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Original Research

Sounds and Vibrations Necessary for Library of Vibroacoustic Events Addressed to Visually Impaired Persons – Questionnaire Results

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Abstract

The aim of our work was to investigate to what extend the perception of sound and vibration sensations may be useful in spatial orientation and mobility (O&M) of blind and visually impaired persons. Results of a questionnaire addressed to visually impaired persons who move independently in a city are presented.

Analysis of the questionnaire is the first step to work out an innovative, professional, and systematic method of spatial O&M teaching and training in laboratory conditions. A fundamental tool of the method will be a library offering a collection of vibration and acoustic signals characteristic of a city, as well as signals that may be helpful or disturbing for orientation and mobility.

Keywords: blind, visually impaired, orientation and mobility (O&M)

Introduction

Definitions of visual impairment, low vision, and blindness are given in [1, 2]. According to them, the term "visual impairment" includes low vision as well as blindness; in this paper this term will be used in the same sense.

The population of blind and visually impaired persons in Poland is estimated to be more than 200,000. Technical devices dedicated for visually impaired people, which are supposed to be helpful in spatial orientation [3-11], usually inform about obstacles by emitting specific sounds. The devices are not widely accepted by the blind community because they require intense concentration of mind on the signals heard. Moreover, these signals can mask informative sounds that are essential for the visually impaired.

Teaching and training of spatial orientation and mobility (O&M) is an important element of education of visually impaired persons. Despite great progress in computer technology and the study of spatial O&M, the visually impaired still use old, not always effective methods. Regrettably, they have not been offered an effective method of spatial orientation based on the sense of hearing, although they are capable of using this sense for orientation as shown in [12-15].

In Poland instruction in spatial orientation (O&M) was included in the teaching program for the blind and visually impaired in 1979 after the first national course for instructors in spatial orientation and independent mobility of the blind with the help of a long cane. This course was run by Stanley Suterko and was based on practical training worked out at the University of Michigan in cooperation with blind

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veterans of World War II. After this first course, O&M was taught in Poland within the school programme or revalidation training. It should be emphasized that so far in Poland there has not been any systematic training in O&M. At the Special Pedagogical University in Warsaw, preparing teachers of the blind and visually impaired and at special centres for blind children, the programme of teaching offers the techniques of independent mobility with the help of a long cane and the techniques based on echolocation. The keywords of the teaching programme and the contents of the subjects taught within O&M do not include the words hearing or acoustics. At the centres for the blind and visually impaired, the teachers are obliged to write a special programme of O&M for each child. Polish teachers of the blind could learn about the role of hearing and vibrations from the books by Swierlov [16] and Wiener [17] – the latter is not available in Polish. Both these authors cover the role of hearing to the extent far too insufficient taking into account the actual role the sound could play in mobility in large space. Moreover, these two books do not mention any systematic method of teaching O&M in large cities on the basis of natural sounds in this environment.

Therefore, a method of spatial O&M training based on environmental sounds may be a huge step in 'opening' blind people to the world surrounding them.

The first step for working out the method of spatial O&M training was analysis of results of a questionnaire addressed to the visually impaired. The questions were related to all situations in which the sense of hearing or sensation of vibrations could be useful for respondents. The construction of the questionnaire was similar to that described in [18] and was first described by [19]. The main objective of the questionnaire was to point to acoustic sounds and vibrations that can be helpful or disturbing for O&M and to point out places and objects that are most important to and the most frequently visited by visually impaired persons. The method is under development and is thought to be a supplement to, not a substitution for, the popular orientation method based on the use of a white cane generally taught by teachers of spatial orientation [20-24].

The method of spatial O&M training that we wish to develop will be professional (created by O&M teachers and acousticians), systematic (possible to use at every stage of study and dependent on the skills of environment interpretation on the basis of sounds) and checked (verified by persons with disabilities of sight). The basic tool for the method of training will be 'a library of sound events and vibrations'. The library will offer a collection of both vibrations and acoustic signals, which may be helpful or disturbing for O&M of visually impaired persons. In particular, the library will have specific sounds of places and objects, which are often pointed out by persons with disabilities of sight. Sounds are the 'universal speech'. Thus, results of our work could be used by visually impaired persons, irrespective of the living place and the beyond borders of Poland. A final result of our work, initiated by the questionnaire, will be to deliver a tool, based on acoustic and vibration signals, for instructors and teachers of spatial O&M. This tool will be fundamental in the first stages of teaching and training of spatial orientation of visually impaired persons which will take place in acoustic laboratories. The aim of teaching supported by 'library of sound events and vibrations' is to introduce this sound-based approach to orientation and to prepare visually impaired persons to interpret typical 'sound-vibration situations' that can be encountered while moving in a city. Recordings were made inside places and objects emitting characteristic sounds, and at the first stage of learning the visually impaired persons will learn how to recognize these places by sound before visiting them personally. A description of the method of recording the sounds and vibrations related to the city environment is beyond the scope of this work. However, the most crucial details will be given below. The acquisition and data collection system was based on a multianalyzer platform PULSE® made by Brüel & Kjær with the portable data acquisition unit type B&K 3650C. A measurement system was equipped with the head and torso simulator type 4100D, binaural microphones B&K type 4101A, sets of microphones B&K type 4189-A-021, and B&K Seismic DeltaTron® Accelerometer type 8340. Signals recorded via the head and binaural microphones are binaural and they can be played back via headphones. Signals recorded via sets of microphones are intended for loudspeaker reproduction. (Recordings are available from E. Hojan.)

It is assumed that the next stages of training and teaching will take place in real conditions in city streets, but training in a laboratory will facilitate the revalidation of the blind in the area of mobility in the city and will help recognition of its characteristic sites.

Profiles of Respondents

The responses to the questionnaire were collected in direct interviews with a respondents. Enumerators had many years of experience in pedagogical work with the visually impaired. Before formulation of the final version of the questionnaire, pilot and preliminary research were carried out. Thirty-two respondents took part in preliminary interviewing.

The questionnaire was subjected to essential analysis by a sociologist and in the final version it consisted of 48 fundamental questions with more than 250 subsections. In many cases the subsections required descriptive answers or personal opinions. Research based on the final version of the questionnaire was carried out in Poland, where 207 persons (113 men and 94 women) were interviewed. They were individuals with disabilities of sight, moving without help of a guiding person in most cases. The respondents were informed about the purpose of the questionnaire and were paid for their service.

Children, youths, and adults (from 10 to above 61 years of age) were interviewed. The respondents of 31-40 years old were in the greatest number (27.7%): those above 61 years old made only 5.3%, which can be explained by the more limited mobility of these persons. The respondents came from villages and different-size cities. Over 50% of the respondents (53.7%) declared living in cities of above

100,000 inhabitants as a large number of respondents came from the city of Poznań (population 680,000). Among the remaining 46.3% respondents, 13.2% came from villages, 10.2% from small towns of up to 20,000 inhabitants, 13.2% from mid-sized towns of 20,000 to 50,000 inhabitants, and 9.8% from towns of 50,000 to 100,000 inhabitants.

General information about visual impairment, frequency of leaving homes and ways of learning O&M of respondents are given in Fig. 1. The respondents represented different degrees and types of sight impairement (Fig. 1a).

The largest group of respondents included those who always use remainders of sight (30.4%), but the group of blind respondents without light perception was also considerable (24%). The numbers of blind persons without and with light perception, those who lost vision before or after ages and visually impaired persons who always use remainders of sight and those who use remainders of sight in good light conditions were similar. The questionnaire was constructed and applied to get answers to questions concerning the most often encountered problems with mobility and orientation in a big city, and to identify acoustic sounds and vibrations that may be helpful or disturbing O&M of visually impaired persons. Therefore, the questionnaire was addressed mainly to mobile visually impaired persons. Most often they were professionally employed. From among the respondents 161 persons were working at present or until recently, 122 respondents had high school or university level education and 47 respondents had vocational training.

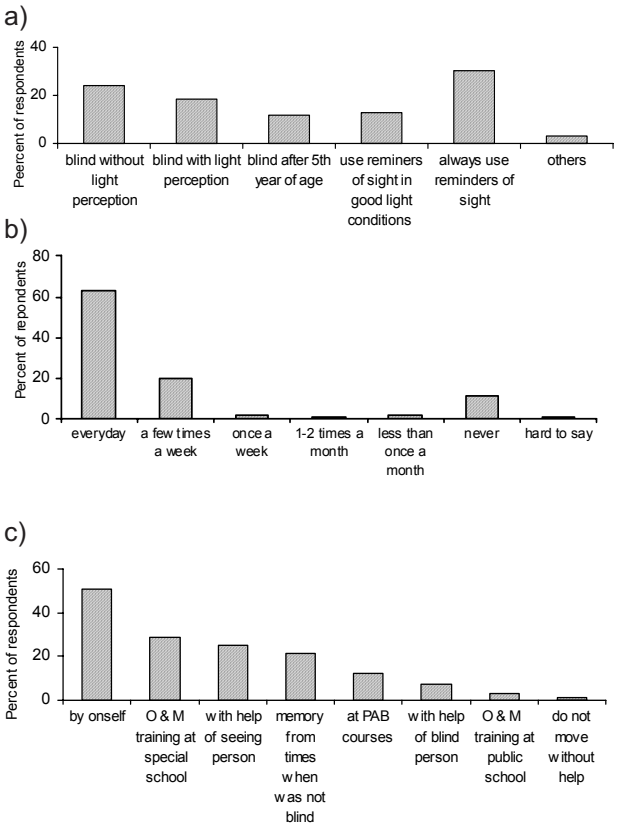

Fig. 1. General information about the respondent group, a) types of visual impairment, b) frequency of events of home leaving, c) ways of learning O&M.

Fig. 1b gives data on the frequency of independent home leaving of respondents. More than 80% of respondents leave their homes several times a week, so they are not "prisoners" of their homes. The ways they have learned skills of independent moving are plotted in Fig. 1c. Over 50% of respondents have learned the skill by themselves; over 40% were taught spatial orientation at public or special schools and in courses organized by the Polish Association of the Blind. This indicates that visually impaired persons need and want to study spatial orientation. Part of the respondents (21.4%) explored their memories from the times when they were not blind, another group was assisted by seeing or blind persons (32.9%).

Results of Questionnaire

Fig. 2a illustrates the importance of information about environment perceived by hearing for visually impaired persons and Fig. 2b gives the analogous data on the significance of vibrations in spatial O&M.

For over 90% of respondents the information about environment perceived by hearing was very important. More than 70% of the visually impaired persons tested were interested in training skills of environment interpretation on the basis of the sound heard. Almost 80% of them noticed significant change in perception of sounds caused by weather condition. Perception of vibration signals was more complicated (Fig. 2b).

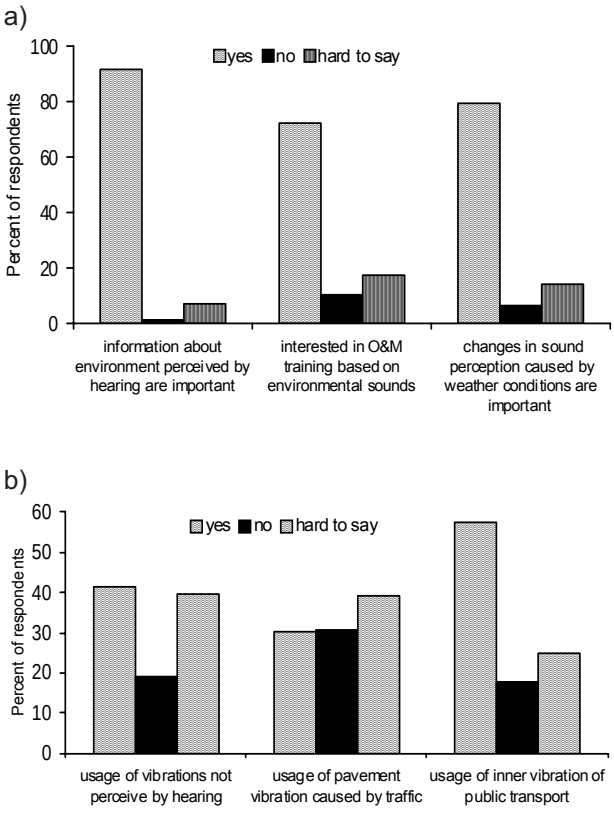

Fig. 2. a) Importance of information about environment perceived by hearing, b) value of vibration in O&M.

Over half of the respondents used inner vibration of means of transport in spatial orientation, but simultaneously only about 30% of them used ground vibration caused by traffic and about 40% did not use vibrations as informing signals at all. A significant part of the respondents had problems with answering the question concerning the use of vibrations in O&M. It can mean that visually impaired persons associated informative meaning of vibration and sound generated by some source in situations when the relation between a vibration signal and an object generating it was obvious enough (e.g. during a bus trip). However, they did not use this information in situations when the relation between vibration and sound was not obvious for them. Probably despite perceiving vibrations of the ground, the blind persons do not know how to interpret them because they had never been taught to do it. Therefore, gathering vibration signals in the library of sound events and vibrations and incorporating them into the method of spatial O&M teaching seems to be of particular importance, because vibration signals can be an additional source of information for visually impaired persons. For example, the sound generated by a passing tram can easily be masked by traffic noise, but the ground vibration produced by the tram can be detected. This fact is often ignored by seeing persons, but for visually impaired people it can be informative.

The respondents were asked about the types of information they used during independent movement in a city. Answers to this question are given in Fig. 3.

The respondents were asked to point out the most important information used in independent O&M (Fig. 3a). For 52.7% of the respondents the most important were tactile information or acoustical information (51.2% of respondents), while 48.1% of the persons interviewed took advantage of technical devices (e.g. GPS, laser cane) and 29.1% of them asked for help from seeing passers-by. The fact that more than 50% of respondents took advantage of acoustic information attested to a large role of hearing in spatial orientation and necessity of the proper training for its use. As much as 79.5% of the respondents relied mainly on the mixed source/system information, i.e. on information from at least two sources shown in Fig. 3a. Fig. 3b illustrates the distribution of different answers of visually impaired persons concerning the use of information in the mixed system. The respondents were asked what kind of information was the most important in the mixed system they used. It can be easily noted that more than half of the respondents answered that sound or acoustic information provided the most important information about the environment.

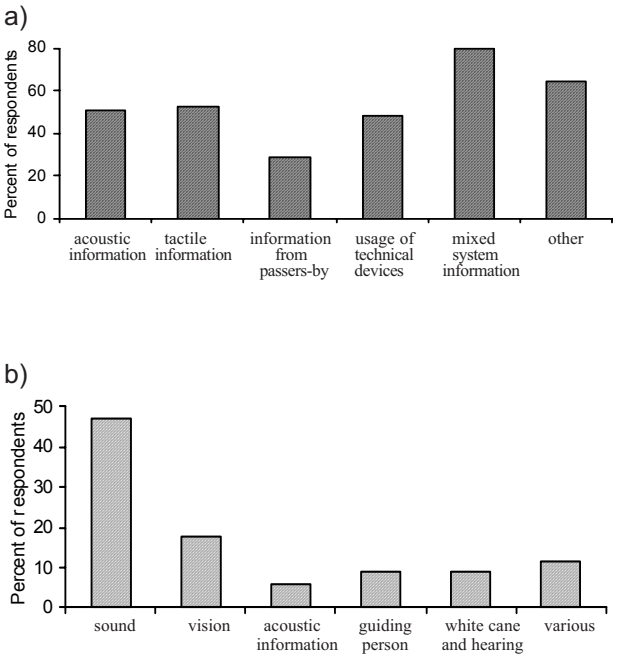

Fig. 3. a) The most important information used in independent O&M – general information, b) the most important sources of information in a mixed system.

The respondents' answers to the question about the sources of city sounds helping/disturbing spatial O&M and to the question about sound generating problems in orientation are presented in Fig. 4.

The most important sound helping with spatial orientation was the sound signalling on pedestrian crossings (69.5%), Fig. 4a. Other sounds that can help visually impaired persons were those generated by means of transport (tramway, train, bus, truck, and car), sounds of church bells or construction equipment, and acoustic situations resulting from the presence of an umbrella roof at a bus/tram stop. As city sounds disturb spatial orientation the respondents mentioned the sounds of construction equipment (64.3%), car engines working near a pedestrian cross-

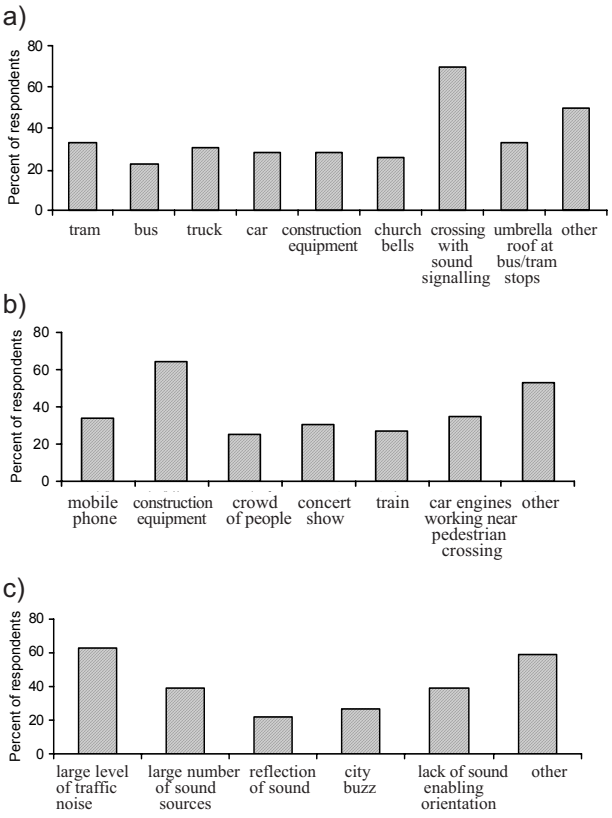

Fig. 4. a) City sounds helpful in spatial O&M, b) typical city sounds disturbing spatial O&M, c) additional sounds generating problems in spatial O&M.

ing (34.8%), sounds of mobile phones (34.2%), and big concert shows (30.7%), Fig. 4b. Interestingly, the same sounds can be helpful or disturbing in spatial O&M (e.g. sounds of trains or construction equipment), depending on the acoustic situation. Fig. 4c presents the distribution of answers to the question concerning problems with correct interpretation of sounds in city environment. A high level of communication noise (62.6%), a large number of sound sources (38.7%), city buzz (38.7%), and reflections of sounds (22.4%) made spatial orientation based on acoustic sounds rather difficult, and in some cases impossible. Thus the library of sound events and vibrations should contain both: recordings of isolated environmental sounds as well as recordings of these sounds together with additional sounds that can disturb spatial orientation. Training based on sounds from the library will permit visually impaired persons to learn how to distinguish between them.

The respondents were asked about places and objects often visited by them independently because they had to go there or wanted to do it. Answers to this question are shown in Fig. 5.

Fig. 5a shows the places and objects related to everyday life most often visited by respondents, e.g. shops and markets; places visited occasionally, e.g. health centres, offices; and places they wanted to visit for fun or meditation, e.g. sport objects, culture centres, churches, and other places. The category of other places frequently visited independently by visually impaired persons included: places of work, school or university, houses of friends and family (Fig. 5b).

The respondents were also asked to point out places and objects emitting specific sounds from the inside that could be heard from the outside. The following objects and places were indicated: post offices (34.7%), hospitals (32.4%), bars (32.8%), churches (35.3%), railway stations (69.2%), and other places and objects (68.8%), as shown in Fig. 6a. The category of "other places and objects" included mainly those characteristic of the city of Poznań, like the Old Market, airport, central roundabout, main communication passages, and bus and tram stations.

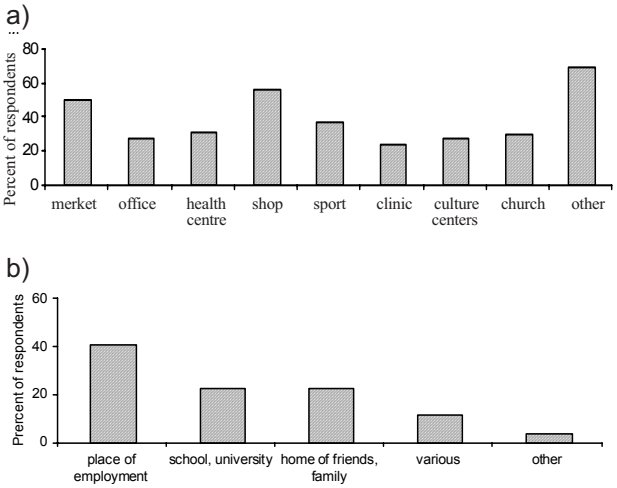

Fig. 5. a) The most frequently visited places and objects, b) other frequently visited places and objects.

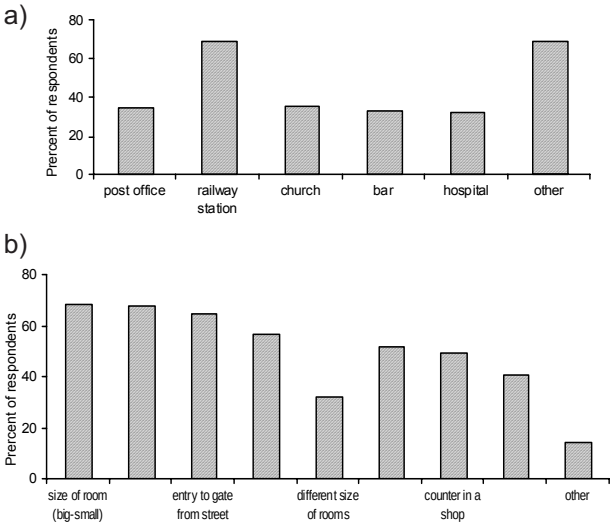

Fig. 6. a) Places and objects emitting characteristic sounds, b) recognizing by hearing different objects and situations.

According to the visually impaired respondents, the sounds related to these places (inner and outer) should be collected in 'the library of acoustic events and vibrations.' A considerable element of training visually impaired persons is development of skills to recognize features of rooms, buildings, different architectural objects, and obstacles by hearing. It seems to be another important reason for training hearing ability. Skills of recognition of different objects and their features by hearing and the percent of respondents claiming to have them are given in Fig. 6b. Almost 70% of the respondents were able to estimate the size of a room (big or small) and to find exit doors from a room using a sense of hearing, 65% of the respondents were able to find by hearing the entry gate from a street and 33% of them were able to find the entry and exit from an underground tunnel. More than 33% of visually impaired persons were able to compare rooms of different sizes. Considerable percentage of the respondents (56.6%) were able to recognize by hearing such obstacles like walls or parked cars, localize a counter in a post office (50%) and a counter in a shop (41.1%).

The respondents were also asked about additional factors helping/disturbing spatial O&M in a big city. An important role in spatial O&M is played by sounds generated intentionally by persons with disabilities of sight to help them localize obstacles. Sounds generated by visually impaired persons and that can be helpful in locating obstacles and the percent of respondents using them are listed in Fig. 7a.

The largest percentage of respondents (55%) took advantage of sounds produced when striking the white cane on the ground. Other sounds produced by visually impaired persons were clicking fingers (25%), clapping hands (8%), and tramping obstacles (16.6%).

The respondents were asked about disturbing effects of weather conditions on spatial O&M. Fig. 7b presents the answers to this question. According to the respondents, the natural factors producing the greatest difficulties in perception of sounds in city environment were: rain (85.1%), wind

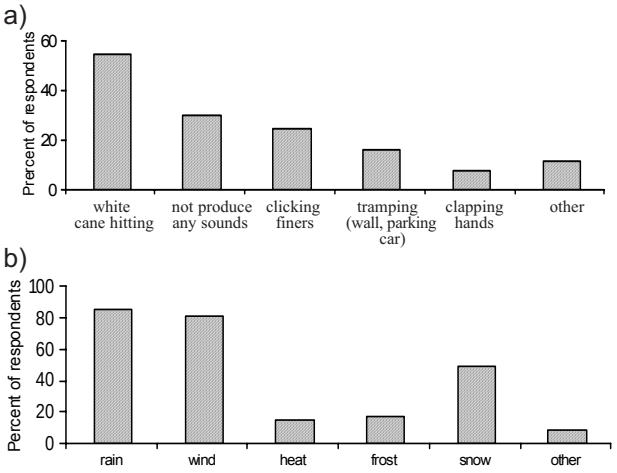

Fig. 7. a) Sounds self-generated by blind persons helpful in obstacle localization, b) disturbing effects of weather condition on spatial O&M.

(81%), and snow (48.2%). The respondents pointed to rain and wind as producing sounds that could mask informative sounds and totally change acoustic environment. They indicated unwanted disturbances related to noise generated by car wheels riding in rain. Snow lying on streets caused unwanted attenuation of sounds, in particular the sounds generated by the white cane.

Conclusions

Analysis of the results obtained from the questionnaire has permitted drawing the following conclusions:

1. Development of a method of spatial O&M teaching based on the properly chosen collection of acoustic and vibration signals in the library of sound events and vibrations can prove of vital importance for visually impaired persons.

1.1. For almost all respondents, information about the environment provided by hearing is fundamental (over 90%). The majority of them are interested in training skills of environmental interpretation on the basis of sounds (over 70%).

1.2. Vibration signals can be additional sources of information about the surrounding city environment. A large group of respondents perceive vibrations of the ground and inner vibrations of means of transport; however, they do not know how to interpret them when relation of vibrations to their source is not obvious, because they have not been taught it.

2. An important fact is that a significant percentage of respondents who use information in the mixed system (acoustic and tactile information, information from passers-by and a guiding person, information from technical devices) declared that sound is the most important source of information (47%).

3. Respondents were able to describe in details the sounds, acoustic events and acoustic situations having direct influence on spatial O&M in a big city, e.g. pedestrian crossings with sound signalling, means of transport (car, tram, train, bus, truck), construction equipment, church bells, etc. Depending on acoustic situations, the same sounds can be helpful or disturbing in spatial O&M (e.g. sounds of trains and construction equipment).

4. The library of sound events and vibrations should contain recordings of isolated environmental sounds as well as recordings of these sounds with additional sounds disturbing spatial orientation, to enable visually impaired persons to learn how to distinguish simple and complicated acoustic situations. The respondents pointed out the following disturbing sounds:

4.1. Sounds of high level, e.g. communication noise, large number of sound sources, city buzz, and reflections of sounds; the presence of these sounds makes the interpretation of the sounds in a city environment and spatial orientation based on them difficult, and sometimes impossible.

4.2. Sounds related to weather conditions. The majority of respondents (almost 80%) noted fundamental change in sound perception caused by rain, wind, and snow on the ground. The respondents pointed to these natural factors as generating masking sounds and totally changing acoustic environment.

5. The library of acoustic events and vibrations should contain typical acoustic situations recorded inside places and objects often visited by persons with disabilities of sight and associated with characteristic sounds: shops, markets, offices, post offices, stations, hospitals, health centres, culture centres, churches, etc. These recordings may inform the persons with sight disability (mainly children) about the acoustic environment of these places in laboratory conditions, before visiting these places in reality.

6. Another important reason showing that training of hearing skills may be very useful for visually impaired persons is the fact that a considerable part of them are able to estimate the size of rooms by hearing, find the exit doors from a room, entry gate from a street, entry and exit from the underground, and various obstacles like walls or parking cars.

7. Persons with disabilities of sight often generate sounds that help them localize obstacles; striking a white cane on a ground, clicking fingers, clapping hands, and tramping obstacles. Such acoustic situations should be incorporated to the library of acoustic sounds and vibrations.

Acknowledgments

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