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The use of the Sonic Pathfinder as a secondary mobility aid for travel in business environments: a single-subject design

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Abstract —

Two studies were conducted using a single subject research design in different business environments to evaluate the efficacy of the Sonic Pathfinder for increasing efficiency in travel with an experienced and accomplished blind traveler. The Sonic Pathfinder is one of eight or nine commercially available electronic travel aids (ETAs) designed for use by blind or visually impaired persons. The use of ETAs are thought to result in more rapid travel and a greater ability to detect and avoid obstacles in one's path. Elapsed time for travel and the number of unintentional contacts made while traveling were used as the dependent variables in both studies. No marked effect was observed for either variable in either study. An additional traveler who was slower and more tenuous in his movements was recruited to participate in the second study to investigate the possibility that a floor effect may have masked the results of the use of the ETA with the first subject. However, no marked effects were observed with this subject either. Yet, both subjects stated that the use of the aid increased their distance for environmental preview over and above that provided by the long cane alone, while providing them with the opportunity to judge the distance of objects approached beyond cane length. Discussion centers on the need to identify other means to evaluate the utility of this aid in light of the positive statements made by the participants of these studies.

Key words: blind, electronic travel aids, ETAs, low vision, sonic signals, wayfinding.

INTRODUCTION

The Sonic Pathfinder (SP) is one of eight or nine commercially available electronic travel aids (ETAs) designed for use by blind or visually impaired persons. "An ETA is a device that emits energy waves to detect the environment within a certain range or distance, processes reflected information, and furnishes the user with certain information in an intelligible and useful manner" (1). ETAs utilize ultrasonic sound navigation and ranging systems (sonar) and/or laser signals to sample the environment for objects in one's path of travel.

ETAs may be classified as either a) an object detector or an environmental sensor, and b) a primary or secondary mobility device. Object detectors provide for obstacle preview in and to the side of one's path of travel, while environmental sensors provide for both object preview and supplemental information about the quality and characteristics of the environment in which one is traveling (e.g., texture and density of objects detected). Primary mobility aids provide for both object and surface preview, while secondary aids provide for just one but not both of these (2).

Farmer and Smith have also classified ETAs into four types. Type I devices have a single output for object preview, while Type II devices have a multiple output. Type III devices provide for both object preview and environmental information (i.e., environmental sensors), while Type IV devices feature artificial intelligence as a component (1). The SP is the only Type IV device currently available.

Previous Studies

Blasch et al. conducted a national survey of ETA users to determine their rate of use and perceptions of the value of the aid to their travel. They found that of the 298 subjects interviewed, 140 had used their aid in the last 30 days before the interview and 62 of those carried their aid with them all the time. Half of the users reported using their aid continuously when they carried it, and the other half reported using it selectively to meet particular needs. In general, they reported that they felt that the use of their aid resulted in more rapid travel, with a greater ability to detect and avoid obstacles in their path of travel. At the time of the study, 39 percent were using a Mowat Sensor (a Type I aid), 24 percent a Laser Cane (Type II: the only ETA classified as a primary mobility aid), 34 percent a Sonic guide (Type III), and 3 percent a SP (Type IV). A number of subjects reported using more than one of the devices listed above (3).

Blasch et al. suggested that it would be useful to observe ETA users to determine whether ETA use actually has the effects on travel that have been reported to them: more rapid travel and a greater ability to detect and avoid obstacles (3). Dodds et al. did just that with the SP when they evaluated it with six subjects in a residential environment to determine the effect its use had on speed of travel (using a productive walking index that divided the time spent walking by the total time taken to complete a route) and the amount of contact with objects (using separate measures for cane contact, body contact, total contact, and accidental contact) in and along their path of travel (4).

They found that its use resulted in a significant decrease in both the total number of cane contacts with obstacles in the environment and accidental contacts with the cane and body as well, but no significant difference was recorded in productive walking (4). McKinley et al. reported similar results from a study conducted in a residential environment with nine totally blind veterans: a significant decrease in contacts with the environment with both the cane and body when using the SP but no difference in walking speed. In fact, they stated that all except one of the subjects studied traveled more slowly when using the SP than without it (5).

Dodds et al. noted that there was considerable variation among participants in terms of walking speed. Two of their subjects walked considerably faster and more efficiently with the aid, while the other four either walked at about the same pace or more slowly (4). They also pointed out that the faster two were the most efficient and experienced travelers in their sample. While referencing Armstrong (6), they speculated that better travelers were more likely to benefit from the aid in terms of walking speed than less efficient travelers.

The two studies described above were both conducted in residential environments but not necessarily those in which the subjects regularly lived or traveled. The complexity of a given environment, however, may have a real effect on the usefulness of the aid and its contribution to increased efficiency in travel. Blasch et al., in fact, concluded their study by saying that they believed it would be useful to understand how environmental variables, such as complexity of the neighborhood in which the visually impaired individual lives or travels, affect the use of, or benefits derived from, electronic travel aids (3). This study attempts to investigate that question with the SP by evaluating its use in both time of travel and detection of obstacles in two business environments of varying complexity.

METHODS

Subjects

Two subjects ultimately participated in this study. Both received approximately 5 hr of training on the SP in the environments, conditions, and manner described in its training manual (7). Once they were comfortable with the aid, training was discontinued and baseline data collected.

Subject One is a totally blind, 43-year-old male who had lost his sight at the age of 8 due to bilateral retinal detachments. An exceptional long cane traveler, he has used various ETAs in the past and had expressed an interest in trying the SP as a secondary mobility aid. Due to both his obvious ability in travel and previous experience with ETAs, it was assumed that he would be likely to benefit from the use of this one (4). Subject Two is a 50-year-old, congenitally blind male, with light projection only. He used a Mowat Sensor regularly during travel and was very interested in trying out the SP.

Although Subject One stated that he did not feel that he was traveling anywhere near peak efficiency in the first venue, he was a very seasoned traveler, and a short observation during the initial baseline phase led us to believe his speed could scarcely be improved. Therefore, we timed him on the route using a human guide, finding less than 5 s difference in the mean times under that condition and during baseline while traveling on his own with the long cane only. Hoping to counter any floor effect on time that may arise from that quick pace, we recruited Subject Two. Also an experienced and capable traveler, Subject Two traveled at a much slower and more tentative pace.

The Sonic Pathfinder

The SP is an ultrasonic sonar device designed to provide object preview in and to the side of one's path of travel for blind or visually impaired persons. It has two transmitting, and three receiving, transducers, mounted in a headband. The transmitting transducers flood the field in front of the traveler with ultrasonic energy. The receiving transducers detect the signals bounced back from objects in its path (1). These are processed by a microcomputer and translated into musical notes over miniature speakers for the traveler.

The auditory signal that alerts the traveler to objects in the path corresponds to notes on the musical scale analogous to distance. Objects detected at the maximum range (2.76-3.06 m) are identified by the highest note and those at the minimum range (0.0-0.75 m) the lowest. As the traveler gets nearer to the object, its signal becomes correspondingly lower in tone. There are eight tones: with the exception of the first or lowest tone, each represents a distance of approximately 0.3 m of travel (7).

While the device detects objects both in front and to the side of the traveler, it responds selectively to those objects that are closer and more central to the line of travel (7). Furthermore, the SP will only inform the traveler of those objects closing in range while ignoring those at a constant or increasing range. This selective attention is referred to as artificial intelligence by Farmer and Smith and is said to result in an aid that "shields the user from confusing information about objects out of the pathway of travel or beyond 2 seconds of travel time" (1). This feature of the SP accounts for its designation as a Type IV device.

As the SP is head mounted, it allows for hands-free operation. Its main purposes are to provide the traveler with 1) an extended range for object preview over that provided by the long cane (i.e., >1 m), and 2) an additional area of preview in the vertical plane from above the waist to approximately head height (7). It does not, however, provide for surface plane preview and, therefore, must be considered a secondary rather than a primary mobility device (2). Ideally, such aids supplement, but do not interfere with, the function or efficiency of the primary aid with which it is meant to be used. Primary mobility aids include the use of a human guide, dog guide, and the constant contact and touch techniques with the long cane.

Experimental Design

A single-subject experimental design (simple reversal) was used, a design recommended for use in research with the visually impaired because of its applicability to the investigation of the effectiveness of interventions and/or instructional approaches required for individualizing rehabilitation programs for this population (8-10). As the focus is on the participants, the validity of such designs does not depend upon drawing representative samples from larger populations, a problem with research conducted upon this population. Often only very small groups can be obtained for the sample, a violation of the premise of statistically based designs. This is not a problem with single-case designs as they do not purport to sample populations or generalize to them, nor is there a problem with masking individual effects by focusing on group means (10).

In single-subject research, the subject acts as his or her own control, and primary data are presented graphically and may be analyzed visually. As a result, the reader is free to determine the significance of the difference directly by viewing the primary data display. Changes in behavior observed across conditions are expected to be fairly obvious, if the differences observed are to be practically meaningful (11,12).

Thus, statistical analysis is not usually required (10,11,14). Furthermore, the subjects in these studies may take an active role in their design by identifying the behavior or behavior(s) to be investigated, as well as the setting in which the investigation is carried out. They or their representatives are also commonly involved in the evaluation of the results by determining the value of the outcome to themselves in relation to the cost to obtain it in terms of both money and effort (11,13). In this study, the primary subject participated in the design by nominating the environments where the evaluation took place, and both subjects were asked to comment on the outcome and the value of the device as a travel aid at the completion of the study.

Procedure

The first study was carried out with a single subject in a familiar business environment. The second was conducted in an indoor shopping plaza with both Subjects One and Two.

The independent variable in this study was the use of the SP as a secondary mobility device. The device used was essentially the same as that evaluated in the previous studies (5,6). However, there have been a number of improvements made to the aid in terms of its appearance and power source, as well as the addition of a transmitter to emit a special code for activating German traffic lights [1], since those studies were conducted. The dependent variables by which the SP was to be evaluated were elapsed time and unintentional contact. These variables were similar to those used in earlier investigations (5,6) and reflected the presumed benefits of the use of the aid (1,3,4).

A simple reversal design (A-B-A-B) was used to establish control of the independent variable over the dependent variable. The independent variable in this study was the use/nonuse of the SP as a secondary mobility device. The nonuse condition established the baseline (Phase A) used for comparison to the intervention (Phase B) where the device was used. Repeated trials were observed in each phase to establish both a level and trend for comparison across phases (14).

Elapsed time for completion of a route was recorded as the primary dependent variable and unintentional contacts as the secondary. Elapsed time was recorded from the time the subject began to travel the route to the time he concluded it. The clock was not stopped at any time during the run, nor was time spent waiting for street crossings factored out in any way. The secondary dependent variable, unintentional contacts, was defined as any contact made with an object or individual that was not the result of a planned or intentional movement. Contact with cane or body was recorded.

Test Environments

Subject One was asked to nominate the environments to be used in this study as those in which he would most likely use the aid in the future. He suggested two business environments, which together constitute the main shopping area of his city, Palmerston North, New Zealand, a small regional center of 75,000 people. He did not nominate his home residential environment, as he felt that he would not use the aid there, where he does not vary his route and with which he is familiar enough to be able to anticipate the location of most obstacles. Those that may not be constant are generally located with the long cane. Business environments posed more challenge to him both in terms of obstacles and heavy volumes of pedestrian traffic in his path. Many of those obstacles (e.g., advertising boards, café tables, product displays) are not permanently placed; as a result, their position and presence varies. Similarly, pedestrians, especially those standing in line to catch a bus or to use an automatic teller machine, create obstacles to travel that may not be as easily anticipated as the more permanent ones present in his neighborhood. Furthermore, people are more embarrassing to locate with the cane than inanimate objects: he would seek to avoid contact with them, if possible, and therefore sought the extra preview provided by the SP for travel in these environments.

The Square

The first test environment was the Square, the central business district of Palmerston North, where the streets and footpaths are the busiest in the city in terms of both pedestrian and vehicle traffic. In addition to heavy traffic, the footpaths are cluttered with a variety of obstacles, including street furniture, bike racks, sandwich boards, product racks and displays, as well as parking meters, lampposts, and signs. Many of these obstacles are portable, and their position varies from day to day.

Three routes were designed for this venue. Route one (R1) consisted of an L-pattern, two city blocks in length, with one light-controlled crossing and one zebra crossing (i.e., black and white striped crossing requiring traffic to stop and give way whenever a pedestrian steps onto it). Route two (R2) consisted of a U-pattern, three city blocks in length with two light-controlled crossings and one zebra crossing. And route three (R3) consisted of another L-pattern three city blocks in length with two zebra crossings and one light-controlled intersection. Walking all three routes is to walk the entire perimeter of the Square.

The subject was asked to walk each route from its starting point to a specific business objective. Each objective constituted the starting point of the next route in the series. The total elapsed time from the start to the time the subject located the objective was recorded, as was the number of unintentional contacts made along the way.

The subject walked the route three times under the two conditions: Phase A, Phase B, and return to Phase A, following the common pattern of a reversal or withdrawal (A-B-A-B) design (14). A final return to intervention was not carried out, as no obvious intervention effect was observed with either of the dependent variables. Data were collected over 3 days.

The Plaza

The Plaza is an indoor, single level, shopping mall. It has irregularly shaped passageways lined with retail outlets, open to the passageways during business hours. There are signs, product displays, planters, and benches located in the walkway. The concentration of pedestrian traffic is the highest here of any place in the city. One particular route from the main entrance to the west entrance was identified by Subject One as a problem area for him and one that he needed to negotiate from time to time. He hoped that the SP might be of some help in doing so.

A single Z-shaped route of travel was used in the Plaza, from the Northern to the Eastern Entrance. The subjects started facing south with their backs to the doors. They turned to their left and traveled east, then south, then east again to the East Entrance. There were open storefronts on both sides of the walkway, and the counter and display area of a florist on the right of the southern leg protruded into the walkway. The southern leg of the route ended at the entrance to a camera shop. There was often a line of people at an automatic teller machine on the east wall before the end of this corridor. The East entrance was at the end of a corridor to the left of the camera shop; the center of the Plaza was to the right. This center is an open area with ever-changing displays that serves as the hub for the various corridors making up this shopping center, and it therefore has heavy pedestrian traffic.

The two subjects were familiarized with the route using a human guide, first without the SP and then with it. Familiarization continued until the subjects were comfortable with the route, which the subjects were then asked to walk repeatedly. Data for total time elapsed and unintentional contacts were taken as in Study One, first for Subject One and then for Subject Two.

Subject One traveled the route first under baseline (Phase A) conditions, then under Phase B, and Phase A, completing the basic pattern (A-B-A) of a withdrawal design. As in Study One, a final intervention phase was not used because no obvious intervention effect was observed on either dependent measure.

Subject Two traveled the route in reverse sequence, Phase B, Phase A, first with the SP and then without. The intervention phase was introduced first in this case to immediately follow his familiarization with the route using the SP. The full cycle (B-A-B-A) of the withdrawal design was carried out with this subject, since an intervention effect was observed on one of the two dependent measures observed.

RESULTS

As can be seen in **Figure 1,** there was no marked or immediate decrease in the amount of time Subject One took to travel the routes in the Square; in fact, he took slightly longer to complete each with the SP. The baseline mean time for R1 was 3 min 42 s, increasing to 4:21 after the SP was introduced and returning to 3:22 when baseline conditions were re-established. Similar results were found for R2 and R3 as well. On R2, Phase A R2 took 5:33, Phase B took 6:03, and the return to Phase A, 5:24. Likewise, R3 went from 5:43 to 6:27 and back to 5:47.

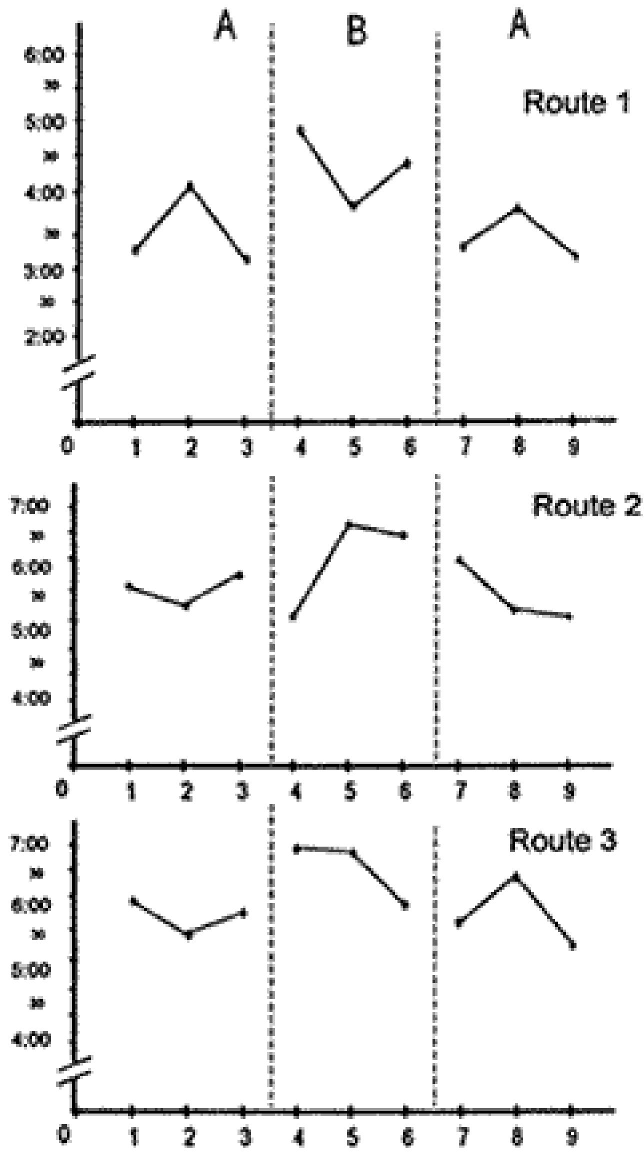

Figure 1. Elapsed time to complete routes across routes with and without the use of the SP.

The mean number of unintentional contacts varied somewhat across phases and routes (**Figure 2,**), increasing from 2 at baseline to 2.3 in the intervention phase and returning to 2 when the baseline conditions were re-established on R1. On R2, the mean number decreased from 5.3 at baseline to 3 during intervention, remaining at 3 when the baseline condition was re-established. On R3, the mean number decreased from 2.3 to 1.3 during intervention and increased to 3 when baseline conditions were re-established.

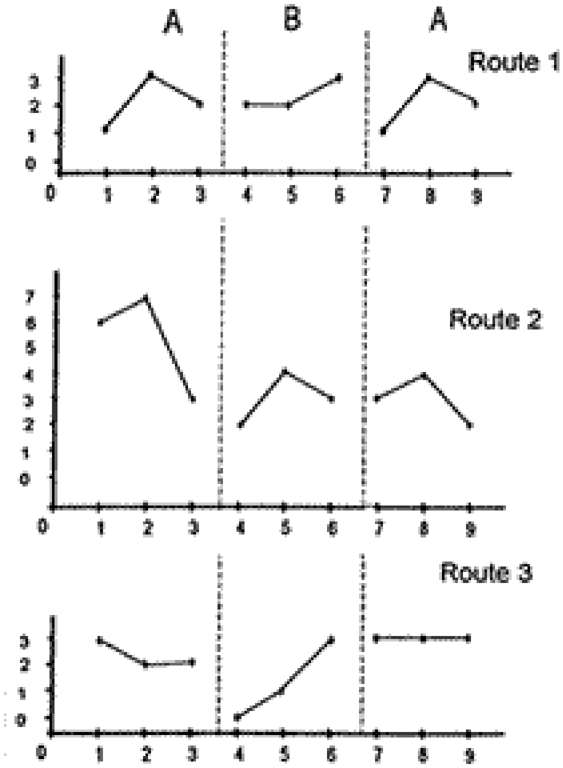

Figure 2. Number of unintentional contacts across routes with and without use of the SP.

As can be seen in **Figure 3,** there was not a marked or immediate decrease in the amount of time taken to travel the route in the Plaza for either subject, nor was control of the independent variable established over the dependent variable in either case. The mean time elapsed during Phase A for Subject One was 1:27. It decreased to 1:19 with the SP, and continued to decrease to 1:15 with the return to baseline.

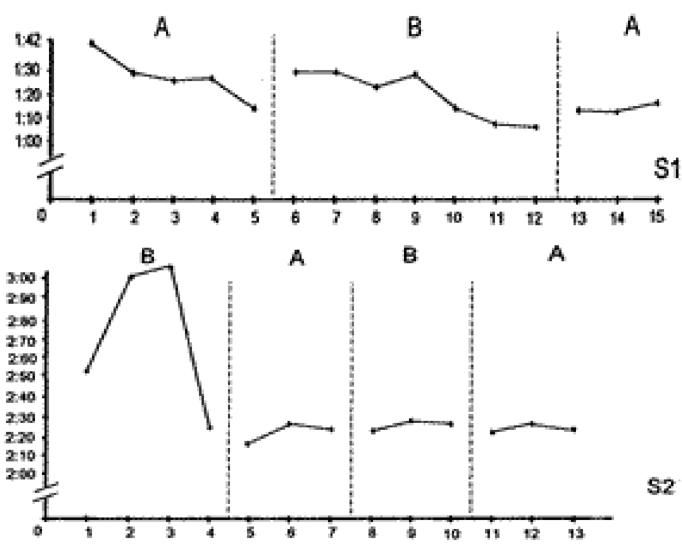

Figure 3. Elapsed time to complete routes across subjects with and without the use of the SP.

Subject Two averaged 2:50 with the SP to complete the course during his initial Phase B. His time decreased to 2:23 during the first baseline phase. The same pattern was observed across the next two phases, with a mean elapsed time of 2:27 on the second Phase B and 2:25 on the final Phase A.

As can be seen in **Figure 4,** the mean number of unintentional contacts made by Subject One had a slightly downward trend across the various phases of this study. During the initial Phase A, the mean number of unintentional contacts was 2.66, decreasing to 2.3 in Phase B, and dropping slightly again to a mean of 2 upon return to baseline. Thus, control of the independent variable over the dependent variable was not established.

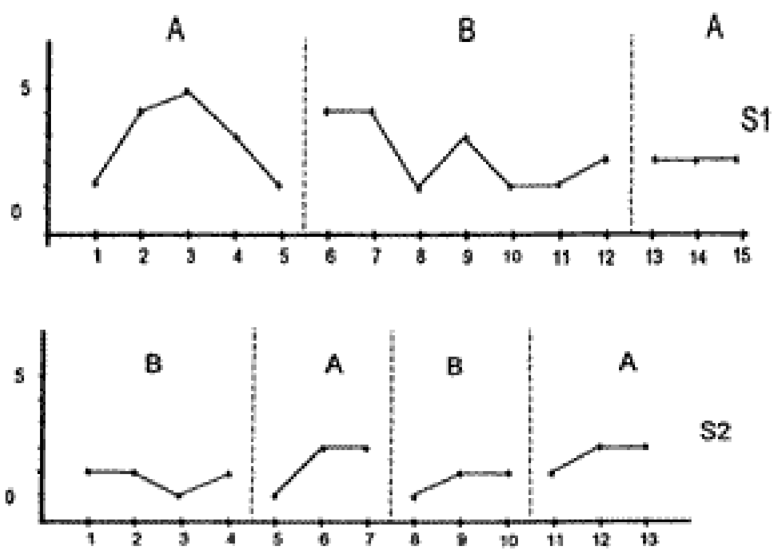

Figure 4. Number of unintentional contacts across subjects with and without the use of the SP.

The average number of unintentional contacts made by Subject Two varied by phase in the manner expected. During the first Phase B, that number was 0.75 and increased to an average of 1.3 under Phase A, returning to 0.7 with the second Phase B, and increasing to 1.6 on the final Phase A. Although the differences in the phases were not great, a degree of control of the independent variable over the dependent variable was established on this variable with this subject.

DISCUSSION

There was no obvious or marked difference found on either of the dependent variables for any of the routes traveled in the Square by Subject One. In both cases, there was too much overlap in data between phases to conclude that control of the intervention over these dependent variables was ever established. Although differences were seen in the total elapsed time taken, it was neither great nor in the direction anticipated. Rather, it was found that overall, he actually took longer to travel these routes with the aid than without it. Thus, we would conclude, like earlier evaluations of this device (4,5) that the use of the aid did not increase his efficiency in travel in terms of travel time. However, unlike those earlier studies, we found no marked effect on the number of unintentional contacts made with objects in his environment. Only on R3 did the level of the data points observed correspond positively with the introduction and withdrawal of the intervention. Having this occur on only one of three routes hardly constitutes a demonstration of control.

These results were discussed with the subject at the conclusion of the trials on the Square. He was asked whether he thought he had sufficient instruction and practice with the aid, a possible reason for these results. He felt that he had had enough instruction. He thought that he may have moved more slowly in this environment for a number of reasons, none of which had to do with problems or difficulties associated with using the device, however. The main one was that he was aware of more obstacles in and to the side of his path and was actively responding to them. He also thought that there may have been a novelty effect with the aid and that he tended to slow to attend to something that he would normally have passed by. Finally, he stated that at times he slowed to pace himself with other pedestrians, thus avoiding contact with them from behind that may have occurred without the aid.

He was also asked about the number of unintentional contacts made. He said that he thought he had, in fact, made fewer unintentional contacts with the aid and was surprised to find that no real difference was recorded on this variable. We, however, felt that although he was making as many unintentional contacts with the aid as he did without it, their nature was different. It appeared to us that while he was moving to avoid some obstacles, he would move into others. When he did make contacts, however, they seemed to be less abrupt. He stated that the aid reduced the startle effect commonly experienced when encountering objects with his cane, as he had some warning of their presence prior to contacting them.

When asked whether he would use the aid in this environment for travel on a regular basis he said no. He did not feel that it had enough effect on his ability to negotiate the region. He was familiar with the layout of the Square and found it relatively easy to deal with. He may, in fact, have been traveling at an optimal walking speed for this environment and therefore had little opportunity to increase his walking speed while using the SP. Thus, there may have been a floor effect on this measure due to his current level of efficiency. As a result, there may have been little opportunity to see a change in the data observed.

It was upon his suggestion that we continued by using the SP in the Plaza: this was an environment that he found challenging, was less sure of its layout, as it is irregular. He thought that the aid might prove to be beneficial there. He did not feel that he was traveling in this environment at anywhere near optimal efficiency.

There was no immediate or marked change in the amount of time taken to travel the route in the Plaza when using the SP as opposed to baseline for either subject, despite the differences in their pace of travel. Control was not established for this variable with either subject. There was, however, some effect on the number of unintentional contacts made and a degree of control demonstrated by Subject Two while using the SP but not by Subject One. Although the total number of unintentional contacts made by Subject Two were small in both phases of this study, there was a degree of control demonstrated over this variable. Despite that demonstration of control, however, it would have to be concluded that the use of the SP as a secondary mobility device had little or no effect on either measure of efficiency used in this study.

At the conclusion of the study, the results were discussed with both of the subjects individually. Neither was surprised that there was little difference in the measures used, but both said that they felt more comfortable traversing this environment while using the SP. Both agreed that the aid did in fact provide them with additional preview. Subject One stated that he liked the aid but probably wouldn't use it for travel in the Plaza as he would either continue to avoid this environment or only travel here as required using a human guide when possible. Subject Two stated that he would use the aid in this environment if he had regular access to it. He thought that he would also use it in lieu of the Mowat Sensor that he regularly used at work, due to its hands-free operation. Both subjects were generally pleased with the aid and felt that it did what it was designed to do.

CONCLUSION

The use of the SP did not increase the efficiency of travel in terms of the amount of time it took either subject to travel in either environment. It did have some effect on unintentional contacts made by one, but not both, of the subjects. These findings are not dissimilar to those reported by (5,6) who, using a very different design and similar but different dependent measures, found that the use of this aid had no significant effect on efficiency in terms of travel time but did have a significant but small effect in terms of number of contacts made. From these three studies, we may conclude that the use of the SP has little effect on these measures of efficiency. Yet, efficiency may not, in fact, be the most appropriate measure for evaluating the efficacy of this aid. In fact, we may rethink this a little and find that it may be a positive finding to observe that the use of this device does not depreciate travel speed to any real extent. Both travelers maintained their speed of travel when using this aid, despite the fact that they varied greatly in the time they used to cover the same route. This would only be relevant, of course, if other benefits were apparent from its use.

One benefit found by Dodds et al. (4) was a significant increase in their subjects' awareness of obstacles in their path of travel. Although this was not directly measured in the current study, the subjects were asked about the preview provided by the aid, and both answered that it did indeed increase their awareness of objects in their environment and the distance at which they are noticed. They also stated that it provided them with an increased ability to judge the distance to these objects, as it is designed to do.

It is apparent that the measures used in this study were not the best for identifying the value of the SP to these subjects. Other dependent variables need to be explored, especially those related to comfort and confidence. In the mean time, subjective data should continue to be considered, as should various measures to determine the effect the aid has on the subjects' knowledge and preview of the environment.

This study only utilized one of the two benefits provided by the aid, extended preview. The other benefit of locating objects higher up in the vertical plane than done by the long cane did not seem to feature because of the type of environment used and the height of the subjects involved. One would suspect that for very tall travelers this feature might be of real value. Further research is indeed required to determine the utility of this aid, how best to take advantage of the extended preview it provides and how best to selectively determine its value to tall travelers or others who wish to travel in less controlled environments than those used here.

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