

The Hidden Demand for Participation in Activities and Travel by Persons Who Are Visually Impaired

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Abstract: As part of a larger field experiment using remote infrared audible signage, 30 participants who were legally blind provided data about their current travel behavior and activities, the number and types of additional trips they desired to make, and what trips they would make if more environmental cues were available. The results showed a large demand for participation in activities and travel that is not being met, but would be if relevant information was available.

The loss of vision can restrict or limit participation in activities outside the home because of the lack of access to wayfinding information, such as signage, while navigating the environment, especially in unfamiliar areas, and attempting to use public transportation. Golledge (1993) noted that the inability to travel independently and to interact with the wider world is one of the most significant handicaps that persons with visual impairments (that is, are blind or have low vision) experience. As nondrivers, individuals who are legally blind face many barriers to travel, including constraints on their ability to use transportation efficiently

(Corn & Sacks, 1994; Golledge, Costanzo, & Marston, 1996; Golledge, Marston, & Costanzo, 1997; Marston, Golledge, & Costanzo, 1997). Some of the most difficult tasks in this regard are finding locations, such as platform doors or gates, bus stops, and boarding areas; finding amenities like ticket booths or fare machines; and overcoming problems associated with finding the correct vehicle (especially identifying buses) and making safe and efficient transfers between modes of transportation (Golledge & Marston, 1999; Marston, 2002; Marston & Golledge, 2000). These reported difficulties are caused by the lack of access to maps, signs, and knowledge about the spatial locations and relationships that are typically provided to other travelers through visual cues. Research on why persons who are visually impaired report the limited use of public transportation has found that the most important thing that is lacking for this group is access to information (Golledge, Costanzo, & Marston, 1995; Golledge &

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Marston, 1999; Golledge et al., 1997; Marston, 2002; Marston & Golledge, 1998a, 1998b; Marston & Golledge, 2000; Marston Golledge, & Costanzo, 1997).

Marston (2002) identified five types of information and spatial knowledge that are restricted or unavailable without vision, especially in unfamiliar areas, as follows:

Specific information and positive identification at locations. Even when a person who is blind finds a location, such as a door, bus stop, or counter, he or she may be uncertain about its identity or function.

Spatial information accessed from a distance. Without vision, a person is limited with regard to learning about near or far places. Touch via the hand or cane can provide only limited help and often produces embarrassing groping or reaching behavior. Therefore, a person without useful vision can be unaware of an important feature that is only several feet away. Spatial layouts cannot be viewed randomly in their entirety, as with vision, but must be learned using a physically active, deliberate, and sequential search.

Directional cues to distant locations. It can be difficult to walk directly to locations without having to follow a learned path. With the exception of some other sensory input (sounds; air currents; heat; or, perhaps, light perception), there are no available directional cues to guide walking to a distant target (such as crossing a large lobby to reach an elevator).

Self-orientation and location. Without vision, it is possible to lose track of where one is in an open space and even which way one is facing. Persons without vision may need to walk to a wall or curb or find a familiar place to orient themselves.

Integrated model of the space. Without vision and easy access to distant cues, it can

be difficult to build a "view" or mental image of a space that contains isomorphisms of the spatial relationship between real and cognized locations. Constructing a maplike image in their minds allows persons to explore spaces with greater efficiency, without having to adhere to learned routes.

These missing cues are of utmost importance to travelers. Individuals can get "lost" or disoriented when they make a wrong choice at a decision point (stop, go straight, or turn). Each of these decision points is an *independent* event, and the probability (P) of success for each event is *multiplied by itself* as the number (x) of decision points increases (P^x). If a skilled traveler who was blind made only one mistake in every 100 decisions, there would be a cumulative probability ($P > 50\%$) of making an incorrect choice after 69 decision choices ($P = .99^{69} = .499$). If a traveler made only five mistakes in every 100 decisions, there would be a cumulative probability of making an incorrect choice after 14 decision points ($P = .488$). In addition, without a way to "view" the world, it can be much more difficult for a visually impaired person to recover from these types of errors. For all travelers, the ability to access cues (with vision or other modalities) by positively identifying a landmark or signs allows them to snap back from their unknown or disoriented position to an oriented position. The difficulties faced by travelers without vision can add excess time to trips, cause missed connections, or lead them to refrain from attempting to travel to places where they can perform desired activities.

Persons who use wheelchairs can face physical, structural, and absolute barriers, such as stairs, narrow doors, or buses without lifts. Persons who are blind face func-

tional barriers (the lack of information about the uses and locational elements of a space) that are relative (spatial information can be learned with training and familiarity), but especially in new environments, these barriers to travel can limit movement and access as surely as do physical barriers.

Talking Signs Remote Infrared Audible Signage (RIAS) provides an opportunity for those with limited or no sight to have a substitute for missing visual cues. This type of accessible signage has been widely tested in transit environments (Bentzen, Crandall, & Myers, 1999; Crandall, Bentzen, & Myers, 1995, 1998; Crandall, Bentzen, Myers, & Mitchell, 1995; Crandall, Brabyn, Bentzen, & Myers, 1999; Golledge & Marston, 1999; Golledge, Marston, & Costanzo, 1998; Marston, 2002; Marston & Golledge, 1998b; Marston & Golledge, 2000). The RIAS used by these researchers consists of a transmitter that continually emits an infrared light beam, which can range in coverage from a small beam width up to 360 degrees. The light beam contains a spoken message that labels or describes the location or offers other information that is delivered to the traveler through a receiver that he or she carries. The user scans the environment with the handheld receiver and hears the message when the receiver is pointing toward the transmitter's location. In this way, the user hears the label or description of the location and, when staying within the broadcast beam of the message, knows that the receiver is pointing directly to the location, thus receiving a directional path to follow.

These previous experiments have shown that RIAS can provide faster, safer, and more confident and independent travel in many types of environments. However, lit-

tle is known about how barriers and restrictions to independent travel affect overall travel behavior and whether improved sources of information and spatial cues would lead to greater participation in activities. To address this concern, an experiment was designed to measure the effect of using RIAS and to gain input from users about how this type of information would affect their participation in activities and travel behavior.

Method

THE EXPERIMENTAL SITE

To measure and identify barriers to the efficient use of transportation, a multifaceted experiment was conducted at the San Francisco Caltrain terminal. The 12-track station occupies a full block face, and three other transit modes are nearby. A taxi stand is located on a street at one side of the station; across the other side street is a light-rail station, and across the street in front of the terminal are several bus shelters. RIAS transmitters were located in the train station—identifying all doorways; track gates; and amenities, such as ticket windows, concession stands, and bathrooms—and at the contact points for the other three modes of travel. In addition, RIAS transmitters were located at street crossings, giving information about the direction of travel, street names, block numbers, the presence or absence of a push button, and nearby amenities or transit options. The RIAS transmitters also provided “real-time” information about the status of the pedestrian “Walk” signal. More detailed information from this experiment about how RIAS promoted faster and safer street crossings, as well as the participants' comments about how the installations would affect travel behavior, is provided

times, and the rest (16%) reported having been there more often.

RESEARCH DESIGN

A wide range of quantitative and qualitative data were collected to measure difficulties with, and restrictions on, travel, transportation behavior, modal transfer abilities, and participation in activities. In particular, we targeted the actions required to make multimodal transfers. A field test was conducted in which the participants simulated making five transit-mode transfers and visiting locations and amenities along the way, for a total of 20 location-finding tasks. Travel and search times, errors, and requests for assistance were recorded to measure quantitatively time constraints, accuracy, and independence for different types of transit locations and tasks. Fifteen participants used their regular methods of travel first and then repeated the experiment using RIAS. The other 15 participants used RIAS on their first trial.

Pretest data were collected from the participants about their actual and desired trip-making frequencies, travel behavior, and choice of modes in two scenarios; transfer-making behavior in six situations; ratings of the difficulty of 26 transportation tasks; and the monetary benefits of independent travel. Posttest interviews asked the same questions on the basis of the participants' actual field experience with RIAS and anticipated changes in their travel behavior if RIAS were available in their potential activity space, at locations similar to those tested. In addition, posttest data were collected on the participants' acquisition of spatial knowledge, ratings of the desirability of RIAS installations, and five open-ended questions comparing regular methods to using RIAS.

Results

In the field tests, all the participants performed their tasks quicker when using RIAS; those who were slower using their regular methods generally saved a higher percentage of time when they used RIAS than did the faster travelers. The mean time saved was roughly 50%. In addition, RIAS users made fewer wayfinding mistakes, did not have to ask for help (which they often did when using their regular methods), and crossed streets more safely. The participants' stated preferences and behaviors showed that they highly agreed that tasks would be easier, travel would be less stressful, they would be able to travel with greater independence, and they would travel more often and to more places.

The entire experiment, which measured accessibility and travel constraints with various techniques, is reported elsewhere (Marston, 2002). This article examines a small portion of that experiment, particularly the participants' actual trip-making and activity data ("actual"); actual trips plus the trips that were desired but not taken ("desired"); and the actual trips, plus the trips they would make if RIAS was installed ("would make with RIAS").

PARTICIPATION IN ACTIVITIES AND FREQUENCY OF TRIPS

The participants were asked to list the number and type of activities they participated in during the previous week and the transportation, walking, and total travel times for each trip to an activity site. These activity trips included any function that took place outside the home, with travel by any means, including walking. Figure 2 displays the number of trips reported by the 30 participants, sorted from the lowest to the

Person-Trips per Week Frequency Distribution

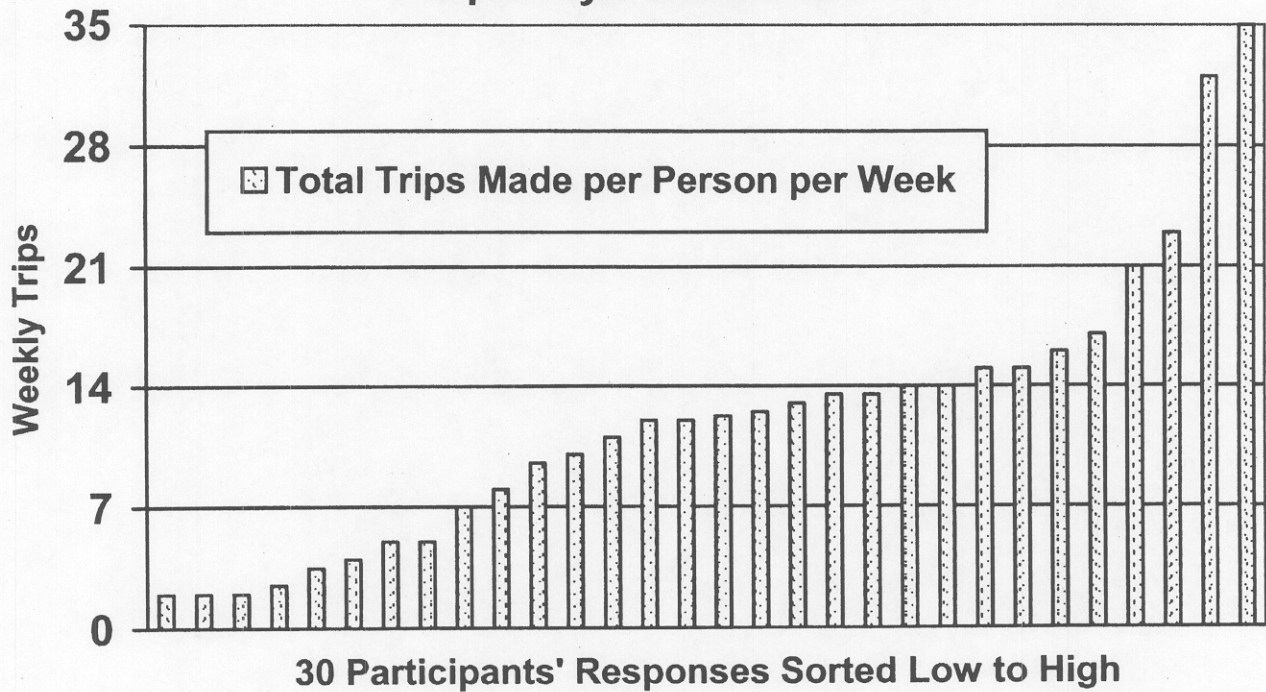


Figure 2. Total trips per person.

highest frequency. The mean number of trips reported was 12.1 per week.

Of the 30 participants, 9 (30%) participated in seven or fewer activities in a week (one per day.) Although all were fairly skilled travelers, 73% participated in two or fewer activities outside their homes per day. The 2 participants who reported the highest number of trips were both young adults who had much useful vision. They reported many trips to visit friends in adjacent apartments and regarded many trips to the local "hangout" corner store as either social or shopping activities.

A major principle in transportation planning is that by removing barriers to travel and increasing ease of movement, accessibility in the system can be increased. For example, it is understood that installing curb cuts and elevators increases access for those who use wheelchairs. An analysis of

the data on trips from before and after such improvements can measure the greater accessibility of an environmental change. When the improvements to access links have not yet been fully implemented, other accessibility measurements, such as anticipated changes in behavior, can be used to estimate the effect of these improvements.

In this experiment, prior to the participants' exposure to RIAS but after the actual weekly trip data were collected, they were asked if there were trips that they did not make because of problems caused by the barriers to independent travel. The actual questions asked were, "Do you sometimes avoid trips or activities because of your visual impairment and the difficulties of independent travel?" "If 'yes,' how often during a week do you avoid these types of trips or activities because of your visual impairment and difficulties with independent

travel?" Of the 30 participants, 20 (67%) said that they avoided some trips because of travel problems caused by their visual impairments. Those who said they avoided some trips reported how many and what types of trips they did not take.

After the field test, the participants reported how many more trips they would make if RIAS was as widely installed in their environment as it was at the test site. All but one participant (97%) reported they would make more trips with the addition of RIAS in their daily activity spaces.

The "desired" data revealed a "pent-up" demand that is not being met. These data are similar to what transportation planners call *hidden demand*. For example, the true capacity demand for a new highway is revealed only after it is built and individuals change behaviors and make more trips, on the basis of the greater ease of mobility and new activity sites available. Thus, hidden demand explains why new highways are often full soon after they are completed.

After the 30 participants used RIAS, only 1 person, who already took 13.5 trips per week, reported she would not make any more trips if RIAS was installed in her area. In addition, 5 participants said they would make 12%–49% more weekly trips, 5 said they would make 50%–99% more trips, 10 said they would make 100%–199% more trips, 4 said they would make 200%–299% more trips, 2 said they would make 300%–399% more trips, and 2 said they would make 400%–499% more trips. The remaining participant, who made only 2 trips a week, reported she would make 12 extra trips if she used RIAS—a 600% increase. Clearly, there is a hidden demand for more activities if travel and transportation were made more accessible. This hidden demand represents a desire or demand for inclusion

and participation that has not been previously addressed or acknowledged.

Table 1 shows the three data sets on the frequency of travel and the number of individuals who participated (or said they would participate) in each activity. The different types of trips are sorted, with the most frequent, currently conducted activities first. Estimates of the desired and anticipated trips were of two types: Some participants reported that they would make more trips of a type they already made, and others said they would make trips to, and participate in, new types of activities. For this reason, a few of the types of activities had a lower mean frequency for desired and anticipated trips than for actual trips—the number of participants was higher, the total number of trips was higher, but the mean was lower. The change in additional trips and new types of activities are discussed later.

There was a mean of 3.7 additional trips that the participants desired but did not make because of travel limitations—a 31% increase in the total desired trips (15.8) from the actual trips reported (12.1). The data indicate that there are strong limitations on daily activities that are associated with the loss of vision and the inability to travel independently. After they used RIAS, the participants anticipated that they would make 25 trips per week, a 107% increase.

Barriers to independent travel were perceived to limit participation in activities and travel, and the availability of additional (and accessible) environmental cues was seen to allow for a larger selection of activities. This is an example of what was described earlier as the effect of functional barriers to travel and transportation; elimination of these barriers should substantially increase accessibility to and participation in activities. To show how these barriers lim-

Table 1

Actual, desired, and anticipated weekly trip-making behavior, by number of participants who reported them.

Type of trip	Actual trips		Actual + desired trips ("pent-up" demand)		Actual + anticipated trips with RIAS ("hidden" demand)	
	N	Mean	N	Mean	N	Mean
Shopping	30	2.6	30	3.3	30	4.9
Social	25	3.1	28	3.6	27	5.0
Work	17	4.7	17	5.0	24	6.7
Entertainment	16	1.4	20	2.0	25	2.7
Banking	15	1.3	19	1.5	25	1.7
Religious	12	2.2	14	2.6	15	2.6
Recreation	9	2.3	19	2.2	25	3.1
Education	8	3.5	13	2.6	23	3.2
Medical	6	1.3	6	1.3	8	1.2
Other	0	0.0	1	1.0	0	0.0
Total trips	30	12.1	30	15.8	30	25.0

ited the participants' travel for different activities, the percentage changes in the number of trips the participants said they would make and in the number of individuals who said they would participate in new types of activities are discussed.

FREQUENCY OF TRIPS

Figure 3 shows the percentage increase in the "desired" trips and "would make with RIAS" trips over the "actual" trips reported. The data are ordered from high to low, on the basis of the data for the "desired" trips.

Desired trips. The participants expressed a desire to take an additional 99% more trips to recreational activities and 79% more trips to entertainment events. It could be argued that these two activities are the most discretionary activities and, therefore, the ones that are first eliminated because of any problems. Banking, religious, shopping, and educational trips can be more obligatory than discretionary, representing trips needed to maintain the quality of one's life. Consequentially, additional trips of these types were desired at a rate of from 40% to 21% more than their actual frequencies. The participants desired to

make only 6% more work trips, and none desired to make more medical trips.

Anticipated trips with RIAS. After experiencing RIAS at the experimental site, the participants seemed to have learned much about what could be accomplished easily and safely using the additional spatial information. The number of trips they said they would make with RIAS was much higher than the number of trips they originally thought they were missing. Highly discretionary trips, such as for recreation and entertainment, were still the two highest in terms of the increase but at a much higher rate, 269% and 198%, respectively. Anticipated educational trips increased by 165%, banking trips by 110%, and work trips by 100%. Next, in decreasing order, were shopping (87%), social (73%), religious (45%), and medical trips (27%).

PARTICIPATION IN NEW TYPES OF ACTIVITIES

If all 30 participants engaged in each of the nine activities, the total number of person-activities would be 270. The "actual" data showed 138 person-activities. The par-

Additional Trips Desired

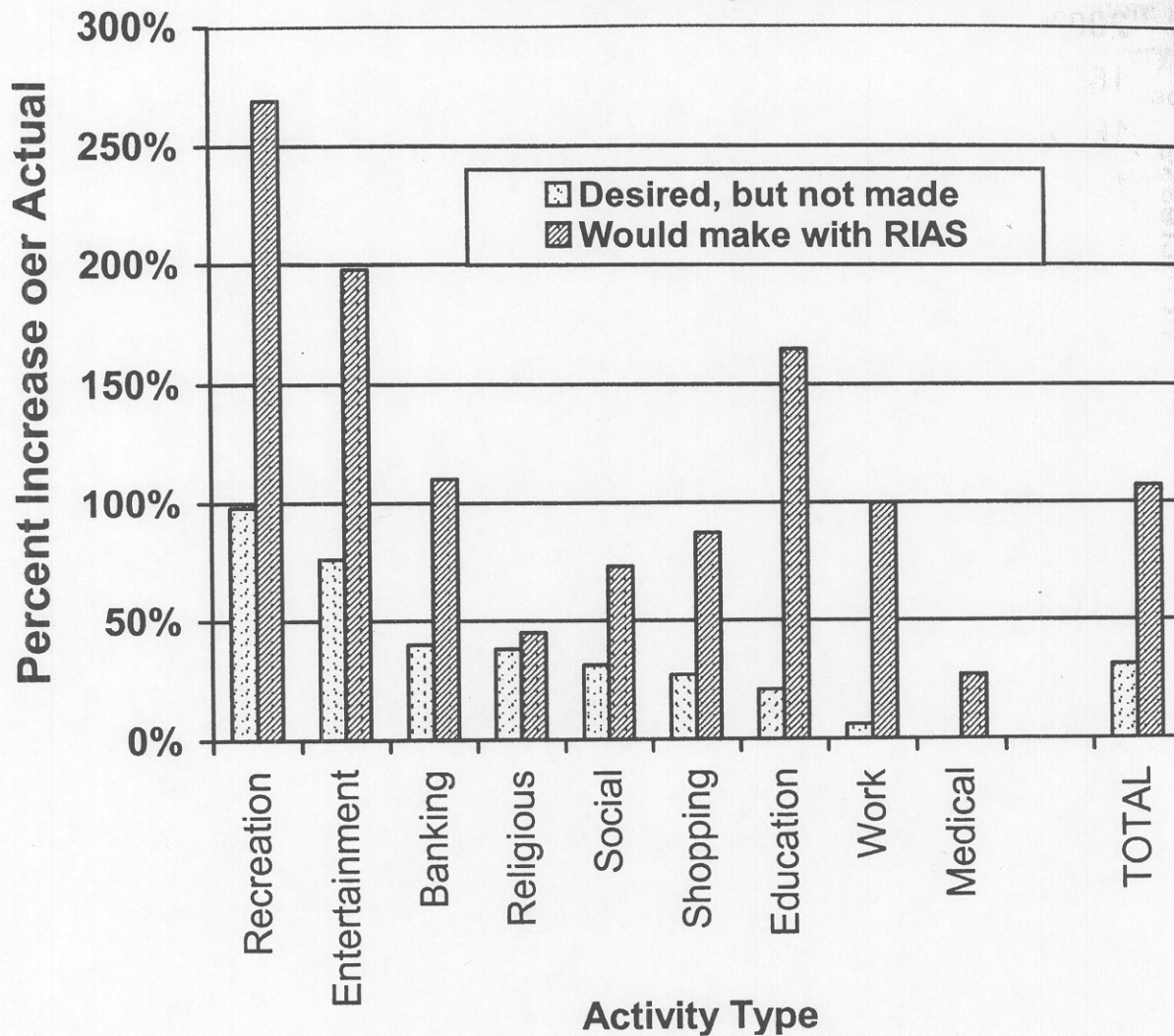


Figure 3. Additional desired and anticipated trips.

Participants indicated that they desired to be involved in an additional 28 person-activities, an unmet demand for 20% more new types of activities, revealing a total “desired” participation of 166 person-activities.

The possibility of the participants making new activities part of their everyday lives when using RIAS was evident in the number of persons who said they would participate in such new activities. The total number of person-activities anticipated if RIAS was available was 202, an increase of 64 (46%) from their current level. This increase represents a hidden demand for more participation

in new types of activities, revealed after exposure to RIAS at the experimental test site.

Figure 4 shows the increase in the percentages of individuals who said they would participate in new types of activities. The data are sorted from the highest increase to the lowest for those who reported activities that they desired but did not make.

New types of desired activities

The “desired” trips not taken data showed that trips to recreational and educational activities were in the highest demand, a 111% and 63% increase, respectively, over the ac-

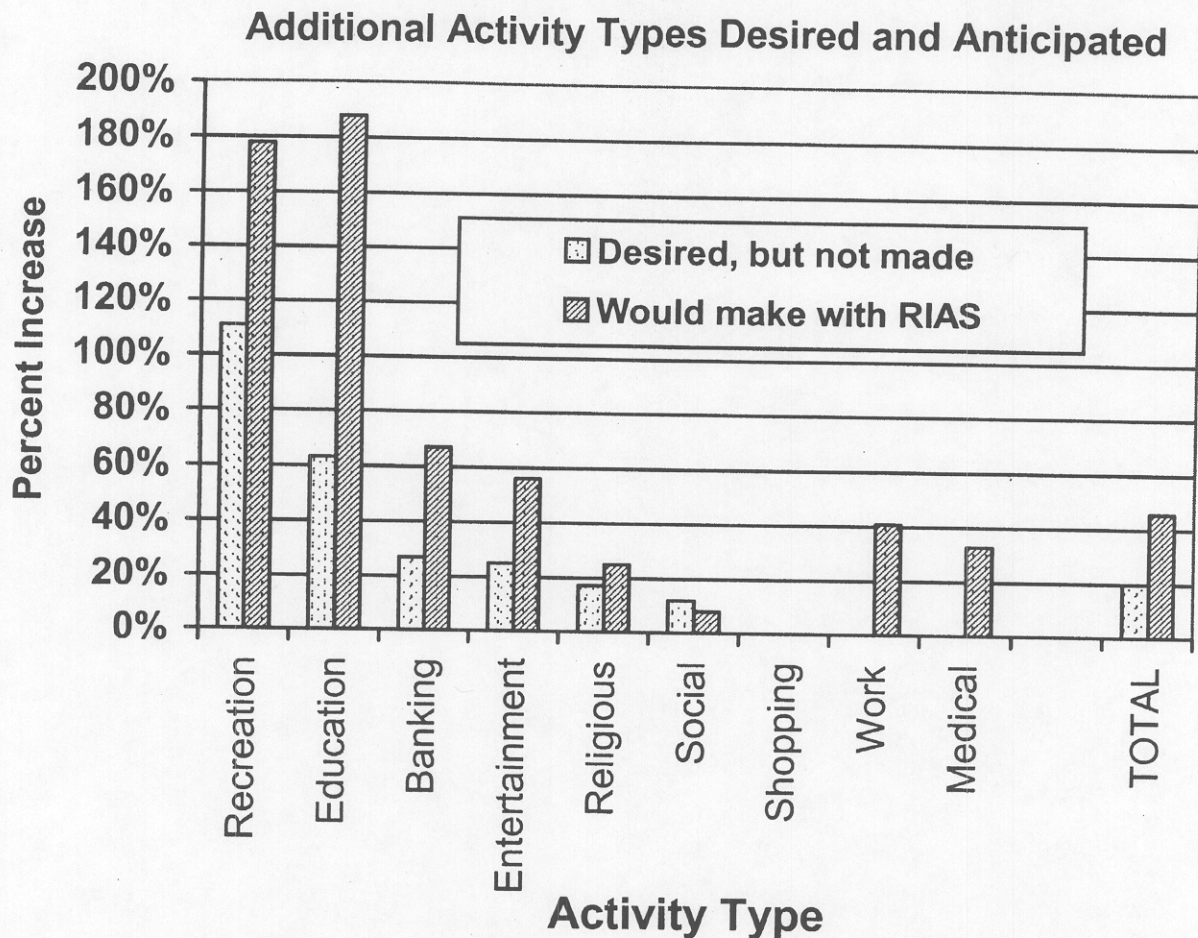


Figure 4. Additional desired and anticipated subject participation.

tual rate. The number of persons who desired to participate in new banking, entertainment, religious, and social activities increased by 27% to 12%. No one reported that he or she desired, but did not participate in, work or medical activities strictly because of limitations in independent travel. These data seem to be in line with what one would expect. Except for the first two discretionary activities, the estimate of "desired" participation was low or nonexistent for critical functions like work and medical care.

New types of activities anticipated with RIAS

The data on "desired" activities showed that the highest percentage increase was for recreational and educational activities. That

same pattern held true for the number of additional persons who said they would make these kinds of trips if RIAS was installed. Educational activities was predicted to attract 188% more individuals if they could use RIAS. The number of persons who were currently making trips to educational activities was 8, and 5 more said that they did not make such trips because of their inability to travel independently. However, after they used RIAS, an additional 15 participants anticipated they would attend educational activities. Clearly, this group valued education, but they thought that problems with independent travel kept their participation at the current level. With RIAS, the number of individuals who anticipated they would participate in recreational

activities increased 178% from the current rate, and 67% and 56% more individuals reported they would participate in banking and entertainment activities, respectively.

The next two types of activities that the participants anticipated they would attend were not even chosen in the "desired" question. Originally, 17 persons made work trips, and no additional persons indicated a desire to make them (see Table 1). However, after experiencing RIAS, an additional 7 (a 41% increase), said they would participate in work activities and make these types of trips. In addition, 6 participants reported making current medical trips, and none said that he or she avoided these kinds of trips because of the inability to travel independently. However, another 2 (33%) said they would make that kind of trip if RIAS was installed. Furthermore,

25% more participants said they would attend religious activities, and 8% more said they would go to social events. Everyone already made shopping trips, so no additional participants were noted.

SUMMARY OF TRIP-MAKING BEHAVIOR

Data were presented showing the actual, desired, and anticipated trip frequencies and participation in activities. For all the daily activities from which a person can choose, the data provide evidence that people with visual impairments are sometimes limited in their access to activities and travel and that there are major functional barriers that can affect their everyday activities. The findings for these participants may be summarized as follows; see Box 1.

Because the actual trips taken and range of activity types were both less than the par-

- Current participation in activities and travel were low for many participants.
- The majority (67%) of the participants reported engaging in limited activities and had a pent-up demand or desire for more trips than they currently made if they could independently travel and use transportation. This group desired to make 31% more trips and participate in 20% more new types of activities.
- Most (97%) participants anticipated that they would make 107% more trips and participate in 46% more types of new activities if RIAS was installed in their environment.
- None of the participants originally thought that he or she was restricted in working because of the inability to travel independently. However, after they used RIAS, an additional 41% said they would participate in work activities.
- The participants anticipated that the frequency of their work-related trips would increase 100% if they could use RIAS.
- Participation in educational activities, after using RIAS, was anticipated to attract an additional 15 persons over the current level of 8, a 188% increase in the demand for education.
- The frequency of trips was anticipated to increase 165% for educational activities if RIAS was available.

Box 1.

ticipants preferred, these data indicate that persons who are legally blind face functional barriers that hinder their full inclusion in activities and opportunities. These barriers include the lack of information and access to environmental cues—factors that are perceived to restrict independent travel. It appears that without additional spatially based information on location and orientation, their activities may be confined to local and familiar areas. Many participants seemed to limit their trips and activities to the most needed (obligatory) functions and to participate less in more discretionary activities.

The additional cues provided to the participants in this experiment appeared to reduce their perceived limitations on independent travel by providing a much higher level of information, spatial awareness, and accessibility. If the environment was made more accessible through the availability of auditory cues, the participants anticipated that their lives could be enriched, in that there would be many more types of activities in which they would participate and they would participate more in activities, particularly the more discretionary ones.

Conclusion

Marston and Golledge (1998b) and Marston et al. (1997) suggested that the dismal 70% unemployment rate of persons with legal blindness (Kirchner, Schmeidler, & Todorov, 1999) is due, in part, to difficulties of traveling independently. These restrictions include not just the daily commute to work, but, perhaps more important, the ability to perform a successful job-search strategy when jobs are located in various and scattered urban locations. For nondrivers, the available job or educational opportunities that are located in accessible or familiar ar-

reas are fewer than the aggregate opportunities that are available to sighted people. Learning unfamiliar routes and traveling to and locating unfamiliar buildings can also drastically increase the time needed for each interview or appointment.

The anticipated demand for participation in more work and educational activities, along with the high demand for more discretionary activities, indicates that substantial personal and societal economic benefits are to be gained by installing more RIAS and thus increasing access to opportunities for this group. Marston (2002) discussed the monetary benefits of RIAS and the cost of installing the transmitters on an urban bus system. Improvements to make the environment equally accessible to all cannot feasibly be based on traditional cost-benefit tradeoffs (because of the difficulties of measuring both). However, a more detailed analysis of benefits (increased earnings and tax base, along with reductions in private and public expenditures) is needed to determine the value of increased mobility and greater participation in activities for this population.

The data reported here were based on a sample of 30 fairly independent travelers and should not be interpreted to apply to the entire population with visual impairments. Travelers who are less independent most likely avoid making even more trips and engaging in more activities than this group did, but that population was not tested to determine if RIAS would increase their total (independent) travel. The research was based on stated preferences or anticipated behavioral changes and may not accurately reveal actual activity and travel behavior if RIAS was more widespread—researchers have consistently found differences between stated and revealed preferences. However, the overall experimental results

showed a high methodological convergence among the many subexperiments concerning the positive effects of RIAS on potential mobility and participation in activities.

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