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FINAL REPORT

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16. Abstract
This project investigated the effects of providing verbal descriptions of intersections and crosswalks on the performance of street-crossing subtasks by individuals who are totally blind. The intersections included crosswalks that varied widely in geometric and operational characteristics, including the presence or absence of accessibility features. In the no-database condition, participants used their typical street-crossing procedures. In the database-condition, participants additionally listened to database-generated descriptions of the intersections and crosswalks before crossing. The database descriptions had significant positive effects on some subtasks (primarily "crossing" subtasks such as deciding when to cross) and not others (primarily "wayfinding" subtasks such as remaining in the crosswalk).

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EXECUTIVE SUMMARY

A growing number of intersections and crosswalks pose barriers to pedestrians with vision disabilities. This project investigated the effects of providing verbal descriptions of intersections and crosswalks on the performance of street-crossing subtasks by individuals who are totally blind. The authors designed an intersection database containing information relevant to crossing subtasks such as finding and aligning with the crosswalk, deciding when to cross, remaining in the crosswalk, and recognizing the end of a crossing. The authors conducted an experiment with blind adults at two intersections in Portland, Oregon. The intersections included crosswalks that varied widely in geometric and operational characteristics, including the presence or absence of accessibility features. In the no-database condition, participants used their typical street-crossing procedures. In the database-condition, participants additionally listened to database-generated descriptions of the intersections and crosswalks before crossing. The database descriptions had significant positive effects on some subtasks (primarily "crossing" subtasks such as deciding when to cross) and not others (primarily "wayfinding" subtasks such as remaining in the crosswalk). Participants' reports of the usefulness of specific features of the database were supported by the empirical findings. Implications of the findings for database development, transportation engineers, blind pedestrians, and orientation and mobility specialists are discussed.

1. Introduction

Many geometric and operational factors contribute to the accessibility challenges encountered by today’s blind pedestrian. For example, channelized turn lanes and actuated multiphase signals were rare 40 years ago but are commonplace today. Similarly, the nearly rectilinear corners and well-defined curbs previously found at intersections, both of which made it easy for blind pedestrians to locate the streets and crosswalks, have given way to large turning radii, angled curb ramps, and blended curbs. As intersection design has evolved, transportation engineers have unintentionally created significant barriers to blind pedestrians' access to the information they need to safely and efficiently cross streets.

Many challenges faced by blind pedestrians at crosswalks are quite different from those faced by pedestrians with other disabilities. For example, the challenge historically faced by individuals who use wheelchairs was largely the physical barrier of a curb (*1*). Kirshbaum, et al. (*2*) discussed the different types of barriers and described barriers for individuals with vision disabilities as information barriers.

This project investigated the effects of providing verbal descriptions of intersections and crosswalks on the performance of street-crossing subtasks by individuals who are totally blind. At the outset of this project (early 2000s), some blind travelers were using a Sendero GPS system running on the BrailleNote Personal Data Assistant; this provided access to Google Transit information as well as to wayfinding information stored in a shared user-generated database. Based on these features, the authors conceptualized an “intersection database” that would make information about intersections and individual crosswalks readily available to blind pedestrians. Although the work presented here was conducted using the BrailleNote device, many other technologies could potentially be used to deliver information from such a database.

However, in lieu of the rapidly changing technology landscape, the vehicle for the database information would best be left to future investigators.

In most respects, the information available to sighted and blind users from current technology is the same. For example, routes can be mapped and traveled, and nearby restaurants and shops can be identified. However, information about the characteristics of the path such as the presence or absence of sidewalks and crosswalks is not generally provided. Information about intersections is usually limited to the names of intersecting streets and the directions those streets travel as they approach and leave the intersection.

2. Methods

Participants

Participants were 9 women and 13 men between the ages of 32 and 65 years. All were totally blind, were experienced long-cane users, had received formal O&M instruction, and reported that they were confident crossing streets at unfamiliar, signalized intersections. All participants walked with a normal gait and had normal hearing. Participants comprised a sample of individuals known to meet these selection criteria based on their previous involvement in the team's research or their affiliation with the Oregon Commission for the Blind, which assisted with recruitment. Participants received an honorarium, and transportation costs were paid by the project. The study was approved by the Institutional Review Board of Western Michigan University.

Intersections and crosswalks

The Milwaukie/Powell and 42nd/Halsey intersections and three study crossings are shown in

Figures 1 and 2, respectively. The intersections were selected because they included crosswalks that varied widely in their geometric and operational characteristics, including the presence or absence of accessibility features such as accessible pedestrian signals (APS) and detectable warnings. Because of intersection geometry and signal timing, the crossings were expected to be difficult for blind pedestrians who were unfamiliar with the intersections. For example, the west crosswalk of Milwaukie/Powell crossed 7 lanes, with a median just outside the crosswalk lines. Although there was a pushbutton installed with APS and a pushbutton locator tone, the button was 10 feet (3.3 m) outside the crosswalk (Figure 1b). As another example, the east crosswalk of 42nd/Halsey (Figure 2b) had very little traffic traveling parallel to the crosswalk to provide a cue to the time to begin crossing. An audible signal was present in the vicinity of the crosswalk, but there was no pushbutton locator tone to assist a blind pedestrian to locate the pushbutton.

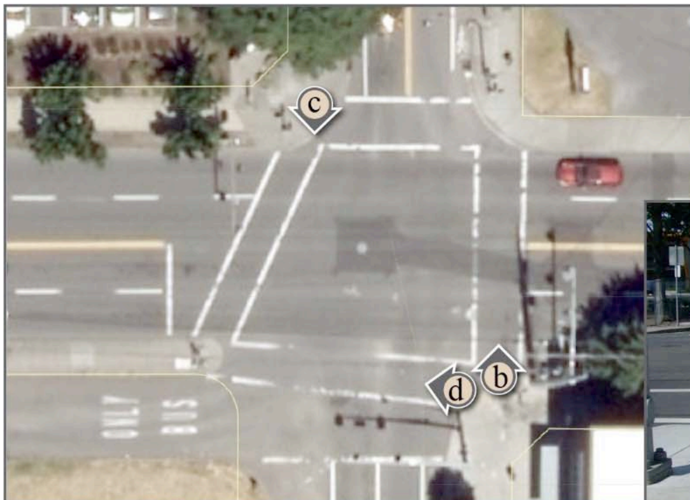
(a) Milwaukie/Powell, aerial photo (source: portlandmaps.com, accessed July 11, 2018).

(b) Milwaukie/Powell, west crosswalk, looking south.

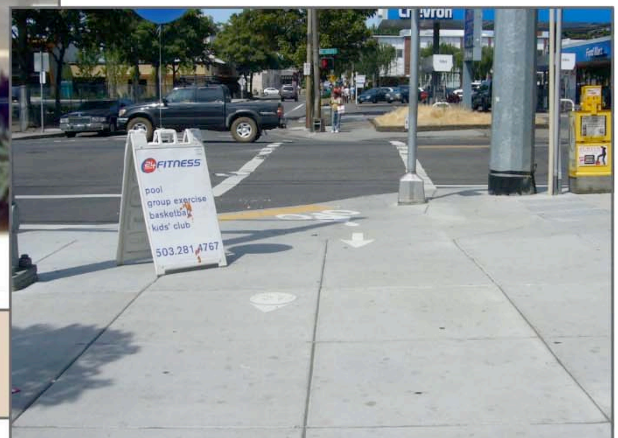
(c) Milwaukie/Powell, north crosswalk, looking east toward channelized turn lane.

(d) Milwaukie/Powell, channelized turn lane crossing, looking east.

FIGURE 1 Milwaukie/Powell aerial view and study crosswalks



(a) 42nd/Halsey aerial photo (source: portland-maps.com, accessed July 11, 2018).



(b) 42nd/Halsey, east crosswalk, looking north.

(c) 42nd/Halsey, west crosswalk, looking south.

(d) 42nd/Halsey, south crosswalk, looking west.

FIGURE 2 42nd/Halsey aerial view and study crosswalks

Intersection Database

The authors designed the intersection database to provide general intersection descriptions as well as specific crosswalk descriptions from each end of a crosswalk. In the intersection database information condition (hereafter, "database condition"), users listened to a BrailleNote-presented general description upon arrival at an intersection and then to the relevant crosswalk description as they prepared to cross. One of the challenges of describing intersections and crosswalks is the lack of standardized terminology across pedestrians who are blind, O&M specialists, and transportation engineers. When possible, terms were those already in common use among all of the target groups such as "APS" and "detectable warnings." For other terms, transportation engineering terms as "right angle" intersection and "split phasing" were adopted. Such terms could readily be (and sometimes are) incorporated into O&M instruction. Descriptions were kept as short as possible and were consistent with the typically truncated, speech-synthesized presentations of accessible GPS systems. For example, unnecessary articles and prepositions were dropped in order to facilitate listening efficiency, and commas and periods were inserted to force the appropriate length of pauses.

Study Design

The study used a mixed design in which differences between two independent groups were examined, with participants undergoing repeated measures across intersections. That is, at each intersection, half of the participants were provided with database information while the other half were not. Participants who used the database at one intersection did not use it at the other. At each intersection, participants made one street crossing in one direction at each of three of the intersection's crosswalks. The orders of the database conditions, intersections, and crosswalks were counterbalanced across participants. The authors assessed each subtask of the street-crossing task. This included finding an appropriate start location, aligning to cross, finding and using the pedestrian pushbutton when one was available, crossing at an appropriate time, and crossing within the crosswalk. In addition to participant behaviors, the authors recorded the signal status at the beginning and end of each crossing. In the database condition, participants were encouraged to request the definitions of terms and the database descriptions as often as they wished; the authors recorded these requests.

Analyses

Upon completion of descriptive statistical procedures, the authors used a Generalized Estimating Equation (GEE) approach to test hypotheses. GEE is often used in place of traditional regression approaches when it is necessary to accommodate correlated response data that are either binary or continuous (*3, 4*). For outcome measures the authors emphasize odds ratios, the widely used metric in statistical analyses that involve binary outcomes and that are particularly applicable to the analyses of 2 x 2 matrices as described next. As an example, if 50% of the participants correctly performed under Condition A and 25% correctly performed under Condition B, the odds of Condition A are 50% divided by (100% − 50%,) or 1, the odds of Condition B are 25% divided by (100% − 25%), or 1/3, and the odds ratio of A to B is 1 divided by 1/3, or 3. Database information and an infrastructure feature installed for pedestrians with vision disabilities (i.e., APS) were used as the predictor variables for all but two outcome variables; Database information and ramp type (separate vs. single diagonal) were selected as the predictor variables for the following two outcome variables: 1) alignment in the correct heading for crossing and 2) initiating the crossing within crosswalk lines. Ramp type was used as an infrastructure predictor variable for these two variables in accordance with the traditional O&M technique of using prominent curbs on each side of a ramp as confirmation of ramp location and as a cue for alignment. All statistical analyses used a significance level of 0.05 and were conducted with SPSS version 25 and R.

3. Results

The results reported here relate primarily to participants' performance of crossing subtasks. Results are also reported for the confusion of a median with the endpoint of crossing and for self-reports of crossing difficulty and cues used for some of the subtasks. Data from only three of the participants were analyzed in the preliminary analyses.

Completing Crossing within Crosswalk Lines

The predictor variables were database information and APS. The interaction effect was not significant (p = 0.715). However, participants completed crossing within the crosswalk lines more frequently when the APS was present (mean = 54%, SE = 7.4%) than when it was not (mean = 14%, SE = 3.7%, odds ratio = 8.83, p = 0.003). That is, the odds of participants completing crossing within the crosswalk lines were almost nine times higher when the APS was present than when it was not. Presence or absence of database information did not have a significant effect on the outcome (odds ratio = 2.26, p = 0.354).

Correct Use of Pedestrian Pushbutton

The predictor variables were database information and APS. The interaction effect of database information and APS was not significant (p = 0.677). However, a higher percentage of participants used the pushbutton correctly (i.e., used it when present and did not look for it when absent) when the database information was provided (mean = 84%, SE = 5.8%) than when no database information was provided (mean = 52%, SE = 6.4%, odds ratio = 5.73, p = 0.005). In other words, the odds of participants using the pushbutton correctly were almost six times greater when they received the database information than when they did not. Presence or absence of APS did not have a significant effect on pushbutton behavior (odds ratio = 2.37, p = 0.145).

Crossing Initiation during Walk Interval

The predictor variables were database information and APS. The interaction effect was not significant (p = 0.176). However, the participants started crossing during the Walk interval (as opposed to Don't Walk or Flashing Don't Walk) at a higher percentage when they received the database information (mean = 70%, SE = 6.7%) than when they did not (mean = 57%, SE = 6.7%, odds ratio = 3.16, p = 0.025). In other words, the odds of participants starting to cross during the Walk interval were more than three times higher when the database information was provided than when it was not. Presence or absence of APS did not have a significant effect on the outcome (odds ratio = 0.58, p = 0.356).

Completing Crossing before the Signal Changes to Don't Walk

The predictor variables were database information and APS. The interaction effect was significant (odds ratio = 15.56, p = 0.001), and therefore simple effects rather than main effects were examined. In the presence of APS, participants completed crossing before the signal changed to Don't Walk at a much higher percentage when the database information was provided (mean = 64%, SE = 8.0%) than when it was not (mean = 19%, SE = 6.2%, $p < 0.001$). In contrast, in the absence of APS, there was no significant difference in the percentage of participants completing crossing before the signal changed to Don't Walk between the database condition (mean = 63%, SE = 10.2%) and the no database condition (mean = 78%, SE = 7.7%, p = 0.189).

4. Discussion

The authors categorized the subtasks of street crossing as either wayfinding or crossing tasks, consistent with related research (15). In general, the results suggest that the database information was more helpful for crossing tasks than for wayfinding tasks.

In the database condition, participants looked for and used the pedestrian pushbutton on 73% of trials where a pushbutton was present, but did so on only 46% of trials in the no database condition, a significant difference. Presented in terms of odds ratios, the odds of looking for and using the pedestrian pushbutton were almost 6 times higher in the database condition. It did not matter whether the pushbutton was at an APS-equipped crosswalk. This is an important finding given the necessity of using the pushbutton to obtain sufficient time to cross at many modern signalized intersections. Most intersections equipped with pedestrian pushbuttons are not equipped with accessibility features such as locator tones and APS. It is essential that pedestrians with vision disabilities be alerted to the presence (and ideally, to the location) of the many silent and therefore "invisible" pushbuttons at the crosswalks they must navigate.

Seven of the participants noted that the database gradually became easier to use and as they became familiar with it and suggested that it would have been more useful had there been an opportunity for more "real-world" training with the database as well as with some of the concepts it presented such as split phasing, audible beaconing, and rapid-tick walk indicators. In recent years, transportation engineering and O&M professionals, along with many individuals outside of these fields who are blind or have low vision, have increasingly collaborated in research and practice efforts to improve the pedestrian environment for people with vision disabilities (*5*). One consequence of this is that O&M specialists and the individuals they instruct are increasingly adopting the vocabulary of transportation engineering to discuss pedestrian and vehicular environments (*6*). However, it is clear from the present project that substantial continuing O&M instruction will be required to cover newer relevant engineering developments. Although in the authors' opinion, the participants were an exceptionally experienced and skillful group of urban pedestrians, many were handicapped by terms and concepts in the database with which they had limited familiarity. Whatever the ultimate potential of an intersection database may be, it is clear that much more than an hour of indoor instruction will be needed to reach that potential.

For future research, the database concept could be expanded to cover a wider variety of complex signalized intersections, alternative intersections, and roundabouts. In addition, the ability to streamline the process of developing relevant database information will be an important aspect in implementation. It may be possible, for example, to have database components developed and submitted as part of the specifications for new or modified signal installations. Database features could also be included as part of an ADA transition plan, concurrent with the upgrading of the physical features of an intersection to meet ADA requirements. It also should be explored whether it would be possible to automate the extraction of relevant database sections from GIS or other databases; this would enable the automated development of database features for intersections that otherwise meet ADA requirements.

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