

Development of a Novel Type of Audible Traffic Signal for the Blind and Visually Impaired Pedestrians and Comparison of Its Acoustic Guiding Function with the Presently Used Audible Traffic Signal

Takashi Yoshiura (Koito Industries, LTD.)
100 Maeda-cho Totuka-ku, Yokohama 244 JAPAN.
Tel:+81-45-822-7101 , Fax:+81-45-826-4591 , E-mail:yoshiura-t@ysys.koito-ind.co.jp

Jinro Takato (Okayama Prefectural University.)
111 Kuboki Soja-shi, Okayama 719-11 JAPAN.
Tel:+81-866-94-2189 , Fax:+81-866-94-2206 , E-mail:jtakato@fhw.oka-pu.ac.jp

Kohei Takeuchi (Universal Traffic Management Systems Society.)
Airman's Building 7th Floor No6, 2 Ichigaya-Tamachi Shinjuku-ku, Tokyo 162 JAPAN.
Tel:+81-3-3235-6520 , Fax:+81-3-3235-6522

Hajime Sawai (Okayama Prefectural University.)
111 Kuboki Soja-shi, Okayama 719-11 JAPAN.
Tel:+81-866-94-2111 , Fax:+81-866-94-2206 , E-mail:hsawai@fhw.oka-pu.ac.jp

Masaki Tauchi (Okayama Prefectural University.)
111 Kuboki Soja-shi, Okayama 719-11 JAPAN.
Tel:+81-866-94-2188 , Fax:+81-866-94-2206 , E-mail:mtauchi@fhw.oka-pu.ac.jp

SUMMARY

We have analyzed the performance of the blind and visually impaired pedestrians to cross intersections at which audible traffic signals (ATS) were equipped and found out that they seem to have severe difficulties to take direction at the starting point of the crosswalk and to maintain direction toward opposite side of the crosswalk. We, therefore, developed a novel type of ATS that may provide the acoustic clue to walk toward the destination. In principle, the new ATS emits sounds alternately from two speakers positioned on both ends of the crosswalk. By using this ATS, it is inferred that blind pedestrians are able to walk at any point on the crosswalk using sound clue emitted from opposite side of the road. In comparison with the present ATS system, it was found that new ATS is able to indicate a certain direction to walk while the effect was almost negligible in the present ATS.

INTRODUCTION

In order to cross the streets safely, visually disabled people must carry out some consecutive subtasks such as to detect crosswalk, to confirm the direction to walk, to estimate its length, to maintain the right direction to walk and to confirm the arrival at the opposite side of the street (see Fig. 1). Previous reports have also shown that the following conditions must be fully met in order to allow the visually impaired to cross the street safely 1,2). It is obvious that all of these tasks are quite difficult or stressful

to perform without any help of certain assisting systems. Since 1965, audible traffic signals (ATS), making sound signals corresponding to phase "walk" pedestrian light signal, have been developed and are ubiquitous in many Japanese cities or towns for the purpose of helping the visually disabled pedestrians to cross intersection. The present ACE may provide the pedestrians with clues for some of the requirements described above, such as detection of the presence of crosswalk and acknowledgment of time when light signals turn to green ("walk"). However, it may still be difficult for the blind to take an appropriate direction to start at the beginning and to keep the direction properly during crossing, since the present ACE emits sounds simultaneously from a pair of speakers facing each other. Therefore, we have developed a new ACE, in which the two speakers locating each end of the crosswalk generate sound signals alternately). Because tones emitted from the two speakers are temporally distinctive each other, it is expected that the new system allows the visually disabled street-crosser to spatially isolate the signal tone that marks the direction toward which he should walk. In this study, we evaluate the effectiveness of both the present and the newly developed ATS systems to guide the visually disabled crossing street by giving a clue for direction taking.

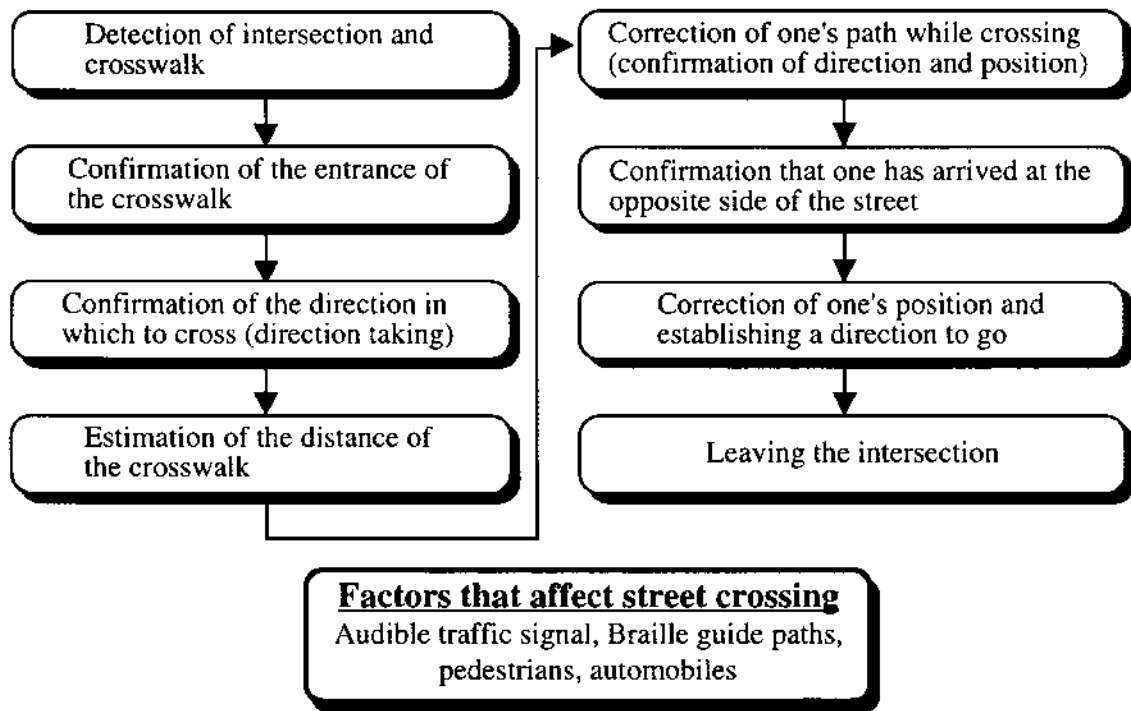


Fig. 1 Schematic diagram showing a series of tasks required to the visually disabled to cross intersection

METHODS

EXPERIMENTAL EQUIPMENT AND ARRANGEMENT

All experiments were carried out in a behavioral sciences laboratory at Okayama Prefectural University. The room (L: 700 cm , W: 645 cm, H: 290 cm) is a semi-anechoic chamber, and can be shielded from external sound and light during the experiments. In the room, a pair of ATS speakers (SP1, SP2) were positioned facing

each other 7 m apart, at a height of 2.25 m above the floor. The speakers were set facing downward toward the floor at an angle 45 degrees. A felt carpet was spread on the floor to suppress any echo. A total of five chairs were placed on the straight line between SP1 and SP2, chair A placed facing SP2 in a position 1.5 m from SP1, and chairs B, C, D, and E placed facing SP2 at 1 m interval. Chair A is taken to be near one end of the crosswalk, and chair E is taken to be near the end on the other side of the street. The experiment employed an ATS for the visually disabled made by Koito Industries, which generates "birdcall" tone as signals in either simultaneous mode or alternate mode. The former mode was denoted "same phase" in which SP1 and SP2 sound simultaneously like the present system, and the latter mode was denoted "different phase", which is newly developed as SP1 and SP2 sounding in alternation.

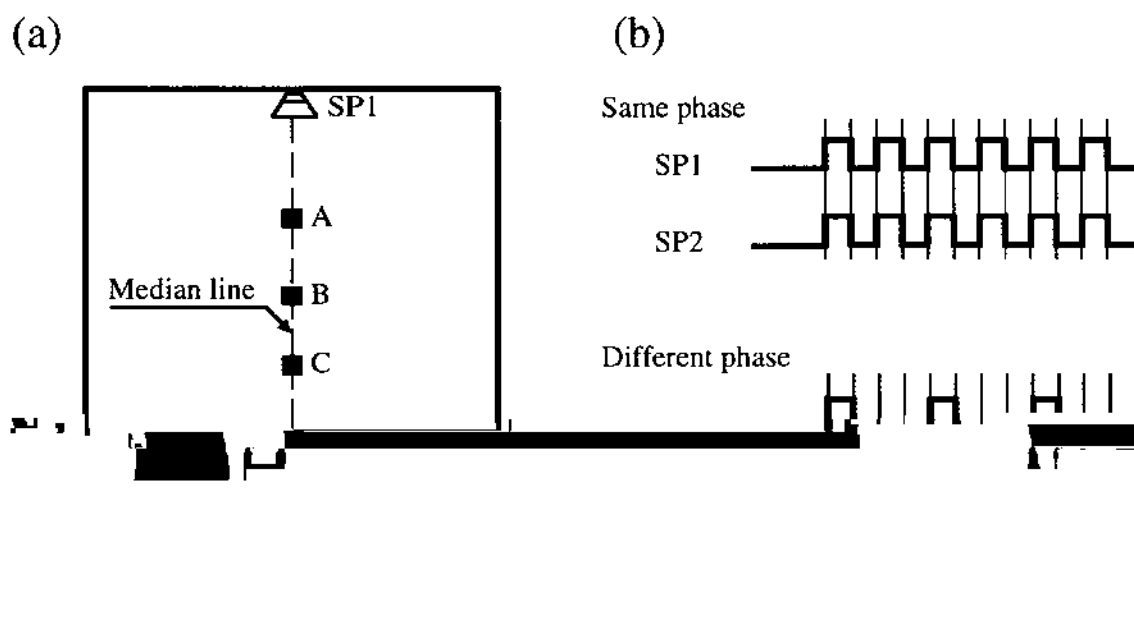


Fig. 2 Outline of the experiment room (a) and sound signaling pattern (b)
 Filled square in (a): seating position, SP: ATS speaker

**EXPERIMENT 1: IDENTIFICATION OF THE SOUNDING SPEAKER
 (FIXED POSITION EXPERIMENT)**

The test subjects were seven sighted persons (three males, ages 47, 38, and 28, and four females, ages 21-22). The subjects were each blindfolded and helped by a guide to a random seat in a position A-E. Signal sound was played once for 10 seconds in either "same phase " or "different phase", and then each subject answered to whether or not the speaker to the front was emitting a sound. This was done a total of 755 times with all the subjects.

**EXPERIMENT 2: DIRECTION TAKING TO THE SOUNDING SPEAKER
 (WALKING EXPERIMENT)**

Eight sighted females (age 21-22) participated in this experiment as the test subject. They were each blindfolded during the experiment. Before starting subjects were directed to face to SP2 at angles 20 degrees left (L20), 0 degrees (MID), or 20 degrees right (R20) in

each trial. Thereafter subjects were asked to start to walk and take direction toward the goal (SP2). For each trail, signal sound was played until the subjects reached to the goal or they were finished to walk by the guide. The trail was done a total of eighteen times (two sounding patterns x three different stating angles x three trials) for each subject. In total, 144 trials was done with all the subjects. Trace of walk by the subjects was recorded by means of 'Ultrasonic Two-dimensional Position Detection Device' developed for this experiment. An ultrasonic emitter attached to a headgear was used by the subjects and the location of subjects while they were walking was calculated by a personal computer.

RESULTS

EXPERIMENT 1: IDENTIFICATION OF THE SOUNDING SPEAKER (FIXED POSITION EXPERIMENT)

The average correct-answer rate at the seat position of each of the subjects was determined, classified by type of sound pattern, and the standard deviation (SD) of the average correct-answer rate of the seven subjects was computed, classified by sound pattern. With the "same phase" sound pattern, the correct-answer rate was 64.17% at seat A, 82.67% at seat B, 93.3% at seat C, 98.3% at D, and 100.0% at position E. With the "different phase" sound pattern, the correct-answer rate was 95.0% at position A, 88.3% at position B, 88.3% at position C, 96.67% apposition D, and 100.0% at position E. Variance analysis was conducted to compare the correct-answer rate for the various positions and the sound pattern conditions "same phase and different phase". This analysis found a significant interaction between position and sound pattern condition ($F(4,20)=3.84, p>0.05$). With regard to the simple effect of position under the condition of "same phase" , multiple comparison by the LSD method showed a significant difference in the average between position A and the other positions B, C, D, and E, and between position B and positions D and E (MSE= 624.4 33, 5% level).

These results show that there is a difference between "same phase" and "different phase" in listening position, and that individually, the average correct-answer rate in position A is significantly higher for "different phase" than for "same phase". With regard to sound pattern conditions, there were no differences in the average correct-answer rate from one position to another with "different phase", but there were with "same phase" . Individually, the average correct-answer rate at position A was found to be significantly lower than at the other positions B, C, D, and E, and the average correct-answer rate at position B was found to be lower than at positions D and E.

EXPERIMENT 2: DIRECTION TAKING TO THE SOUNDING SPEAKER (WALKING EXPERIMENT)

This experiment was done to examine whether the subjects are able to use the sound clue for direction taking while they are walking from one speaker toward another speaker. In four out of 36 trials in the "same phase", the subjects failed to reach the goal area set below SP2. On the other hand, they failed only twice in the "different phase". All the last walking traces in each of the three different starting angles were overlaid and shown in Fig. 4. In both L20 and R20, there seems to be a tendency that traces in the "different phase" (blue lines) locate more centrally along the median line (Fig. 2-a) than those in the "same phase" (red lines). When the subjects walked straight toward SP2 (MID), the traces in the "different phase" tend to converge more around the median line than those seen in the "same phase". Most of the subjects described that they could walk with confident in direction taking in the "different phase" rather than in the "same phase". Quantitative measurement was also done to clarify the difference between "same phase" and "different phase". For this purpose, deviation of traces from the median line was measured at three different locations (1.5, 2.5, and 3.5m from the starting point). The veering from median line, observed as average distance and standard deviation, is always larger in "same phase" than that in "different phase".

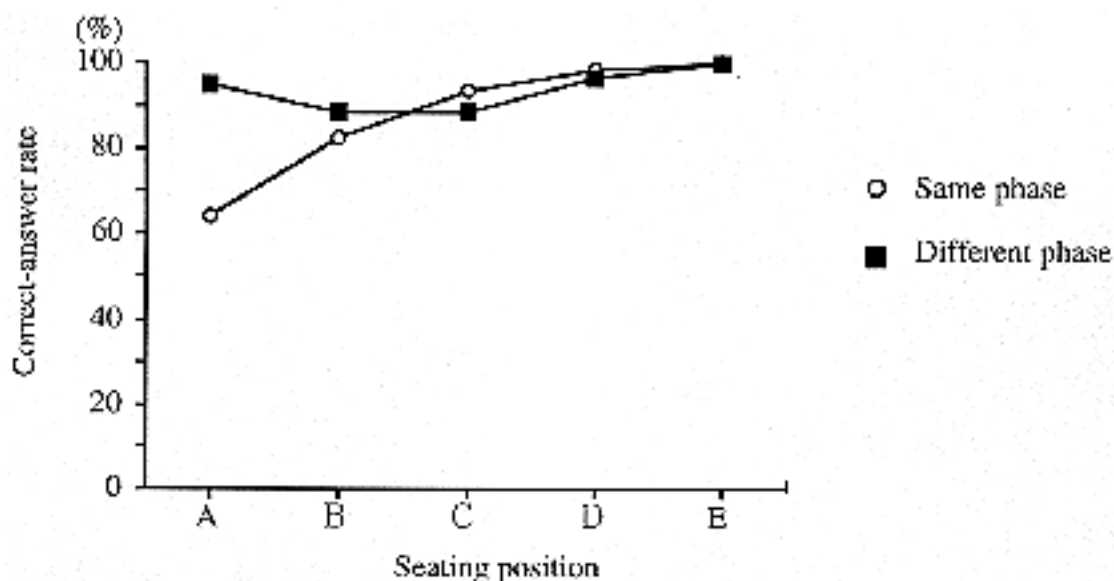


Fig. 3 The correct-answer rate at various seating positions under various sound pattern conditions

Analysis of variance between different seating positions in the 'same phase' condition showed a significant difference between A and B, C, D, E, and between B and D, E. In different sound pattern conditions, a significant difference between 'same phase' and 'different phase' was found at position A.

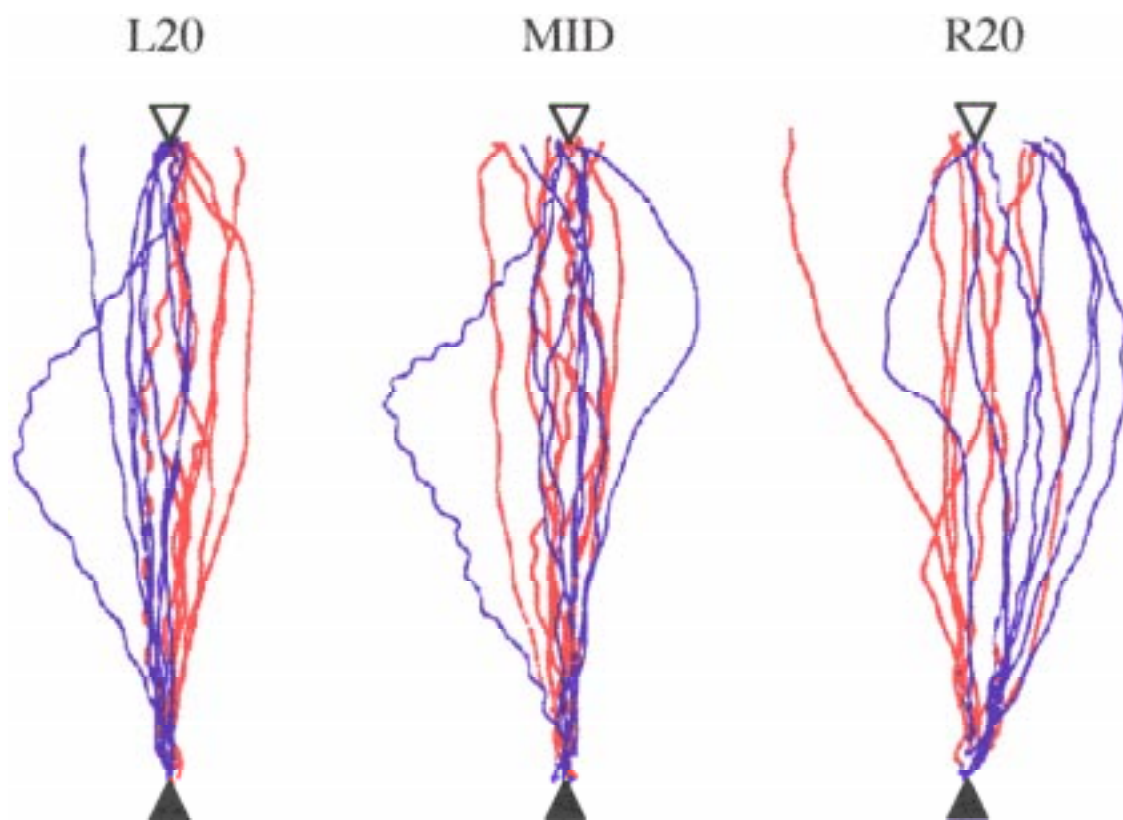


Fig. 4 Comparison of the trace of Subjects between different sound pattern conditions

Subjects stood below one speaker (filled triangle, SP1 in Figure 1-a) started toward the other speaker (open triangle, SP2 in Figure 1-a) at angles 20 degrees left (L20), 0 degree (MID) and 20 degrees right (R20) to the straight line connecting two speakers. Blue trace: 'same phase', Red trace: 'different phase'

DISCUSSION

This study was motivated by the observation that the visually disabled have few tactile or auditory clues about the direction in which they are walking and whether they are keeping to the right path in crossing the street. The two kinds of experiments, "fixed position and walking experiments", were carried out to estimate to what extent the current type ("same phase") ATS and newly developed type ("different phase") ATS help in confirming the direction (orientation) in which to cross, and maintaining one's path while crossing the street. We conducted a study of whether the ATS for the visually disabled that are currently in use provide, with their sound patterns, the functions of indicating direction and guiding the visually disabled pedestrian, and a comparative study with the "alternate sound" method that is proposed recently 3). In the first experiment (fixed position experiment), a comparison between "same phase" and "different phase" showed that the average correct-answer rate at the various listening positions is roughly constant under the "different phase" condition and those values are as high as 93.7% in average, which indicates that the sound of the speaker on the opposite side of the street may be distinguished from where the pedestrian enters the crosswalk. Under the condition of "same phase", the average correct-answer rate is lowest, 64.2%, at the position A (corresponding to the beginning of the crosswalk) and describes a curve that gradually rises thereafter. This raise is thought to be because the sound volume of the speaker on the opposite side appears gradually louder as one approach to the speaker, providing

confirmation. There is a significant difference at the position A (presumed as a beginning of the crosswalk) when one alternately compares these "same phase" and "different phase" conditions. This suggests that near the beginning of the crosswalk it is easier to recognize the sound of the speaker on the opposite side of the street under the condition of "different phase" than under the condition of "same phase".

The above makes it clear that the sound from the opposite side of the crosswalk is more difficult to recognize at the beginning of the crosswalk with the present system than with the "alternate sound" method. That is, the orientation of the sound source for the direction in which the pedestrian should cross (meaning measuring the spatial positions of the sound source, the direction of the sound source, and the distance from the sound source) is difficult to determine with the present system ("same phase", "simultaneous sound"), which suggests that the "alternate sound" method (different phase) makes it easier to determine the goal toward which to walk. Applying the results of these experiments to the case in which different positions are hypothesized along the crosswalk, with the present system it is difficult to determine the direction as one begins to cross but becomes possible as one draws nearer to the speaker on the other side of the street (at intermediate locations). By contrast, the "alternate sound" method makes it possible to identify the direction regardless of one's position in the crosswalk.

It must be noted that what the experiment 1 resolved was the identification of a single sound source (confirmation of the sound from the speaker located in the forward direction), and not necessarily how accurately the position of the sound source can be determined. The fixed position experiment is somewhat different from real situation in which visually disabled have to cross intersection without any stop on their travel to the goal. We thought that the experiment 2 (walking experiment) in which the subjects walk taking direction toward the sounds emitted from the speaker located in front of them would give an answer to this question. As a result, "alternate sound" method appeared to be more reliable to take direction during walking than "simultaneous sound" showing that the deviation of the subject's traces from the most efficient line to reach to the goal is smaller (Fig. 4). From this result, it is implied that visually disabled pedestrian could rely on the "alternate sound" for taking direction not only at the beginning but also while crossing the street.

At Present there are no audible traffic signals that satisfy all the requirements that visually disabled need to cross the street safely. But the "alternate sound" method proposed in this paper seems to suggest one solution for a number of these requirements.

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REFERENCES

- 1)Ohkura, M., Murakami,T., Shimizu, O., Tauchi,M. & I. Tanaka : Clues for blind travelers to cross intersection. Proc. of International Mobility Conference 6, 219-222, 1991
- 2)Tauchi,M., Ohkura, M., Murakami,T. & Shimizu, O.: A consideration of tactile tiles and Audible traffic signals installed in Japan. Proc. of International Mobility Conference 7, 206-209, 1994
- 3)Tauchi, M., Sawai, J., Takato,J. & Yoshiura, T. : A novel system of auditory traffic signals which may navigate the blind to cross streets. Jpn. J. Ergonomics, 33 (suppl.) 310-312 ,1997 (in Japanese)