INFLUENCES OF THE SIZES OF TACTILE BARS AND DOTS ON DISCRIMINABILITY IN PEOPLE WITH VISUAL IMPAIRMENT

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Abstract

Tactile bars and dots served as tactile landmarks so that people with visual impairment could use the same consumer products as those used by sighted people. However, reliable data on the appropriate sizes of products was not readily available. The purpose of this study was to evaluate the influence of tactile bar and dot sizes on the discriminability of the two among younger and older adults with visual impairment. This was done to determine appropriate tactile bar size (as distinguished from tactile dots). Participants tactually discriminated several sizes of tactile bars and dots presented individually, in random order, via a two-alternative forced-choice task (2AFC) using the index finger of the preferred hand. Results showed that longer dimensional differences between tactile bar width and length is an important factor for correctly discriminating tactile bars. Most participants in both groups distinguished tactile bars that were larger than +2.0 mm from tactile dots quickly and with high accuracy. Meanwhile, tactile dots with a larger edge radius of curvature had greater discriminability than tactile dots with a smaller edge radius of curvature in the case of dots with an identical diameter.

According to a survey conducted by the Japanese Ministry of Health, Labour and Welfare (2008) in 2006, there were about 300,000 people with visual impairment in Japan. It is important to market consumer products that meet the physical needs of individuals with visual impairment. Many countries across the world are also facing the same issue. Several consumer electronics manufacturers actively provide support to older adults by improving the tactile accessibility of their consumer products. In Japan, several companies apply tactile dots (dot-shaped tactile symbols) and bars (bar-shaped tactile symbols) to the manual operating portions of their existing products so that people with visual impairments can use the same products as those used by the visually able. The tactile bars and dots contribute greatly to the access of information and acceleration of independent communication of people with visual impairment. However, previously, many companies have used tactile bars and dots of various sizes more discretely; this has caused confusion for people with visual impairment. Under such circumstances, the Japanese Standards Association standardized new “Guidelines for all people including elderly and people with disabilities—Making tactile dots on consumer products” (JIS S 0011; 2000), to specify guidelines for the design of tactile bars and dots. Additionally, the International Organization for Standardization also enacted guidelines (ISO 24503; 2011) for tactile bars and dots on the basis of JIS S 0011.

The standards provide that tactile bars and dots be applied to manually operated product keys for two purposes: to provide location information for other functions
on the device and to identify control functions. These standards also specify that tactile dots mark the button to start the basic function of the device and that tactile bars mark the button to stop the basic function. However, the recommended sizes of bars and dots were not determined by objective and quantitative data, and sufficient reliable data on their appropriate sizes is not readily available. Specifically, the standards do not contain provisions concerning cross-sectional shapes, despite the probability that cross-sectional shapes affect the operational performance of these products. Hence, quantitative evidence for the appropriate dimensions of tactile bars and dots is required to revise existing (and devise new) standards. One of the most important issues is to clarify the sizes of tactile bars as distinguished from tactile dots among users with visual impairment. This is because tactile bars and dots are applied to keys with different functions as mentioned above.

In this paper, we evaluated the influence of tactile bar and dot sizes on the discriminability of the two among people with visual impairment.

**Method**

**Participants**

Ten younger adults (mean age 26.1 ± 4.6 years; range of duration of vision loss 0–3 years old) and 10 older adults (mean age 65.3 ± 4.0 years; range of loss of vision 0–12 years old) with visual impairment participated in this experiment. All participants were without skin injuries or dermatosis on their upper limbs.

**Stimuli**

Dots and bars of several sizes were used as stimuli for this experiment. Dot diameter, bar width, bar length, and the edge radii of their curvature (hereafter referred to as the “R”) were controlled (refer to Fig. 1 and Table 1). The height of all stimuli was 0.5 mm.

![Diagram of Tactile Bar and Dot](image)

**Fig. 1.** Dimensions of tactile bars and dots used in the experiment

<table>
<thead>
<tr>
<th>Table 1. Size conditions of tactile bars and dots</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Tactile bar conditions</td>
</tr>
<tr>
<td>R (mm)</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>0.00, 0.25</td>
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<tr>
<td>0.50</td>
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</table>

(b) Tactile dot conditions

<table>
<thead>
<tr>
<th>R (mm)</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00, 0.25</td>
<td>0.5, 0.8, 1.0, 1.5, 2.0</td>
</tr>
<tr>
<td>0.50</td>
<td>1.0, 1.5, 2.0</td>
</tr>
</tbody>
</table>

* The actual length is the size that adds each width to each length condition.
Tactile bar conditions were as follows. Bar widths were 0.5 mm, 0.8 mm, 1.0 mm, 1.5 mm, and 2.0 mm with each R of 0.0 mm and 0.25 mm. Moreover, the widths were 1.0 mm, 1.5 mm, and 2.0 mm with an R of 0.5 mm. We controlled the length of all tactile bars, and we added each width to each length condition: +0.5 mm, +1.0 mm, +2.0 mm, +3.0 mm, +4.0 mm. There were 65 conditions for the bar stimuli.

Tactile dot conditions were as follows: the diameters were 0.5 mm, 0.8 mm, 1.0 mm, 1.5 mm, and 2.0 mm with each R of 0.0 mm and 0.25 mm. The diameters were 1.0 mm, 1.5 mm, and 2.0 mm with an R of 0.5 mm. There were 15 conditions for the dot stimuli. All the above-mentioned conditions covered current recommended standardized sizes of tactile bars and dots. All stimuli were created by cutting the acrylic at the center of a 50 mm × 50 mm acryl plate.

Procedure

Participants tactually discriminated stimuli presented individually, in random order, by a two-alternative forced-choice task (2AFC, bar or dot). Participants touched the stimuli using only their index fingertip of the preferred hand throughout this experiment. Sixty-five bar conditions were presented three times each, and 13 dot conditions were presented 15 times each for a total of 390 trials for each participant (so as to eliminate order effects). Practice trials were presented before starting the experiment. Accuracy rates and discrimination times were measured. The influences of diameter and the R of tactile dots within each participant group were evaluated using analysis of variance (ANOVA) followed by Bonferroni adjustments for multiple comparisons on accuracy rates and discrimination times.

This study obtained permission from the Ethical Committee on Human Research of Waseda University.

Results and Discussion

Results of the tactile bar conditions

Both participant groups discriminated tactile bars from tactile dots faster and more accurately as the dimensional difference between bar length and width increased, regardless of the width and R conditions (refer to Fig. 2 & 3). In particular, most participants in both groups distinguished tactile bars of more than +2.0 mm from the tactile dots in less time and with high accuracy. On the other hand, in the + 0.5 mm and + 1.0 mm length conditions, both groups were not able to correctly discriminate all sized conditions of the tactile bars.

Previous studies have shown that both sighted individuals and those with visual impairment display age-related declines in tactile spatial resolution when passive tactile stimuli are applied to their index finger (Stevens et al., 1996; Goldreich et al., 2003). In contrast, Legge et al. (2008) proposed that people with visual impairment retain high spatial acuity of active touch well into old age on account of their daily tactile activities. Therefore, there was no marked difference in the tactile bar length condition between the two age groups because older participants had rich experiences with using touch for approximately 50 years since the loss of their vision.

On instrumental grounds, it is important to note that among younger and older adults with visual impairment, the discriminability of tactile bars depends on the difference between their length and width. The width and the R of the bars were not critical factors. Consumer electronics manufacturers cannot necessarily control the edge radius of curvature of tactile bars owing to limitations in the manufacturing process. However, they can apply
Fig. 2. Results of tactile bar conditions among younger participants

Fig. 3. Results of tactile bar conditions among older participants
discriminable tactile bars to their products by designing the bars in a way that they contain a sufficient difference between their width and length.

Results of the tactile dot conditions

The ANOVA results revealed the following effects. There was a significant effect of discrimination times in the younger group for diameter ($F_{2, 18} = 11.11, p < .001$). There was also a main effect for the R ($F_{2, 18} = 6.78, p < 0.05$) and diameter ($F_{2, 18} = 10.03, p < .01$) in accuracy rates for older adults. Each R ($F_{2, 18} = 13.86, p < .001$) and diameter ($F_{2, 18} = 20.50, p < .001$) as well as their interaction ($F_{4, 36} = 3.42, p < .05$) in terms of discrimination times achieved statistical significance. Overall, tactile dots with a larger R had higher discriminability than those with a smaller R for dots that were of identical height. Furthermore, both groups tended to perceive a tactile bar with a large R as a tactile dot when the difference between the length and width of the bar was very small, as in the +0.5 mm length condition (refer to Fig. 4 & 5).

One possible reason for the high discriminability of tactile dots with a large R is the loss of the dots’ morphological characteristics. Participants might perceive tactile dots with large a R as mere point stimulations, because the dots do not have sharp edges that are easily traceable by the finger nor do they have a large, flat surface on the top. Additionally, the superficial, touchable dimensions of these tactile dots might be slightly smaller than those dots with a small R. This is because the former dots have wide skirts, and skin tissue cannot easily conform to them. Thus, participants might perceive the dots with a large R as smaller than they really are. For these reasons, tactile dots with a larger R are more suitable when a tactile bar and a tactile dot are concurrently applied.
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References


