A STUDY OF SONIC GUIDANCE SYSTEMS FOR VISUALLY IMPAIRED PERSONS TRAVELING ON THEIR OWN

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SUMMARY

Various types of sonic guidance systems, using multiple speakers, were considered for the purpose of providing navigational clues for vision impaired people traveling on their own or people moving under low visibility conditions. Three types of sonic guidance systems were examined for this study. Each of them consisted of one pair, two pairs or multiple pairs of speakers emitting identical or different sound at various intervals. To provide navigational clue for visually disabled people, a pair of speakers located at both ends of a certain route appeared to be sufficient when different sound signals form a pair. The system using one pair of speakers, however, had a limitation in pinpointing sound sources for users with visual disability. The systems using two pairs of speakers were found to be more advantageous to localize sound sources rather more precisely than that using a pair of speakers. There seem to be a lot of possibilities to introduce these sonic guidance systems into various outdoor or indoor environments for reducing mental stress and danger of visually disabled travelers who walk alone.

INTRODUCTION

The growth in opportunities for visually impaired persons to take an active role in society has brought with it the need for assistance measures to ensure the safety of visually impaired persons traveling on their own and make it more convenient for them to do so. Convoluted routes, open spaces without any tactile clues, short train platforms, limited time for crossing streets, level changes, and the need to avoid dangerous items not only pose difficulties for visually impaired persons, they are also often accompanied by danger.

Audible traffic signals have been used at crosswalks for many years in Japan to help overcome these problems 1,2.3,4). Audible traffic signals are well known as a classic assistance tool for visually impaired persons traveling on their own, and they are used widely around the world. Through recent research, however, it has become evident that the only function of these very widely used audible traffic signals is to inform visually impaired pedestrians of when the walk signal is green 5,6). They do not possess features for indicating crossing direction, and because of this visually impaired persons experience considerable stress as they actually encounter danger and experience difficulties. Not enough audible traffic signals have been installed thus far, and consideration must be given when proceeding with future installation to improving audible traffic signals in line with users' needs and to incorporating navigation assistance features.

A new type of audible traffic signal with navigational features has recently been developed and is now actually being used at crosswalks in Japan 7,8). This new type of signal alternately emits different sounds from speakers located on opposite sides of a crosswalk, in contrast to conventional audible traffic signals, which emit the same sound simultaneously from speakers on opposite sides of a crosswalk. With this new sonic guidance system it will be possible to provide visually impaired pedestrians with pointers to help them determine the direction in which they wish to cross before they begin crossing the street and help them to confirm their position and make any necessary adjustments while crossing.

There are still a number of issues surrounding this system requiring further investigation. One question is to what extent visually impaired persons crossing long crosswalks will be able to pinpoint the source of the sound coming from speakers positioned on opposite sides of a crosswalk, far away from them, with this new system. Another is to what extent this system will be able to overcome the impact of many different acoustic reverberations and environmental noise from the area surrounding the crosswalk.

In the present research we attempted to identify the strengths and weaknesses of various sonic guidance systems in guiding visually impaired persons along routes chosen by the persons themselves by building test models of the various systems, specifically focussing road crossing. Our evaluation of these systems focused on how accurately and quickly the subjects were able to determine their forward direction with little psychological burden. On the basis of these tests, a number of potential systems were chosen, and directions for development in line with conditions in the usage environment were identified.

RESEARCH METHODS

Acoustic Workstation: Using an acoustic workstation (DPP200 from Cameo Interactive Co.), we emitted multiple sounds (1-10 ch) at various places and at random timings. The sound used in the experiments was white noise, a sine-modulated version of white noise, or sounds used with audible traffic signals in use in Japan (simulated bird sounds). White noise and a simulated bird song (chirp sound) were used with identical-sound systems and a simulated bird song (cuckoo) was used with differentiated-sound systems. One typical

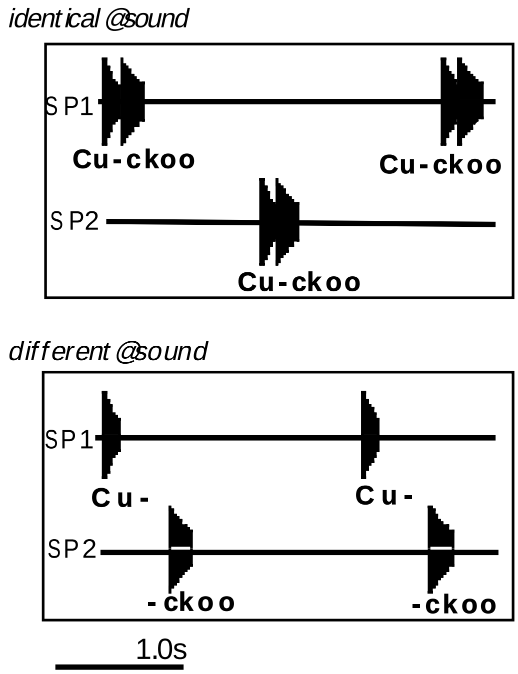

Fig.1 Patterns of sound signal emitted from a pair of speakers. In this example, a simulated bird song, cukoo sound, is shown.

example of a simulated bird song is shown in Fig.1.

Speaker installation: We used compact speakers (number 21 speakers according to Police Agency specifications) 9). The speakers were set at a 45-degree angle to the road and installed at a height of 2.0 meters (2.5 meters outside).

Experiment Site: The experiments were conducted in an indoor semi-anechoic chamber (6 by 7 meters) and in an outdoor parking lot (40 by 40 meters).

Subjects: Five sighted persons (wearing eye masks) and five visually impaired persons participated in the experiments. After having the subjects walk according to the various experimental conditions, we questioned them about their impressions in line with a prepared list of questions. The impressions asked were confidence of localizing sound sources, simplicity in catching sound cue, rhythm adjustment between gait and sound cue, strength of concentration on catching sound cue and so on.

Recording Method: The tracks of the subjects as they walked, guided by acoustic pointers, were recorded with an ultrasonic two-dimensional movement analysis device indoors and by two video cameras outdoors.

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FINDINGS

Two-Speaker Sonic Guidance System

Sonic guidance systems using two speakers are used in existing audible traffic signals. In this experiment, two speakers were positioned at the opposite ends of a route of travel (straight-line configuration). Different sounds were emitted from the respective speakers at comparatively short intervals (from several hundred milliseconds to three seconds). When the same type of sound was emitted from both speakers, the subjects became unable in many cases to distinguish between the two sounds at the midpoint of the walking path. In contrast, when different sounds were used, the subjects were able in a significant majority of cases to clearly distinguish between the two sounds across the entire walking area. The ease with which subjects were able to identify the sound source was largely affected by the volume of the sound, the distance between the speakers, and the interval between the

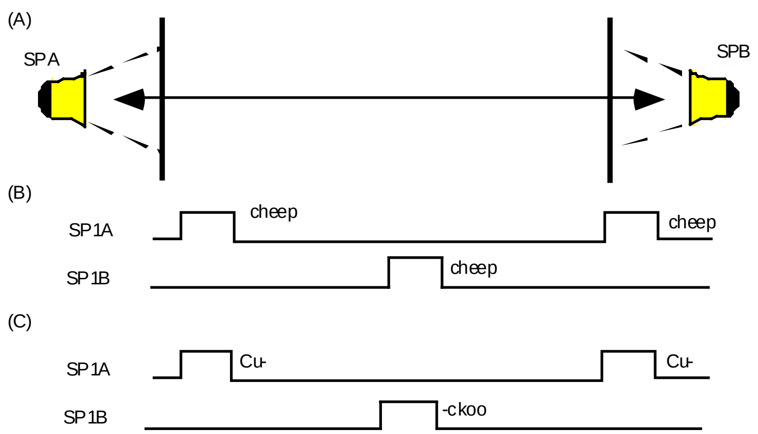

Fig.2 The schema shows a sonic guidance system with a pair of speakers. A timing of sound emission of "identical sound" and "different sound" is shown. Different sound emission mode functions better than identical sound mode in terms of sound localization.

sounds. Many of the subjects reported that when the interval at which the sounds are emitted exceeds one second, it takes time to pick up the sound, making it more difficult to navigate by the sounds. From these findings it appears that consideration must be given both to how easy it is to orient oneself and to walk with respect to a sound source, and to this end the duration of the sound and the interval between sounds must be set properly in this type of system.

Four -Speaker Sonic Guidance System

In an experiment using four speakers, two pairs of sound-emitting speakers were positioned at the opposite ends of a route of travel (straight-line configuration). The two speakers on the same side were placed one to three meters apart, perpendicular to the route of travel, so that the midpoint between the speakers would correspond to the center of the imagined route of travel. A comparatively short sound (100-500 milliseconds) was used. The following four methods of emitting sounds were examined:

1) Two pairs of speakers were formed with the speakers in each pair positioned parallel to the route of travel. Sounds were emitted simultaneously from one side, and then the same or different sounds were emitted from the speaker pair on the other side (Fig. 3).

2) Sounds were emitted alternately from the same speaker pair as in (1) and alternately from the other pair, and the same or different sounds were used (Fig. 4).

3) Two pairs of speakers were formed with the speakers in each pair positioned diagonally to each other on opposite sides of the route of travel, and sounds were emitted under the acoustic conditions described in (1) and (2) above (Fig. 5).

4) Two pairs of speakers were formed with the speakers in each pair positioned on both ends of the route of travel. Different sounds were emitted alternately from the speakers at opposite ends of the route of travel and by the same method by the pair at the other end after a time interval (Fig. 6).

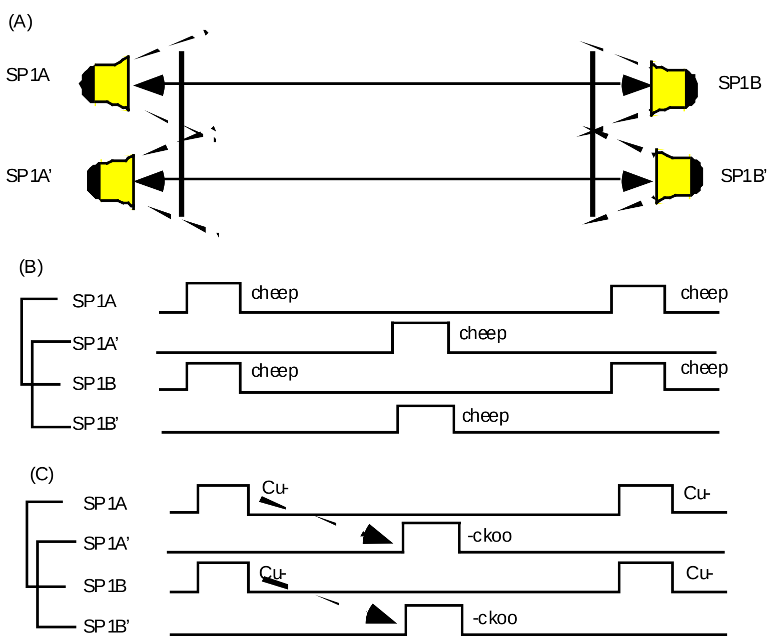

Fig.3 Two pairs of speakers emit identical or different sound alternately. Each pair of speakers emits signals simultaneously. (A) arrangement of speaker locations on a straight route. (B) timing of sound emission of an identical sound. (C) timing of sound emission of an identical sound.

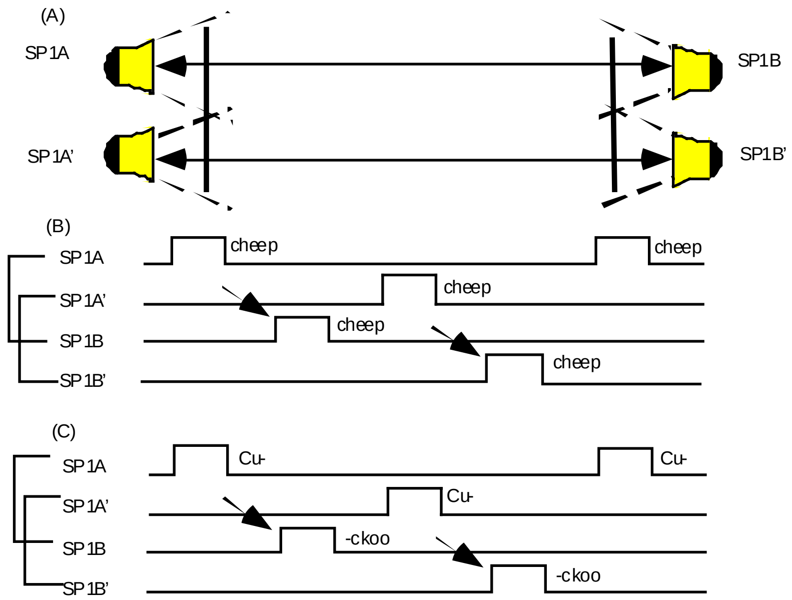

Fig.4 Two pairs of speakers emit identical or different sound alternately. Each pair of speakers also emits a signal alternately. (A) arrangement of speaker locations on a straight route. (B) timing of sound emission of an identical sound. (C) timing of sound emission of an identical sound.

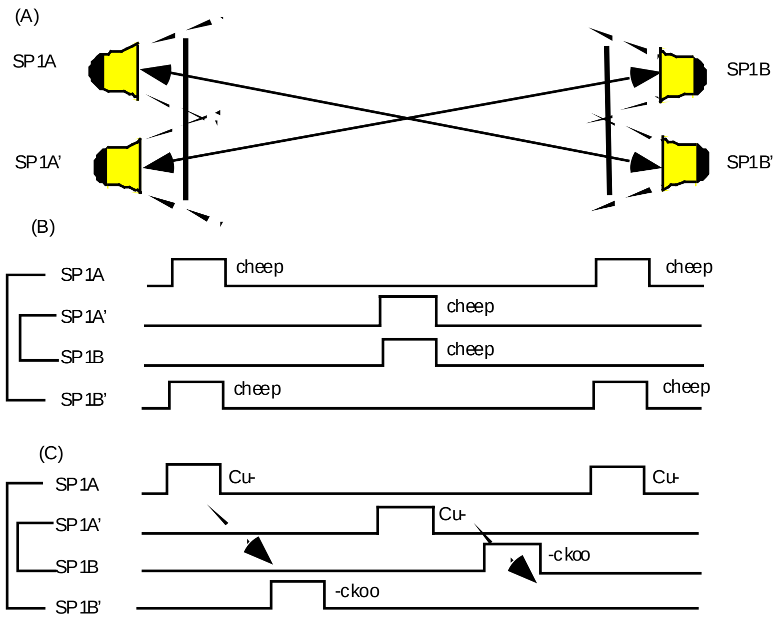

Fig.5 Two pairs of speakers positioned diagonally emit identical or different sound alternately.Each pair of speakers emits a signal simultaneously or alternately. (A) arrangement of speaker locations on a straight route. (B) timing of sound emission of identical sound. (C) timing of sound emission of different sound.

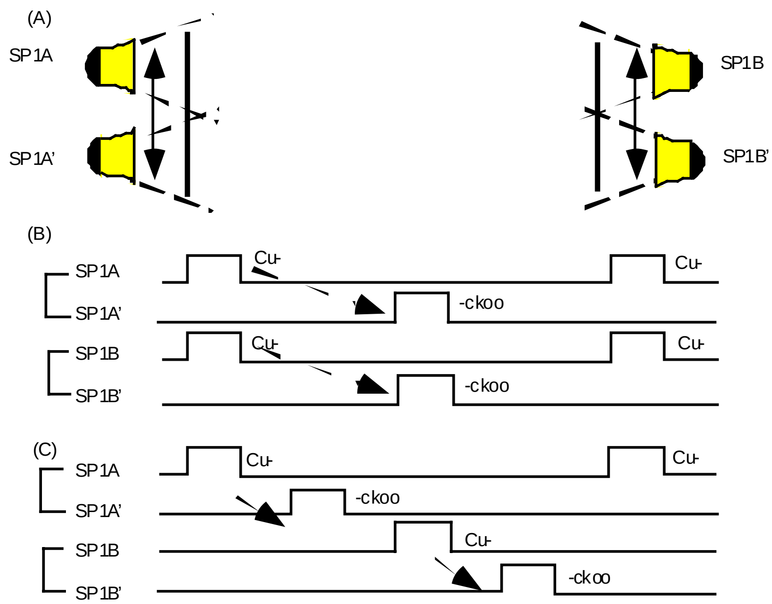

Fig.6 Two pairs of speakers located side by side form pairs at both side of a straight route.Two pairs of speaker emit a signal simultaneously (B) or alter-nately (C). A pair of speakers emits a signal of different sound.

Through this experiment we found that while all four methods are effective, all except the fourth method suffered from the same problem: When the subjects strayed significantly out of the route of travel, it was difficult for them to return to it.

Using Multiple Speakers

In two and four-speaker guidance systems described above, a method was adopted of giving pedestrians a single point as a remote target using a comparatively small number of speakers (two to four). In this part of the experiment, however, we tested a method that involved placing a relatively large number of speakers (five to twelve) along the route of travel and emitting the same type of sound simultaneously or at a specified time interval from the speakers. We found that with this method it is effective to create a sound flow as long as the speakers are comparatively close to one another (three meters but depending on volume of sounds) so that the sound of each of the speakers can be clearly heard. It was thought, however, that a different flow would be required in each direction of travel. Many of the subjects reported that a method of simply emitting sound from each speaker was easy to use because the volume gets louder as you proceed.

OBSERVATIONS

Visually impaired persons moving about on their own encounter a wide variety of difficulties in the various environments they navigate; on sidewalks (and train platforms), in open spaces (parks, crosswalks), and in closed spaces (corridors and stairways inside buildings). It is essential to properly provide visually impaired persons, who have difficulty orienting themselves (determining their own position within the environment), with a variety of information before they depart or at the actual sites of travel. Providing proper assistance at actual sites is especially important when visually impaired persons are performing tasks that must be completed within a limited amount of time or are navigating dangerous places, such as level changes, or environments where the only pointers are visual ones. Sonic guidance, our main focus here, is regarded as a simple and economical assistance system that can appeal to visually impaired persons' other senses and that makes it possible to indicate specific remote targets that cannot be conveyed through tactile information. Each of the sonic guidance systems that we studied at this time has different features, but most are effective to some extent in helping visually impaired persons to navigate. It is impossible, however, to discuss their application in real environments without reference to the characteristics of the environments in which they are to be used 10). Efforts must be made to clarify the range of environments in which such systems can provide assistance, including methods for assisting in tasks that must be performed in open spaces within a limited amount of time and navigation assistance during emergency evacuations and in dangerous places, where tension is extremely high, taking into consideration environmental conditions and psychological state of visually impaired persons.

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