POLISH RESEARCH ON ACOUSTICAL ASSISTANCE FOR BLIND AND VISUALLY HANDICAPPED PERSONS

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ABSTRACT

Acoustical assistance for blind and visually impaired persons has become in recent years an important topic of practical significance in Poland. Helping visually handicapped persons in using acoustic signals and vibrations in independent and safe navigation in urban environment is a part of counteracting social exclusion of them. Three issues are described in the paper: (1) a process of preparing a unique method for teaching and training of orientation and mobility based on environmental sounds, (2) a concept of a non-acoustic system for marking and identification of dangers spots in a city using wave - vibrating markers, and (3) a concept of auditory training aimed to sensibilize blind children and teenagers to differences in sounds and taught them to concentrate auditory attention on small differences in parameters on an acoustic wave, essential for independent and correct interpretation of environment by hearing and listening.

1. INTRODUCTION

The population of blind and visually impaired persons in Poland is estimated to be about 200.000. Reception and correct interpretation of acoustically conveyed information about environment is very important for them. Interpretation of sounds is taught during orientation and mobility (O&M) teaching and training usually carried on in natural environment, e.g. in a vicinity of an education centre for blinds or on city streets. Unfortunately, the teaching and training of O&M still use old, not always effective methods. The ability of spatial orientation is of substantial importance for the visually handicapped individuals improving their functioning in everyday life, increasing the safety of independent mobility and recognition of the surrounding. A set of characteristic features of a sound source is encoded in physical parameters of its sound. The features enable to distinguish different sound sources. Reception and correct interpretation of acoustically conveyed information is necessary for safe and effective navigation in the environment, particularly for children and adolescents [1]. A second important source of information for visually handicapped persons is a sense of touch. Unfortunately, the sense of touch is used for orientation and mobility by visually handicapped people very seldom and in very limited range (vibrations of a white stick, or vibration of assistive devices) [2]. The next issue is a potential effect of auditory training and its onset time on orientation and mobility skills of blind/visually impaired children and adolescents [3]. All above facts have been or currently are investigated in frames of projects financed by The National Centre of Science ad Development (projects: *Development of a method for teaching orientation and mobility in a big city of blind individuals, using sounds of the environment,* application no.: N R11 0008 04, 2008-2010; and *Elaboration of a method for marking dangerous spots and particularly places in a big city for blind people with utilization of wave-vibrating markers*, application no. N R17 0017 06/2009, 2009- 2012) and the National Science Centre (project: *Investigation of the effect of auditory training on selected auditory skills in children and adolescents with vision disorders,* application no.: 2012/05/B/HS6/03863, 2013 – 2016).

2. THE METHOD FOR TEACHING ORIENTATION AND MOBILITY IN A BIG CITY FOR BLIND INDIVIDUALS BASED ON ENVIRONMENTAL SOUNDS

In Poland the instruction in spatial orientation (O&M) was included in the teaching program for the blind and visually impaired in 1979. It should be emphasized that till 2010 in Poland there has been no any systematic training in O&M any systematic method of teaching O&M in large cities on the basis of the sounds natural in this environment [4].

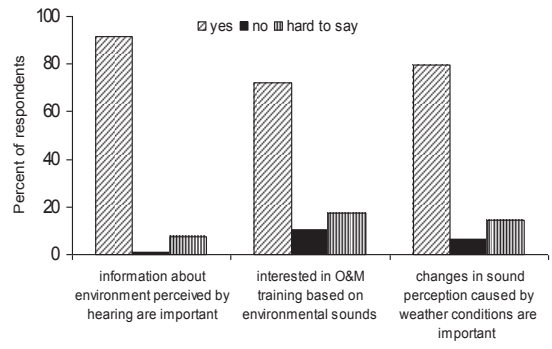

Figure 1: Importance of information about environment perceived by hearing [1].

The first step to work out the method of spatial O&M training was analysis of results of a questionnaire addressed to the visually impaired persons. 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 the most important to and the most frequently visited by visually impaired persons. The most important types of sound assisting in spatial orientation are the following [4]: external and internal sounds generated by individual vehicles in different situations, sounds of traffic, city noise without and with moving vehicles, specific sounds along the route most often walked by the blind, sounds and vibrations generated at characteristic places such as hospitals, health centers, churches, post offices, shops, banks, stadiums, schoolyard, airplanes, cleaning vehicles, construction machines, lawnmowers, bells, flapping banners, sounds related to atmospheric phenomena and nature. Answers for questions about importance of information about environment perceived by hearing and about perceiving of vibrations encountered in a city are shown in Figures 1 and 2.

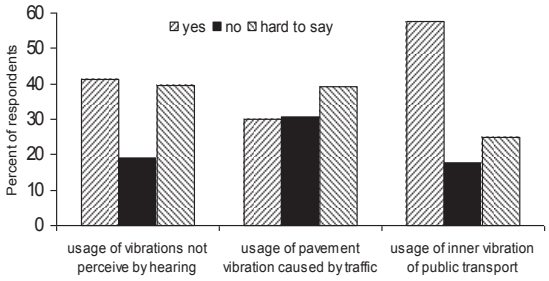

Figure 2: Utilization of vibration in orientation and mobility in urban environment [1].

Next, identification, classification and recording of the sources of sound were performed for making a database and later a library of acoustic events needed for training in spatial orientation in urban environment. In Figure 3 an example of a recording place is shown.

Figure 3: Example of a recording place for environmental signals necessary for the library of acoustic events and situations characteristic of a city life.

Next task was to make a library of acoustic events and situations characteristic of a city life in the form of an acoustic map of the city, CD records and a computer programme for teaching spatial orientation. The choice of the acoustic events and situations was made on the basis of experience of spatial orientation teachers and a questionnaire addressed to the blind persons.

The most important outcome of the study was to develop a method of spatial orientation teaching with employment of sounds and verification of the method in the Sound Laboratory in Owińska, Communication Map of Poznań, Communication Map of Owińska and the Spatial Orientation Training Park in Owińska. Special tactual relief maps of Poznan and Owińska were prepared coupled with sound effects. The typhlological maps of Poznan were equipped with sounds using the Pen Friend technology and coupled with binaural records of acoustic events. The work also resulted in making a special instruction film addressed to spatial orientation teachers and persons taking care of the blind. The film "The world depicted by sound" illustrates the method by showing the functioning of an adult who has been blind from childhood in the aspect of the sounds received and interpreted by him [4].

Additional task was to analyse acoustic signals in order to deliver their parameters to a new standards for sound signalisation at pedestrian crossings. On the basis of the study the following solutions for acoustic signalisation at crossroads were proposed [5].

1. At the crossroads without tram rails the signals proposed are to be periodically repeated complex, of rectangular temporal envelope and filled with rectangular wave of the fundamental frequency 880Hz, 20 ms duration and 5 Hz of repetition rate.
2. At the crossroads with tram rails the signals proposed are to be periodically repeated, complex, of rectangular temporal envelope filled with a rectangular wave of the fundamental frequency 1580 Hz, 20 ms duration and 5 Hz of repetition rate.
3. The level of the acoustic signal should be adjusted to the geometry of the pedestrian crossing and the level of street noise.

3. THE SYSTEM FOR MARKING AND IDENTIFICATION OF DANGEROUS SPOTS FOR BLIND AND VISUALLY IMPAIRED PERSONS

The mobility of blind and visually impaired individuals significantly depends on the ability of spatial orientation skills and mastering the techniques of movement. Since 2009 there is a research project being carried out on AGH University of Science and Technology which aims at developing a method of using wave-vibration tags in marking dangerous and significant places for the blind in urban terrain: stairway (separately up/down directions), railway platform, pedestrian crossings, all types of areas/obstacles existing only in given time, e.g. excavations, road works, bridges. The system also is universal, silent (not generating sounds that could mask environmental sounds), easy for installation, where the deciding factor is its introduction and maintenance economy [6].

The prototype system for marking and identification of the spots dangerous and of special importance for vision impaired persons in the big city with use of the wave-vibration markers was made up of three modules [7]:

– bracelets: using vibration - sense of touch,
– antenna: transmitting and receiving system that records the appearance of a blind person in the hazard or important

area for the blind and then sends the information to the controller,

– controller: receives information from the antenna, analyzing and transmit the appropriate signals to the bracelet.

Solutions supporting the spatial orientation based on sound information increase the number of acoustic stimuli. In addition, they do not work well when there is excessive noise. The idea of creating a system based on vibration signals and the sense of touch is well-founded, because it does not interfere with the reception of the natural sound environment. Furthermore, such a system can be used by the deafblind people [7].

4. AN INFLUENCE OF AUDITORY TRAINING ON AUDITORY SKILLS IN BLIND AND VISUALLY CHILDREN AND TEENAGERS

A number of studies have shown that adult blind or visually handicapped people perform better than sighted individuals in tasks related to attention focusing, sound source localization, speech perception, word memorization and pitch discrimination [8, 9]. Some papers indicate that congenitally blind or early-blind adult individuals display superior performance compared to late-blind persons [8]. The possible reasons for such behavior of early- and late blind persons are beyond the scope of this paper as they are of neuropsychological nature. In brief, it may be said that blind subjects (especially early blind) may be more susceptible to changes in brain function induced by blindness [10], e.g. for blind persons a larger tonotopic map in the auditory cortex was found, compared to the sighted reference group [11].

The main aim of the project which has started in the Spring 2013 is investigation of an effect of auditory training and its onset time on performance in selected psychoacoustic task (pitch discrimination, pitch-timbre categorization, pitch memory and localization of sound sources) in blind and visually impaired children and adolescents. In other words, the aim is to establish whether appropriate auditory training is able to sensibilize blind persons to differences in sounds and taught them to concentrate auditory attention on small differences in parameters on an acoustic wave, essential for independent and correct interpretation of environment by hearing and listening. The effect of auditory training on results of the above psychoacoustic tasks has not been reported frequently. It was show in the report describing the influence of early non-visual experience on acuity of proprioceptive-spatial discrimination, that congenitally blind adults who had attended orientation and mobility training before the age of 12 years, better compensated lack of vision by hearing and touch than people who had started training after the age of 12 [12]. Gordon-Salant and Friedman [13] have shown that speech-in-noise intelligibility in older blind adults frequently listening to recorded speech material (e.g. audiobooks) was better than in the contemporary reference group of sighted participants who had not used speaking devices. They motivated this finding in blind adults by better concentration of attention on verbal information, or simply on acoustic and listening training. It can be noticed from the literature review that a proper auditory training may be beneficial to blind and visually handicapped people, provided it is started in the appropriate moment of life. Such reports for children and adolescents have not been encountered in the literature published so far, and if so, there are fragmentary reports. For this reason the above project is innovatory and the problem is new and not described yet. A preliminary experiment concerning pich-timbre categorization was performed for blind children (7- 13 years old), teenagers (14 – 18 years old) and reference groups of sighted children and teenagers [9]. Additionally, obtained results were compared to results for blind adults reported in [10]. Signals containing four tones of equal amplitude (basic frequency and three harmonics) were presented simultaneously. The signals had two levels of pitch and two levels of timbre. Pitch was determined by the frequency of the first tone f_1: 294 Hz (for low pitch) or 417 Hz (for high pitch). Timbre was determined by manipulating harmonics of the first frequency f_1. Signals of frequency f_1 and harmonics 3 f_1, 4 f_1 and 5 f_1 had softer or darker timbre. Signals of frequency f_1 and harmonics 4 f_1, 5 f_1 and 6 f_1 had sharper or brighter timbre.

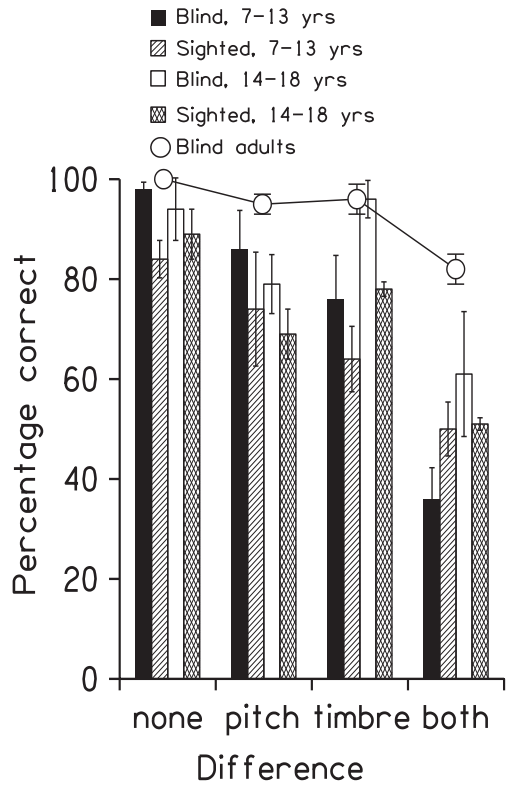

Figure 4: Mean and standard errors of percentage correct answers in the preliminary pitch-timbre categorization experiment for both age groups of blind children and teenagers and corresponding reference groups [9]. Empty circles indicate results for congenitally blind adults obtained by Wan et al. [10].

The task of the subjects was to assess a pair of signals in both pitch and timbre. They were asked to say whether the signals were similar in pitch and timbre, and if not – which feature was different. Possible answers were: no difference in pitch and

timbre, difference in pitch only, difference in timbre only, difference in both pitch and timbre. Results of the pitch-timbre categorization experiment are shown in Figure 4.
In the pitch-timbre categorization experiment (conditions 'changes in both pitch and timbre' and 'changes in timbre only') blind teenagers performed much better than the remaining three groups of our subjects, but still worse than congenitally blind adults for the condition 'changes in both pitch and timbre'.

5. FINAL REMARKS

The aim of all actions described above was to make urban environment friendly for blind/visually impaired persons. Although the described solutions are addressed to the whole community of people with vision disorders, they are especially dedicated for children and teenagers as they are the most keen on new solutions, curious of world and ready to experimenting and learning. Helping visually handicapped persons in using acoustic signals and vibrations in independent and safe navigation in urban environment is a part of counteracting social exclusion of them.

6. REFERENCES

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