Effectiveness of the SoundFlash Device in Enhancing Non-Visual Spatial Perception

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The purpose of this study was to determine the effectiveness of the SoundFlash device in enhancing non-visual spatial perception. A mixed-methods, A-B-A-B-A-B research design was used to evaluate the effectiveness of the SoundFlash. Three vision impaired individuals participated in the study, which included echolocation training both with and without use of the SoundFlash device. At the conclusion of the study, a focus group was conducted to gather qualitative data from participants. The results of the qualitative portion of the study supported the effectiveness of the SoundFlash, while the findings of the quantitative portion were inconclusive. The SoundFlash might be helpful in improving the non-visual spatial perception abilities of individuals who are blind. Major limitations of this study include the use of a quasi-experimental research design without a control group; a small sample size (three participants); and a researcher-designed assessment tool that was not pilot-tested prior to use in the study.

Loss of the sense of vision can have wide-ranging implications for a variety of skills, including the ability to successfully navigate one's environment for completion of daily functional tasks. There are currently many assistive devices and technologies that assist persons with vision impairments in improving their orientation and mobility (O&M) skills. The exponential growth in computing technology in the past decade has also facilitated the development of new technologies to assist persons with vision impairment in gaining information about the spatial properties of objects in their environments (Baldwin, 2003).

Following vision, hearing has the most extensive capabilities for assisting people in obtaining information about the environment. Various technologies have been designed to enable people who are blind to use their hearing to obtain information about objects in their environments. One electronic echolocation device, the SoundFlash, was designed by Kish to assist people who are blind to gain increased information regarding objects in their environments through the use of auditory perception (Kish, 2007). While anecdotal evidence supports the use of this device and the echolocation system that it is based upon (Kish, n.d.), there is no hard evidence to substantiate its effectiveness. The purpose of this mixed methods study was to examine the effectiveness of the SoundFlash device in helping young adults who are blind to identify and locate objects in their environment.

Literature Review

Typically, humans use vision as the primary sensory method for perception (McGrath, Waldmann, & Fernstrom, 1999). Because blind and vision impaired individuals are lacking this important sense, they must depend on their remaining senses to obtain information about the environment (Arno, Capelle, Wanet-Defalque, Catalan-Ahumada, & Veraart, 1999; McGrath, Waldmann, & Fernstrom, 1999). Blind individuals often rely on hearing to assist with O&M activities.

Echolocation

Echolocation, which can be defined as the process of interpreting and perceiving reflected sound waves called *echoes*, is a method of using auditory sensation to compensate for visual deficits using auditory perceptual capabilities. Echolocation is an important skill since it allows some persons who are blind to perceive objects and spaces from a distance. The interpretation of echoes can allow a person to make determinations about several key characteristics of objects. These characteristics include the location of the object (lateral, vertical, and anterior-posterior position, and distance from the person); dimensions of the object (height and width); and density of the object (solidity versus sparsity, and absorbance versus reflectivity) (D. Kish, personal communication, January 28, 2009).

While there is a great deal of anecdotal evidence about and professional support for the effectiveness of echolocation, limited research supporting the effectiveness of echolocation exists. A study by McGrath and colleagues (1999) demonstrated that vision impaired individuals may be able to use auditory sensory information in place of visual sensation to obtain information about the environment. The results of this study support the use of echolocation to aid perception for blind individuals (McGrath, Waldmann, & Fernstrom, 1999).

Sensory Substitution

Research by Arno and colleagues (1999) investigated the concept of sensory substitution using audition to substitute for vision. The experiment involved an artificial vision system that coded visual information into auditory signals. The results of this study demonstrated that individuals who were trained in the correct use of the device demonstrated clear improvements in their ability to interpret the patterns, whereas those who were not trained improved only slightly. This study showed that sensory substitution is possible, and that training can greatly improve a person's ability to use auditory information for perception.

Factors Affecting Echolocation

There are many variables contributing to the successful use of echolocation. One of these is the type of signal used. The signal used should be controlled by the individual, have good alignment with the ears, be consistent, and be familiar to the observer. In order to accomplish this, the signal should either be self-produced or specially designed. Electronic signal generation enables precise generation and manipulation of the signal as well as incorporation of optimal echo characteristics. The SoundFlash device has been designed to produce a signal that can be used for echolocation (Kish, n.d.).

However, research is necessary to determine whether or not the device is effective. The purpose of the present study is to investigate the effectiveness of the SoundFlash device in enhancing non-visual spatial perception skills.

Participant ID Number: _______________

Date of Assessment: __________________

Administrator: ______________________

PRETEST POSTTEST A1 A2 A3 (no SoundFlash) POSTTEST B1 B2 B3 (with SoundFlash)

	Trial 1	Trial 2
HEIGHT		
Which item is the tallest?	Correct/Incorrect	Correct/Incorrect
Which item is the shortest?	Correct/Incorrect	Correct/Incorrect
WIDTH		
Which item is the widest?	Correct/Incorrect	Correct/Incorrect
Which item is the narrowest?	Correct/Incorrect	Correct/Incorrect
DEPTH		
Which item is the deepest?	Correct/Incorrect	Correct/Incorrect
Which item is the least deep?	Correct/Incorrect	Correct/Incorrect
DISTANCE		
Which item is the furthest away?	Correct/Incorrect	Correct/Incorrect
Which item is nearest?	Correct/Incorrect	Correct/Incorrect
Total Correct:	____________	____________
Total Incorrect:	___________	____________

Average correct: ______________ Average % correct: ____________

Figure 1. Non-visual spatial perception measure for the SoundFlash device.

Method

Design

This study involved both qualitative and quantitative methods. The quantitative portion used a quasi-experimental multiple measures design (A-B-A-B-A-B pre-test/post-test study design) in which a pre-test and multiple post-test measures was taken from a single group of participants. Each subject's baseline scores were compared to his/her post-intervention scores (Portney & Watkins, 2003). The qualitative portion of the study consisted of a post-intervention focus group.

Participants

This study involved three subjects, all of whom had a diagnosis of legal blindness (either congenital or acquired). Two males and one female between 18 and 26 years old were selected via convenience sampling for inclusion in the study. All participants had intact hearing. None of the participants had cognitive or learning disabilities that might have interfered with their abilities to learn the echolocation process. These participants all had previous O&M training; all participants used long canes for O&M, and one participant also used a dog guide. Participants also had prior basic training in the use of passive echolocation.

Instrumentation

The SoundFlash device is designed to provide users with information regarding the dimensions, location, and density of objects (D. Kish, personal communication, January 28, 2009). A researcher-designed assessment tool was used to gather quantitative data regarding the effectiveness of the SoundFlash in providing users with information regarding dimensions (height and width), location (distance), and depth of objects (Figure 1). Questions regarding density were not included on the assessment tool. As a result of time constraints associated with the researchers' academic school year schedule, the researchers were not able to pilot test the assessment tool prior to use in the study.

While "depth" was included as a variable in the assessment tool, this was later dropped from the testing process as the developers of the assessment tool learned that the SoundFlash was not designed to provide information about this characteristic. Once testing was initiated, it was also found that the design of the pre- and post-test would not allow the researchers to adequately measure the capabilities of the SoundFlash in providing users with information regarding distance. Thus, the researchers were only able to gather data regarding the effectiveness of the SoundFlash in providing users with information regarding dimensions (height and width) of objects.

Apparatus

The SoundFlash device is an electronic apparatus that generates an auditory signal designed to be used for echolocation. The device is encased within an upholstered sleeve which is secured to the user's head with an elastic band. The sound-producing mechanism is centrally located on the user's forehead, with the operating buttons located near the user's left temple. The operating buttons are arranged to represent a Braille cell; by pushing various combinations of these buttons the volume and signal repetition rate can be modified. These buttons are located on the motherboard, which is similar in shape and size to a credit card. The battery responsible for powering the device is located near the user's right temple. Because the sleeve the apparatus was housed in for the purposes of the present study was not waterproof, users had to be careful not to get the device wet.

Procedure

The study took place at a state university in the Midwestern United States. Testing took place outside in the centre courtyard of the university. The training aspects of this project took place at various locations throughout the university's campus. Prior to implementation, the researchers gained approval from the university's Institutional Review Board.

Data Collection

The same procedure was used for both pre-testing and post-testing. A pre-test using the researcher-designed assessment tool was administered to participants at the beginning of the research study. Participants were asked to answer simple, yes or no questions regarding characteristics of three objects (a barstool chair, an artificial pine tree, and a sofa), such as height and width. The participants stood three metres away from the objects for all tests.

Each trial involved asking two questions regarding the height of the objects (which is the tallest/which is the shortest), and two questions asking about the width of the objects (which is the widest/which is the most narrow). The three objects were rearranged between these questions to prevent participants from learning their locations. The participants were allowed to use whatever object recognition technique that they currently used, including active or passive echolocation; however, they were not allowed to touch the objects. The results provided baseline data.

Upon completion of the training, a multiple measures post-testing technique was used, that employed the same researcher-designed assessment tool to obtain data. An A-B-A-B-A-B design was used. The three items selected for inclusion in the pre-test were again used during these assessments. The A phases of the assessment process involved asking the participant to identify the characteristics of the selected items using active echolocation techniques, but without the SoundFlash device. During the B phases of data collection, participants were asked to again identify various characteristics of the three objects, this time using active echolocation with the assistance of the SoundFlash device. This A-B cycle was completed a total of three times to reduce an order effect on the resulting data. It was believed that if the B phases consistently showed increased echolocation abilities compared to the A phases, then this would provide evidence that use of the SoundFlash, rather than just the participation in intensive training in active echolocation skills, contributed to improvements in non-visual spatial perceptual skills.

The qualitative portion of this study involved a focus group held at the commencement of the study to explore whether or not any changes occurred in the participants' opinion of their perceptual abilities that resulted from the use of the SoundFlash, and to learn about their thoughts and feelings regarding the SoundFlash device. Also included in the qualitative aspect of this study were observations and experiences noted during the course of the training and assessment. Data from observations consisted of field notes taken by the researchers during the training sessions.

Intervention

The participants received approximately 25 hours of advanced echolocation training following Kish's FlashSonar training protocol (Kish, 2006), and were taught how to use the SoundFlash device by Daniel Kish and one of the authors (D.B.), both of whom are O&M specialists. Training took place over a three day period. During the training, participants received training and practice using echolocation both with and without the SoundFlash device.

Results

Descriptive data analysis methods were used to evaluate pre- and post- intervention data. The A phases of the testing were completed without the use of the SoundFlash; the B phases were completed with the SoundFlash device. The order in which the phases were completed was as follows: A1, B1, A2, B2, A3, B3. During each phase of testing (A1, B1, A2, B2, A3, B3), participants were asked to rank presented objects in terms of height (tallest/shortest) and width (narrowest/widest). There were a total of four responses relating to each object characteristic (four responses with regard to height of objects, and four responses with regard to width of objects) for each phase of the assessment (A1, B1, etc.). The arrangement of objects was changed throughout the testing process to reduce learning effects. The total number of correct responses, out of four, appears in the corresponding box in Table 1.

Visual analysis of the data indicates that the results were inconclusive. As Table 1 reveals, participants demonstrated minimal improvement in perceptual skills from pre- to post-intervention, as well as with versus without the use of the SoundFlash. Participant 1 appeared to have improved only in the width perception category; this is also the only area that Participant 2 improved in. Participant 3 appeared to have not improved non-visual spatial perception with the use of the SoundFlash device. No recognisable pattern exists in the results that would reveal that an order or fatigue effect took place.

However, the data obtained during the qualitative portion of this research demonstrated that the participants believed they benefitted from the training on the device while incorporating echolocation. Analysis of data collected throughout the SoundFlash training and during the post-treatment focus group revealed the following themes: (a) an improvement in confidence with O&M; (b) ease of use of the SoundFlash device;

Table 1. Participant pre and post-test scores.

		Pre-Test	Without SoundFlash			With SoundFlash			Average Without Sound-Flash	Aver-age With SoundFlash
			A1	A2	A3	B1	B2	B3		
Participant 1	Height	2	0	0	0	0	0	0	0	0
	Width	3	1	4	4	2	4	4	3	3.34
Participant 2	Height	3	3	2	2	2	2	2	2.34	2
	Width	4	1	4	4	2	4	4	3	3.34
Participant 3	Height	0	2	2	2	0	0	0	2	0
	Width	2	2	0	4	3	1	0	2	1.34

and (c) an overall satisfaction with the intervention and device.

(a) *Improved Confidence in O&M*. All participants agreed that the SoundFlash enabled them to pay better attention to the details of objects in their environment. One participant stated that she could walk "faster " and "smoother" with the use of the SoundFlash than when only a cane was used for mobility. This same participant said that the SoundFlash device cued her to turn her head to scan the environment, thereby increasing awareness of the environment around her and enabling her to perceive more as well.

(b) *Ease of use of the device*. All participants commented that the SoundFlash was very user-friendly. One participant stated, "It's easier to use than my DVD remote!" Another participant stated, "It is one of the easiest devices for blind people!" Participants noted that the SoundFlash was easy to use because the operation buttons resembled a Braille cell. The participants commented that the various functions of the SoundFlash, for example, the ability to easily change the volume and repetition rate of the sounds produced by the SoundFlash, were helpful because these changes enabled them to better identify various features of the environment.

(c) *Satisfaction with intervention and device.* All participants stated that they believed the SoundFlash was useful for echolocation. As a group, participants agreed that the SoundFlash improved their confidence and their O&M skills. They also agreed that the learning experience was positive because of the user-friendly qualities of the SoundFlash device.

Observations Of Researchers

The researchers' observations further supported the effectiveness of the SoundFlash device. Participants were observed to have noticed objects in the environment while using the SoundFlash that they did not notice without the SoundFlash. For example, while walking outside, one participant stated that he could detect a very tall slender object with something larger at the top of it – this object was, in fact, a tall flag pole with a flag at the top that was approximately 20 yards away from the participant. At another point in the training, while walking down a hallway, participants using the SoundFlash device were observed to turn their heads as they passed doorways or alcoves as though they were "noticing" them. This reaction did not occur when the participants were not using the SoundFlash device.

Discussion

Interpretations

The qualitative data and the observations of the researchers suggest that the SoundFlash device was helpful in assisting participants better perceive spatial qualities of the world around them. Specifically, it was reported by participants that the SoundFlash helped them improve their confidence in their O&M skills. The researchers observed that, as the SoundFlash training progressed, the participants appeared to walk faster and more smoothly in various locations throughout the training site. The researchers also observed that participants' perceptions of the height and width of objects in their surrounding environments improved as they become more skilled in use of the SoundFlash. For example, when walking across the college campus during a SoundFlash training session, one participant stated that he could detect a very tall slender object with something larger at the top of it. This tall slender object was a tall flag pole and flag located approximately 20 yards away from the participant.

Additionally, the participants' awareness of objects' borders/boundaries appeared to be enhanced through use of the SoundFlash. For example, during a SoundFlash training session, participants were observed to turn their heads as they passed doorways or alcoves along hallways, as if they were 'noticing' them. The participants' abilities to estimate their distance from solid objects (particularly walls) also appeared to improve when they used the SoundFlash during mobility tasks.

In contrast, results of the quantitative portion of the study were largely inconclusive. One of the major factors contributing to inconclusive quantitative results was the poor face validity of the assessment used. After completing the research, it was discovered that both the assessment tool and the method of assessment used were not effective for measuring non-visual spatial perception of objects. Because the method of assessment and measurement was not valid or effective, the resulting quantitative data were unclear and should not be interpreted as either supporting or negating the use of the SoundFlash device.

Implications

Results and interpretations of this research provide evidence that the SoundFlash device has the potential to help individuals who are blind improve their non-visual spatial perception. Participant comments and researcher observations seems to indicate that the SoundFlash is beneficial in enhancing non-visual spatial perception abilities. However, further research is necessary to determine conclusively whether or not the SoundFlash device is effective in aiding non-visual spatial perception.

Limitations of the study

Several limitations were present in this study. First, this study's small sample size (three participants) was inadequate to allow for generalisation of the findings to a larger population. Second, all participants had been raised in the same household. Hence, a similar upbringing might have influenced the participants' ability to master echolocation and the SoundFlash. Third, participants ranged in age from 18 to 26 years and were familiar with using technology to assist the completion of daily tasks. Familiarity with technology might account for the participants' belief that they benefitted from the SoundFlash device. Fourth, a quasi-experimental research design was used which limits the generalisability of the findings (Portney & Watkins, 2000). Because this study did not include a control group, the researchers cannot conclude with certainty that the improvements in non-visual spatial perceptual abilities that were reported by participants, and observed by the researchers, were the direct result of SoundFlash use. It is possible that other factors, such as the intense three-day echolocation training program that was included in the research protocol, also contributed to the improvements in non-visual spatial perception abilities. Fifth, the assessment tool used for this study was designed by the researchers. This tool was not checked for reliability and validity prior to use in this study. It was only after the research study was implemented that deficits were identified in both the researcher-designed assessment tool and the pre- and post-testing protocol, which ultimately limited the researchers' ability to adequately evaluate all of the object characteristics the SoundFlash was devised to detect.

The testing conditions themselves might have affected post-test results. Both the pre- and the post- tests were conducted outdoors. The weather on the post-test day was considerably worse than the pre-test day, with noticeable increases in wind and rain, along with a decrease in temperature. These adverse weather conditions may have negatively affected the participants' performance on the post-test.

A sixth limitation of the study is the objects selected for the testing phase. Particular objects were selected because of the rich auditory echolocation feedback they provided. It is possible that the echolocation skills demonstrated by participants would decrease if they used the SoundFlash to judge objects in the 'real-world' (e.g., desks or playground equipment). Further, during testing, the selected objects were placed in a large, empty courtyard, perhaps making them easier to detect.

Future research

Future research employing random sampling and use of a larger sample size would help increase the study's worth by including more participants of various ages and demographics. It is also recommended that care be taken when selecting the objects to be used to assess the participants in the study. Additionally, a different evaluation tool, than that employed, would be useful in increasing the ability to accurately measure the effectiveness of the SoundFlash. It is recommended that researchers conducting research on the SoundFlash pilot test their assessment tools prior to using them in a study. Testing the assessment tools will ensure the successful evaluation of the effectiveness of the SoundFlash in providing users with comprehensive information about dimensions, location, and density of objects in their surrounding environments. In addition, controlled testing conditions would be useful in helping to decrease the effects of varying environmental conditions (pre- versus post-test) on assessment outcomes. Based upon feedback received from the participants in the study, it is also recommended that training occur over a longer period of time and for shorter durations each day to decrease the chance that fatigue might affect the participant's abilities.

Conclusion

A mixed-methods, A-B-A-B-A-B research design was used to evaluate the effectiveness of the SoundFlash. Three blind individuals participated in the study. The process included echolocation training both with and without use of the SoundFlash device. Through observations of participants during the training, it became apparent that the SoundFlash device helped enable the participants to detect and locate objects in their environment and navigate throughout it. While the quantitative portion of the research project did not yield data in support of the SoundFlash device, it is believed that these results may be inaccurate due to a low face validity of the assessment tool. The qualitative aspect appeared to yield far more accurate results. Further research is needed to identify and create an assessment tool that can more adequately capture the abilities of the SoundFlash device.

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