Perceptions of sounding or silent objects' existence by visually impaired people in their daily life

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Abstract: Visually impaired people have difficulties in perceiving environmental information including the size of a space and the presence of objects, by means of visual information. Particularly, auditory-trained visually impaired people can recognize 3-D spatial information by means of environmental sounds. However, a systematic learning method of auditory spatial perception for walking training has not been sufficiently established because of insufficient information regarding visually impaired people's movement in the real environment; most acquire this ability through practical experience. In this report, the authors aimed at demonstrating the mobility of visually impaired people, for example, which acoustical factors can be used in some living situations and in what kind of environmental situations do they find it difficult to perceive silent objects. Results indicated the following facts: Totally visually impaired people tend to get more spatial information from auditory cues than do not-totally visually impaired people. Regarding available auditory cues, items of rotating the head in order to listen carefully to environmental sounds, and hitting floors forcefully with a white cane or foot to increase the volume of reflected or reverberated sounds were the cues most often selected by the totally visually impaired participants who can perceive obstacles with auditory information.

Keywords: Visually impaired people, orientation and mobility (O&M), auditory spatial perception

1. Introduction

Visually impaired people have difficulties in recognizing the size of a space and the objects in a space, by means of visual information. Due to this, they perceive some spatial information using their other senses such as auditory and tactile senses. Particularly, auditory-trained visually impaired people can recognize 3-D spatial information due to environmental sounds. In addition, it is known that auditory-trained visually impaired people can localize sounding and, even, non-sounding objects in the environment by using the ability called "auditory obstacle perception" (also known as "obstacle sense"), which is the ability that enables them to perceive objects solely by hearing [1]–[5]. It has been reported that some auditory-enhanced visually impaired people can detect an object's existence, and also can estimate its distance, size, and shape [6]–[9].

A large number of special education methods for acquiring auditory spatial perception have been proposed to

help the visually impaired in walking and carrying out other routine activities [1]. Seki et al. proposed an auditory training CD and system for visually impaired people, and education/training institutions have used these as supplemental learning material [10],[11]. However, a systematic learning method of auditory training has not been sufficiently established because visually impaired people have acquired this ability mainly through practical experience in their actual environment. This is due to the fact that visually impaired people at the training phase do not have enough information to aid their mobility in the real environment. It is necessary to investigate in what kinds of situations the auditory sense is mainly used, in what kinds of conditions do visually impaired people have difficulty acquiring spatial information, and which specific acoustical cues can be used for auditory spatial perception, in some cases of the living environment.

In this report, the authors aimed at demonstrating the conditions under which visually impaired people move, for example, which acoustical factors can be used in some living situations and in what kind of environmental situations do they find it difficult to perceive silent objects. These situations are investigated through the questionnaire described in Section 2. After the result is stated, the orientation and mobility of the visually impaired are discussed in Section 3.

2. Method

2.1. Participant

Forty-one totally visually impaired persons (19 males and 22 females) (including students of a university and a school for the visually impaired) participated in this investigation. Fig. 1 shows the age group and disability grade (in Japanese standards) of the participants. The sample was mainly composed of young people (10s: 14.6 %, 20s: 51.2 %, and 30s: 19.5 %), in comparison with the research of the Japanese Ministry of Health, Labor, and Welfare (MHLW) [12]. With regard to disability grade, 68.3 % of the participants were 1st-grade and 19.5 % were 2nd-grade (1st-grade: people whose summation of binocular corrected visual acuity is less than 0.01, 2nd-grade: those whose summation is 0.02–0.04.).

2.2. Questionnaire outline

Detailed questionnaire items are shown in Appendix 1. The original sentences were written in Japanese: these questionnaire sentences are a translation by the authors. This questionnaire aimed at investigating the following items:

1) Situation of orientation and mobility, regarding walking training and walking method.
2) How they perceive obstacle's presence during their walking, e.g., tactile sense with hands or white cane, etc.; oppressive sensation on the face, in cases where the obstacle was in close proximity; and cases where their auditory sense of the sound field changes.
3) Inside or outside environments in which the participants find it easy or difficult to perceive obstacles.
4) Coping skills for recognizing obstacles, e.g., walk with their hand extended in front or rotate their head to listen carefully to surrounding sounds.

Questionnaire items were determined by referring to those of MHLW's [12] and Nakamura-Funaba's study [13]. The questionnaire was distributed in a computer-based electronic text file format (for university students) or a paper-based one (for students at the school of visually impaired). The electronic file was distributed by means of e-mail, and then participants inputted with their own computer and replied to the authors. Paper-based questionnaires were filled in by support persons of the participants and then were submitted to the authors.

3. Result and discussion

3.1. History of walking training and current outgoing situation

Participants' learning history with regard to walking training is illustrated in Fig. 2. All of the participants had learned gait walking. Table 1 shows the learning history against the disability grade. Most of the 1st grade participants (mainly, totally blind people) have learned gait walking through the school for visually impaired or a program at a rehabilitation center, while other grades' participants (mainly, low-vision people) through practical experience.

Fig. 3 shows the results with regard to the outgoing situations of the participants. Participants' outgoing frequency, shown in Fig. 3, indicates that 46.3 % of all participants go out nearly every day. This group includes 33% of totally visually impaired people and 68.8% of not-totally visually impaired people. The outgoing frequency of totally visually impaired people is less than half that of the not-totally visually impaired people.

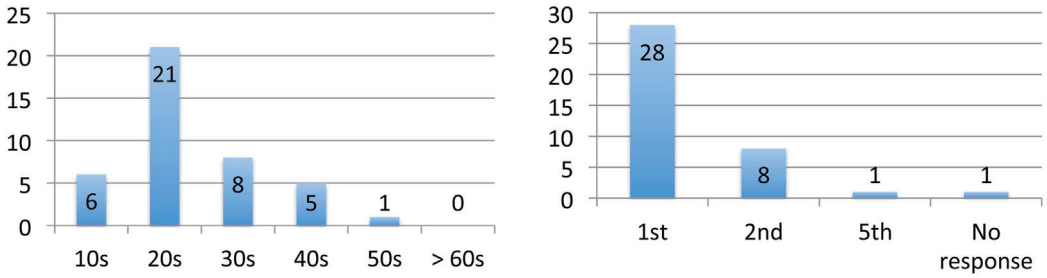


Fig.1. The number of participants' age-group (left) and disability grade (right) in this report's investigation

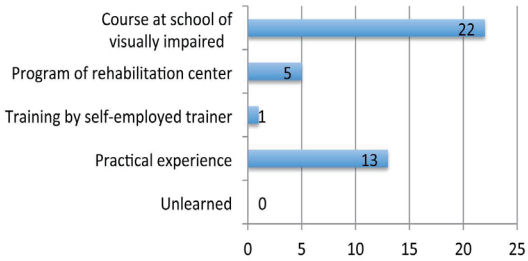


Fig. 2. Learning history of walking training

Table 1. Learning history of walking training against the disability grade

	1st	2nd	3rd	4th	5th
Course at school of the visually impaired	19	3	0	0	0
Program of rehabilitation center	5	0	0	0	0
Training by self-employed walking trainer	1	0	0	0	0
Practical experience (can go out alone)	3	5	1	0	1

Table 2. Number of participants who checked at (left) auditorily-perceived or (right) oppression sensation among totally and not-totally visually impaired participants

	Totally	Not-totally
Checked	15	7
Unchecked	4	8

	Totally	Not-totally
Checked	11	5
Unchecked	8	10

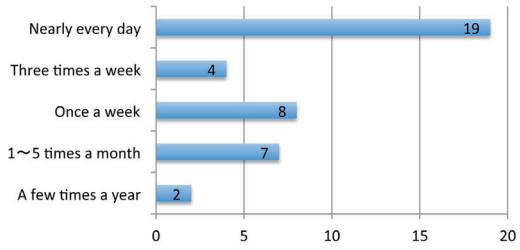


Fig. 3. Frequency of their outgoing

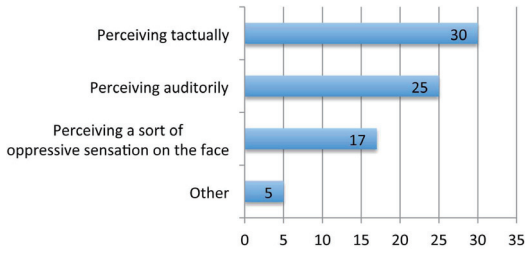


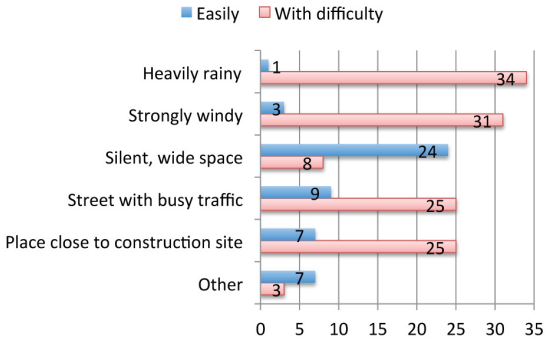
Fig. 4. Methods to perceive obstacle's presence

3.2. Perception of silent objects

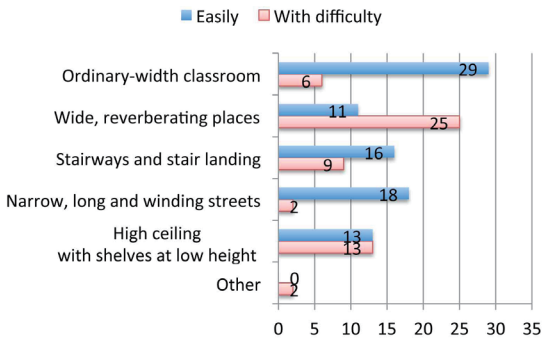
The method through which the participants perceive obstacles' presence is illustrated in Fig. 4. Results show that 37.5%, 31.3%, and 21.3% of participants have perceived obstacles tactually, auditorily, and through a sort of oppressive sensation on the face, respectively. Totally and not-totally visually impaired participants showed the same tendency with regard to the tactile perception of obstacles. Meanwhile, the two groups differ with regard to auditory perception or oppression sensation, as shown in the left side of Table 2. Totally visually impaired participants tended to check these items more than did not-totally visually impaired participants. However, cross-tabulation of whether totally visually impaired participants checked auditorily-perceived against whether they checked oppression sensation, in the right side of Table 2, indicates that the number of participants who perceive only oppression sensation or auditory cues is smaller than the number of those who checked both, and the number of those who checked only auditorily-perceived is more than those who checked only oppression sensation. Though oppression sensation caused by close obstacles was reportedly closely related to cues from the auditory senses [2]–[4], some totally visually impaired participants may have understood it as a different sensation.

3.3. Environments in which objects can be perceived easily or with difficulty

Outside or inside environments in which the participants can easily/with difficulty perceive obstacles are shown in Fig. 5. Most of the participants selected heavily rainy or strongly windy environments as difficult out-

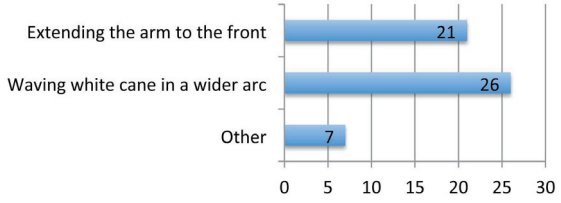


(a) Outside

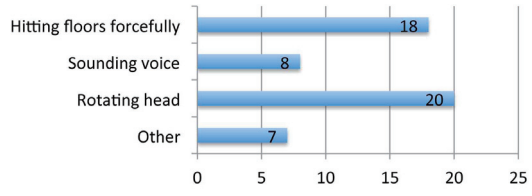


(b) Inside

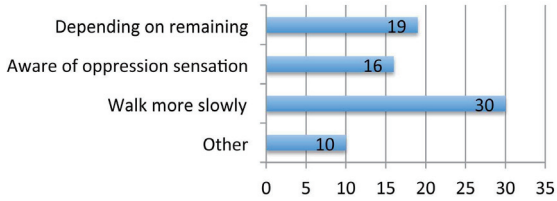
Fig. 5. Environments in which the participants can easily/with difficulty perceive obstacles



(a) Tactile sense



(b) Auditory sense



(c) Other sensations or methods

Fig. 6. Coping skills to utilize each modality for obstacle perception

Table 3. Number of totally visually impaired participants who checked “auditorily-perceived” against those who checked “silent empty space”

	Unchecked	Checked ”auditorily-perceived”
Unchecked	2	5
Checked ”silent, wide space”	2	10

Table 4. Number of totally visually impaired participants who checked “auditorily-perceived” against those who checked “hitting floors” (top) or “rotating head” (bottom)

	Unchecked	Checked ”auditorily-perceived”
Unchecked	2	4
Checked ”hitting floors”	2	11

	Unchecked	Checked ”auditorily-perceived”
Unchecked	3	6
Checked ”rotating head”	1	9

side environments for obstacle perception, as shown in Fig. 5(a). Meanwhile, a silent, wide space was selected as an easy outside environment. Totally visually impaired participants who checked “auditorily-perceived” in answer to the question in section 3.2 tended to mainly select this item as shown in Table 3. Regarding other items, differences between not-totally and totally visually impaired participants are not observed.

The left side of Fig. 5 shows the easy/difficult outside environment for obstacle perception. Most of the participants selected the ordinary-width classroom as an easy inside environment for obstacle perception. However, a wide reverberation space was selected as a difficult inside environment. Differences between answers of not-totally and totally visually impaired participants were not observed.

3.4. Coping skills with regard to perceiving obstacles

Fig. 6 shows participants’ coping skills with regard to perceiving obstacles. As illustrated by Fig. 6(a), 43.3 % and 35.0 % of participants selected waving a white cane and extending an arm to the front, respectively. Participants who checked “tactually-perceived” for the question in section 3.2 selected these items. Differences between not-totally and totally visually impaired participants are not observed. In the free descriptions, most of the participants who selected “other” mentioned relying on plantar sensation as the coping skills for obstacle perception.

The right side of Fig. 6 shows participants’ coping skills for perceiving obstacles. In this report, the method related to auditory sense and other sensations are discussed. With regard to auditory cues, rotating the head to listen to environmental sounds carefully (33.3 %) and hitting floors forcefully with white cane or foot to increase the volume of reflected or reverberated sounds (30.0 %) were methods often selected by the participants. These items were selected mainly by the participants who selected “auditorily-perceived” in answer to the question in section 3.2; they were totally visually impaired people, as shown in Table 4. In the free descriptions, most of the participants who selected “other” mentioned stopping and then listening carefully as the coping skills for auditory obstacle perception.

The left side of Fig. 6 shows the results of the coping skills related to other sensations, which indicate that 37.5 %, 23.8 %, and 20.0 % of participants selected walking more slowly, using remaining eyesight, and experiencing an oppression sensation related to a close obstacle, respectively. In the free descriptions, most of the participants who selected “other” mentioned use of their olfactory sense: they carefully smelled food-related shops. The coping skills of walking slowly was commonly checked by both totally and not-totally visually

impaired, while that of using remaining eyesight and that of oppression sensation were checked mainly by not-totally or totally visually-impaired persons, respectively.

4. Conclusion and future work

The authors aim to demonstrate the mobility situations of the visually impaired by means of a questionnaire. This questionnaire deals with situations of orientation and mobility, how to perceive obstacles, inside or outside environments in which the participant can easily or with difficulty perceive obstacles, and the coping skills for recognizing obstacles. Results indicated the following:

1) Totally visually impaired people go outside less frequently than do not-totally visually impaired people.
2) Totally visually impaired people tend to get more spatial information from their auditory senses than do not-totally visually impaired people. Tactile information is used by comparable numbers of people in both groups.
3) Silent, wide spaces are an environment in which obstacles are more easily perceivable for auditory-trained visually impaired people (particularly, totally visually impaired).
4) Regarding available auditory cues, rotating the head to listen carefully to environmental sounds and hitting floors forcefully with a white cane or foot to increase the volume of reflected or reverberated sounds were the cues often selected by the totally visually impaired participants who can perceive obstacles with auditory information.

Future work will involve acquiring more data by administering the questionnaire not only to young but also to older people and then summarizing the results in order to propose a systematic walking training program or devices.

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Appendix. Detailed questionnaire items (excerpt from [14])

No.	Question
1	Which range of your age belongs to? A. 10s B. 20s C. 30s D. 40s E. 50s F. over 60s
2	Which gender are you? A. Male B. Female
3	How did you acquire solely walking? Please select the appropriate choice from following items. A. Learned in the class of school for visually-impaired B. Learned in the program of rehabilitation center C. Training by self-employed gait walking trainer D. Just self-experienced (possible to outgo solely) E. Unlearned (impossible to outgo solely)
4	Please input the disability grade. If there are no objections, please write down the acquired time of vision loss or other description. [Example] category I, 1st-grade (totally blind). category I, 2nd-grade (low-vision, nyctalopia, tunnel vision)
5	How frequent do you outgo? Please select the most appropriate choice from the following items. A. Nearly every day B. Three times a week C. Once a week D. 1∼5 times a month E. A few times a year
9	Have you ever perceived obstacle presences while you are walking? If your answer is yes, please select appropriate choices from the following items. (Check all that apply) A. perceiving tactually B. perceiving auditorily C. perceiving as a sort of oppression sense at the face D. Other (free description)
11	Questions about the situation which you can easily or hardly perceive obstacles
11-1	Which situation can you perceive easily the existence of walls and objects when you are at outside? (Check all that apply) Please select appropriate choices from the following items. A. Heavily rainy B. Strongly windy C. Silent wide space such as not-busy car parking places D. Street with busy traffics E. Places close to the construction site F. Other (free description)
11-2	In contrast, which situation can you perceive hardly the existence of walls and objects when you are at outside? (Check all that apply) Please select appropriate choices from the following items. A. Heavily rainy B. Strongly windy C. Silent wide space such as not-busy car parking places D. Street with busy traffics E. Places close to the construction site F. Other (free description)
11-3	Which situation can you perceive easily the existence of walls and objects when you are at inside? (Check all that apply) Please select appropriate choices from the following items. A. Ordinary-width classrooms B. Wide spaces which reverberation occurs easily (e.g. gymnasium) C. Up-down stairways and stair landings D. Narrow and long-forward places which reverberation occurs somewhat strong (e.g. corridor) E. High ceiling places with low-height shelves (e.g. supermarket) F. Other (free description)
11-4	In contrast, which situation can you perceive hardly the existence of walls and objects when you are at inside? (Check all that apply) Please select appropriate choices from the following items. A. Ordinary-width classrooms B. Wide spaces which reverberation occurs easily (e.g. gymnasium) C. Up-down stairways and stair landings D. Narrow and long-forward places which reverberation occurs somewhat strong (e.g. corridor) E. High ceiling places with low-height shelves (e.g. supermarket) F. Other (free description)
12	Questions about know-hows for recognizing obstacles
12-1	Do you have any know-hows of perceiving obstacle existence with tactual cues? Please select appropriate choices from the following items. A. Extending the arm to the front B. Waving white cane more widely C. Other (free description)
12-2	Do you have any know-hows of perceiving obstacle existence with auditory cues? Please select appropriate choices from the following items. (Check all that apply) A. Hitting floors stronger by white cane or foot for turning up the volume of reflected or reverberated sounds, B. Voice utterance C. Rotating head for listening to environmental sound carefully D. Other (free description)
12-3	Do you have any know-hows of perceiving obstacle existence with other senses? Please select appropriate choices from the following items. (Check all that apply) A. Depending on remained visual sense (e.g. light sensation) B. Being aware of oppression sensation related to obstacle existence C. Walk more slowly D. Other (free description)