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Research article

Experimental observations on the optimal layout of orientation blocks for safe road crossing by the visually impaired

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ABSTRACT

For people with visual impairments who face difficulties when crossing the road, in urban areas of Japan the infrastructure designed to provide an indication of crossing direction and the curbstones at sidewalk-roadway boundaries often varies in reliability from one crossing to another. If anything, this promotes stress for users and is an issue for which improvement is urgently needed. The authors have proposed new orientation blocks to be installed at crosswalk entrances as a means of more accurately indicating to people with visual impairments the trajectory to follow when crossing the road, and in prior research have derived desirable specifications for the profile of these blocks and their position relative to tactile walking surface indicators (TWSI).
For this paper, in order to examine in greater detail the desirable position of orientation blocks relative to TWSI, the authors conducted an experiment using totally blind subjects to evaluate conditions on a 10 m walk that simulated an actual crossing. The results, based on observations of the trajectories walked by participants in the experiment and interviews eliciting their subjective evaluations, showed that separating orientation blocks and blister tactile blocks by about 8–12 cm is effective in constraining lateral deviation at a point 5 m from the start of crossing and that an 8 cm separation was desirable in order to maintain an effective reduction of mental stress while crossing.

1. Introduction

In Japan, to ensure that people with visual impairments can move around outside safely and securely, guidance systems such as tactile walking surface indicators (TWSI), acoustic traffic signals, and tactile maps and information boards are widespread throughout the country. In the half-century since TWSI were invented in Japan in 1965, they have spread to countries around the world as a way to support independent walking by people with visual impairments, and Japan has taken the lead in developing guiding principles and guidelines with respect to methods for installing them.

Crossing at intersections is one of the situations frequently cited as problematic for the visually impaired when moving around in urban areas; there are even reports that one in five people with visual impairments have experienced an accident in a crosswalk [1]. Specifications and installation methods for tools such as acoustic traffic signals and "escort zones" to assist people with visual impairments when crossing the road have been discussed from various approaches, with a great deal of research conducted and numerous examples of application in the real world [2,3]. Nevertheless, as in situations where installation is problematic for various reasons or the protrusions in escort zones have worn over time to the point that they provide greatly reduced support [4], there are many cases in which crossing support infrastructure is inadequate or inappropriate and the continuity of support has not been maintained because TWSI at sidewalk-roadway boundaries have not been properly installed [5,6]. Because TWSI spread without sufficient consideration of installation methods or clearly determined guidelines after they were first installed in Japan in 1967, they can be found around the world in many forms and using many installation methods that were developed independently, resulting in numerous variations from country to country. Today, progress has been made in creating standards and guidelines for installing TWSI and other tactile guidance methods and there is great significance in finding in Japan, where efforts are being made to lead the way in reviewing more correct methods, a model case for solving problems that occur when crossing the road.

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At the same time, people with visual impairments often "square off," a basic technique for determining direction of movement [7], using curbs at the sidewalk-roadway boundary [8]. This involves detecting the difference in level at the curb with the underside of the foot and determining the crossing direction to be perpendicular to the line along which the curb is aligned. However, this often leads them to head in the wrong direction since the curb is not necessarily perpendicular to the proper crossing direction [5], and there are also cases where this technique cannot be used due to the elimination of the difference in level at the sidewalk-roadway boundary. There have been efforts to balance the needs of the visually impaired with the demands of wheelchair users by making the surface of the curb bumpy or making the crossings slope multi-stepped [9], but the question of how to resolve the issue of the difference in the relationship between the curb alignment and the crossing direction for people with visual impairments has not yet been considered.

Although there are multiple clues at crosswalk entrances to assist the visually impaired in identifying the direction in which they should cross, their reliability often varies by crossing situation along the walking route, a situation that, if anything, promotes stress for those involved, can inadvertently induce mistaken crossing behavior, and is an issue for which improvement is urgently needed. While it would be desirable to actively confirm and correct inappropriate installations of TWSI based on accessibility guidelines such as *Doro no ido to enkatsuka seibi gaidorain* [Guidelines for Improvements to Facilitate Roadway Mobility] [10], there may be cases in which such repositioning unavoidably requires numerous drastic, large-scale measures. If, in such cases, the addition to existing infrastructure of equipment dedicated to orienting users to the crosswalk direction would more easily create a highly reliable support environment, then the need to develop such a tool would be high.

The authors, seeking to develop methods to increase safety for the visual impaired when crossing the road, have previously proposed a new type of block to be installed at crosswalk entrances that is dedicated to indicating direction ("orientation blocks") [11] and, through walking experiments conducted with totally blind subjects in a test space, have derived desirable specifications for the profile of these blocks and their positioning relative to TWSI. This paper seeks to evaluate longer-distance walking conditions that approximate actual crossing distance and to examine, in more detail than the experiments done during prior research, how to install orientation blocks to ensure optimal positioning that provides effective guidance.

2. Overview of orientation blocks that support road crossing

The safety of people with visual impairments when crossing has dramatically improved due to the installation of acoustic traffic signals and, in recent years, the proliferation of escort zones, but in addition to such improvements not being available at many crosswalks there are also examples, such as in Fig. 1, where vehicular traffic has eroded the protrusions to the point where they no longer provide support. In addition, although the *Doro no ido to enkatsuka seibi gaidorain* [Guidelines for Improvements to Facilitate Roadway Mobility] [10] establish the principle that lines of linear blocks (TWSI) at crosswalk approaches are to be positioned such that they indicate the crossing direction, in many cases they are not aligned in the crossing direction or do not connect to the escort zone, breaking the continuity of support (Fig. 2). Furthermore, many people with visual impairments use the difference in level at the curb as a clue to orient themselves at intersection crossing entrances. At intersections where the curb is not aligned perpendicular to the crossing direction, as in Fig. 3, this may not support crossing because people with visual impairments who use the basic "squaring off" technique to orient themselves with the alignment of the curb may veer off in a different direction.

Fig. 1. Example of erosion of protrusions on crosswalk.

Fig. 2. Example of tactile blocks not perpendicular to the crossing direction.

To solve such problems, the authors have proposed, as a tool dedicated to assisting with orientation to the crossing direction at crosswalk entrances, a method of installing linear protrusions oriented perpendicularly to the crossing direction. As illustrated in Fig. 4, the linear protrusions (orientation blocks) are installed behind the blister blocks and enable users to more accurately cross the road by stepping on them

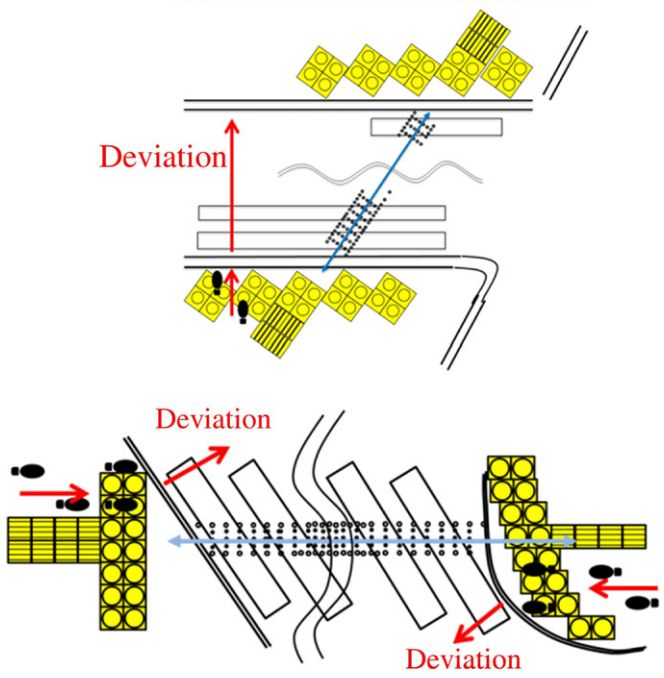

Fig. 3. Examples of curbs not perpendicular to the crossing direction.