The Impact of Orientation and Mobility Aids on Wayfinding of Individuals with Blindness: Verbal Description vs. Audio-Tactile Map

Eleni Koustriava, Konstantinos Papadopoulos, Panagiotis Koukourikos, and Marialena Barouti(✉)

University of Macedonia, Thessaloniki, Greece
marialenab90@gmail.com

Abstract. The aim of the present study was to examine if a verbal description of an urban area or an audio-tactile map would support the development of an effective cognitive route that could be used consequently for detecting specific points of interest in the actual area. Twenty adults with blindness (total blindness or only light perception) took part in the research. Two O&M aids were used: verbal descriptions and audio-tactile maps readable with the use of a touchpad device. Participants were asked to use each aid separately to encode the location of 6 points of interest, and next to walk within the area with the scope of detecting these points. The findings proved that an individual with visual impairments can acquire and use an effective cognitive route through the use of an audio-tactile map, while relying on a verbal description entails greater difficulties when he/she comes into the physical environment.

Keywords: Blindness · Touchpad · Audio-tactile aid · Orientation and mobility

1 Introduction

Individuals with visual impairments face significant challenges traveling in the physical environment. Independent movement is directly connected to the quality of someone's life and thus orientation and mobility issues are always listed on the top priorities of research in the field.

The belief of inferiority of individuals with visual impairment in spatial abilities has an impact on their life, as usually, they are excluded from many employment opportunities [1]. Many work places require actions which are considered to be improper or inaccessible for individuals with visual impairment (e.g. operating a computer, driving a car) [1]. Similarly, difficulties in transition to their workplace are believed to entail reduced independence and activity in limited spaces [1].

Individuals with blindness are facing significant difficulties during their orientation and mobility in space. The majority of the researchers that examined spatial performance of individuals with visual impairments and sighted individuals came to the conclusion that visual experience influences decisively spatial behavior [2–4] Moreover, blindness has a negative impact on the development of blind people's spatial skills [4–6].

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Orientation, wayfinding and cognitive mapping are prerequisite skills to manage novel spatial environments. Wayfinding involves the ability to learn and recall a route as well as to update one's orientation as he/she moves along the route [7]. Wayfinding is one aspect of the spatial knowledge arisen from cognitive mapping [8].

Even in modern cities, wayfinding is difficult for an individual with blindness [9]. Vision plays a chief role in comprehending the spatial structure of an environment [10] and as such, individuals with blindness seem to face difficulties in the acquisition of concepts relevant to spatial relationships [11]. Nevertheless, it has been argued that even individuals who are congenitally blind are able to form mental representations based mainly on tactile and acoustic stimuli [12, 13].

These mental representations, stored in the long-term memory are called cognitive maps and determine the behavior of individuals with blindness in a space [14]. More specifically, cognitive maps are symbolic structures which reflect spatial knowledge and lead individuals with blindness take crucial decisions, related to where to move to, how to move and which path to follow [15]. However, all information available on the cognitive maps of an individual with blindness is in dynamic relation with the individual's experience and they together contribute to planning and decision making related to movement in space [16]. Individuals with visual impairment can create a mental map through the use of vestibular, haptic, auditory, and even olfactory information and locomotion [17, 18].

According to [11], the conceptualization of the environment depends mainly on three interrelated types of experiences which are visual, acoustic, and tactile (combined with motor activities). Individuals with blindness, in order to form their own cognitive maps, compensate the lack of vision by gathering experiences for space through other senses. Touch and hearing are the main senses through which individuals with blindness acquire knowledge about the structure and the content of an environment [19, 20].

It is impossible for people with blindness to collect the external visual stimuli from the environment or to use conventional maps. Therefore, the provision of spatial information through tactile aids is important [21, 22]. The usefulness of tactile maps for spatial knowledge by individuals who are blind has been demonstrated in several studies [23, 24]. Maps constitute a significant orientation and mobility aid supporting the absolute and relative localization of streets and buildings as well as the estimation of directions and distances between two points [25]. The view provided from a tactile map can replace to some extent, the visual view of the environment [26].

Verbal descriptions refer to descriptions of the layout of an area or instructions of how someone could travel within an area, and may contain information relative to landmarks, routes and techniques for specific situations etc. [27]. The value of verbal descriptions in developing spatial knowledge is disputable because they may embed complex or unknown concepts, they may contain imprecisions [27], or even entail memory load and as such, verbal descriptions subject to time restrictions. A main advantage provided by verbal aids is that the information provided on these issues is more detailed compared to tactile maps. Furthermore, verbal aids do not require braille skills [27].

Assistive technology plays a fundamental role in education and everyday life of individuals with blindness [28, 29]. Assistive technology has recently shown great strides in the field of non-visual access to information for individuals with blindness [30].

In case of audio-tactile maps, information can be represented by tactile graphics, audio symbols, tactile symbols, audio-tactile symbols (combined e.g. a tactile symbol that when a user touches it, he can hear additional information) and Braille labels. That allows a vast amount of information to be presented in auditory modality.

Research data reveal that coexistence and adaptation of auditory and tactile information has been proved significant to the success of an application for spatial knowledge with respect to the satisfaction of individuals with blindness [25]. The comparison of an audio-tactile map with a tactile map demonstrated that interactive audio-tactile maps are more usable and preferred by the users [31].

Audio-tactile maps become available with the use of technological devices, such as the touchpad [32]. The benefits of combining audio and tactile information with the use of relative device have been reviewed in MICOLE project [33].

The study of how people build spatial knowledge through multisensory applications can contribute significantly to the improvement and redesign of similar approaches in the future [14]. Quite an optimistic prospect is that in future the low cost of tactile devices will allow individuals with blindness to have their own multimodal map system at their home [34].

2 Study

The aim of the present research was to examine if a verbal description of an urban area or an audio-tactile map would support the development of an effective cognitive route that could be used consequently for detecting specific points of interest in the actual area. A comparison of the effectiveness of the two aids was an objective of this study.

The present study is part of an extended research which aims at examining whether spatial knowledge structured after an individual with blindness had studied a map of an urban area, delivered through different aids (a verbal description, an audio-tactile map with the use of a touchpad device, and an audio-haptic map with the use of a force feedback haptic device) could be used for wayfinding and detection of specific points of interest in the area.

2.1 Participants

A basic criterion to include a participant in the study was not to have other disabilities, apart from visual impairments. Twenty adults with blindness (total blindness or only light perception) took part in the research. The sample consisted of 15 males and 5 females. The age ranged from 19 years to 61 years (M = 31.75, SD = 10.70). The visual impairment was congenital for 9 participants and acquired for the rest 11 participants – in 4 out of these 11 participants vision loss occurred at the first year of life.

The participants were asked to state the way of their daily move in outdoor places, by choosing one of the following: (a) with the assistance of a sighted guide, (b) sometimes myself and sometimes with the assistance of a sighted guide, and (c) myself, without any assistance. Moreover, the participants were asked to indicate the frequency of their independent movement using a 5-point likert scale: always, usually, sometimes, seldom, or never. According to their answers, 14 participants move without the assistance of a sighted guide and 6 participants sometimes with assistance, sometimes all by themselves. Moreover, 10 participants stated that they “always” move independently, 8 stated “usually”, 1 participant stated “sometimes”, and 1 participant stated “seldom”.

As far as their Orientation and Mobility (O&M) training is concerned, 15 participants stated that they have participated in O&M training sessions, while 5 participants have never been trained in O&M. The training for 12 out of those 15 participants endured from 10 to 100 h in total, while just 3 of the participants have been trained in O&M for more than 100 h. Moreover, 7 participants declared that they have “never” read tactile graphics or maps, 10 participants that they “rarely” have read tactile graphics, 2 participants that they have read tactile graphics “a few times” and 1 participant that he/she has read “many times” tactile graphics. None of the participants had ever used and audio-tactile map.

2.2 Instruments

Two O&M aids were developed for the aims of the experiment: verbal descriptions (maps) and audio-tactile maps readable with the use of a touchpad device. Specifically, three maps depicting three different areas of the Thessaloniki city (areas around the city center with apartment buildings and stores) were developed for each of the two types of O&M aid (verbal description and audio-tactile map). All areas had approximately the same extend and included 5 blocks each. Maps consisted of streets, points of interest and the locations that are extremely dangerous for people with blindness. The number of points of interest was 6 and was the same on each map. The 3 maps were slightly different concerning the degree of difficulty.

The verbal description aid included 3 audio files (.mp3 files), one for each map. Verbal descriptions were initially written in text and subsequently were converted into audio files via TextAloud software (NextUp Technologies). The voice used was Loquendo Afroditi (Greek voice). The verbal descriptions included information for the streets, the six points of interest, the dangerous locations, and the boundaries of the map.

For the study of audio-tactile maps, IVEO (ViewPlus) touchpad tactile device was used. Touchpad is an educational device for individuals with visual impairments, which combines audio and tactile stimuli in order to enrich visual information. The audio-tactile aid consisted of three tactile maps, one for each area, and the corresponding computer files (SVG files). Maps were printed on microcapsule paper using the PIAF machine. Audio-tactile maps included streets, points of interest, dangerous locations and soundscape for intersections. The soundscape of intersections was recorded in real time using a Stereo Dat-Mic microphone (TELINGA) and a ZOOM H4n-Handy Recorder. For the study of audio-tactile maps a personal computer was connected to the touch-tablet. Headphones connected to personal computer were used for the listening of verbal descriptions.

2.3 Procedures

Participants were asked to use each aid separately to encode the location of 6 points of interest, and next to walk within an area with the scope of detecting these points. During the phase of aid use, each participant tried to form a cognitive map that would help him/her to move within an area and precisely locate 6 points of interest during the second phase that was executed in this same area (in the physical environment).

The selection of the map to be studied was based on a cyclic procedure, with the first participant listening to the verbal description of the first area, the second participant listening to the verbal description of the second area, and so on. Moreover, the first participant was reading the audio-tactile map of the second area, the second participant reading the audio-tactile map of the third area, and so on. Furthermore, not all the participants started the procedure by listening to the verbal description. On the contrary, half of them began with reading the audio-tactile map. The cyclic procedure was followed so as to decrease the potential effect due to the ease or the difficulty of the studied map, as well as to avoid a possible learning effect influence.

The participant had 15 min at his/her disposal in order to use the aid (verbal description or audio-tactile map) but he/she could stop the procedure earlier, if he/she considered that he/she had fully finished the study. The second phase of the procedure, i.e. the independent movement within the area with the scope of locating the 6 points of interest, began 10 min after the end of the first phase, due to the relocation of the researcher and the participant to the actual area of the studied map. Initially, the researcher placed the participant at the starting point of the area. The participant was asked to navigate in the area without any help, choose his/her own orientation and route, as well as to define the correct position of as more of the six points of interest as he/she could. The route followed by each participant was noted by the researchers. The participant had at his disposal a maximum time span of 20 min but he/she could stop searching for the points of interest earlier, either if he/she had found all six points of interest or if he/she could not recall any other information from the mental map he had formed during the first phase.

In cases of emergency and only when the blind participant was on danger the code word "freeze" was told by the researcher in order to freeze the navigation of the participant. Moreover, the researcher did not provide any assistance to the participant in relation to his/her navigation, unless the participant chose a direction in a street that set himself/herself out of the area of the map. In that case, the researcher relocated the participant back into the specified area, noted the mistake and the participant continued his/her navigation.

The comparison of the two aids was processed with reference to 4 variables: (a) number of sections (the parts of a street from intersection to intersection) with points of interest crossed by the participant, (b) number of sections with points of interest that were not crossed by the participant, (c) number of sections that were crossed by the participant more than once, and (d) whether the participant followed the ideal route, or not. As the ideal route was defined the one that if followed, the participant would have met all the 6 points of interest, it would be the shortest possible route, while it would be unnecessary for the participant to traverse a section more than once.

3 Results

Initially, the scores of the following 4 variables were calculated: (1) 'sections crossed' which represents the number of sections with points of interest crossed by the participant, (2) 'sections non-crossed' which represents the number of sections with points of interest that were not crossed by the participant, () 'sections crossed' which refers to the number of sections that were crossed by the participant more than once, and 4) 'perfect route' which refers to whether the participant followed the ideal route, or not (this variable was calculated through the scores 0 = not, and 1 = yes). The mean and standard deviation (SD) of scores for each one of the two aids are presented in Table 1. Each correct or wrong answer was scored to 1. The sections including points of interest were 7 in average for each of the 3 maps.

Table 1. Mean and standard deviation (SD) of the crossed sections (with points of interest), non-crossed sections (with points of interest), repeated sections, and following the perfect route.

	Verbal description		Audio-tactile map	
	Mean	SD	Mean	SD
Sections crossed	5.10	1.77	5.75	1.77
Sections non-crossed	1.75	1.41	1.40	1.39
Sections repeated	.95	.89	.40	.75
Perfect route	.10	.31	.65	.49

The implementation of repeated-measures ANOVAs revealed significant differences for the variables: 'Sections repeated' [$F (1, 19) = 5.487$, $p < .05$], and 'Perfect route' [$F (1, 19) = 23.222$, $p < .01$].

The analysis of the results indicated that the participants followed the ideal route statistically significant fewer times after they had listened to the verbal description that they had read the audio-tactile map. In this same case, it seems that participants crossed the same section/s more than once. In addition, the participants appear to have crossed more sections with points of interest after they had read the audio-tactile map than listened to the verbal description. However, this difference is not statistically significant.

Interesting enough are the findings concerning the differences in the variable 'perfect route'. The number of the participants they followed the 'perfect route' using the verbal description was 2, while the participants following the 'perfect route' after they had read the audio-tactile map were 13.

4 Conclusions

In the present study, the cognitive maps of individuals with blindness were examined after they had listened to a recorded verbal description and they had explored an audio-tactile map using a touch pad device. This research is significant twofold: not only the comparison of a verbal description with an audio-tactile map has not been met in the field, but also the assessment of cognitive maps in the physical environment (instead of laboratory conditions) which reflects a real situation is generally avoided [35].

According to the results, an individual with blindness can acquire and use an effective cognitive map through reading an audio-tactile map. However, relying on a verbal description before entering an unknowing area entails challenges. The participants' performance was significantly better in the spatial tasks after they had read the audio-tactile map than in the case of listening to the verbal description. It seems that following an ideal route i.e. meeting all the 6 points of interest, detecting the shortest possible route and being quick by avoiding walking repetitions of sections, becomes an easier task after the preparation with an audio-tactile map. This proves not only, that audio-tactile maps constitute an effective orientation and mobility aid but also, that they provide much more support compared to verbal descriptions.

Previous research has also proved that audio-tactile map result in adequate spatial knowledge [36].

A possible explanation of the dominance of audio-tactile maps over verbal description could be the advantages of combining tactile and auditory stimuli, on one hand, and the drawbacks of verbal descriptions, on the other. Taking these results into consideration, it could assumed that audio-tactile maps combining significant advantages of tactile maps with auditory information enable more efficiently the individual with visual blindness when he/she arrives to physical environment. Verbal description appears to be a weaker tool for wayfinding and points of interest detection in the physical environment. This means that while combining tactile and auditory information may consequently lead to a more complete concept [37], verbal descriptions may embed complex or unknown concepts, contain imprecisions, or even entail memory load [27].

The findings of the present study contribute to the understanding of issues concerning the development of cognitive maps in individuals with blindness. These findings are specifically significant in the case of familiarization with a novel area and the consequent creation of a new cognitive map. Thus, the results of the study have implications for both educators and orientation and mobility specialists.

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