The Evaluation of Compasses Tools for Visually Impaired Children

Yung-Hsiang Tu*, Chih-Fu Wu**, Tsung-Jui Chung***, Ling-Yun Chen****

ABSTRACT

In order to help the children with visual impairment to learn more knowledge by touch, it is important to utilize the sensation of hands and fingers at the operation of assistive device. Owing to the lacking of visual assistance in the task of drawing pictures, visually impaired children usually unable to achieve exact drawing they desired. This study focused on the evaluation of three types of compasses tool, which make use of touch in different ways on the tasks of circle-drawing by measuring the action time and circle deviation. The three types of compasses were: (a) P-type, which had two pins to position the center and the radius. (b) F-type, which used the index finger to point the center and the radius. (c) G-type, which used a pin to point the center and a gear-head to draw the circle. There were 10 blind children recruited from the School for Visually Impaired Children joined the complete balanced experiment. Four circle-drawing tasks that used the compasses tools to make tactile circles were conducted: (1) Center-constrained circle. (2) Radius-constrained circle. (3) Center-radius-constrained circle. The MANOVA test found that the G-type had the significantly lower action time at the circle-plotting stage and radius-adjusting stage. Also, the G-type had the significantly lower circle-shape deviation. It is concluded that the new gear-headed compasses, G-type, has some significant advantages that improve the different kinds of circle-drawing tasks for visually impaired children.

Keywords: Compasses, gear-headed, circle-drawing, visually impaired children

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1. INTRODUCTION

Triangular, square, pentagon and circle are the basic geometry figures mostly used in the graphic design. To blind children, the concepts of triangular, square, pentagon are simpler item for them to learn than the circle, because those figures are combination of straight lines. And the concept of a circle is not similar as square because its shape is rounded with continuous arcs. For this reason, to design a proper compasses with a simple concept for the children with visual impairment is an much more important issue than a straight-line ruler. The visual impaired people do their better way to employ their sensor of hearing and touching to catch information but they have less experience of gathering proper information, thus some of them might never reach certain major concepts that other normal children might have, such as color, distance (Scholl, 1986). The major tool for teaching children such concepts falls on the hearing by ears and feeling certain models by hands with touch.

Gibson (1962) proposed the concept of active touch and passive touch that the major difference between these two concepts is the form of receiving information: the active touch means actively using our finger to reach the information; and the passive touch means the force of environment press on one’s touch sensor passively to feel the information, commonly on palm or large skin region. It was thought that the active touch and the passive touch might results different performance at certain tasks by some works, Learning Trough Touch (McLinden, McCall, 2002), but some others researchers found that the differences were not significantly evidenced. Till these days, the way of using a pen to write or to draw a picture onto a special paper for the blind children to express their ideas is still the simple and proper way for the teacher or instructor to guiding them to learn concepts of the world. In the school for visually impaired children, the teacher fix a special paper onto a “haptic platform” for the children to express their insight thought with a special pen.

Edman (1992) explained the variety ways of using the haptic drawing platform: one simple way was to fix the plastic paper with glue; another way was to thrust two special pins into the proper holes in order to fix the paper on the rubber plat. When the paper is well fixed on the platform the children may freely using their pen tool without having to press the paper to prevent accident strokes. This is special important to the task of plotting a smooth circle or exact arc. Leung, Cheng-Yee and Hsu, Kuang-Chieh (2007) investigated the way of using the current compasses, they conducted an observation on the operation of the current compasses by 5 blind children and found that the circles made by the children were not smooth and the center points were usually glided. This study was aimed to design and to verify two different designs for improving the situation mentioned before in order to find out a better design of compasses for the children with special needs.
2. The Experiment

2.1 Subjects

There were 10 blind children recruited from junior high and primary schools of Taipei, three girls and seven boys, all of them are right handed. The participants reported themselves or from the instructors that no injury on their fingers and palms. All of them had some experience of using the current compasses at their school.

2.2 Materials

There were three compasses prepared in this experiment: (1) P-type, which had two pins to position the center and the radius; (2) F-type, which used the index finger to point the center and the radius; (3) G-type, which used a pin to point the center and a gear-head to draw the circle.

(1) The pin compasses (P-type)

The P-type compasses was currently operated in the schools for visually impaired. The basic principal of this type of compasses came from the compasses adopted for the normal children but the legs of it were much longer and the head of the both legs were slightly obtuse, one of the legs was for positioning the center point and the other was to nick the paper to produce the circle, see figure 1.

(2) The finger compasses (F-type)

The concept of this F-type compasses was that the sensation of the finger of the blind children might be acute than normal children as Chih-Fu Wu, Yung-Hsiang Tu, and Kuang-Chieh Hsu (2007) implied. So this design employed the index finger as the major “pointer” of the center point, which the user had to put his index finger into the hole of the tool to feel the center position and pushed down a component to fix the hole onto the paper, then the other hand of the user move the indicator on the Axes to the location of proper radius and press it to have the circle produced, see figure 2.

(3) The gear compasses (G-type)
The design of this G-type compasses, figure 3, was aim to integrate the current pin compasses (P-type) and the concept of the current gear pen, figure 4, which design for the user to “draw” a line with a gear head on a special pen. The principle of this design was to merge the action of pointing the center and the assignment of the radius, which the user was to hold the center cylinder on one hand and to move the mark bar horizontally to the right value by counting the marks slipped in to the left side.

![Figure 3 the Model of gear compasses (G-type)](image)

(4) Experiment environment and measuring instrument
The paper prepared was the PP plastic paper, 0.2 mm thickness, which suggested from another gear-head experiment which conducted by the authors, and the size of the paper was 400 × 400 mm. A quiet and independent room with a see through window was prepared for this observation and two video cameras were installed for recording the action of the subject through the whole experiment. The action time was measured by reviewing the video file using the Movie Maker on Window XP, and the circle deviation of the task result was measured by a vernier with precision of 0.02 mm.

![Figure 4 gear-heed pen (Photo by Thomas Bergman)](image)

### 2.3 Procedure

(1) Tasks
There were 4 tasks assigned in this experiment which were: Centerpoint-constrained task (C task), Radius-constrained task (R task), Centerpoint-radius-constrained task (CR task) and Two-homocentric circle task (2H task). On the paper there was one or two lines already plotted on the near side to the
subject (at the condition of R task or CR task and 2H task), or a center point already hint on the center of the paper (at the condition of C task or CR task). The balanced complete experiment that the subject was told to finish the 4 tasks with randomized order of these 3 compasses (P-type, F-type, G-type) completely followed by a free practice and a fully explanation of the steps for using each of the compasses.

(2) The Measurement of Using the Compasses

Each task was stepwise into 4 stages which were adjusting the radius, positioning the center point, plotting the circle, and checking the result, the action time of each stages was measured and at the same time the deviation in this experiment was also detailed into 4 measured items: radius deviation, center point deviation, dynamic center point deviation, and the incomplete arc deviation, see figure 5.

![Figure 5: The four possible deviation items which happened at the tasks of plotting a circle](image)

The factors in this experiment were the compasses, which had 3 levels; the tasks, which had 4 levels and the performance variables were the 4 action time: adjusting radius, positioning center, plotting circle, and checking the result; and the 4 deviations: radius deviation, center point deviation, dynamic center point deviation, and the incomplete arc deviation. The 2-way MANOVA test of SPSS was employed for the analysis of the differences among the factors and the levels.

3. Result

3.1 The MANOVA test (Compasses and Tasks)

(1) Descriptive statistics

As Table 1 showed that the G-Type had the least mean action times and least mean circle deviations, it was a hint that G-Type might be the best compasses among three compasses, also noticed that the F-type performed better at mean action time than the P-type but performed worse at the mean deviations. This description was a possible result but it still needed to be confirmed by the next inferential analysis.
Table 1 The mean action times and circle deviations of the Compasses and in the Tasks

<table>
<thead>
<tr>
<th>Compasses / Tasks</th>
<th>Action Time (second) (stages of plotting a circle)</th>
<th>Circle Deviation (mm) (deviations of center or arc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusting radius</td>
<td>Positioning center</td>
</tr>
<tr>
<td>P-type</td>
<td>44.3503</td>
<td>11.4298</td>
</tr>
<tr>
<td>F-type</td>
<td>27.4577</td>
<td>10.9672</td>
</tr>
<tr>
<td>G-type</td>
<td>23.0055</td>
<td>8.4572</td>
</tr>
<tr>
<td>C task</td>
<td>--</td>
<td>11.2370</td>
</tr>
<tr>
<td>R task</td>
<td>36.4787</td>
<td>--</td>
</tr>
<tr>
<td>CR task</td>
<td>32.7583</td>
<td>11.6653</td>
</tr>
<tr>
<td>2H task (outer )</td>
<td>28.2530</td>
<td>8.7247</td>
</tr>
</tbody>
</table>

(2) Inferential Analysis

As Wilks' Lambda in the two-factor MANOVA test showed that there was a significant interaction between the two factors, Wilks' Lambda=0.505, $F(64, 744)=1.463$, $p=0.013^*$, which meant that there were significantly different effects among these 3 compasses on the 5 tasks, or at either way. The between subject effects showed that there were significant differences found at the adjusting radius time, plotting time, and all of the 4 deviations.

Because the interaction between the two factors was significant, the data file was then separated by the tasks to see whether the different effects exist among the 5 tasks; and also separated by the compasses to see whether the different effects exist among the 3 compasses. The values of Wilks' Lambda for each task were all significant, $p<0.001$, which showed that the effect of 3 compasses at each task did show significant difference.

Table 2 the Performance of the Three Compasses by Different Tasks

<table>
<thead>
<tr>
<th>Performance Variable</th>
<th>C task</th>
<th>R task</th>
<th>CR task</th>
<th>2H task (inner )</th>
<th>2H task (outer )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusting radius time</td>
<td>--</td>
<td>P-type &gt; F-type, G-type</td>
<td>--</td>
<td>P-type &gt; F-type, G-type</td>
<td>--</td>
</tr>
<tr>
<td>Positioning center time</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Plotting time</td>
<td>--</td>
<td>F-type &gt; P-type, G-type</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Checking time</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Center point deviation</td>
<td>F-type &gt; P-type, G-type</td>
<td>--</td>
<td>P-type, F-type &gt; G-type</td>
<td>P-type, F-type &gt; G-type</td>
<td>--</td>
</tr>
<tr>
<td>Radius deviation</td>
<td>--</td>
<td>P-type, F-type &gt; G-type</td>
<td>--</td>
<td>P-type, F-type &gt; G-type</td>
<td>--</td>
</tr>
<tr>
<td>Incomplete arc deviation</td>
<td>F-type &gt; P-type, G-type</td>
<td>--</td>
<td>P-type, F-type &gt; G-type</td>
<td>P-type, F-type &gt; G-type</td>
<td>--</td>
</tr>
<tr>
<td>Dynamic center deviation</td>
<td>F-type &gt; P-type, G-type</td>
<td>--</td>
<td>P-type, F-type &gt; G-type</td>
<td>P-type, F-type &gt; G-type</td>
<td>--</td>
</tr>
</tbody>
</table>

As the Table 2 showed the results of the Post Hoc comparisons among the three compasses at the plotting time, incomplete arc deviation, and dynamic center deviation were the same as F-type > P-type,
G-type, which represented that the P-type, G-type were better at these performance items. At the other performance items, the G-type had the lower action time and deviation than other compasses, especially at the radius deviation item, which indicated the G-type was better than the F-type and G-type compasses.

4. Discussion

The design of G-type obviously well enough than the other two compasses and the experiment might be discussed as follows:

(1) Action time: The G-type was designed in a lower body with a round shape of gear-head, this might be the reason that it was speedy than the others, to have the advantage of saving the radius adjusting time and to keep a more steady and smooth posture of movement.

(2) Center deviation: The major difference between P-type and G-type was the way of plotting, P-type used a pintail to scrape the material where the G-type employed a gear to scroll on the paper. The subjects had voted the G-type through their finger touch in this experiment and thus this design might be a good choice for related device. The reason for the G-type had the lowest deviation of center point might be the pintail was sharper than the others, but it was still an issue to make a balanced design between the sharpness of the pintail and the safety of the fingertip.

(3) Radius deviation: It was not told why the P-type and G-type had the lowest radius deviation, but it was clear that the F-type had a significant radius deviation than P-type, G-type. This might be an implication that the upstanding style compasses was better than the landscape one.

5. Conclusion

The study compared 3 types of compasses to find a better design of compasses tool for blind people, the result of this experiment showed clearly evidences that the new design, G-type, which used a pin to point the center exactly and a gear-head to draw the circle steadily has the better performance than the others at those action times and circle deviations measured. There are some other issues should be further studied such as the safety of the tool must be reconsidered at the research and design for the visually impaired person, also the convenience of storing the tool with the other related components. It would be much more important for us to design a compasses which has the stronger haptic effects of arcs or circles on the general paper than to draw circles on the special paper because the subject has to touch and feel the circle, sometimes many circles at the same paper, to know the meaning of this plotting at place other than school.

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