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A survey of the use of echolocation cues for wayfinding in campus environments by a student with visual impairment

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Abstract: Andy is a 20years old college student who was born blind without visual memory and light sensitization. He lives in the school dormitory from Mondays through Fridays and spends most of his time on campus. Andy tells us that he has had experience since childhood in using echoes to search for objects and spatial scales in the environment (e.g. buildings, plants, doorways, etc.). He believes "using echoes to identify one's location is an effective method". Thus, we investigated objects that can provide Andy good echoes when he is walking along a specific route on campus. Such object is usually an element of campus design and is set by the designer. This study refers to these objects, of which echoes can be perceived, as echolocation cues.

Keywords: Visually Impaired People, Echolocation Cues, Campus, Wayfinding

1. Rationale

People usually depend on vision when travelling in space, which can be employed to acquire much information on location and configuration of faraway and nearby spaces [1](Warren, 1978). In addition, people are also accustomed to using sound as a tool for perception and action [2] . Like vision, hearing is a sensation with sense of distance [3]. The visual impaired can move in space by using reflected sounds. For example, they can walk parallel to a wall through using echoes caused by reflection of the sounds they make (cane tapping, fingers snapping or footsteps) on the wall. The echoes create a wall of sound on the travelling side [4]. The interface of objects in the environment blocks transmission of sound and affects reflected and absorbed hearing signals, causing then to create hearing or sound shadow [5]. These sound shadows allow them to be particularly noticeable of environmental characteristics [6].

Andy can sense virtual and real interface echoes of object from 250cm away (see Figure 1). He carries a long cane with him when travelling in the campus and is accustomed to creating sounds by tapping the cane on the road surface to determine echoes from objects. These echoes also become important cues for Andy's wayfinding. This study refers to these cues as echolocation cues. We expect to determine answers to issues such as which types of echolocation cues are frequently applied by Andy as well as distances between Andy and echolocation cues. The purpose of this study is to understand the use of echolocation cues when Andy travels around in the campus environment as reference for improvement solutions when developing campus environment design in the future.

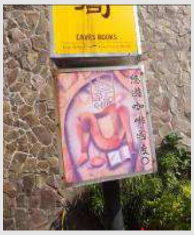
Figure 1. *Andy determining echo of a high wall*

2. Survey

Andy is a student holding a severe visual disability manual. The government of Taiwan issues visual disability manuals based on degree of visual impairment, which includes three levels (mild, moderate and severe). The severe level is when the visual acuity of both eyes is 2/200 (0.01) or below when measured separately.

This study has obtained Andy's informed consent and passed the review by Ethics Committee of National Taipei University of Technology (IBRCOD1020424001). The route investigated starts at Andy's department house and ends at his dormitory (see Figure 2). The route is approximately 480cm wide and 11,100cm long with asphalt concrete pavement and has no sidewalks; there is no pedestrian and vehicle separation (see Figure 3). Andy usually likes to take pictures with an automatic digital camera by using sounds and echoes from a person or object to determine the direction of focus (see Figure 4). Thus, we invited Andy to use a camera to record important echolocation cues when walking. We also measured the distances between Andy and these echolocation cues. Finally, we carried out a deep interview with Andy regarding these echolocation cues.

Table 1. *Recordings and measurements of echolocation cues*

Echolocation Cues		(cm)		Echolocation Cues		(cm)	
A-1 High wall		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	600 2700 1250 750 6.76%	A-8 Slope		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	300 65 150 300 2.7%
A-2 Doorway		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	520 250 1050 600 5.41%	A-9 High wall		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	450 1600 550 750 6.76%
A-3 Doorway		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	820 350 1000 900 8.11%	A-10 Doorway		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	450 350 1050 750 6.76%
A-4 Bush		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	120 110 300 120 1.08%	A-11 Sign		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	76 400 300 200 1.8%
A-5 Tree		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	直 65 950 250 350 3.15%	A-12 Eaves		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	200 45 650 200 1.8%
A-6 Bulletin board		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	103 230 250 250 2.25%	A-13 Canopy		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	250 400 0 250 2.25%
A-7 Doorway		W H $\overline{oa}$ $\overline{bc}$ $\overline{bc}$/L	560 350 1250 650 5.86%	Andy took pictures of all echolocation cues Total length of route (L) =11,100 ㎝ Echolocation cue dependency rate (Er)= 54.69%			

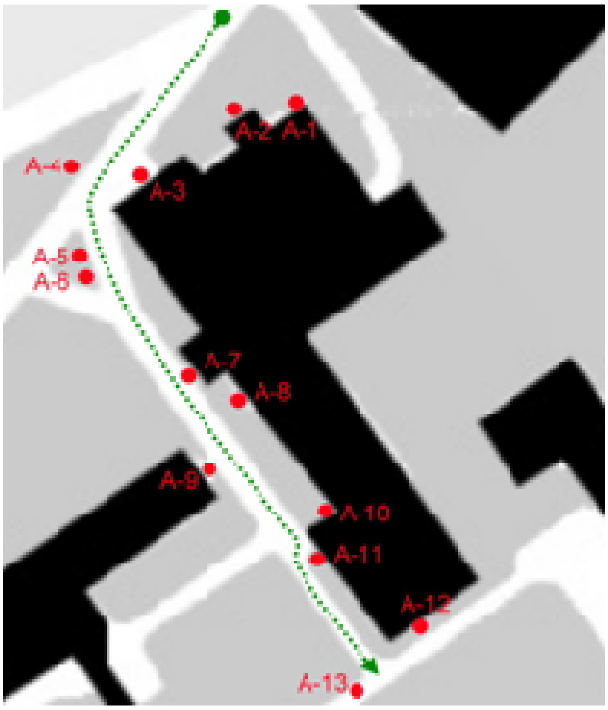


Figure 2. *Plan of the route investigated and locations of echolocation cues*

Figure 3. *Status of route investigated*

Figure 4. *Andy taking a picture of echolocation cue*

3. Echolocation Cues Recordings and Distance Measurements

The results of investigation show that Andy thinks there are 13 significant echolocation cues along the route, of which the types included: high wall of building (higher than 3m), slope (lower than 70cm), doorway, glass window, eaves, tree, bush, billboard, intersection and canopy (see Table 1).

For measuring the distance between Andy and an echolocation cue, we measure the distances of $\overline{oa}$ and $\overline{bc}$ for each cue (see Figure 5). Definitions of points a, b, c and o are as follows:

(1) Point a is the location of an echolocation cue.

(2) Point b is the location where Andy begins to hear the echo of an echolocation cue. (starting point)

(3) Point o is the location where Andy hears the maximum echo of an echolocation cue.

(4) Point c is the location where Andy could not hear the echo of an echolocation cue. (terminal point)

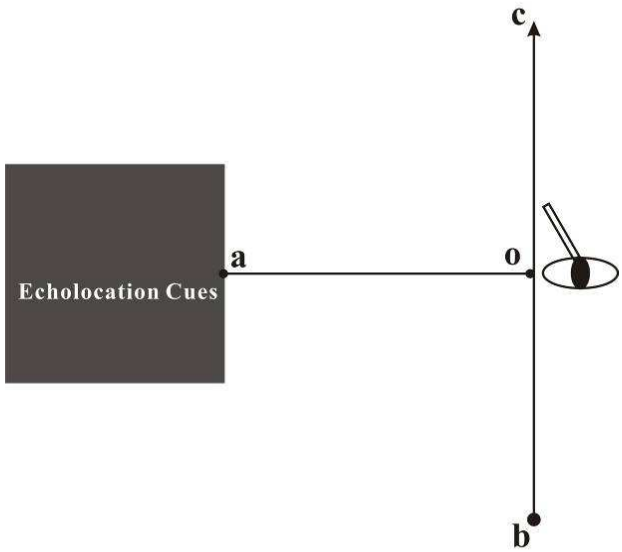


Figure 5. *Illustration of measuring the distance of echolocation cues*

4. Andy's Response

Andy can sense the echo from the high wall over 3m of a building and perceive that the echolocation distance ($\overline{oa}$) is directly proportional to the height of the high wall (see A-1, A-9). He can sense the echolocation distance ($\overline{oa}$) of a doorway is within 1000-1250cm (see A-2, A-3, A-7, A-10). He can sense the echolocation distance ($\overline{oa}$) of 350cm high eaves is within 650cm (see A-12). He can sense the echolocation distances ($\overline{oa}$) of tress and bulletin boards are within 650cm (see A-5, A-6). He can sense the echolocation distances ($\overline{oa}$) of bushes and signs are within 300cm (see A-4, A-11). He can sense the echolocation distance ($\overline{oa}$) of a slope lower than 70cm is within 150cm (see A-8). In addition, Andy must be standing directly under a canopy to perceived its echo, so $\overline{oa}$ =0cm (see A-13). Andy states that, although he is able to sense low walls, bushes and signs, he neglects these cues with weaker echo strength when travelling and uses clear echolocation cues as primary reference messages.

5. Final Thoughts

We defined the "echolocation cues dependency rate" (Er) for expressing the frequency Andy depends on echolocation cues when walking. It is the proportion of the sum of distance between two points, i.e. where an echo starts and ends, in the total length of the route walked in each trip (see Table 1).

$$Er=(ab) / (L)*100\%$$

When Andy walks along this route, the echolocation rate (Er) of echolocation cues that he can depend on is 54.69%. A high Er indicates the echolocation rate that he can refer to is also higher when he walks along this route.

The yellow region in Figure 6 indicates that, when Andy is standing within the area surrounded by points a, b and c, he can hear the echoes from this echolocation cue. Since variation in spectra of surrounding sound field can provide information on the structure of surrounding space [7], Andy can identify immediately the configuration of an echolocation cue in an environment where multiple echolocation cues exist (see Figure 7). The range of distance perceived through such echoes is greater than that reachable by white cane. Therefore, Andy believes that "using echoes to identify one's location when walking is also an effective method".

Compared to tactile cues (e.g. texture of ground surface), the environmental information provided by echolocation cues is superior in long distance and immediateness. Environmental designers can further analyze physical features of echoes from echolocation cues and configure them along paths for the visual impaired who, like Andy, are accustomed to using echoes, that is, establishing a space model of mental passageways.

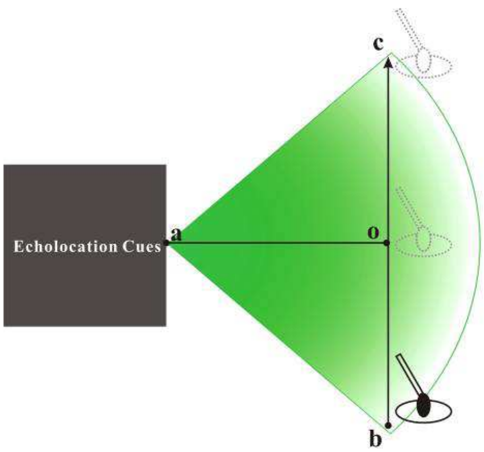


Figure 6. *Illustration of the range of echolocation cues perceived by Andy*

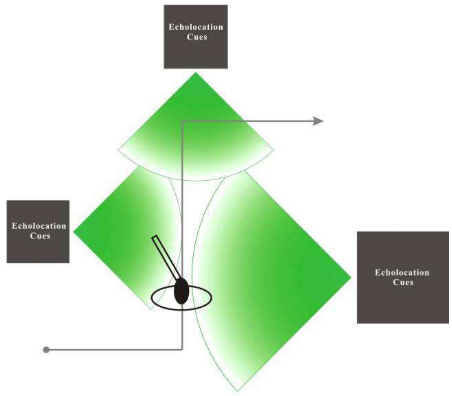


Figure 7. *Illustration of Andy sensing echoes from multiple echolocation cues*

References

[1] Warren, D. H. (1978). Perception by the blind. In E. Carterett & N. Friedmann (Eds.), *Handbook of perception* (pp. 65–86). New York: Academic Press.

[2] Stoffregen, T. A., & Pittenger, J. B. (1995). Human echolocation as a basic form of perception and action. *Ecological Psychology, 7*, 181–216.

[3] Blauert, J. (1997). *Spatial hearing: The psychophysics of human sound localization* (rev. ed.). Cambridge, MA: MIT Press.

[4] Ashmead, D., & Wall, R. S. (1999). Auditory perception of walls via spectral variations in the ambient sound field. *Journal of Rehabilitation Research and Development, 36*, 313–322.

[5] Gordon, M. S., & Rosenblum, L. D. (2004). Perception of sound-obstructing surfaces using body-scaled judgments. *Ecological Psychology, 16*, 87–113.

[6] Gardiner, A., & Perkins, C. (2005). "It's a sort of echo . . .": Sensory perception of the environment as an aid to tactile map design. *British Journal of Visual Impairment, 23,* 84 –91.

[7] Wiener, W. R., Lawson, G., Naghshineh, K.,Brown, J., Bischoff, A., & Toth, A. (1997).The use of traffic sounds to make streetcrossings by persons who are visually impaired.*Journal of Visual Impairment &Blindness, 91*, 435–445.

Biography

Shu-Chuan Yu received a Ph.D, College of Design, from National Taipei University of Technology, Taiwan, in 2014. She is also a teacher of special education. Since 2001, she has been devoted to special education, with the main subjects of education and research covering children with autism, intellectual disabilities, visual impairment and emotional disorders. Her research interests are environmental cognition and environmental behavior of the disabled, and the improvement programs of barrier free environment.