

Environmental information for inclusion in orientation and mobility maps, identified by travelers with blindness: the cases of city centres and neighborhoods/ residential areas

Introduction

Nowadays the European landscape is spotted with cities. An urban city centre usually consists of high-density terraces or high rise housing and offices. City centres are complex places that host and serve a wide range of people and purposes (business, shopping, entertainment etc.). On a daily basis, individuals with impairments are challenged by streetscape structures such as street furniture (tables, chairs, etc.), damaged or uneven surfaces, and roads running under construction. Navigating these features in a crowded city centre can be even more dangerous for people with disabilities.

For individuals with visual impairments in particular, orientation without visual feedback in unknown environments is a difficult and demanding task. The type of information used by individuals with blindness for orientation and mobility is different from those without blindness (Passini & Proulx, 1988). Koutsoklenis and Papadopoulos (2011a; 2011b & 2014) found that there are specific auditory, haptic and olfactory cues that are used by individuals with visual impairments for wayfinding and spatial knowledge.

Recent neuroscientific work points out differences between individuals with and without visual impairment in spatial knowledge acquisition (Schinazi, Thrash & Chebat, 2016). The former usually have received special training by orientation and mobility specialists who help them to learn the main walking routes with audio-tactile feedback techniques making use of their auditory and haptic sense (Sauerburger, 1996). Such training is beneficial for orientation;

however, it entails a lot of effort to learn the most important cues for finding a way (Ungar, Blades & Spencer, 1993), and it is time-consuming.

To support orientation and wayfinding of individuals with visual impairments, many orientation and mobility aids have been developed in the previous decades. Raised-line graphics of the spatial environment, such as tactile maps, have been used to prepare individuals with visual impairments to navigate space more safely and efficiently (Espinosa, Ungar, Ochaita, Blades, & Spencer, 1998). Thus, tactile maps contribute to spatial awareness (Habel, Kerzel, & Lohmann, 2010) supporting wayfinding (Passini, Duprés, & Langlois, 1986) as well as orientation and mobility of individuals with profound visual impairments (Lawrence & Lobben, 2011).

The next generation of tactile graphics was audio-tactile representations with the addition of auditory information to the tactile graphics. Audio-tactile maps have been used to examine the ability of individuals with visual impairments to encode space (Siekierska, Labelle Brunet, McCurdy & Pulsifer, 2003; Papadopoulos, Barouti & Charitakis, 2014; Koustriava, Papadopoulos, Koukourikos, & Barouti, 2016; Papadopoulos, Barouti, & Koustriava, 2016a; Papadopoulos, Koustriava, & Barouti, 2017, Papadopoulos, Barouti, & Koustriava, 2018). Tactile graphics are placed on top of touch-sensitive surfaces such as NOMAD (Parkes, 1988) or IVEO (Gardner, Bulatov & Kelly, 2009) and auditory information is delivered to the user by tapping at a certain spot. Thus, in the case of audio-tactile maps, information can be represented by tactile graphics, audio symbols, tactile symbols, audio-tactile symbols (e.g. when a user touches a tactile symbol, he can hear additional information) and Braille labels. This allows a vast amount of information to be presented in auditory modality.

Koustriava and her colleagues (2016) investigated the cognitive maps of persons with

visual impairments, and they found that audio-tactile maps are more helpful for wayfinding and detection of specific points of interest in a certain region than recorded verbal descriptions. The findings of Papadopoulos et al (2016a) point in the same direction. It seems that audio-tactile maps that use a tactile map augmented with special auditory information (i.e. from the real environment) at places such as intersections are helpful to improve spatial knowledge in familiar city areas. Wang Li, Hedgpeth and Haven (2009), with the participation of six users with blindness, showed that audio-tactile maps from their prototype system convey the most important map information and are potentially useful aids for local navigation.

Audio-tactile maps have given rise to a variety of orientation and mobility aids – from high tech to low tech – that are used or could possibly be used for spatial learning and navigation. Abd Hamid & Edwards (2013) studied how route learning using audio-tactile maps could become more interactive and accessible to the user with blindness. Their approach allows the user to rotate the Talking Tactile Tablet, thereby facilitating the development of an egocentric cognitive map. Brock, Truillet, Oriola and Jouffrais (2010) investigated the usage of multi-touch displays in interactive audio-tactile maps. Their system relies on a tangible overlay placed on top of the multi-touch screen. Furthermore, a touch-sensitive pin-matrix display integrated with an audio-haptic system has been developed (Zeng, Miao & Weber, 2014) to improve map accessibility for individuals with visual impairments while reading city maps and establishing pre-journey routes. The system allows users to explore large-scale areas through pinning and zooming. Jacobson (1996) used talking tactile maps and combined them with auditory beacons in the environment to remind the users of specific landmarks when they move outside.

All these means have been introduced to enable access to spatial information for

individuals with visual impairments. Although there has been extensive work on audio-tactile stimuli, little research concerning user requirements has been detected. What is needed, is to specify audio-tactile symbols for audio-tactile maps through a user-centered approach. The end-users (individuals with visual impairments) of audio-tactile maps should define what information should be incorporated in audio-tactile maps and in which format they should be presented.

In an online survey, Abd Hamid and Edwards (2013) asked 15 mobility instructors about what landmarks are useful for the orientation of persons with visual impairments. They identified auditory cues and ranked them based on importance: sounds from ground texture, vehicle passing, vehicle brakes, street traffic, running water, vehicle horn, people leaving/entering buildings, sounds of trees, footsteps, road works and sounds made by animals. They also evaluated landmarks according to their importance: road crossings, buildings, junctions, entrances, bridges, curbs, transport stations, bus/taxi stands, telephone booth, lamp posts, streets, fences, sidewalks, alleyways, parks, water, parking lots, and fields.

Leonard and Newman (1970) found that information that refers to specific environmental characteristics such as crossing a street, identifying which side of the street should be used, changing walking directions, up or down curbs, warnings and roundabouts, help with orientation during a journey. This is also confirmed by studies done by Passini and Proulx (1988), who found that wayfinding was supported by four behavioral categories such as changing walking directions, changing levels, maintaining a walking direction, and finding close ranged architectural elements in a space. Moreover, Papadopoulos (2004) suggested that cognitive maps of individuals with visual impairments appear to contain basic environmental features such as streets, buildings, parks, fixed obstacles, and bus stops.

Though all of the above recommendations are significantly useful, the review of the

literature suggests that, on one hand, the use of electronic mobility aids is not widespread because they haven't managed to fully meet the needs of individuals with visual impairments (Roentgen, Gelderblom, Soede, & De Witte, 2008) and on the other hand, there are inconsistencies and lack of standardization in the production of tactile maps that hinder their success in addressing the needs of end-users (Rowell & Ungar, 2003).

There is a series of research that approached the specific features contained in the cognitive maps of individuals with visual impairments, and suggested that if this information could be included on tactile maps, it would turn them into a more useful navigational tool. Koutsoklenis and Papadopoulos (2011a; 2011b & 2014) examined which auditory, haptic and olfactory cues are more frequently used, and which ones are actually more useful for wayfinding, environment recognition and hazards avoidance in urban areas. They found that there is a discrepancy between the most frequently used and the most useful ones.

In the same direction, Gardiner and Perkins (2005) investigated the environmental information that individuals with visual impairments recognize in order to customize tactile maps using meaningful features. Thus, they found that an amount of audio, haptic and olfactory information can be perceived, while the environmental circumstances (for instance weather) interfere with recognition. The main question arising here is whether the information that end-users can perceive themselves is indeed the right tactile information to be included on a relative map, or the information that the end-users could not perceive themselves should be included to complete their spatial encoding, or a combination of both would be preferable.

For this reason, Papadopoulos et al (2016b) decided to investigate the user requirements of 40 young adults with blindness regarding the information to be included on two different types of audio-tactile mobility maps: (a) audio-tactile maps of indoors, and (b) audio-tactile maps

of campuses. The main result of this study was the identification of the most important information that should be included on each one of the two different types of audio-tactile maps. The importance factor was calculated by multiplying frequency of occurrence with significance (usefulness) for each information. The research presented on the current paper constitutes an extension of the previously mentioned research (Papadopoulos et al., 2016b).

Study

The present research article was derived from a wider research project which aimed at the specification of user requirements of adults with blindness regarding the information to be included (mapped) on audio-tactile maps of a) indoor places, b) campuses, c) neighborhoods/residential areas, d) city centres, and e) geographical scale (political, physical, thematic, and historic). It presents the part of a research concerning the user requirements of adults with blindness regarding the information to be included on audio-tactile maps of city centres and of neighborhoods/residential areas. In order to meet the purpose of the research, the investigation focused on the usefulness (importance) that individuals with blindness attribute to a large number of different spatial information (items) that could be identified in both the environment of a city centre and of a neighborhood/residential area. For these reasons, the usefulness that individuals with blindness consider for each item of information was evaluated. The result of this research is the identification of the information that end users wish to be included on audio-tactile maps and in orientation and mobility aids in general, assorted in a hierarchical from the most useful item to the least useful one.

A secondary objective of the research was to examine if the usefulness of the items had any relation to specific attributes of the items (i.e. to the way they are used). This research, particularly investigated how the participants ranked the usefulness of the information that help

them move safely, the information about services, or the information that they use for wayfinding and their orientation during movement. Moreover, this study aimed to examine whether the usefulness is related to individual characteristics of persons with blindness (country of origin, gender, age, age at onset of visual impairments, and ability of independent movement).

At first, two initial lists of spatial information were developed; one for the city centres including 103 items, and one for the neighborhoods/ residential areas including 100 items. The information included in these lists was considered to be important based on previous studies (Koutsoklenis & Papadopoulos, 2011a; 2011b & 2014) and on the experience of the researchers. The lists were created in English, and translated in three different languages (Greek, German and Turkish). Finally, these lists were further enriched with information suggested by focus groups that were conducted in the respective countries (i.e. Greece and Cyprus, Germany, Turkey). The sample of the focus groups consisted of individuals with blindness (potential users of the orientation and mobility aids) as follows: 7 from Greece, 6 from Cyprus, 4 from Germany and 5 from Turkey. The sample of the focus groups consisted of 11 male and 11 female individuals. The age ranged from 23 years to 50 years ($M = 34.6$). Twenty participants had total blindness or severe visual impairments and 2 had legal blindness (visual acuity less than 1/20). The visual impairment was “congenital” for 14 participants and “acquired” for 8 participants.

Having completed the procedure with the focus groups, the final lists emerged and two consequent questionnaires were formed. The questionnaire concerning city centres consisted of 222 items (119 additional) and the one referring to neighborhoods/ residential areas consisted of 226 items (126 additional).

Participants

The participants, 115 adults with blindness, originated from four countries: 40 from Greece, 8 from Cyprus, 50 from Turkey, and 17 from Germany. The convenience sample came from various associations of their country of residence. The sample consisted of 65 (56.5%) males and 60 (43.5%) females. Their age ranged from 18 years to 64 years ($M = 34.82$, $SD = 11.11$). Of the participants, 79 had total blindness, 30 had profound visual impairments (their visual acuity was less than 1/40) and 6 had legal blindness (their visual acuity was less than 1/20). The visual impairment was congenital for 62 participants and acquired for 53 participants. In terms of their level of education, 71 participants were university graduates, 21 were university students, 15 had graduated from high school, and 8 had graduated from primary school.

The majority of the participants (63%) declared that they move with and without the assistance of a sighted guide, 35% of them move without any assistance of a sighted guide, while the rest declared that they always move with assistance. The participants were also asked to indicate the frequency of their independent movement (without sighted guide) using a 5-point likert scale: always, often, sometimes, rarely, or never. Sixty-one out of the 115 participants stated that they often move independently, 30 participants stated that they always move independently, while the majority of the rest ($n = 19$) stated that they sometimes move independently.

Instruments and Procedures

The questionnaires were developed as an accessible text document (.docx file) to allow the participants to use a screen reading software of their preference. The text document was structured using plain text, 1st level Headings, numbered lists and bulleted lists.

During the testing procedure, the participants were asked to evaluate each item included in the two questionnaires based on its usefulness using a five-point likert scale (1 = not significant at all, 2 = somewhat significant, 3 = neutral, 4 = significant, 5 = very significant).

Results

The means for the information were calculated. In the two lists derived from the participants' answers, the items were sorted in a descending order, starting with those considered the most useful. Table 1 presents the mean score, the standard deviation (SD) and the range of the values for the top 50 items reported by the participants for each different environment (i.e. city centres and neighborhoods/ residential areas), in a hierarchical order, from the most useful (order = 1) to the least useful. The value in the brackets next to the mean score shows the order that each item holds in the respective environment. As shown in the table, there are also values in brackets greater than 50. This was necessary in order to show the order of an item in relation to both environments respectively.

<Table 1>

Table 2 presents the means of the usefulness per each category of information and each country of origin. For the purpose of the analysis, the items of each questionnaire were classified in three categories: a) safety (for instance, emergency exit, stairs, tree, obstacle), b) location of services (for instance, gym, police station, park), and c) wayfinding/ orientation during movement (for instance, pedestrian street, sound source, tactile paving for individuals with blindness, olfactory landmark). The classification of each item in one or more of the three categories was based on the criterion of how an individual with blindness could use the information during their movement. The researchers who completed the classification were all

experienced (both in research and teaching) in the field of orientation and mobility of individuals with blindness. There were cases of information that were included in more than one category.

With regard to the city centres, it seems that the participants considered the information concerning “location of services” and “wayfinding/ orientation during movement” more useful than the information concerning “safety”. The same applies to the neighborhoods/ residential areas however; the difference in means is smaller (see Table 2, Figures 1 and 2).

<Table 2>

<Figure 1>

<Figure 2>

However, it was observed that the items concerning safety differ in ascribed usefulness. Some of them were scored as highly useful (such as traffic light with audio signals for individuals with blindness, stairs, pedestrian road crossing, railroad crossing, dangerous area, dangerous point) while others were not (such as poster, newspaper or magazine stands, people selling goods on the street, plants, flower pot). These usually were informational items that do not have a high frequency of occurrence or are not directly related to the safety of the traveler with blindness. Moreover, there are a lot more items concerning “safety” that scored below 3.50 compared with the other two categories of information. For example, regarding the city centres, scored below 3.50, 53 out of 96 (55.2%) items concerned “safety”, 25 out of 84 (29,8%) items concerned “wayfinding/ orientation during movement” and 29 out of 100 (29.9%) items concerned “location of services”.

Participants attributed greater usefulness to the information concerning “safety” ($t = 2.200$, $df = 114$, $p < .05$), “wayfinding/ orientation during movement” ($t = 4.847$, $df = 114$, $p < .01$)

and “location of services” ($t = 3.470$, $df = 114$, $p < .01$) in city centres than in neighborhoods/residential areas.

Paying close attention to Table 2, one could observe a divergence of the mean scores among countries. With reference to the city centre, there are differences in the mean scores among participants from different countries concerning “safety”, while with reference to neighborhoods/residential areas, the differences concern not only “safety” but also both “wayfinding/ orientation during movement” and “location of services”. From all these differences, only the difference between Greek and German participants was statistically significant. The participants from Greece attributed greater usefulness to the information concerning “safety” compared to participants from Germany both as far as city centres ($t = 2.320$, $df = 55$, $p < .05$) and neighborhoods/residential areas ($t = 2.129$, $df = 55$, $p < .05$) are concerned.

In order to examine if the usefulness attributed by the participants to the three categories of spatial information (items) could be influenced by the individual characteristics of the participants, six linear multiple regression analyses were carried out – three concerned the city centres and three the neighborhoods/residential areas. The variables “gender”, “age”, “age at onset of visual impairments”, and “ability of independent movement” were used as possible predictors of the usefulness that individuals with blindness attribute to the spatial information relative to the wayfinding/ orientation, the location of services, and safety during movement.

Concerning the city centres, the first multiple regression analysis yielded an adjusted R^2 of .026 ($F = 1.747$, $p = .145$). No significant individual predictors of the usefulness of the information referring to “wayfinding/ orientation during movement” have emerged. The second multiple regression analysis yielded an adjusted R^2 of .057 ($F = 2.713$, $p < .05$). Significant

individual predictor of the usefulness of the information referring to “location of services” was age ($b = -.248, p < .01$). Elder individuals appeared to consider the information concerning “location of services” less useful. The third multiple regression analysis yielded an adjusted R^2 of .049 ($F = 2.481, p < .05$). A significant individual predictor of the usefulness of “safety” items was age ($b = -.193, p < .05$). Elder individuals appeared to consider the information concerning “safety” less useful.

As far as neighborhoods/ residential areas are concerned, the first multiple regression analysis yielded an adjusted R^2 of .055 ($F = 2.662, p < .05$). The significant individual predictor of the usefulness of items referring to “wayfinding/ orientation during movement” was age ($b = -.238, p < .05$). The second multiple regression analysis yielded an adjusted R^2 of .119 ($F = 4.833, p < .01$). Significant individual predictor of the usefulness of the information referring to “location of services” was age ($b = -.336, p < .01$). The third multiple regression analysis yielded an adjusted R^2 of .095 ($F = 4.007, p < .01$). Significant individual predictor of the usefulness of the information referring to “safety” was age ($b = -.260, p < .01$). Moreover, the analysis has featured the variable “gender” as a close to significant individual predictor ($b = -.171, p = .060$). Older individuals appeared to consider the information in all three categories less useful. Moreover, females appeared to consider the information concerning “safety” less useful.

Discussion

The results of the descriptive statistical analysis of both the items for city centres and the items for neighborhoods/ residential areas show that the participants consider public transport information (for instance, a bus stop, metro station, and taxi stations) to be more useful. Moreover, participants consider the information necessary for safe and independent movement as

O&M in city centres and neighborhoods

useful (e.g. traffic lights and traffic lights with audio signal for individuals with blindness, pedestrian streets, pedestrian road crossings, railroad crossings, intersections, tactile paving for individuals with blindness such as textured ground surfaces with indicators that assist pedestrians with blindness, stairs, danger points and dangerous areas, squares, street names, and area names). Those findings were expected since the research was focused on orientation and mobility aids. The basic aim of those aids is the provision of information that supports safe and successful mobility and orientation within an area. Roentgen et al (2008) also noticed that the main functionality of electronic mobility aids is obstacle avoidance (safe and independent movement), while Gardiner and Perkins (2005) pointed out the importance of depicting hazards on maps. In addition, participants mentioned useful items they use for daily needs – for instance, service centres for individuals with blindness, toilets, hospitals, clinics, shopping malls or shopping centres, supermarkets, grocery shops, banks, post offices, automated teller machines, and parks.

Some mean scores are diverse for items from the two environments (see Table 1), such as the tactile paving for individuals with blindness, railroad crossings, danger points, patisseries, pedestrian streets, and entrances or exits. This result confirms the need for further investigation on the usefulness attributed to each item in different environments, which was also an aim of the present research. The research of Gardiner and Perkins (2005) and Koutsoklenis and Papadopoulos (2011a; 2011b & 2014), shows that the wayfinding cues to which individuals with visual impairments attribute importance are environment-specific. These differences between the two environments are probably due to the structure of the two different environments, and due to the fact that some of the items does not occur that frequently in either of the two environments. For example, the tactile paving for individuals with blindness, as well as railroad crossings, occur less frequently in neighborhoods/ residential areas than in city centres. Moreover, the

differences are likely due to the different needs of individuals with blindness when moving in each of the two different environments.

Some items that were placed high in the participants' preference hierarchy provide olfactory, auditory and haptic cues that could serve as landmarks; for instance, traffic lights with audio signal for individuals with blindness, bus stops (with emphasis on the noise the bus makes when it stops), parks (with emphasis on the difference in the soundscape), bakeries, restaurants or taverns or grills and tactile paving for individuals with blindness. Hence it is possible that some items were preferred because they serve an additional purpose or multiple purposes depending on the nature of the environmental features – permanent or temporary; auditory, haptic or olfactory. Moreover, the inclusion of items in a tactile map depends on the targeted use of the tactile map (i.e. spatial encoding and cognitive map development, route decisions, landmarks or points of interest localization). The decision of which items should be included on which map constitutes very complex work. The present research studied end-users' preferences, but it did not focus on how individuals with blindness use the information. It would be useful for future research to investigate how the useful items are used by individuals with visual impairments and if these serve different purposes under various circumstances.

Furthermore, heterogeneity has been observed in the information concerning safety. Some items were mentioned as very useful but many were not. Those items were usually the ones with a small frequency of occurrence in the environment. This outcome suggests that the safety category was less valuable than the other two categories, and the notion of safety needs clearer definition by travellers with low vision or blindness. Concerning safety, the findings indicate that participants from Greece attributed greater usefulness to the information concerning "safety" compared to the participants from Germany, both as far as city centres and neighborhoods/

residential areas are concerned. The divergence of the mean scores of the participants from different countries might have resulted from a variety of factors, such as the extent of O&M training, the emphasis laid on specific skills, unfortunate experiences, and collisions with obstacles and/or previous injuries during city travel. The differences that exist between different countries, lead us to consider examining in future research, the possible differences in preferences of users from the same country or from the same city, as well as the factors that cause them. The design of orientation and mobility aids that will meet users' preferences requires such studies.

Participants attributed greater usefulness to the information in all three categories in city centres than in neighborhoods/ residential areas. This possibly is a result of the city centres' complexity, which necessitates the appearance of the above-mentioned information on orientation and mobility aids more often than in the case of quiet and low traffic neighborhoods/ residential areas.

It is worth mentioning that the mean score of the least useful item in city centres was 2.658 and the mean score of the least useful item in neighborhoods/ residential areas was 2.292. These mean scores fall between “somewhat significant” and “neutral”, so even these low-scoring items had some value.

There is no previous study identifying the user requirements of individuals with blindness for information to be included on audio-tactile maps. Thus, the findings of the present study will be particularly important for designers of orientation and mobility aids for individuals with blindness. Moreover, the findings can be useful for orientation and mobility specialists, rehabilitation specialists, and teachers who design and construct O&M aids for their students with blindness. It should be mentioned that, although the present research refers to audio-tactile

maps, the participants' answers depict their preferences for information they need to know about the environment that should be included in orientation and mobility training and the development of other navigational aids. When using the terms "orientation and mobility aids" or "navigational aids", we do not refer to aids such as long canes, sighted guide and guide dogs. We refer to any aid (mainly tactile and audio-tactile maps) in which tactile or audio information is used to present spatial information that is capable to help the user with blindness to form a spatial cognitive map, and in general to learn a space in order to be able to move within it safely and successfully.

Any research on user requirements of individuals with impairments, such as the present study, is particularly useful and can effectively guide the specialists involved in making aids for these users. A constant requirement of individuals with visual impairments is to develop aids that respond to their needs, and not devices that are simply presented as innovative and useful by researchers and developers, but are actually far from what they promise. However, apart from this general benefit, this study enables designers of orientation and mobility aids for individuals with blindness to choose what information they will present on the aids they develop each time, in relation to the aim of the aid and the number of items that can present (due to restrictions in the dimensions and the scale of the map). For example, if the aim is to create a tactile map as a mobility aid in a particular area and print it on a single A3 size sheet, so that the user can easily have it with him/her when he/she moves around that area alone, then the map scale is proportional to the size of the area that is required to fit into the A3 size paper. The map scale, almost always, does not allow the presentation of all the information existing in the environment on the aid. However, this information would probably be useful (more or less) to a user with

blindness, and in that case, a selection of the information to be included in the aid should be made in order to achieve maximum level of usefulness for the user.

Limitations

A possible limitation of this study arises from generating mean values from a Likert scale. Such scales assume that the space between 1-2 is the same as the space between 2-3, etc. This however is not absolutely correct as there could be some differences related to the attribution of values. The list of useful items for inclusion in accessible maps is not necessarily exhaustive, but provides technology developers with a good indication of the priorities of travellers with visual impairments, and can be added to subsequent studies.

Acknowledgements

The work presented in this paper was conducted in the frames of the AT-MAPS project. The project (543316-LLP-1-2013-1-GR-KA3-KA3MP) has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

- Abd Hamid, N. N. & Edwards, A. (2013). Facilitating Route Learning Using Interactive Audio-Tactile Maps for Blind and Visually Impaired People. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '13) (pp 37-42). New York: ACM. DOI: <http://dx.doi.org/10.1145/2468356.2468364>
- Brock, A., Truillet, P., Oriola, B., & Jouffrais, C. (2010, November). Usage of multimodal maps for blind people: why and how. In *ACM International Conference on Interactive Tabletops and Surfaces* (pp. 247-248). ACM.

- Espinosa, A., Ungar, S., Ochaíta, E., Blades, M., Spender, C. (1998). Comparing Methods for Introducing Blind and Visually Impaired People to Unfamiliar Urban Environments. *Journal of Environmental Psychology*, 18, 277-287.
- Gardiner, A. & Perkins, C. (2005). 'It's a sort of echo...': Sensory perception of the environment as an aid to tactile map design. *British Journal of Visual Impairment*, 23, 84-91.
- Gardner, J., Bulatov, V., & Kelly, R. (2009). Making journals accessible to the visually impaired: the future is near. *Learned Publishing*, 22, 314-319.
- Habel, C., Kerzel, M., & Lohmann, K. (2010). Verbal assistance in tactile-map explorations: A case for visual representations and reasoning. In *Workshops at the Twenty-Fourth AAAI Conference on Artificial Intelligence* (pp. 34-41), Atlanta, GA, USA, July 11–15.
- Jackobson, R. (1996). Talking tactile maps and environmental audio beacons: An orientation and mobility development tool for visually impaired people. In *Proceedings of maps and diagrams for blind and visually impaired people: Needs, solutions and developments*, October 21-25 1996, Ljubljana, Slovenia.
- Koustriava, E., Papadopoulos, K., Koukourikos, P., & Barouti, M. (2016). The Impact of Orientation and Mobility Aids on Wayfinding of Individuals with Blindness: Verbal Description vs. Audio-Tactile Map. In *Proceedings from UAHCI 2016: 10th International Conference on Universal Access in Human-Computer Interaction*. (pp. 577–585). Toronto, CA, 2016.
- Koutsoklenis, A. & Papadopoulos, K. (2014). Haptic Cues Used for Outdoor Wayfinding by Individuals with Visual Impairments. *Journal of Visual Impairment & Blindness*, 108, 43-53.

- Koutsoklenis, A. & Papadopoulos, K. (2011a). Olfactory cues used for wayfinding in urban environments by individuals with visual impairments. *Journal of Visual Impairment & Blindness*, 105, 692-702.
- Koutsoklenis, A. & Papadopoulos, K. (2011b). Auditory cues used for wayfinding in urban environments by individuals with visual impairments. *Journal of Visual Impairment & Blindness*, 105, 703-714.
- Lawrence, M. M. & Lobben, A. K. (2011). The design of tactile thematic symbols. *Journal of Visual Impairment & Blindness*, 105, 681-691.
- Leonard, J. A. & Newman, R. C. (1970). Three Types of 'Maps' for Blind Travel. *Journal of Ergonomics*, 13, 165-179.
- Papadopoulos, K. S. (2004). A school programme contributes to the environmental knowledge of blind people. *British Journal of Visual Impairment*, 22, 101-104.
[doi:10.1177/0264619604050046](https://doi.org/10.1177/0264619604050046)
- Papadopoulos, K., Barouti, M., & Charitakis, K. (2014). A university indoors audio-tactile mobility aid for individuals with blindness. In K. Miesenberger, D. Fels, D. Archambault, P. Penaz, W. Zagler (Eds.), *Lecture Notes in Computer Science*, 8548 (pp 108-115). Switzerland: Springer International Publishing.
- Papadopoulos, K., Barouti, M., & Koustriava, E. (2016a). The Improvement of Cognitive Maps of Individuals with Blindness Through the Use of an Audio-Tactile Map. In *Proceedings from UAHCI 2016: 10th International Conference on Universal Access in Human-Computer Interaction*. (pp. 577–585). Toronto, CA, 2016.
- Papadopoulos, K., Charitakis, K., Kartasidou, L., Kouroupetroglou, G., Gumus, S., Stylianidis, E., ... Lithoxopoulos, N. (2016b). User requirements regarding information included in

- audio-tactile maps for individuals with blindness. *Lecture Notes in Computer Science*, 9759, 168–175.
- Papadopoulos, K., Koustriava, E., & Barouti, M. (2017). Cognitive maps of individuals with blindness for familiar and unfamiliar spaces: construction through audio-tactile maps and walked experience. *Computers in Human Behavior*, 75, 376-384.
- Papadopoulos, K., Barouti, M., & Koustriava, E. (2018). Differences in Spatial Knowledge of Individuals With Blindness When Using Audiotactile Maps, Using Tactile Maps, and Walking. *Exceptional Children*, 84(3), 330 –343
- Parkes, D. (1988). 'NOMAD – An audio tactile tool for the acquisition, use and management of spatial distributed information by partially sighted and blind people'. In *Proceedings of the Second International Conference on Maps and Graphics for Visually Disabled People*. Nottingham, UK, (pp 24-29).
- Passini, R., Duprés, A., & Langlois, C. (1986). Spatial mobility of the visually handicapped active person: A descriptive study. *Journal of Visual Impairment & Blindness*, 80, 904-907.
- Passini, R. & Proulx, G. (1988). Wayfinding without vision: An experiment with congenitally totally blind people. *Journal of Environment & Behavior*, 20, 227-252.
- Roentgen, U. R., Gelderblom, G. J., Soede, M., & De Witte, L. P. (2008). Inventory of electronic mobility aids for persons with visual impairments: A literature review. *Journal of Visual Impairment & Blindness*, 102, 702-724.
- Rowell, J. & Ungar, S. (2003). The world of touch: an international survey of tactile maps. Part 1: production. *British Journal of Visual Impairment*, 21, 98-104.

- Sauerburger, D. (1996). O&M living history - where did our O&M techniques come from? In *Newsletters of the Metropolitan Washington Orientation and Mobility Association*. May 1996. <http://www.sauerburger.org/dona/omhistory.htm>
- Schinazi, V. R., Thrash, T., & Chebat, D. R. (2016). Spatial navigation by congenitally blind individuals. *Wiley Interdisciplinary Reviews: Cognitive Science*, 7, 37-58.
- Siekierska, E., Labelle, R., Brunet, L., McCurdy, B. & Pulsifer, P. (2003). Enhancing spacial learning and mobility training of visually impaired people – a technical paper on the Internet-based tactile and audio-tactile mapping. *The Canadian Geographer*, 47, 480-493.
- Ungar, S., Blades, M., & Spencer C. (1993). The role of tactile maps in mobility training. *British Journal of Visual Impairment*, 11, 59-61.
- Wang, Z., Li, B., Hedgpeth, T., & Haven, T. (2009). Instant tactile-audio map: Enabling access to digital maps for people with visual impairment. In *ASSETS 2009 - Proceedings of the 11th international ACM SIGACCESS Conference on Computers and Accessibility*. (pp 43-50). ACM.
- Zeng, L., Miao, M., & Weber, G. (2014). Interactive audio-haptic map explorer on a tactile display. *Interacting with Computers*, 27, 413-429.

O&M in city centres and neighborhoods

Table 1

The most useful information in each environment. Mean, order, range and standard deviation

Items	City Centres			Neighborhoods		
	Mean	Range	SD	Mean	Range	SD
Point of access to public transport	4.68 (1)	1-5	.71	4.72 (2)	3-5	.50
Bus stop	4.66 (2)	2-5	.65	4.82 (1)	3-5	.41
Metro station	4.61 (3)	1-5	.80	4.58 (4)	1-5	.78
Traffic light with audio signals for the blind	4.58 (4)	1-5	.85	4.65 (3)	1-5	.78
Traffic lights	4.53 (5)	1-5	.85	4.51 (7)	1-5	.91
Pedestrian road crossing	4.53 (6)	1-5	.85	4.40 (15)	1-5	.84
Street name	4.50 (7)	1-5	.95	4.41 (12)	1-5	.97
Service centre for individuals with blindness	4.49 (8)	1-5	.88	-	-	-
Hospital	4.49 (9)	1-5	.87	-	-	-
Public transport station	4.46 (10)	1-5	.82	4.36 (19)	2-5	.80
Intersection	4.44 (11)	1-5	.94	4.50 (8)	1-5	.81
Bus stop shelter or tram stop shelter	4.43 (12)	1-5	.92	4.47 (10)	1-5	.90
Clinic or infirmary or doctor	4.39 (13)	1-5	.76	4.36 (18)	2-5	.83
Roundabout	4.38 (14)	1-5	.93	4.30 (23)	1-5	1.00
Taxi station	4.38 (15)	1-5	.83	4.52 (5)	1-5	.83
Shopping centre	4.37 (16)	1-5	.81	4.22 (30)	1-5	.96
Square	4.36 (17)	1-5	.95	4.40 (16)	1-5	.89

O&M in city centres and neighborhoods

Bank	4.36 (18)	1-5	.93	4.30 (22)	1-5	.85
Tactile paving for individuals with blindness	4.36 (19)	1-5	1.04	4.00 (63)	1-5	1.34
Toilet	4.35 (20)	1-5	1.12	4.41 (13)	1-5	1.02
Railroad crossing	4.34 (21)	1-5	.94	3.93 (69)	1-5	1.25
Supermarket	4.33 (22)	1-5	.83	4.43 (11)	1-5	.84
Stairs	4.31 (23)	1-5	1.10	4.30 (24)	1-5	1.07
Public service building	4.31 (24)	1-5	.80	4.29 (25)	2-5	.77
Town hall	4.30 (25)	1-5	.88	-	-	-
Sidewalk with tactile paving	4.30 (26)	1-5	1.09	4.12 (46)	1-5	1.17
Danger point	4.30 (27)	1-5	.98	4.00 (62)	1-5	1.25
Audio guide	4.28 (28)	1-5	1.09	4.06 (55)	1-5	1.17
Hotel	4.28 (29)	1-5	.88	-	-	-
Automated teller machine	4.28 (30)	1-5	1.02	-	-	-
Area names	4.28 (31)	1-5	1.04	4.19 (32)	1-5	1.03
Park	4.26 (32)	1-5	.93	4.22 (28)	1-5	.96
Dangerous area	4.26 (33)	1-5	.98	4.48 (9)	1-5	.87
Market place	4.25 (34)	1-5	.98	4.25 (26)	2-5	.79
School	4.25 (35)	1-5	.99	4.11 (48)	1-5	.94
Grocery shop	4.25 (36)	1-5	.97	4.18 (34)	1-5	.98
Two way Driveway	4.24 (37)	1-5	1.01	3.89 (72)	1-5	1.24
Entrance to underground pedestrian passageway or subway station	4.23 (38)	1-5	1.03	4.51 (6)	1-5	.95

O&M in city centres and neighborhoods

Sea	4.21 (39)	1-5	1.10	4.32 (20)	1-5	.99
Danger line	4.21 (40)	1-5	1.14	4.00 (61)	1-5	1.22
Railway station	4.19 (41)	1-5	1.16	4.25 (27)	1-5	1.04
Restaurant or tavern or grill	4.18 (42)	1-5	.88	4.12 (47)	1-5	1.03
Police station	4.18 (43)	1-5	.94	3.98 (66)	1-5	1.14
Footbridge	4.18 (44)	1-5	.93	4.22 (29)	1-5	.84
Patisserie	4.17 (45)	1-5	.94	3.77 (80)	1-5	1.11
Landmarks	4.16 (46)	1-5	1.09	-	-	-
Pedestrian street	4.16 (47)	1-5	1.15	4.40 (14)	1-5	.88
Road	4.16 (48)	1-5	1.25	3.65 (98)	1-5	1.36
Signpost with audio notice	4.15 (49)	1-5	1.11	3.41 (130)	1-5	1.57
Prohibited area	4.15 (50)	1-5	1.18	4.13 (44)	1-5	1.16
Pharmacy	-	-	-	4.37 (17)	1-5	.85
Entrance or exit	4.02 (77)			4.31 (21)	1-5	1.03
Information desk	4.14 (54)			4.22 (31)	1-5	1.04
Underpass	4.08 (65)			4.18 (33)	1-5	1.05
Lake	3,75 (109)			4.17 (35)	1-5	1.15
Haptic information	4.10 (62)			4.17 (36)	1-5	1.17
Underground entrance	4.03 (73)			4.16 (37)	1-5	1.08
Emergency exit	4.10 (60)			4.16 (38)	1-5	1.16
Elevator	4.12 (58)			4.15 (39)	1-5	1.13
Information booth	4.05 (70)			4.14 (40)	1-5	1.18
Stairs leading to the subway	4.11 (59)			4.14 (41)	1-5	1.03

O&M in city centres and neighborhoods

Quay	4.14 (53)	4.14 (42)	1-5	1.07
Direction of the driveway	4.09 (64)	4.13 (43)	1-5	1.07
Street market	4.15 (52)	4.13 (45)	1-5	.92
Coffee shop	4.03 (74)	4.11 (49)	1-5	1.04
Buildings	3.83 (99)	4.11 (50)	1-5	1.14

O&M in city centres and neighborhoods

Table 2

Means of the usefulness per each category of information and each country of origin

	City Centres			Neighborhoods/ residential areas		
	Wayfinding-orientation	Location of services	Safety	Wayfinding-orientation	Location of services	Safety
Greece	3.84	3.83	3.74	3.74	3.82	3.71
Germany	3.84	3.78	3.19	3.74	3.68	3.24
Cyprus	3.81	3.78	3.39	3.64	3.71	3.44
Turkey	3.81	3.79	3.52	3.54	3.54	3.31
Total	3.83	3.80	3.54	3.65	3.67	3.50

Figure 1

City centres: interaction between the category of information and the country of origin

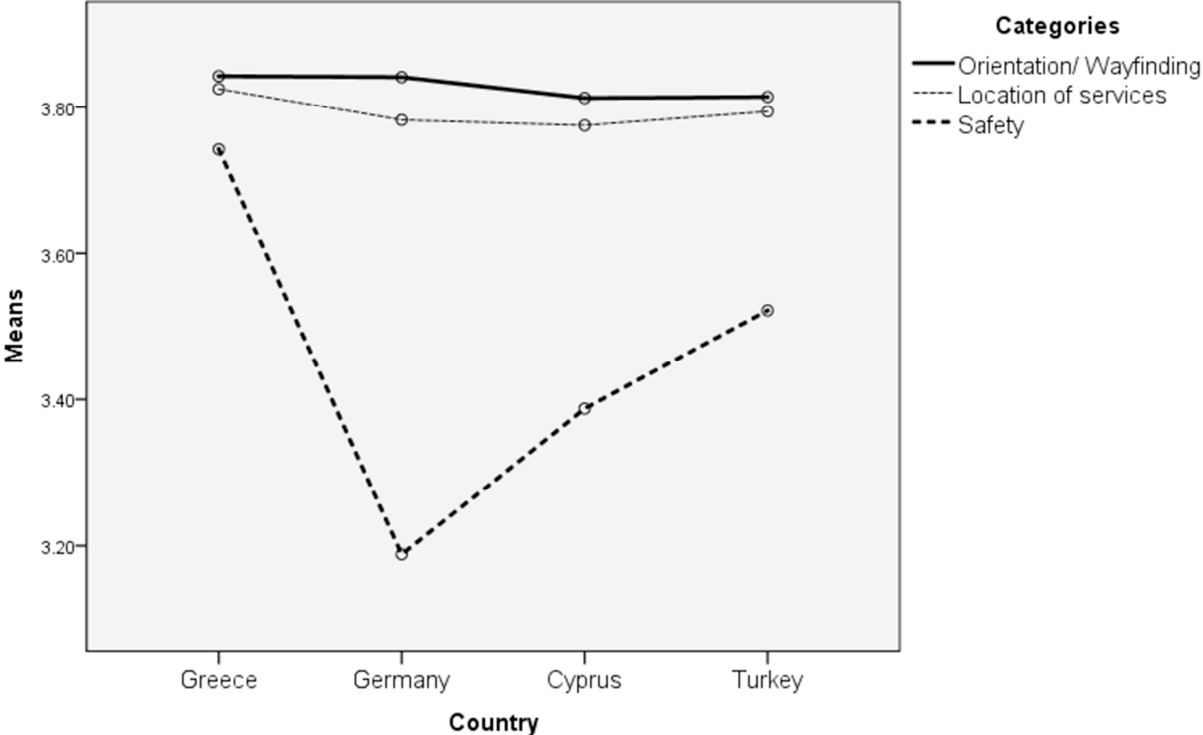


Figure 2

Neighborhoods/ residential areas: interaction between the category of information and the country of origin

