

# QUANTITATIVE AND QUALITATIVE ANALYSIS OF BARRIERS TO TRAVEL BY PERSONS WITH VISUAL IMPAIRMENTS AND ITS MITIGATION THROUGH ACCESSIBLE SIGNAGE

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## SUMMARY

Casual observation and common sense reveal that wayfinding and travel can be difficult and time consuming for persons with visual impairments. Researchers still have little understanding of what the various degrees of difficulty are for various tasks, and how they affect travel and activity behavior. This paper summarizes a “real-life” field experiment at a large urban terminal where 30 blind participants performed travel and transit tasks using their regular navigation skills and also when using auditory signage technology. Pre-test interviews showed a low rate of activity participation outside the home, and a high degree of difficulty when performing many necessary transit tasks, which lead to a low occurrence of making transfers to save travel time. The field test data showed that people using the additional cues obtained through auditory signage were able to complete the tasks much faster, with less errors, less assistance from others, and with a higher degree of safety. Post-test evaluations showed that, when provided with accessible environmental cues, transit tasks were no longer rated as difficult. This group anticipated participating in many more activities outside the home and traveling more often and to more places, they anticipated making many more transfers than currently made, and they exhibited highly improved spatial knowledge of this environment and the ability to make shortcuts through it. Comparisons between regular travel and travel with auditory cues showed that participants thought the additional cues would greatly increase their travel options and mitigate many of the problems inherent in travel without sight. Finally, a “relative access measure” is discussed to empirically derive the degree of difficulty for various types of wayfinding activities. Combined, these data strongly argue the case that it is the lack of accessible cues in the environment that can cause limited access to activities and travel, and that the addition of accessible cues would greatly enhance the lives and productivity of persons with visual impairments.

## INTRODUCTION

Independent travel by persons with visual impairment and their access to urban opportunities is often limited by the lack of accessible cues. Especially difficult are many tasks associated with transit use and making transfers from either one vehicle to another or one mode of transportation to another. These difficulties are not absolute structural barriers but are relative. That is, they are of a more functional or informational nature such as knowing what things are in the environment, where these things are located, and the spatial relations between these locations. When visual cues are not available, information about what is available in the external world is more difficult to come by. These functional barriers to travel can be so exacerbated that trips and activities are sometimes not made, or a trip might be cancelled enroute. With the increased interest in technologies that can help this group gain access to additional information and cues, it is critical to examine the effect these barriers have on travel behavior and analyze ways in which these barriers can be measured and mitigated. Little research has been conducted to determine the specific spatial and environmental locations that create these barriers to independent living, how people with vision loss traditionally deal with these barriers, and the impact technologies can have to minimize these barriers. This paper examines the use of auditory cues that allow this group to better understand spatial layouts and to identify and find locations from a distance.

A field experiment was conducted using 30 legally blind persons at a large urban multi-modal transit terminal along with pre- and post-test interviews and evaluations. Pre-test questions revealed participants' current transit usage, their ratings of the difficulty of various transit tasks, their current participation in activities outside of the house, and their perception of how their travel and activity behavior is affected by barriers caused by visual impairments. Post-test questions revealed how participants anticipated Talking Signs<sup>®</sup> Remote Infrared Audible Signage (RIAS) - a system that labels various locations and gives direction information - would change their current travel and activity patterns. Qualitative and quantitative data are discussed, which provide novel ways to measure the effect of vision loss on travel, identify specific types of barriers, and suggest ways to increase the opportunities to travel and participate in activities. A relative access measure is used to identify which types of locations cause the most difficulty and result in empirically derived coefficients that can be used to rate barriers to travel and to model current problems and the effects of adding accessible cues to an environment.

## FIELD EXPERIMENT

Thirty persons who were legally blind and were skilled urban travelers made five transfers between a large urban railroad terminal and three other nearby modes of transportation. The terminal area (see Figure 1) was equipped with 51 Talking Signs<sup>®</sup> RIAS; each labeled one of a set of environmental locations and gave precise identity and directional cues to a person using a hand-held receiver. RIAS transmitters were installed at every entrance and exit at the terminal, at the boarding doors of all 12 train tracks, three concession stands, the ticket and information window, two bathrooms, pay phones, and a water fountain. Outside of the station, RIAS transmitters were

located at a cab stand, a fare machine at the nearby light rail station, and a nearby bus stop. In addition, two street intersections had RIAS transmitters. This site was a large and complex area that was well equipped with auditory cues, making it an ideal location to test how these additional cues could affect travel behavior, safety, and speed, as well as determine if they could help users gain a better understanding of spatial relationships among various environmental features.

Fifteen people first attempted the transfers using their regular travel methods and strategies for navigation and then repeated the test using RIAS. The other 15 people used RIAS for their first trial. This method allowed for both within and between subject comparisons. While navigating the route to the transfer point, participants also had to locate various amenities and features along the way, such as a ticket window, a concession stand, or a restroom. In all, each participant had to find 20 locations, including places for crossing streets. Recorded data included times to complete the tasks, errors made, and the number of requests they made for assistance.

## **FIELD TEST RESULTS**

Previous experiments have amply demonstrated that RIAS is easy to learn and to use, decreases search and travel times, provides for large reductions in navigational errors, and promotes a marked decrease in dependency on others (Crandall, 1995; Crandall, 1996; Crandall, 1998; Marston, 1998; Bentzen, 1999; Crandall, 1999; Crandall, 1999; Golledge, 1999). In this test, times to make the five searches and reach the transfer points with RIAS were about half of that achieved while using normal navigation skills. With RIAS, there was a large reduction in errors, and many more participants completed each of the 20 tasks in the allotted time. During the experiment, people could ask passersby for verbal assistance of any type (as is done in everyday life). This was done quite often when performing tasks using their normal travel strategies. However, when using RIAS, no participant asked any passersby for help.

## **STREET CROSSINGS**

RIAS installations at street intersections consist of two elements. One element is a narrow beam that delivers the “real-time” Walk or Wait signal, with a directional beam that orients the user to the correct crosswalk area. In addition, another element gives information about the person’s cardinal direction of travel, the names of the perpendicular and parallel streets, current block number, and other information, such as the existence of a pedestrian signal activation button or what amenities or transit options are nearby.

Without RIAS, some people chose not to attempt the street crossing within the allotted four minutes. Other participants, perhaps more confident and/or better-trained, waited for several light cycles in order to detect the pattern of traffic flow before attempting the crossing. Their crossing alignment was often off-target and dangerous. Indeed, some people crossed at an angle that did not bring them to the opposite side. With RIAS, all people crossed the street as soon as the Walk cycle began. They were able to follow the directional beam directly across to the proper corner. Without this degree of safety and sureness for travelers with visual impairments, some activities (such as

crossing dangerous streets) are avoided or travel plans are altered or even cancelled (Marston, 2000).

## **LIMITED TRAVEL AND ACTIVITY PARTICIPATION**

Many of our participants reported minimal activities outside the home. Thirty percent of those interviewed reported making only 2 to 7 outside trips to any kind of activity per week. Fully 75% of the sample participated in 14 or less activities per week. Participants reported that there were some trips and activities they did not make because of transit problems caused by their vision loss (termed, “pent-up demand”). After using RIAS in the field tests, they reported that there was a very large desire for more types of activities and more trips (termed, “hidden demand”) if RIAS was installed in their environment. The number of trips the participants said they would make if RIAS was installed were twice as many as they currently made (Marston, 2002; Marston, 2003).

## **TRANSIT TASK DIFFICULTY**

Participants rated various transit tasks during the pre-test interview. Using a five-point scale, from “extremely difficult” (1) to “not at all difficult” (5), 69% of these tasks were rated between “very difficult” and “difficult,” while 27% were rated between “somewhat difficult” and “difficult.” Some of the most difficult tasks were finding the proper boarding area, transferring between buses, and finding a bus stop. After using RIAS, they were asked to rate the difficulty of the same tasks if the system was available to them. All but one task was rated as more toward “not at all difficult” than “somewhat difficult.” In fact, 30% of the tasks were rated between 4.9 and 5.0, or “not at all difficult.” Thus, RIAS use resulted in the average participant ratings of task difficulty shifting two categories. These results help identify that the problem in transit use is directly tied to the type and amount of cues that are accessible to a blind traveler (Marston, 2000; Marston 2001; Marston 2002).

## **TRANSFERS BETWEEN MODES AND VEHICLES**

Transportation research shows that many car drivers actively take measures to save small amounts of time while driving. The same *utility of saving time* does not seem to hold for passengers considering changing transit vehicles in order to make time-saving transfers. Thirty randomly sampled sighted transit users (interviewees) reported that they would need to save at least 12 minutes on a one-hour transit ride before they would consider making a transfer that was at a familiar same-block location. Participants were asked to estimate their transfer-making behavior during six scenarios, same-block, one-block and three-blocks distances, and in both familiar and unfamiliar locations. For these six scenarios, 7% of the sighted participants said they would not make a transfer even if they could save 30 minutes. In contrast, 71% of the blind participants would not make the same time-saving transfer. The effect of area familiarity was also important for the blind participants. While sighted interviewees had no significant differences of their estimated transfer making behavior in familiar

and unfamiliar areas, the blind participants showed a significantly higher resistance to making a transfer in an unfamiliar area. After using RIAS, the blind participants reported perceived transfer-making behavior that was not significantly different than that reported by the sighted group. When accessible cues are available to the blind traveler, unfamiliar areas are no longer viewed as more difficult than familiar areas (Marston 2002).

## **SPATIAL KNOWLEDGE ACQUISITION AND COGNITIVE MAPS**

Twenty questions were asked to determine how well participants had learned spatial relationships between locations they had visited. Those using their normal methods of navigation had a mean correct response rate of 44%, while those using RIAS doubled their correct responses with a mean of 88% correct.

The ability to make a shortcut through unfamiliar areas is also an indication of spatial knowledge or of a person's "cognitive map" information. The field test offered two opportunities to make travel shortcuts - preferable in terms of minimizing time and distance. In one task, 27% of the participants using normal travel strategies spontaneously figured out how to make a shorter path, while 100% of those using RIAS spontaneously determined and used the shorter path. In a second task, where a shortcut was possible, 18% of the regular travel strategies group took the shorter path, while 89% of the RIAS users took the shorter path. These data show that the addition of accessible cues provided by RIAS enabled the blind participants to gain spatial knowledge that allowed them to save time and effort by taking new paths to reach their destination.

## **USER EVALUATIONS AND COMMENTS**

Four open-ended questions were asked at the end of the experiment, allowing users to compare RIAS use to their regular travel strategies. They compared the differences at street crossings, terminals, making transfers, and for overall travel-making behavior. Participants unanimously agreed that with RIAS they could be independent and did not need to ask for help. They strongly agreed that they could find locations much faster. They reported that street crossings were much safer, and they had access to street information not previously available. They also strongly agreed that the use of RIAS made them more comfortable and assured, and that its use would allow them to travel with less stress. Almost all participants said they would travel more often and to more places if RIAS were available. They also reported how easy it would be to travel to new places without having to undergo accompanied travel training. These positive comments from users give insight into the barriers to successful and independent travel by this group. Having access to identity and directional cues has been shown here to make a positive impact on the life style of this group.

## **RELATIVE ACCESS MEASURE**

A relative access measure (RAM) has been used to quantify the time or distance (termed “effort penalty”) when having to take a longer route with a wheelchair because of structural barriers (Church, 2003). This measure compares the effort of travel required of a person with restricted mobility to the effort required of a “typical” user with unrestricted mobility.

In the field experiment with visually impaired participants, this measure was used to quantify the effects of vision loss on travel behavior within the context of different tasks and locations (see Table I). Participants used their normal travel strategies to locate platform doors three different times in this experiment, and these tasks resulted in a large time penalty for the blind user as compared to a sighted traveler. Making the street crossing at King St., which was a high-speed street, was also a very difficult task, with times for participants using their normal travel strategies much higher than for a sighted user. Crossing 4<sup>th</sup> Street (a slow-speed area), and also when walking to the corner were not very difficult and had a lower penalty. These last two tasks are the types of situations that can be learned through Orientation and Mobility training, and the results confirm this practice. The hardest types of locations to find were inconsistent locations with no cues such as a fare machine that was not located in a typical spot, a bus shelter that had no informational markings, and a flower concession at the terminal. These tasks were all made easier when additional cues were available using RIAS. By comparing the penalty of blind access and the penalty for those using RIAS, planners and trainers can identify and model which kinds of locations need the most attention to make them accessible (Marston, Submitted).

## **CONCLUSION**

By using qualitative and quantitative inquiry methods, combined with a "real-world" transportation mode transfer experiment, the barriers that inhibit travel and transit use for this group were revealed. Objective data identified the locations and functions that caused impediments to travel, and subjective data identified the way in which these impediments negatively affected the quality of life for this group. The mitigating effect of increased spatial information and additional environmental cues, as provided by RIAS, was empirically measured and quantified. The experiment showed that persons who are blind can indeed navigate a busy and complex area, without previous training or knowledge, if appropriately accessible cues are available to them.



TABLE I: Relative Access Measure (RAM), Extra Time Needed to Perform Tasks Compared to a Sighted Person

Tasks or Locations	Regular Travel Methods	Using RIAS
Walk and Search for Train Track Doors	5.0	2.1
Crossing Hard Difficulty Street	6.0	0.4
Crossing Medium Difficulty Street	0.8	0.1
Walk to and Search for Street Corner	1.3	0.7
Find Inconsistent Locations with No Cues	19.0	1.7



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