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ScienceDirect

Procedia Computer Science 67 (2015) 223 – 230

Procedia Computer Science

6th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Infoexclusion (DSAI 2015)

Audio-Haptic Map: An Orientation and Mobility Aid for Individuals with Blindness

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Abstract

The aim of the present research was to examine whether spatial knowledge structured after an individual with visual impairments had studied an audio-haptic map, could be used: a) for his/her independent and efficient movement within the mapped area, as well as b) for detecting in the area specific points of interest initially presented on the map or not. The map was provided through a multimodal application and was studied with the use of a force feedback haptic device. Eleven adults with blindness (total blindness or only light perception) took part in the research. The age ranged from 20 years to 61 years. The results clearly support the significance of the specific application as an aid to structure spatial knowledge and cognitive maps. That kind of knowledge could be used consequently for orientation and mobility in an urban environment.

Peer-review under responsibility of organizing committee of the 6th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2015)

Keywords: individuals with blindness; orientation and mobility; audio-haptic map; haptic device; spatial knowledge

1. Introduction

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

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Peer-review under responsibility of organizing committee of the 6th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2015)
doi:10.1016/j.procs.2015.09.266

individuals came to the conclusion that visual experience influences decisively spatial behavior[1,2,3]. Moreover, blindness has a negative impact on the development of blind people's spatial skills[3,4,5].

Maps contribute to the handling of daily living problems inducing autonomy, independence and a better quality of life for individuals with visual impairments[6,7,8]. Mobility aids such as tactile maps or audio-tactile maps are passive mobility aids, according to the categorization of Lahav and Mioduser[9], and as such they help individuals with visual impairments explore and code spatial environment before they actually reach real environment.

A fundamental way to deal with spatial coding is by using compensatory sensorial channels to collect information[9]. Receiving tactile and auditory information in combination with each other is suggested to provide a more complete concept in less time than each medium separately would require. That is because tactile graphics present the relationships among the elements, while auditory cues supply detailed information[10].

Auditory support, specifically, can be either verbal descriptions about spatial relations, textual labels[11], suggestions for specific techniques to be used in specific travel situations or cultural and aesthetic information for particular environments[12]. It has been suggested that verbal descriptions, because of their sequential nature, promote incremental structuring and updating of spatial knowledge contributing to speed and accuracy of map exploration[11]. Soundscape constitutes also an auditory support. Individuals with visual impairments may use soundscape – a sound or a range of sounds that come from sound making factors in the environment[13] – to perceive the structure and configuration of an environment[14], to identify and localize objects[15], maintain their orientation[16] and avoid hazards[17]. 3D sounds (or spatial sounds) are more appropriate than simple sounds, such as auditory icons or earcons, to spatial (geo-) information[18] and thus spatial sounds have been widely used in interactive maps (e.g.[19,20]).

Research results prove that individuals with visual impairments use auditory cues to create cognitive maps[14]. For this reason auditory cues have used in combination with haptic feedback in an audio-haptic map. Rice, Jacobson, Golledge and Jones[21] combined auditory support with haptic feedback on a map that a user could scan using a force-feedback mouse. Kaklanis and his colleagues[20] used a force feedback haptic device on a digital map that compounded haptic interaction with a sonification system and Text to Speech (TtS) module. Parente and Bishop[22] used auditory icons, TtS and haptic feedback to deliver spatial information to individuals with visual impairments. Ren, Hikichi and Sezaki[23] examined their multimodal 3D GIS that allows user to explore 3D maps using a force feedback haptic device. The results showed that participants were able to complete map exploration rapidly and memorize a great piece of information reducing in the same time mistake rate.

In some cases, researchers tried to detect the development or improvement of spatial knowledge by examining the cognitive map created after the exploration of an audio-haptic map. Lahav and Mioduser[9] examined the construction of cognitive maps in individuals with blindness after the latter have studied a virtual environment with a force feedback joystick. They found that participants developed a thorough and comprehensive knowledge of the targeted space and were able to use the created cognitive map to apply complex spatial skill and perform successfully orientation and mobility tasks in the real space. A tablet application providing vibration and auditory feedback used by one participant with blindness in the research of Simonnet, Bothorel, Maximiano and Thepaut[24]. In the same research the participant used this application to explore an interactive map and afterwards was asked to draw the map. The researchers pointed out that the drawn map was surprisingly precise[24].

The research results seem to draw contradictory conclusions. From one point of view, audio and haptic outputs may not increase spatial knowledge[9], while vibrations have been considered less effective at presenting graphical information compared to raised-line drawings. On the other hand, audio-tactile presentations may result in spatial awareness if there is previous training on how someone to use touch and hearing in these cases[9]. Moreover, it has been suggested that using audio feedback to receive supplementary information, and haptic feedback to identify objects and relationship, major cognitive resources could be pumped into overall mapping of an area[9]. Yatani, Banovic and Truong[25] noted that the participants with visual impairments in their research performed better in sketching geographical information after examining space using auditory and vibration output than after using just auditory feedback.

In any case, research results seem to conclude that prior exploration and anticipated cognitive maps are useful orientation tools when navigating unfamiliar spaces. Overall, the researches mentioned above examining cognitive maps (e.g.[9,24,25]) proved that, even if audio-haptic feedback while exploring space through relative applications and devices, do not result in "conceptual" space, it seems that it well contributes to "practical" space. Piaget and Inhelder[26] made the distinction between "practical" space (the ability to act in space, for instance, to move from