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Visibility of Guide Signs for Pedestrians in Motion: An Application of an Immersive Visual Simulation System

1. Introduction

   Urban facilities are growing increasingly larger and more complex, often leading to difficulty and stress for people seeking to navigate them. When we visit a complex railway station or a large shopping mall, we rely on guide signs to find our destination. These are not always helpful, however, since the sheer number of signs around us may distract us from picking up the necessary information. The presence of other pedestrians also adds to the difficulty by blocking our view. In crowded situations where we cannot disturb pedestrian flow, we must moreover be able to read signs while walking and paying attention to the people ahead. With the above in mind, the present study uses an immersive visual simulation system to examine the influence of observation conditions on sign detection and recognition by pedestrians in motion.

   Most previous research dealing with way-finding and guide signs (e.g., Tanaka and Sugawara, 2004) do not discuss the influence of observation conditions on sign detection and recognition from a quantitative viewpoint. Although many psychophysical studies have focused on the readability of individual sign attributes, for example color and type of lettering as well as background contrast, most have been conducted using static targets in laboratory settings that exclude environmental factors. Yata and Uehara (1991) tested the visibility of signs in a real setting (a railway station), but again only under static observation conditions.

2. Method

   Two experiments were performed for the present study. The first examined the readable range (readability threshold) of three types of sign lettering in motion. This served to determine conditions for the second experiment as well as to test the performance of the immersive visual simulation system known as the D-vision (Fig. 1). The D-vision displays wide-angle images (180 degrees both vertically and horizontally) capable of filling viewers' peripheral vision; viewers may also gain stereoscopic vision through the use of polarizing glasses. The second experiment tested the influence of various observation conditions on sign detection and recognition.
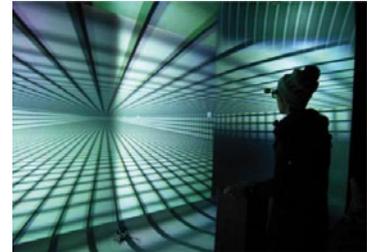

Figure 1: The immersive visual simulation system D-vision
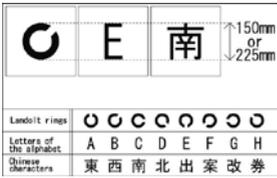
Left: Experimental setting for the standard stimulus

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Figure 2: Three types of targets

a) Landolt rings

b) Letters of the alphabet
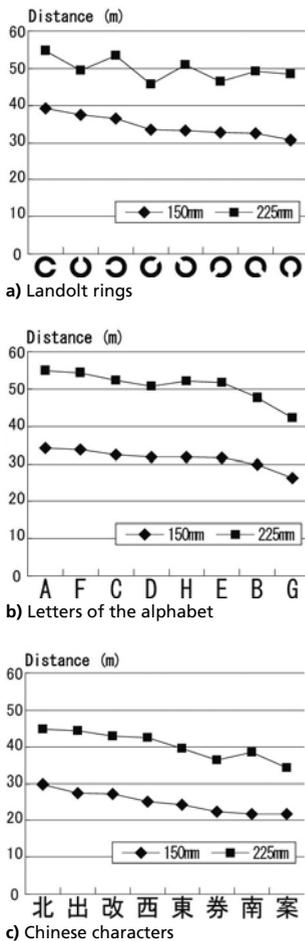

c) Chinese characters

Figure 3: Readability thresholds (average distance at which each target was detected)

3. Experiment 1: Threshold of sign readability from an observer while walking

3.1 Objectives and method

   To obtain the perceptual threshold (readability) of signs in motion, a series of psychophysical experiments was conducted using D-vision. Three types of stimuli were used: 1) Landolt rings, 2) letters of the alphabet, and 3) Chinese characters. Eight different figures were provided for each type (Fig. 2). The figures were printed at 2 different heights (150 mm and 225 mm) on square boards measuring 350 x 350 mm and 450 x 450 mm, respectively. The signs were put up in a virtual corridor 10 m wide and 5 m high at 4 positions combining 2 possible horizontal alignments (immediately in front of the viewer and 10 m to the side) with 2 vertical ones (2 m and 5 m high from the floor).
   The subjects, 3 university students, participated in 6 sessions (3 types of figures x 2 sizes). For each session, subjects were asked to tap a keyboard when they detected the target figure (assigned from among the 8 figures possible) while moving through the virtual space at a walking speed (1.5 m/s). At the moment of response, the distance between the observation point and the target was recorded.

3.2 Results and discussion

   At each session, detection distances were recorded for all 8 figures in all 4 possible positions, resulting in a total of 32 measurements per session. Since there was no clear difference in data whether by subject or by sign position, the results were analyzed by calculating the average detection distance for each target (Fig. 3). Although the absolute values have little meaning, given that they are based on data obtained in a virtually simulated space, they nonetheless indicate the relative readability of each figure: the farther the distance at which the target was detected, the easier it was to read. As expected, readability of figures fell along with increasing complexity. Interestingly, the readability of Landolt rings varied according to the position of the gap. Rings with a gap at the right, left, top, or the 45° positions in between tended to be detected at a farther distance, i.e., were easier to read, than those with the gap at the bottom. While the readability of Landolt rings is supposedly the same regardless of where the gap is (the reason they are used as standardized

symbols for testing vision), this does not seem to be the case for when they are in motion (Fig. 3a).

4. Experiment 2: Influence of observation conditions on sign detection and recognition

4.1 Objectives and method

Experiment 2 examined the influence of various observation conditions on sign detection and recognition while in motion. The factors tested were sign layout and presence of other pedestrians.

The degree of influence of a factor was determined by analyzing the detection distance for a comparison stimulus versus for a standard stimulus. Fig. 4a shows the virtual setting displayed by the D-vision for the standard stimulus. The main experimental space, made to resemble a concourse in a large railway station, was 15 m wide and 3.5 m high with byways 5 m wide extending every 15 m on both sides. The subject entered this space from a corridor 30 m long and 5 m wide shown at the bottom.

The subjects were 9 (4 male and 5 female) university students. The procedure for the experiment was the same as in experiment 1. Two indicators of degree of influence were calculated from the data as follows:

(1) Variation ratio (V)
    V = detection distance for comparison stimulus / detection distance for standard stimulus
(2) Detection ratio (D)
    D = number of targets detected / number of targets displayed

4.2 Results and discussion

4.2.1 Layout of signs

Density of signs: Two comparison stimuli were used for this test: lower density (7 signs per row, rows placed 10 m apart) and higher density (7 signs per row, rows placed 5 m apart). A significant difference (P < 0.01) in variation ratio was observed between the standard and higher-density stimuli, while the lower-density stimulus did not result in significant change (P = 0.068). The findings suggest that because the signs moved toward subjects at constant speed, the amount of visual information that they were required to process grew as the density of signs
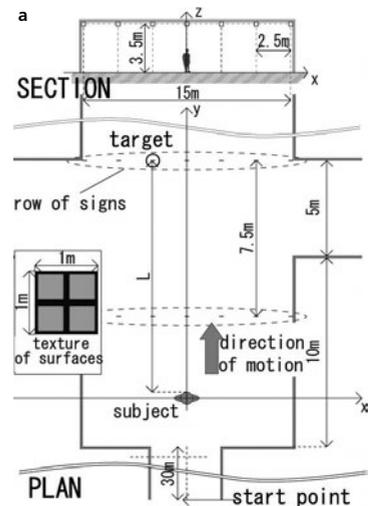
Figure 4: Experimental setting for the standard stimulus
a) Experimental setting
b) Standard stimulus:
- Seven Chinese-character signs displayed per every row placed 7,5 m apart in depth.
- Five occurrences of the target (selected from the 8 characters in Figure 3c) randomly placed among 210 signs.

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increased, resulting in information overload and lowered
performance after a certain level.

Aggregation: In this comparison stimulus, 2 sign boards were
paired above and below and placed at the same position as in the
standard stimulus. To make the number of signs (i.e., the amount
of information) per distance equal to that in the standard
stimulus, the distance between rows was made twice as long
(15 m). Two tests were conducted using signs of different sizes
(150 mm and 225 mm). As shown in Fig. 6, the results obtained
were inconsistent. With the smaller signs (150 mm), aggregation
had a significantly negative effect on readability ($P = 0.023$), while
for the larger signs the effect appeared positive, although the
significance level was low ($P = 0.053$). These phenomena may be
interpreted as follows. Since in the aggregated stimulus subjects
were faced with 14 signs at once, it took them more time to
complete searching for the target than with the standard
stimulus, thus lowering performance. This effect was more
remarked for the smaller signs because the distance at which
subjects grew able to read the lettering was shorter and the
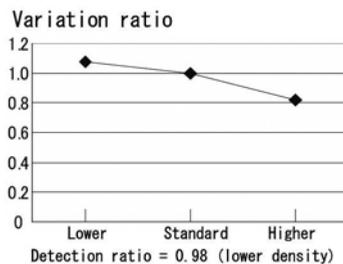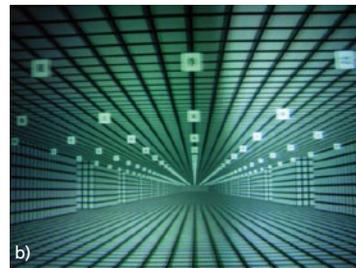movement of the signs away from view (optic flow) was therefore

Figure 5: Influence of density of signs
a) Comparison stimulus (lower density:
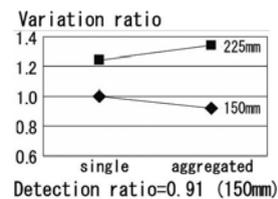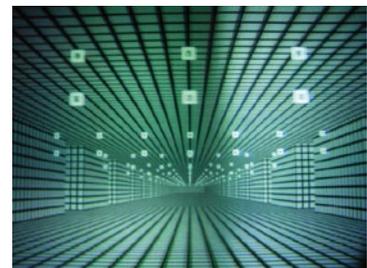7 signs/10 m); b) Comparison stimulus
(higher density: 7 signs/5 m

Figure 6: Influence of aggregation of signs;
Comparison stimulus (aggregated 150 mm
signs)

faster. As for the inconsistent effect seen for the larger signs, it may be that doubling the signs made them more noticeable, allowing subjects to know farther in advance where they would need to look before the lettering actually became readable.

Alignment: In this comparison stimulus, the sign boards were placed irregularly, i.e., they were shifted randomly from their original positions to the right and left and front and back within a range of 1.2 m as well as up and down within a range of 1.0 m. As shown in Fig. 7, a significant difference ($p < 0.01$) in variation ratio was observed between standard and irregularly placed stimuli. This may be because the lack of smoothness in eye movement caused by the irregular layout cost subjects more time while searching for the target.

4.2.2 Presence of other pedestrians

In a real setting such as a railway station, other people are usually also present and may affect readability of signs in at least 2 ways: as distracters of attention and as visual barriers.
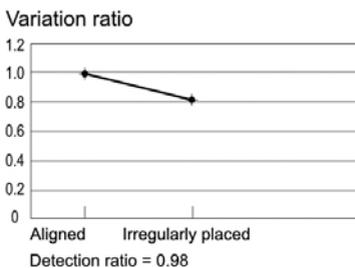

Figure 7: Influence of alignment of signs; Comparison stimulus (irregular placement)
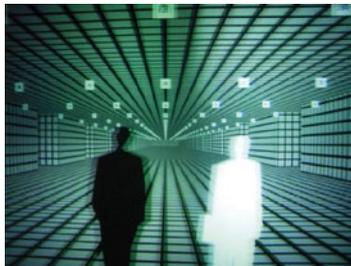
Figure 8: Influence of other pedestrians ahead; Comparison stimulus (silhouettes of other pedestrians ahead)

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Figure 9: The controller

Pedestrians ahead: In this comparison stimulus, silhouettes of pedestrians ahead (Fig. 8) were added to the standard stimulus. Subjects were asked to use a handheld controller (Fig. 9) to change motion along with the silhouettes, which moved at uneven speeds. The hypothesis that pedestrians ahead would disturb detection of the target was supported by the drop in the variation ratio ($P = 0.047$) and the detection ratio (0.82). This result may be explained by the allocation of subjects' limited resources of attention away from the task of searching for the target to keeping pace with others near them.

Density of surrounding crowd: In this comparison stimulus, silhouettes of a surrounding crowd (Fig. 10) were added to the standard stimulus at 3 levels of density. Signs were also placed on the side walls in addition to the ones on the ceiling. The signs on the wall were hidden by the crowd from time to time, while the ones on the ceiling stayed always visible.

The influence of crowd density on the readability of signs was not clearly evident from the variation ratio. However, the detection ratio of the signs on the ceiling dropped to 0.53 in highly crowded settings, while that of the signs on the wall remained at 0.97. It is interesting that the subjects tended to fail to detect the always visible signs on the ceiling while almost completely detecting the occasionally hidden signs on the wall. This result may also be related to allocation of attention.

5. Conclusion

The above experiments conducted using an immersive visual simulation system revealed that the readability of figures viewed in motion may differ from when they are viewed under static conditions. The following factors were found to be relevant to sign detection and recognition while in motion: 1) density of signs (amount of visual information), 2) smoothness of eye movement from one sign to another, and 3) allocation of visual attention. Although the results were obtained in virtual experimental settings, and the absolute numerical values therefore have limited meaning, the results nonetheless empirically clarify some of the mechanisms involved in the detection and recognition of guide signs by pedestrians.

References

Tanaka, M. and Sugawara, F.: The influence affect user with mixture environment of the sign for movement, and indoor advertising sign: A case of JR East Tokyo Station, Journal of Architecture, Planning and Environmental Engineering No. 585, Nov., 2004

Yata, A. and Uehara, K.: Hoko kukan ni okeru keiro tansaku no tokusei [Characteristics of way-finding behavior in pedestrian spaces], Proceedings of the AIJ [Architectural Institute of Japan] annual conference, 1991, pp. 689-90

Detection ratio
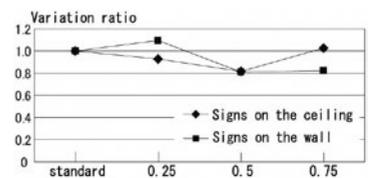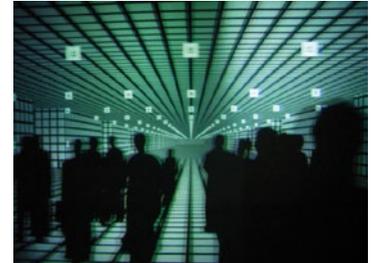
position	density (person/m²)		
	0.25	0.5	0.75
ceiling	0.81	0.86	0.53
wall	1	0.97	0.97

Figure 10: Influence of other pedestrians; Comparison stimulus (silhouettes of other pedestrians)