The Benefits of Using Echolocation to Safely Navigate Through the Environment

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This study investigated participant use of echolocation skills. Specifically, participants were asked to describe what methods they used to generate sound, and what echolocation assisted them to do in terms of their orientation and mobility (O&M). Contrary to previous research findings, it was found that most participants preferred to use cane tapping to generate sound. Possible reasons for this finding are discussed. Participants reported that echolocation assisted them to self-orientate and detect, locate and differentiate between objects in the environment.

Definition of echolocation

In the Orientation and Mobility (O&M) profession, the ability to detect objects that do not produce sounds is widely referred to as “echolocation”. Echolocation is based on perceiving variations in the ambient sound field as individuals’ move about their environment. Although the term echolocation is frequently associated with the detection of obstacles, the auditory ability is also important for maintaining one’s orientation in the environment in relation to solid architectural features such as walls and doors (Ashmead & Wall, 1999).

The auditory perception of the spatial features of a person’s environment can be classified into two categories: (a) active echolocation: the localisation of sound-producing objects such as pedestrians, telephones and vehicles (b) passive echolocation: the ability to detect and localise features of the environment that do not themselves produce sounds such as poles, walls, street signs and door openings.

Echolocation can be a very natural and easily understood way to perceive the environment and is simply the ability to hear echoes. Echoes and other sounds can convey spatial information that is comparable in many ways to that conveyed by light. With echoes, a vision impaired traveller can perceive very complex, detailed and specific information from distances far beyond the reach of the arm or long cane. Echoes make information available about the nature and arrangement of objects and environmental features such as walls, doorways, poles, parked vehicles, trees and many other solid objects in the environment. Echoes can provide the vision impaired traveller with detailed information about the location of objects, their dimension and density. By understanding the interrelationships of these qualities of the object in the environment, a great deal can be perceived about the nature of the object or multiple objects. For example, an object that is tall and narrow may be quickly recognised as a pole, or something...
tall and very broad may register as a wall. Similarly, the awareness of the density of the object (i.e., its solidity or sparseness) adds considerable richness and complexity to the environmental information available to a traveller (Kish & Bleier, 2007).

Methods used for sound generation

Sound generation used for echolocation can be achieved through self-produced sounds such as the tapping of the long cane, mechanically or orally produced finger or tongue clicking, clapping, footsteps, chirps and hisses. These sounds strike an object in the environment, and the reflected sounds can be used to determine the object’s size, shape and texture (Blumsack, 2003). Although it appears that few studies have investigated echolocation, some authors suggest that sounds produced near the ears, such as tongue clicking, is most effective for the echolocation of objects (Kish, 1995). Similarly, Burton (2000) and Schenkman and Jansson (1986) concluded that echolocation is less effective when sounds are produced below the waist, for example, by cane tapping, compared to when sounds are produced above the waist such as a tongue click or finger clicking.

Benefits of using echolocation

The ability to use echolocation to maintain orientation is important for people with vision impairments because it can be used in many environments and, once developed, is always readily available to the person. Unlike electronic travel aids such as the Miniguide or ‘K’ Sonar, echolocation does not require a battery or other power source, nor does the technique make noises that distract the user or necessarily produce noise that may bring attention to the vision impaired traveller. Even for people that use guide dogs or other mobility aids, it is still beneficial to for them to develop echolocation skills to the fullest extent possible to aid the comprehension of the path travelled. Although high frequency sounds such as orally produced hisses and clicks can, in some cases, be used to locate objects in the environment, excellent high frequency hearing is not essential for all aspects of echolocation (Carlson-Smith & Wiener, 1996).

Factors that affect echolocation

Kish and Bleier (2007) found that the distance and detail that echoes can carry depend largely upon the following factors:

1. Quality of echo signal: Signals produced deliberately by the traveller are usually more effective for echolocating rather than random sounds emitted from the environment. Signals produced near the ears typically create clearer echoes, because echoes return most of their energy to the origin of their signal. Echoes from tongue clicks are easier to interpret than those from cane taps or footsteps;

2. Surface characteristics: Objects near the head are typically easier to detect than those below the waist. Large objects can camouflage or overshadow small objects that are near them;

3. Ambient noise: Background or ambient noise may produce useful echoes, but it generally masks or absorbs echoes, because echoes are relatively quiet. The more ambient noise, the more difficult it is to perceive echoes;
(4) Quality of hearing: Often, functional hearing offers the highest potential for using echoes effectively;

(5) Degree of vigilance: This is possibly the most important factor. Because there are many cues that must be analysed and integrated for successful navigation, concentration is often divided among many elements. Since echo information is relatively subtle, it requires at least a moderate degree of continued concentration for effective use. It is also possible that extended learning experiences may enable a person to selectively perceive relevant echoes.

What helps or hinders echolocation?

(1) Too much guided travel will impede the development of echolocation over the long term. If guided, then echoes have no functional significance;

(2) Rain does not necessarily interfere with echolocation, but it can be quite distracting and confusing for the traveller;

(3) The perception of echoes may be slightly improved in cold weather or after rain. Sound waves tend to travel more effectively in cold air, and wet objects tend to reflect more sound energy;

(4) Strong winds or noise will hamper echolocation. A strong echo signal is necessary for good perception under these conditions;

(5) Anything that covers or shadows the ears such as umbrellas, hats, or hooded jackets can strongly interfere with echolocation;

(6) Age factors: key echolocation skills tend to increase with age and experience;

(7) Residual vision: clients with light perception or visual memories often confuse echo images with visual images. They appear to “see” what they hear. The brain can interpret echo sensation in a visual reference, which can cause confusion between the sensory channels (Kish & Bleier, 2007).

Methodology

Ten clients of Guide Dogs NSW/ACT who were regular known users of echolocation were invited to participate in this study. Half of this group was congenitally blind and participants ranged in age from 19 years to 65 years. Six of the participants were male and four were female. Nine participants had been using echolocation for more than five years while one participant had been using echolocation for four years. The author gathered information from eight participants in a face-to-face interview, while two participants were interviewed by telephone. Questions were asked of each participant that included: (a) Do you use echolocation in your everyday travels? If so, in what form does echolocation take for you? (b) What does echolocation assist you to do?

Results

Participants were asked to comment on their methods used for sound generation. The responses are detailed in Table 1.

Participants were asked to comment on what echolocation assisted them to do as reported in Table 2.

Discussion

It is evident that echolocation is a highly useful skill that was used effectively by the...
10 participants. Echolocation enabled participants to detect, locate, avoid and negotiate around objects in the environment. For some participants, echolocation also provided a method to shoreline and maintain straight line travel.

All participants reported that they naturally acquired the skill of echolocation and that it was not taught to them. The majority of participants also reported that they used echolocation almost subconsciously to enhance their mobility. One participant commented that she did not realise how often she used the technique until she thought about it. Another participant stated that he would find it difficult to maintain orientation without using echolocation.

This study’s findings are in contrast to those reported by Burton (2000), Blumsack (2003) and Schenkman and Jansson (1986). Participants reported that instead of preferring to generate sound from above the waist by using, for example, hand clapping, the majority of participants described cane tapping as the most preferred method of sound generation. Participants provided two main reasons why they preferred the cane tap method to generate sound. First, because it provided accurate and dependable information about their environment in addition to the information already provided through ambient sounds. Second, the cane tapping method was a behaviour that the participants felt would be viewed by the public as natural and ordinary, reducing the risk of unwanted attention.

Although this study did not investigate the reasons why participants wanted to reduce the risk of unwanted attention, it might be that participants wanted to remain anonymous by blending into the crowd, felt embarrassed to emit sounds from less subtle sources such as their voice or hand clapping, or felt vulnerable of being harmed. It might

<table>
<thead>
<tr>
<th>Client</th>
<th>Cane Tapping</th>
<th>Tongue Clicks</th>
<th>Finger Clicks</th>
<th>Hand Clapping</th>
<th>Footsteps</th>
<th>Mouth Sounds</th>
<th>Voice</th>
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<tr>
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<td></td>
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<td></td>
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<tr>
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<tr>
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<tr>
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<td>1</td>
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be then, motivated by the desire to reduce the risk of unwanted attention, that cane tapping was effective because it was performed with greater intensity, creating an echo that could be more easily perceived.

Echolocation appears to be an effective skill to assist in O&M. When training clients to use echolocation, it seems important to consider individual preferences for the methods used to generate sound. It cannot be taken for granted that the ‘above the waist’ sound generation methods such as tongue or finger clicks will be preferred or even useful to all clients. Rather, O&M instructors, service providers and researchers need to investigate other ‘below the waist’ methods that are subtle and/or explicit to meet the client’s needs, preferences and expectations.

Table 2. Orientation skills achieved using echolocation.

| CLIENT 1 | • Locate bus shelters  
|          | • Locate tunnels  
|          | • Locate awnings  
|          | • Detect solid objects up ahead e.g. a car/truck |
| CLIENT 2 | • Identify underground areas e.g. tunnels and underneath a staircase  
|          | • Detect environmental changes e.g. from a brick wall to open space |
| CLIENT 3 | • Locate the mailbox  
|          | • Detect objects up ahead, example: cars obstructing footpath/driveways  
|          | • Identify underground tunnels  
|          | • Avoid pedestrians  
|          | • Locate bus shelters  
|          | • Locate different shops e.g. the chemist  
|          | • Differentiate between a closed and open door |
| CLIENT 4 | • Negotiate through narrow spaces  
|          | • Locate corners, examples: within an educational setting or inside the home  
|          | • Detect obstacles/pedestrians  
|          | • Negotiate around pillars  
|          | • Detect open spaces |
| CLIENT 5 | • Detect walls  
|          | • Detect open spaces e.g. within a University campus |
| CLIENT 6 | • Follow shorelines  
|          | • Negotiation around poles and other obstacles  
|          | • Detect solid objects in front  
|          | • Detect doorways and differences between closed/open doors |
| CLIENT 7 | • Negotiation around large obstacles on the path of travel e.g. a furniture van |
| CLIENT 8 | • Negotiate crowded areas e.g. on city streets  
|          | • Locate underground tunnels  
|          | • Maintain straight line travel and follow a physical shoreline |
| CLIENT 9 | • Negotiate around obstacles in front e.g. parked cars, trees and poles  
|          | • Detect walls  
|          | • Assist to turn corners  
|          | • Fast and smooth mobility  
|          | • Locate entrances to buildings e.g. doorways  
|          | • Shoreline walls without using the long cane |
| CLIENT 10 | • Maintain straight line of travel  
|           | • Negotiate around obstacles in the environment  
|           | • Assist to turn corners  
|           | • Awareness of the direction needed to travel |
References


