A Comparison of Selected Secondary Electronic Travel Aids with a Primary Mobility System

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This study examines the performance of participants who are blind and have light perception or less when using a secondary electronic travel aid (ETA) and their primary mobility system (e.g., cane, vs. their performance with a cane, alone). The secondary devices studied were the Miniguide US™ and the K Sonar Device™. The participants' performance was measured by their ability to detect obstacles on the vertical and horizontal planes; detect drop-offs and curbs; detect and avoid overhead obstructions, and determine natural and man-made landmarks that could possibly be used for orientation. In addition, the variable "speed of execution" was measured. Increased or decreased efficacy between the participants' performance with their primary system alone and their performance using both their primary mobility system and one of the two secondary electronic travel aids in conjunction were measured.*

Introduction

Making the environment accessible for individuals with disabilities has been a continual concern in the USA since 1959 when the American National Standards Institute (ANSI) began to establish guidelines. However, Blasch and Stuckey (1995) have asserted that this issue was a primary concern for persons who are blind in the United States since the inception in 1929 of the Seeing Eye.

The short cane was used in conjunction with the dog guide for about ten years, but since Richard Hoover's introduction of his modified cane techniques using the long cane at Valley Forge General Hospital the use of the short cane is seldom now seen (Wiener & Sifferman, 1997). Most Orientation & Mobility (O&M) instructors seldom, if ever, work with a student who uses a short cane.

Although travel with the long cane or dog guide by persons who are blind was and still is the norm, there has been significant professional interest in electronic travel aids (ETAs) since Leslie Kay developed the Ultrasonic Hand-Held Torch in 1959. Continued interest is evidenced by the development of the Pathsounder™ by Lindsay Russell in 1964; the Sonic Guide's™ predecessor the Binaural Sensory Aid in 1966; the Laser Cane™ in 1966 by Malvern Benjamin; the Mowat Sensor™ in 1977 by Geof Mowat (Wiener & Siffermann, 1997); and more recently the UltraCane™, the K Sonar Device™*, the Miniguide™ in both tactile/haptic and auditory configuration, the Miniguide US™, and the Handguide™ by Guideline (LaGrow, 1999; Penrod & Blasch, 2005; Penrod & Simmons, 2005; Penrod, Corbett, & Blasch, 2005; Penrod, Bauder, Simmons, Belcher, & Corley, 2006). Unfortunately, since the death of Malvern Benjamin, inventor of the Laser Cane™, that device is no longer on the market, neither is the UltraCane™ since its parent company (Soundforesight) went out of business in 2007. Currently, there are only 'secondary' devices commercially available to persons who are blind. A 'secondary' device is an electronic travel aid (ETA) that is used in conjunction with a cane, dog guide, or human guide to increase the user's safety. These secondary devices however, have stimulated renewed interest in ETAs.

The O&M instructor traditionally has the task of teaching the student to travel independently, safely, efficiently and gracefully (Hill & Ponder, 1976). This notion might increasingly be expanded to include instruction on ETAs as a replacement for, or supplement to, traditional systems, (e.g., the long cane or dog guide).

The O&M instructor accomplishes this task of instilling safe and efficient independent travel capability by educating students about the techniques of O&M including the use of the long cane when the student is ready. Canes are viewed by many as the more advantageous mobility aid in familiar environments with little outside stimulus that interferes with the detection of landmarks and clues (Farmer & Smith, 1997).

Some have considered dog guides as the better option when travelling in heavy traffic or when such weather conditions as ice and snow make the environment difficult to navigate (Gitlin & Mount, 1997). While some people, mostly the young and professional favour dog guides, there are currently less than 10,000 active dog guide teams, while the 1990 National Health Interview Survey indicated that there were then 109,000 individuals who reported using a white cane as their main mobility device (Gitlin & Mount, 1997).

Regardless of whether or not a student chooses a dog guide or a long cane, objects beyond the reach of the cane or that the dog guide circumvents most often go unnoticed by the person who is blind. This inability to detect possible landmarks is seldom a problem for the user on a known and familiar route, but is extremely important in new or novel situations where landmarks and objects above the wrist or beyond the reach of the cane user need to be identified, noted, or circumvented, as appropriate. It is in these circumstances that the ETA may be a viable option, and for infrequent or selective use there is no substitute for a secondary ETA used in conjunction with the user's cane or dog guide.

ETAs are devices used to transform information about the environment that would normally be perceived through the visual sense into a form that can be perceived through another sense by the person who is blind (Blasch, Long, & Griffin-Shirley, 1989). They are briefly categorised into four types: Type I, go, no go system; Type II, multiple output (audible or tactile-haptic); Type III, devices that gave environmental information (qualitative data); Type IV, combined obstacle preview with artificial intelligence (Farmer & Smith, 1996). With the advent of new devices performing the same function using a different energy source, this nomenclature system became obsolete. ETAs are currently divided into two broad categories, primary devices and secondary devices. A primary device is one that might be used safely and efficiently by itself by a person who is blind independent of a cane or dog guide. A secondary device is one that must be used in conjunction with a cane or dog guide to ensure safe and efficient travel (Farmer, 1980).

In a 1989 study entitled *Results of a National Survey of Electronic Travel Aid Use*, 298 ETA users were interviewed by telephone about their mobility aids. Of those questioned, 67% used the long cane, 14% used dog guides, 10% used the Laser Cane™ and 6% used human guides as their primary means of travel. The researchers found that the more simple and convenient the device, the more likely people were to use ETAs (Blasch, Long, & Griffin-Shirley, 1989). This finding is consistent with the notion that many times low-tech options, for example the cane, are often combined with high tech options (Baldwin, 2003).

Two relatively new secondary ETAs have recently been introduced and have generated considerable interest in the field of vision impairment. The Miniguide US™ and the 'K' Sonar Device™* might be considered

Figure 1. Miniguide US™.

secondary devices that use ultrasound to detect objects on the vertical and horizontal planes.

Although the Miniguide US ™ is capable of auditory output, most individuals who are blind choose the tactile-haptic feature rather than sacrifice the increased compactness, lightness, and portability provided by this feature. Totally vibratory (as tested), the Miniguide US™ has only five modes and these are listed as they appear in the device's menu commands; effective at four metres, two metres, one metre, one-half metre, and eight metres. It also has a gap-finding feature that is useful in detecting doors and intersecting hallways (Figure 1). It is light, small, easy to carry in the user's pocket or purse, and the unit is contained in a hard impact resistant case.

The Miniguide US™ uses pulse ultrasound to determine the presence, and distance of objects from the user. It sends ultrasound through one of its round, mesh-covered ports and receives ultrasound back through the other port. Ultrasound pulses produce a symmetrical, slightly flattened cone-shaped coverage pattern, with the widest part of the cone near the end of the range. The coverage area narrows slightly horizontally at the far end of the range. The Miniguide US™ (as tested) indicates the presence of an object in its range by vibration - the closer the object, the faster the vibration. An absence of vibration indicates that there is no detectable object in range (Terlau, 2005).

The 'K' Sonar* was developed with ease of use in mind while increasing the user's ability to travel safely, independently and gracefully (Figure 2). Developed by Dr. Leslie Kay and Bay Advanced Technologies, Ltd. (BAT), the 'K' Sonar* uses echolocation to detect the presence of objects in the traveller's path. According to instructional material for the use of the device, "just as naval sonar allows mariners to make perceptions about underwater environments, so the 'K' Sonar* device allows those who use it to make perceptions about their surroundings that otherwise would not be possible" (Bay Advanced Technologies, 2007a). When attached to a cane the device gives the illusion of being a primary ETA and when detached it is considered a secondary device. The 'K' Sonar* identifies objects in the path of the user through ultrasonic echoes. These echoes are then converted electronically into sounds heard through small headphones that transmit the shape and size of the objects in the user's path (Bay Advanced Technologies, 2007b). The device has two ranges. Long range is about 16 and ½ feet while the short range is approximately 6 and ½ feet.

Purpose

The purpose of the present research was to determine whether or not the use of ETA devices (Miniguide US™, 'K' Sonar Device™* when detached from the user's cane, and the 'K' Sonar* when attached to the user's cane), would increase the participants' ability to detect obstacles on both the vertical and horizontal planes; detect drop-offs and curbs; detect and avoid overhead obstructions, and determine natural and man-made landmarks that could possibly be used for orientation as compared to the participants' standard mobility device. In addition, the variable speed of execution using each device was compared to that of using their primary mobility system alone.

Figure 2. ‘K’ Sonar™* Device.

Method

Participants

The participants consisted of five adults (two females and three males) with light perception or less and no additional disabilities. All were considered to be proficient travellers with their respective standard mobility devices. Two were deemed proficient with both the cane and their own dog guides. All were proficient cane users and travelled independently. Four out of five of the participants were college educated and one of the participants has an earned Ph.D. Participants ages ranged from 32 to 54. Three participants were congenitally blind and two were adventitiously blinded as adults. Four participants were employed in a full-time capacity and one was a parent/homemaker.

Human Subjects Approval

An Institutional Review Board (IRB) (i.e., similar to an ethics or Human Subjects Review committee) at the University of Louisville approved this study. All participants were provided with information necessary to make an informed decision and each participant signed the approved form prior to the beginning of the study.

Pre-Training

Each participant received individual instruction using the respective ETAs for a period of approximately five hours. An O&M instructor with over four years of experience and who was well versed in the use of these particular ETAs provided the training. Each participant was then allowed to use the device for up to ten days for familiarisation purposes, and then tested for proficiency by the O&M instructor. The O&M instructor tested the proficiency of each of the participants

Figure 3. Man-made vertical obstacle.

by having them walk along a clean concrete walkway and indicate the presence of five man-made obstacles placed randomly along the participant's path. All participants had to demonstrate proficiency by locating and identifying four of the five man-made obstacles before they were allowed to engage in the data collection process.

Setting

Each participant was asked to travel an outdoor route in a controlled setting. The obstacle course was one city block long that was split into two routes. One complete loop of the obstacle course consisted of four routes with eight possible encounters in each route. The routes were parallel to a busy street,

Figure 4. Man-made horizontal obstacle.

had smooth and unbroken sidewalks, small trees, parking metres, speed limit signs, and telephone poles that were typically spaced at eight to ten metres apart. None of the routes had a grass-line between the sidewalk and the curb. Additional obstacles were placed in various locations throughout the city block that resulted in seven natural and nine man-made obstacles. The man-made obstacles were PVC pipes held in position by lumber blocks and were three different types: a 50” high L shaped obstacle, a 60” high L shaped obstacle, and a 50” high straight obstacle (see Figures 3 and 4). These obstacles were placed throughout the course.

Data Collection

Participants were asked to indicate the presence of all obstacles along the route and any identifiable landmarks that might be encountered. If the cane encountered an obstacle or landmark, then the encounter was scored as identified (correct). If the participant identified the obstacle or landmark, then the identification was likewise scored as correct. If the obstacle or landmark was not encountered with the device, then this was scored as an error. If the participant identified an obstacle that was not there, then this was scored as an error. If the participant identified the obstacle but did not note the L shaped extension (Figure 4) or came into contact with the extension, then this was scored as an error (Table 1).

Table 1. Scoring of correct and incorrect responses.

Behaviour	Correct	Incorrect
Participant identifies landmark or obstacle verbally without making contact	(+)	
Participant identifies landmark or obstacle verbally but makes unintentional contact		(-)
Participant identifies landmark or obstacle but makes deliberate contact e.g., modified upper-hand and forearm (Hill & Ponder, 1976) to push the object out of the way	(+)	
Participant does not identify landmark or obstacle and makes unintentional contact		(-)
Participant does not identify landmark or obstacle and does not make contact		(-)

During each route sequence the man-made obstacles were moved from one side of the sidewalk to the other so that each route would be different thus negating both the practice effect and considerations regarding degrees of difficulty between trials.

Data were collected on speed of execution, number of correctly identified obstacles, and the number of incorrect errors the subject identified while traversing the route. Observing the route was a data collector and another person who replaced the artificial obstacles and collected data for inter-observer agreement.

Procedure

A trial began by having a human guide take each participant to the beginning of the designated course. Participants were asked to complete the designated route using the user's standard long cane to establish standard mobility performance. Participants, using the same route, were asked to complete the same designated route using the respective ETAs in conjunction with the user's

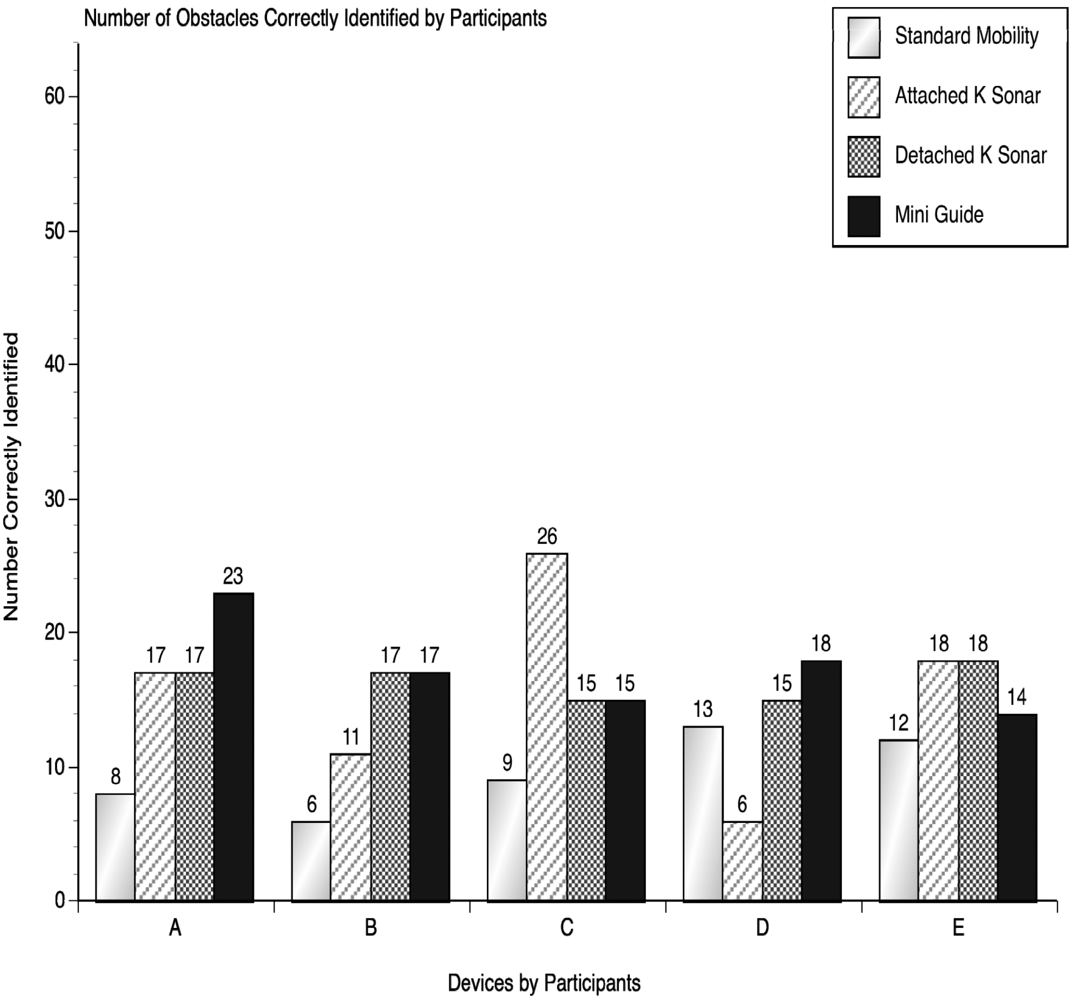

Figure 5. Subject A through E: Number of obstacles correctly identified.

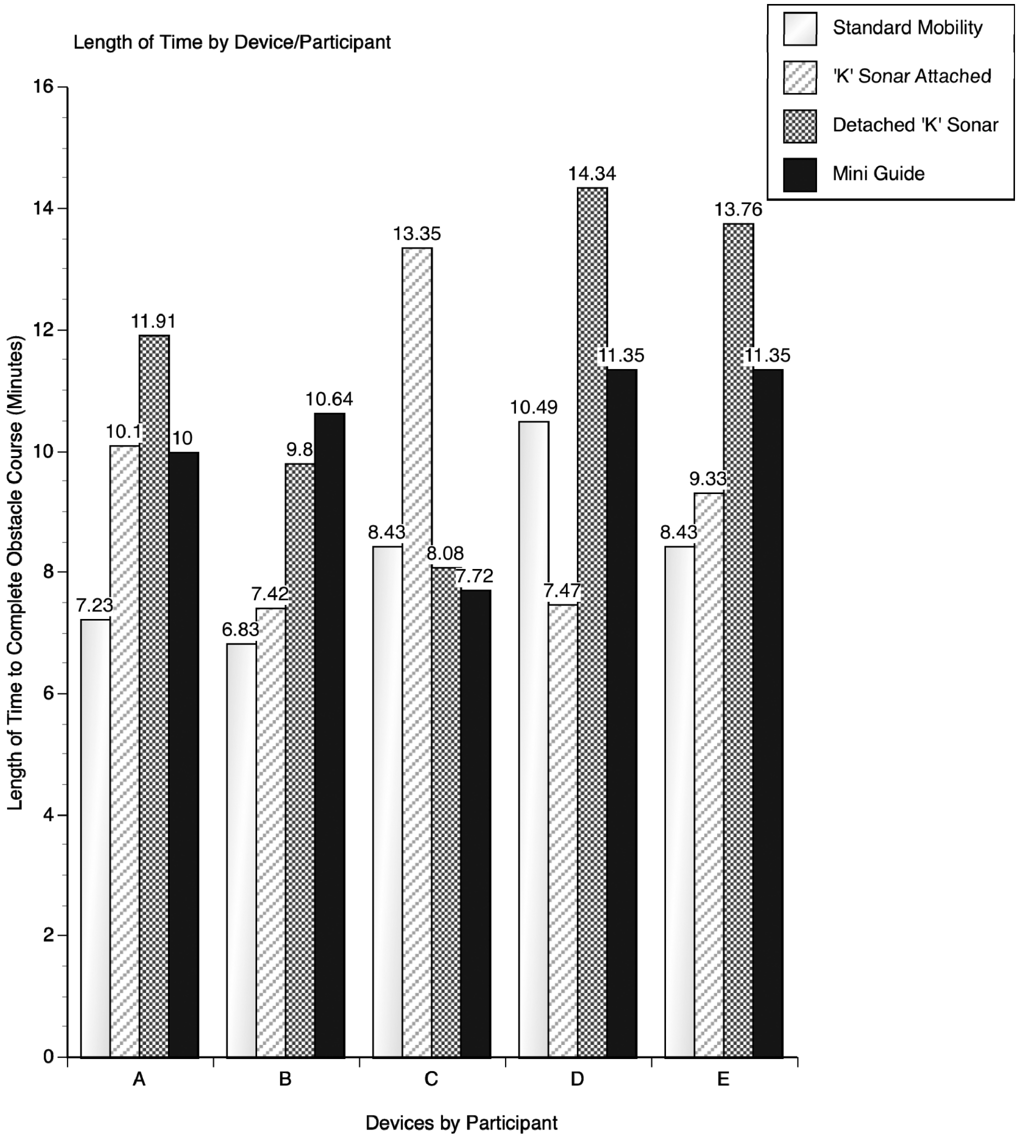

Figure 6. Subject A through E: Length of time by device/participant.

cane. The entire process was repeated for the second and third ETAs. Artificial obstacles were randomly moved after alternate trials to minimise any undesirable consequences of practice effect.

Results

Inter-observer agreement was determined by having two observers compare data sheets and determined by dividing the data sets by the larger number and then determine a decimal (e.g., observer 1 determines that there were 9 unintentional contacts while observer 2 recorded 10 unintentional contacts, 9 ÷ 10 = .90 inter-observer agreement). Inter-observer agreement was determined on 40% of the trials of each participant. Inter-observer agreement was calculated to be 92%.

There were five participants involved in this research study to show the efficacy of the Miniguide™ and the 'K' Sonar Device™* devices. Figure 5 presents the performance of each participant in identifying obstacles using their standard mobility device and the added ETAs. Participants A through E are shown. Figure 5 demonstrates that, with the exception of participant D during the attached K Sonar Device™* condition, all participants identified more obstacles using an ETA then were identified by the participants while using their standard mobility devices. These improvements ranged from a low of two obstacle observations (participant E) to a high of 15 (participant C) additionally identified obstacles over the condition in which the participants' standard mobility device was used.

Other than with participants C and D under the attached K-Sonar* condition, there

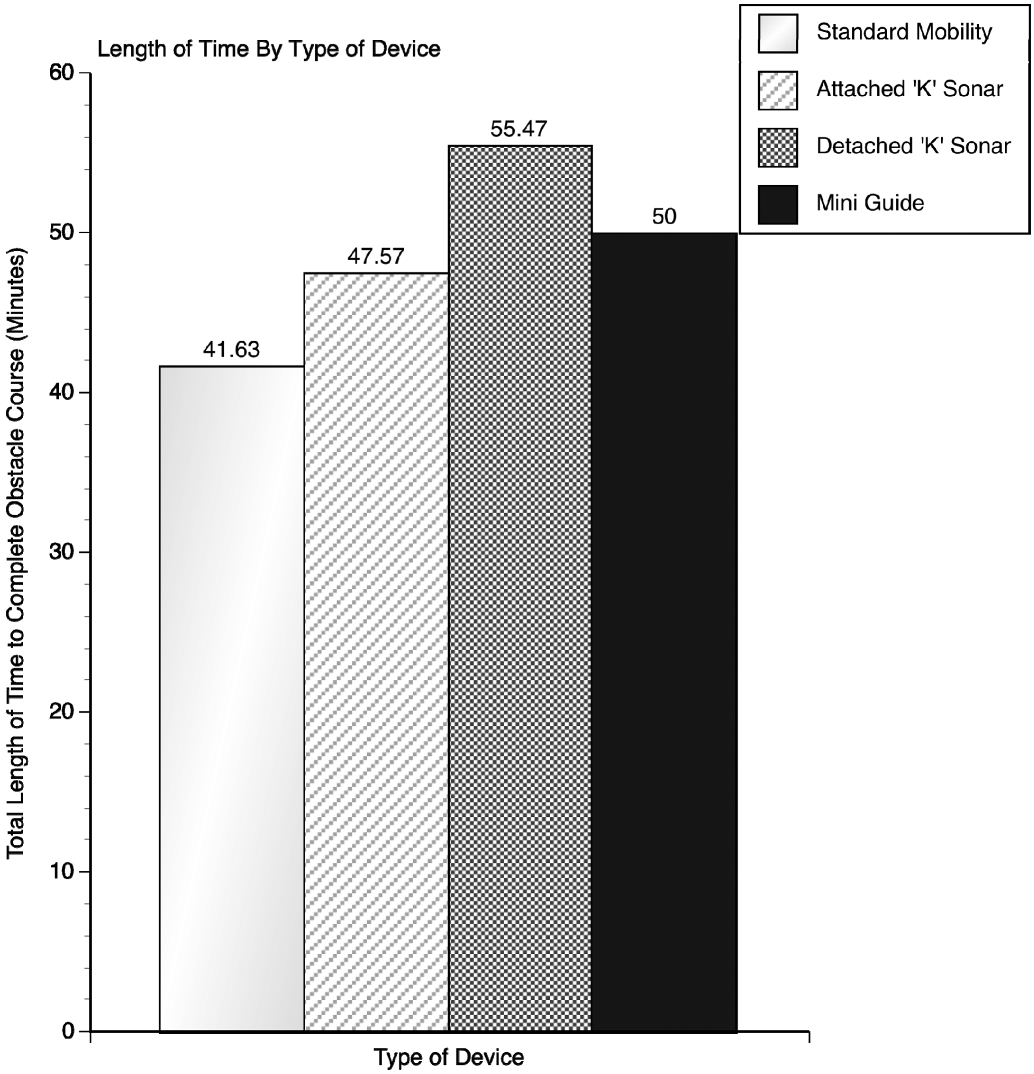

Figure 7. Length of time by type of device.

did not appear to be a significant benefit in identifying obstacles for any of the ETAs for the participants. Thus, it appears that each participant equally improved their identification of obstacles using each of the three ETAs. The two outliers in this study were Participants C and D. Participant C identified 26 (81%) obstacles under the K Sonar* attached condition. Participant D on the other hand only identified 6 (19%) obstacles under the K Sonar* attached condition.

As previously noted, duration of time was recorded in the performance of the obstacle course for each of the conditions. This was achieved by using a stopwatch that was started and stopped when the human guide indicated "begin" to start the trial and "end" to end the trial for each of the respective participant's trials. Figures 6 and 7 indicate a range in the duration performance for each of the participants. While all of the participants generally traversed the obstacle course in the 7 to 8.5 minute range with their standard mobility device, the time range was higher during the conditions that the ETAs were used. The added duration of time it took for the ETAs conditions ranged from a low of 7.47 minutes (Participant D in the K Sonar* attached condition) to a high of 14.34 minutes (Participant D in the K Sonar* detached condition) (Figure 6). For all participants, Figure 7 shows that the shortest combined duration was 41.63 for the standard mobility condition with the longest combined duration being 55.47 minutes for the Detached K Sonar* condition.

Table 2 presents the average obstacle identification per minute. In general, all participants identified equal two or more obstacles per minute during the ETA conditions than were identified during participants' standard mobility condition. Participant D was again the one exception. Participant D's performance during the Attached 'K' Sonar* condition indicates both a shortened duration and reduced obstacle identification outcome.

Discussion

This study explored the differences in obstacle identification of five individuals with vision impairments using their standard mobility device with the addition of two ETAs (Miniguide™ and the 'K' Sonar Device™*). The data appear to indicate that both of the ETAs impact upon and improve performance of identifying obstacles. Both appear to allow the user to identify and manoeuvre around obstacles as compared to their standard mode of traversing a variety of environmental travel impediments. These

Table 2. Average obstacles identified per minute.

Condition	Standard Mobility	Attached 'K' Sonar*	Detached 'K' Sonar	Mini Guide
Participant A	1.1	1.7	1.4	2.3
Participant B	.9	1.5	1.7	1.6
Participant C	1.1	2.0	1.9	1.9
Participant D	1.2	.5	1	1.6
Participant E	1.4	1.9	1.3	1.2

improvements might possibly prove significant regarding impact for users to supplement their standard mobility. According to the data, the user was better able to detect obstacles, landmarks and other impediments that might cause harm or pose problems. Furthermore, problems may be averted or additional obstacles located that would not have occurred during the user's normal mobility practice.

The improvements evidenced varied by participant. It appears that at least one of the participants, when using the 'K' Sonar*, attempted to move through the obstacle course quite quickly and consequently did not take advantage of the added information provided by the ETA device. The other participants seemed to benefit however. All participants seemed to gain added information that could be helpful in what potentially might be dangerous conditions (i.e., limbs or wires hanging down after a major storm, raising and lowering fence gates that do not extend completely to the ground).

The secondary ETA provided each participant with a means to: detect obstacles on both the vertical and horizontal planes; detect drop-offs and curbs; detect and avoid overhead obstructions, and determine natural and man made landmarks that could possibly be used for orientation. In addition, when the variable "speed of execution" was calculated, there does not appear to be a "significant" overall increase in the amount of time using a cane and using a cane with a secondary device. This would suggest, in some circumstances, that an addition of a secondary ETA would not impede a person's ability to efficiently travel in their environments. Further, while the participants were trained and had over a month of experience with using the two ETAs, it might be that with further use, the participants' time-related efficiencies will improve over time.

There are several issues that should be distinguished regarding the two ETAs used in this study. These issues include the modalities that each ETA uses and the environment in which each device is used. The Miniguide US™ uses a vibratory mechanism to impart information about obstacles, while the 'K' Sonar Device™* uses an auditory transmission of information. Both devices provide added information but persons with auditory or neuropathy problems may benefit from using the particular device that meets their individual needs. Additionally, the environment in which one uses the device could impact the ETA's utility. If one is travelling through congested areas or in areas of very high traffic noise or heavy vibrations the respective ETAs might impede or decrease the each type's utility.

Although it was found that both devices might be a viable addition to the array of secondary ETAs available to persons who are blind, there are many variables that would yield a better understanding of the utility of secondary ETAs. Other areas of research on ETAs should include age of the user (elementary age, secondary age and adult), reliability of the device to accurately indicate obstacles, practical daily usage, durability, and utility with differing abled users.

In conclusion, although we examined the performance of participants who are blind and have light perception or less when using a secondary ETA and their primary mobility system, the small sample size limits the extent to which the results can be generalised. Further, replications of this study are needed to determine whether or not similar results occur when participants have varieties of vision impairment such as low vision, retinitis pigmentosa (RP), or blind with additional disabilities.

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*Please note that the American Printing House for the Blind (APH) who at the time of this writing is the sole distributor of the device in the US, only advertises it as a secondary device.

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