value
between treatments	6.503	2	3.251	0.257	0.774
Error(within treatments)	416.491	33	12.62		
total	422.99	35			

Table 5 ANOVA analysis of Response Accurate on blind children

ANOVA-Response accuracy

Source of Variation	SS	degrees of freedom	M.S	F	P-Value
Between treatments	0.062	2	0.031	0.632	0.537
Error (within treatments)	1.623	33	0.049		
Total	1.685	35			

Sighted children also spent the least time in responding the small size but performed more accurately in large size, shown in Table 6. The results of ANOVA analysis, the response time and accuracy with the three sizes of tactile pictures for sighted children, are no significance differences, shown in Table 7 and Table 8.

Table 6 Response time and accuracy on blindfolded

sighted	Response time (s)			Response accuracy (%)		
	S	M	L	S	M	L
Strawberry	13.4	12.91	14.69	70%	60%	60%
Banana	9.34	9.43	9.5	50%	80%	80%
Apple	14.03	9.78	11.9	70%	80%	80%
Grapes	8.22	8.86	11.06	80%	70%	70%
Nail	10.19	11.39	16.32	80%	50%	60%
Scissors	9.24	9.23	8.17	80%	90%	90%
Pencil	9.05	5.69	9.39	70%	80%	70%
Book	19.65	20.50	23.73	40%	30%	60%
Key	8.11	12.09	13.98	80%	90%	70%
Cup	13.35	14.92	17.47	70%	90%	90%
Cap	21.51	18.18	16.26	30%	50%	40%
Umbrella	11.45	11.45	8.98	90%	90%	90%
平均數	12.29	12.031	13.45	68%	72%	71.6%

Table 7 ANOVA analysis of ResponseTime on blindfolded children

ANOVA-Respond Time

Source of Variation	SS	degrees of freedom	MS	F	P-Value
Between treatments	13.70	2	0.03	0.359	0.7
Error(within treatments)	629.36	33	19.1		
Total	643.06	35			

Table 8 ANOVA analysis of Accuracy on blindfolded children

ANOVA-Response accuracy

Source of Variation	SS	degrees of freedom	MS	F	P-Value
Between treatments	0.013	2	0.01	0.217	0.806
Error(within treatments)	1.05	33	0.03		
Total	1.069	35			

The results of T-test analysis, the comparison on the response time and accuracy with all sizes of the tactile pictures for blind and blindfolded children, are no significance differences, shown in Table 9.

Table 9 T-test on the Response Time and accuracy of blind / blindfolded children

T-test

	S-blind	S-blindfolded	M-blind	M-blindfolded	L-blind	L-blindfolded	S-blind	S-blindfolded	M-blind	M-blindfolded	L-blind	L-blindfolded
Mean	9.87	12.29	10.02	12.03	10.84	13.457	0.65	0.675	0.716	0.716	0.616	0.716
StDev	11.58	19.28	11.64	17.218117	14.63	20.71	0.064	0.032	0.036	0.039	0.046	0.023
N	12	12	12	12	12	12	12	12	12	12	12	12
freedom	22		22		22		22		22		22	
T-Value	-1.51		-1.30		-1.52		-0.27		0		-1.30	
P(T<=t)	0.1452		0.206		0.141		0.78		1		0.204	

4.2 Comparison of the scales between tactile pictures and objects on blind children / blindfolded children

Blind/blindfolded children spent the same time in responding the right scale and all performed more accurately in the right scale shown in Table 10. The results of T-test analysis, the response time with the right scale and wrong scale of tactile pictures for sighted people for blind/blindfolded children, are no significance differences, shown in Table 11; but there are significance differences on the accuracy, shown in Table 12.

Table 10：Comparison of Blind / Blindfolded children on respond time and accuracy with right scale and wrong scale of tactile pictures.

subject	Response time (s)		Response accuracy (%)	
	Right Scale	Wrong Scale	Right Scale	Wrong Scale
Strawberry	15.83	13.25	65%	53%
Banana	11.91	10.6	75%	60%
Apple	11.61	10.7	85%	73%
Grapes	12.69	8.87	65%	70%
Nail	9.87	10.62	80%	65%
Scissors	8.1	6.97	90%	87%
Pencil	6.34	8.61	85%	65%
Book	17.55	16.72	60%	40%
Key	7.87	10.77	85%	65%
Cup	11.75	15.01	85%	60%
Cap	15.63	16.53	45%	20%
Umbrella	8.19	8.79	90%	80%
total	11.44	11.44	76%	61%

Table 11：T-test on the response time of right scale and wrong scale of blind / blindfold children.

T-test

	Right Scale	Wrong Scale
Mean	11.445	11.44833
StDev	12.63694	10.3944
N	12	12
T-Value	-0.00241	
P(T<=t) two-trails	0.998102	

Table 12：T-test on the accuracy of right scale and wrong scale of blind / blindfold children.

T-test

	Right Scale	Wrong Scale
Mean	0.758333	0.614167
StDev	0.019924	0.031749
N	12	12
T-Value	2.196957	
P(T<=t) two-trails	0.038851	

5. Conclusion and discussion

This study meant to find out the effect of shape, size, and scale of pictures on the tactile picture cards. The result of data on the factor of scale had no significant differential on the respond time and the accuracy between blind children and blindfold children.

Considering the scale factor of the pictures, though the response time were all quit high, the accuracy of 1:1 scale picture was rather higher than others, 76% against 61%, with significant differential. This implicated that every object should have its proper size / scale of represent picture. The represent picture and the scale of it had relative effect to the recognition of the picture.

There were some phenomena should be mentioned in this study:

(1) Some of the children indicated that the curves of some pictures (such as grapes, cap) were too close to be recognize, and they preferred to recognize those pictures on large scale of cards.

(2) Some of the pictures (such as nail, cup) were observed wrong recognized quit often on cards with scale other than their actual scale (1:1). For example the 2:1 card of the nail picture was recognized to be the umbrella.

(3) Some the pictures such as scissors, key, with highly specific features, could be recognized quit easily no matter at what scale of cards.

(4) The complexity of the shape of picture could cause the factor of respond time, such as book, grapes, against to pencil, apple, implied the shape of represent pictures should be carefully designed.

(5) The respond time and the accuracy between different scales of pictures were found no significant differential, because some of the pictures were easily recognized, especially the children were told the pictures were within 3 kinds of things at the beginning of this test.

(6) The result shows that blind and blindfolded subjects were performed as the highest accuracy in recognizing the category of stationery, and it is differ from the result of Wan-Xiu Chen, 2002[12]－the category of daily things.

The future work of this study will located on the next fields:

(1) The characters of the represent pictures

The highest accuracy in recognizing pictures performed well in the category of the stationery than those in the category of daily things. That is because scissors and pencil have unique characters with their shape, so subjects can quickly tell the name of tactile pictures. Thus next study will redesign the picture of objects by investigating the frequency of occurrence of livelihood things and find out the proper characters for product in expression. By this way we can reach further and avoid floor effect.

(2) Grabbling skills and constrains

In this experiment we found the children had different grabbling strategies conducing variety of effect on the respond time. Future work should focus on the topic and design more precisely experiments.

(3) The subjects and the varieties

Adding more subjects of blind children will get more accurate data, and dividing them into 5 groups, congenitally blind, congenitally low-vision, late-blind, late low-vision, and blindfolded, to see the effect of grades of defeat on vision.

(4) The effect of scale, rotation, position, and texture

Combining the factors of design could generate much more complicate of pictures, and the performance of the tactile pictures will be totally different, our study shall introduce the improved back-propagation neural network prediction modes to reduce the combination set of those factors and setting up the databank of factors-performance matrix for each category of the blind children.

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