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BRAILLE BOX : ANALYSIS OF THE PARALLELISM CONCEPT TO ACCESS GRAPHIC INFORMATION FOR BLIND PEOPLE

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Abstract-**According to the parallelism concept, the more sensors we use, the more precisely and easily we could access information. The “Braille Box” has been developed by modifying Braille cells to form an array of tactile stimulators which is compatible with fingertip. Each pin can be controlled independently so that we can change the size and type of array to study the tactile perception of simple and more complex graphical shapes and therefore control the parallelism of inputs in this visual-tactile perception device. The result from the experiment with 25 subjects shows us that the quality of perception is influenced by the characteristic of array. The main result is that the form detection is made easier with a multiple sensor array rather than with the mono sensor array. Some other parameters, such as the type of form, the strategy of exploration, also influence the recognition performance. Further experiments need to be done with this Braille Box in order to improve this device and help blind people to access graphic information.**
Keyword-**Braille, blind, tactile perception**

I. INTRODUCTION

Acquiring graphic information for blind people is different from acquiring text information because the graphic information can present free forms and many details. At the end of 1960s, P. Bach-y-Rita [1] invented a device, TVSS (Tactile Vision Substitution System), to help blind people to acquire graphic information.

The “suppléance perceptive” group of University of Compiègne has also developed assistive technology devices and techniques for helping blind people to access graphic information [2] precisely and easily. We have also studied how to improve tactile feedback devices. We thus have developed a “Braille Box” based on a tactile stimulator array to study the parallelism concept in order to help us to understand the advantage of parallelism in the enrichment and enlargement of sensations and actions for graphic recognition performance.

We have then used the Braille Box to study the parallelism effect with the following hypothesis.

1. The number of detection fields affects the exploration and recognition performance of geometric forms.
2. The size of each detection field affects the exploration and recognition performance of geometric forms.

II. MATERIAL AND METHODOLOGY

A. Hardware and Software

Two Braille cells are used to form an array of tactile stimulators, 4 columns and 4 rows (1.0 x 0.8 cm.^{2}), which is suitable for fingertip exploration as shown in Fig. 1a.. Each Braille cell has 2 columns and 4 rows. Each pin of the tactile stimulator array can be controlled independently, so we can define and modify the size and type of array for the experiment.

A tablet and a stylus (WACOM), shown in Fig 1b. and 1c., are used in this experiment to explore the graphic form and to draw the recognized form.

(a) (b) (c)

Fig. 1 a) Braille Box b) Tablet c) Stylus

We have used specific softwares, developed by the “suppléance perceptive” group, which permit us to define and modify the type of detection field matrix, to record data and to show the trajectory after exploration.

B. Experimental setup

Twenty-five subjects (male and female), aged from 15 - 40 years old, were divided into 5 groups according to the type of matrix that they used. The subject was blindfolded and used the stylus to explore the figure on the tablet, with a tactile feedback from the Braille Box. Each subject used only one type of matrix to explore 11 figures with a constant sequence of figure presentation. The experiment had 2 sessions :

1. Practice session

The blindfolded subject explored an ellipse form in order to get familiar with all the instruments used in this experiment and with the tactile perception.

2. Experiment session

The blindfolded subject began to explore the 11 figures with a fixed 90-second period of exploration for each figure. After this time, he was asked to draw the figure that he had perceived, being still blindfolded. Then he went on the experiment until he completed the whole 11 figures.

We used a closed form, an ellipse, for the practice session and open form for experiment session (Fig. 2.). They are 2 types of open forms : 1) Simple forms (1 segment) : form 1-4, 2) Complex forms (2 segments) : form 5-11.

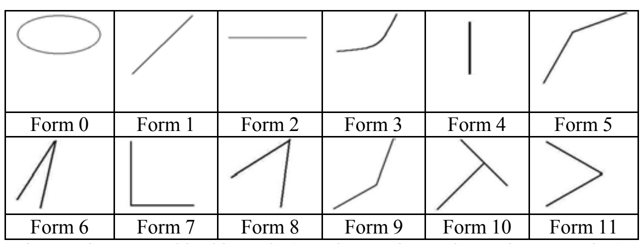


Fig. 2. Figures used in this study (practice session and experiment session).

We tested 5 types of matrix in this experiment. Each field of the detection matrix is related to a pin of the tactile stimulator array as illustrated in Fig. 3. The position of the center of the detection field is given by the stylus position on the tablet.

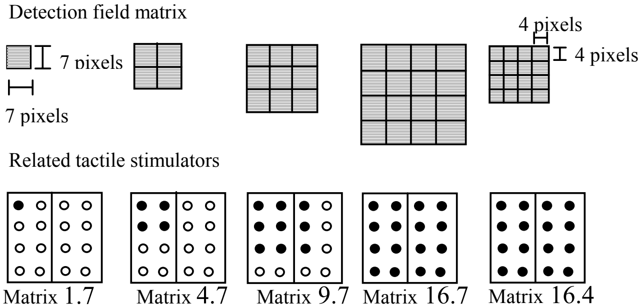


Fig. 3. Types of detection field matrix and corresponding tactile stimulator array

C. Exploration performance

If the trajectory made by the subject during the exploration phase is similar to the reference form, we consider that the subject is able to intentionally explore the whole figure.

Considering Fig. 4a., 4 subjects (E, F ,V and Y) could explore form 1 (simple form) and in Fig. 4b., 3 subjects (G, H and M) could explore form 8 (complex form). Therefore, the exploration performance of form 1 with the matrix 1.7 is 80 % (4/5) and 60 % (3/5) for form 8 with the matrix 16.7 .

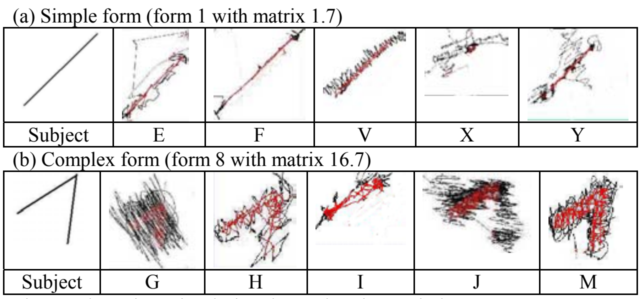
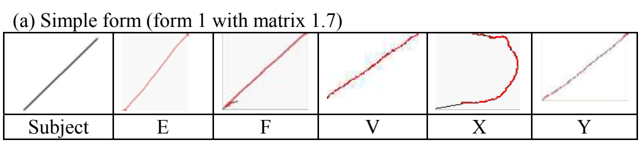


Fig. 4. The trajectories during the exploration period

D. Recognition performance

After the exploration, if the subject draws a figure which is globally similar to the reference form, we consider that the subject is able to recognize the figure.

We still consider the same example as used in Fig 4. For Fig. 5a., 4 subjects (E, F V and Y) could draw a figure similar to the reference form, so the recognition performance of form 1 with the matrix 1.7 is 80 % (4/5). For Fig. 5b., only 2 subjects (H and M) could draw this form. Therefore, the recognition performance of form 8 with the matrix 16.7 is only 40 % (2/5).



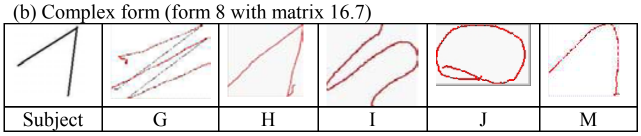


Fig. 5. The figures drawn by subjects after finishing the exploration period

III. Results

We used ANOVA and t-test to analyze the exploration and recognition performances of each type of matrix. We find that there is a significant difference of exploration performance between the different detection field matrix ($F_{4,50} = 4.629$, $p < 0.003$). In contrast, there is no significant difference of recognition performance between the different matrix ($F_{4,50} = 0.775$, $p > 0.5$).

We have then considered the effect of the type of figure (simple and complex) on the exploration and recognition performances. We have found that there is no significant difference between the matrix for simple form in both exploration performance ($F_{4,15} = 0.500$, $p > 0.7$) and recognition performance ($F_{4,15} = 0.812$, $p > 0.5$).

However, there is a significant difference of exploration performance ($F_{4,30} = 6.425$, $p < 0.001$) but no significant difference of recognition performance for complex form ($F_{4,30} = 1.245$, $p > 0.3$). Moreover, if we consider the exploration performance of complex form, we have found that there is a significant difference between the mono field matrix (Matrix 1.7) and the multiple field matrix (Matrix 4.7, 9.7, 16.7 and 16.4) but there is not any significant difference among the different multiple field matrix.

IV. Conclusion

We can conclude that the parallelism concept can be applied to help blind people to explore graphic information, and particularly complex forms. However, we cannot conclude from this study which type of multiple detection field matrix has the best exploration performance.

Furthermore, we cannot conclude from this experiment about the influence of parallelism effect to the recognition performance. Other factors may affect the recognition performance. Thus, more experiments need to be done to clarify their effects. These knowledge would permit us to improve the performance of exploration and recognition of geometric form in order to help blind people to access graphic information with this kind of assistive technology system.

References

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