Orientation & mobility aids for individuals with blindness: verbal vs. audio-tactile map

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Abstract

Individuals with visual impairment 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 among the top priorities of research in the field. The aim of the present research was to examine the level of accuracy of the cognitive map developed through the use of a verbal description versus the cognitive map developed using an audio-tactile map. A comparison of the effectiveness of the two mobility aids in detecting specific points of interest in the physical environment was an objective of the research. The procedure involved the study of a map using the two mobility aids, and an assessment through the transfer to the corresponding physical environment. The results suggest that an individual with visual impairment can acquire and use a functional cognitive map through the use of an audio-tactile map, while relying on a verbal description entails greater difficulty in detecting specific points of interest when he/she comes into the physical environment.

Introduction

It has been suggested that one of the most severe consequences yielded by vision loss is the inability to travel independently (Golledge, 1993). While individuals with visual impairments face challenges in mobility while traveling, they seem to choose known routes to avoid disorientation, which in turn leads to frustration, stress, and fear (Golledge, 1993; Hill, Rieser, Hill, Halpin, & Halpin, 1993). For these reasons, the possibility of previewing the place to visit or the route to travel should be supportive and generate confidence. Orientation and mobility aids that help an individual with visual impairments before he/she comes into contact with the physical environment are passive aids, such as maps, verbal descriptions, and models (Lahav & Mioduser, 2008).

Verbal descriptions refer to descriptions of the layout of an area or instructions on how someone could travel within an area, and may contain information relative to landmarks, routes, and techniques for specific situations, etc. (Bentzen, 1997). The main advantages of verbal descriptions appear to be the abundance of information that they may contain, especially compared to tactile maps, as well as the lack of prerequisites for access to printed material, for instance Braille reading ability (Bentzen, 1997).

On the other hand, the value of verbal descriptions in developing spatial knowledge seems to be disputable because they may embed complex or unknown concepts, they may contain imprecisions (Bentzen, 1997), or even entail memory load, and as such, verbal descriptions are subject to time restrictions. These weaknesses of verbal descriptions may be especially evident when they are used by a subject without any simultaneous contact with the spatial environment. However, a series of research studies has shown that verbal descriptions support spatial learning and wayfinding either in real time environmental contact (i.e. when the subject is in the actual environment) (Giudice, Bakdash, & Legge, 2007) or when an environment is explored through computer-based simulated layouts with the use of virtual verbal interfaces, prior to the subject's transfer in the actual environment (Connors, Chrastil, Sánchez, & Merabet, 2014a; Connors, Chrastil, Sánchez, & Merabet, 2014b; Giudice & Tietz, 2008). These researches suggest that an interaction with an environment underpinned by real-time verbal descriptions could result in cognitive map development.

Other orientation and mobility aids, such as tactile maps, may be considered more efficient communication tools with spatial environment (Papadopoulos & Karanikolas, 2009) since they could provide information about distant places, and simplify wayfinding (Passini, Duprés, & Langlois, 1986). The superiority of tactile maps, which have been found to be more supportive to cognitive mapping than direct experience with the environment, has been highlighted (Cattaneo & Vecchi, 2011). Espinosa and Ochaita (1998) found that individuals with blindness presented better spatial knowledge after they had consulted a tactile map than after they had relied on a verbal description. Similarly, Caddeo, Fornara, Nenci, and Piroddi (2006) observed that individuals with visual impairments learned a new route more efficiently when they had read a tactile map than in the condition of direct experience with verbal descriptions. Participants' walking time was better and their deviations from the route were less in the condition of using a tactile map. Thus, it seems that tactile maps could substitute visual maps (Ungar, Blades, & Spencer, 1993) and prepare individuals with visual impairments for safe and efficient traveling, increasing their independence and autonomy (Espinosa, Ungar, Ochaita, Blades, & Spencer, 1998).

Despite the advantages of tactile maps, a series of limitations have been pointed out. These limitations include the need for extended Braille labeling in the map's legend, the amount of information processing for cartographers – i.e. the simplification, generalization, classification, and symbolization of the spatial information on the map – the low resolution afforded by the fingertip (Jacobson, 1998), the design requirements that need to be carefully met (Papadopoulos, 2005; Rener, 1993), as well as difficulties in reading and comprehending the map (Harder & Michel, 2002).

Many of these limitations have been counterbalanced by the introduction of auditory information with the tactile map resulting in interactive multimodal maps (Brock, Truillet, Oriola, Picard, & Jouffrais, 2012). For instance, Braille labels can be replaced by respective audio information. Audio information may also include explanations of spatial relations (Habel, Kerzel, & Lohman, 2010), locations of significant landmarks or points of interest, comprehensive data for complex spatial entities (Habel et al., 2010; Wang, Li, Hedgpeth, & Haven, 2009), and even soundscape, which can possibly promote inference on spatial configurations and development of cognitive maps (Papadopoulos, Papadimitriou, & Koutsoklenis, 2012). Moreover, it has been suggested that providing tactile and auditory information in combination could result in a more complete concept, since tactile stimuli could allow the comprehension of the map components' interrelation, and the auditory stimuli could enable the immersion in explanatory data (Landau, Russell, & Erin, 2006). Furthermore, supporting both touch and hearing appears to align with neurobiological indications. It seems that spatial information, acquired through other than vision sensory modalities, is processed by the visual cortices differently (Cattaneo, Vecchi, Cornoldi, Mammarella, Bonino, Ricciardi,

& Pietrini, 2008; Thinus-Blanc & Gaunet, 1997), and encoded with the function of compensatory mechanisms (for a review see Dulin, Hatwell, Pylyshyn, & Chokron, 2008).

These audio-tactile maps become available with the use of technological devices, such as the touch tablets (Holmes & Jansson, 1997), touchpads, or refreshable touch displays (O'Modhrain, Giudice, Gardner, & Legge, 2015). O'Modhrain and her colleagues have provided an overview of the main refreshable touch displays focusing on the need to consider: a) the fact that specific tangible graphics require a specific type of technology depending on the information to be conveyed and the aim of the task in each case, and b) the strengths and weaknesses of each touch display including the exploratory procedures it supports. They conclude that multimodal interfaces seem to entail the most promising results.

The benefits of combining audio and tactile information with the use of a relevant device have been reviewed in the MICOLE project (2006). The ancestor of such audio-tactile devices was NOMAD, a pioneer tool presented by Parkes (Parkes, 1988). Thereafter, this type of audio-tactile device has evolved and been the subject of further research. Landau and his colleagues (2006) found that using a Talking Tactile Tablet (TTT or T3) device enabled access of students with visual impairments to graphics allowing them to be independent and work at their own pace. Similarly, Brock and her colleagues (2012) examined the usage of an audio-tactile map placed on a touchpad device and ascertained participants' appreciation of being able to use multimodal interactive maps.

However, in order to study the usage of all these orientation and mobility aids it would be useful to examine the way they deliver spatial information, and if this way is in line with the strategies that individuals with impairments use both physically and cognitively to code space. Lahav and Mioduser (2008) review a series of studies to present how individuals with visual impairments process spatial information at the perceptual and conceptual level. At the perceptual level, touch and hearing constitute the main sensorial channels with the former to receive spatial information through progressive exploration of hands, fingers, feet, or cane, and the latter to perceive environmental sounds that can be translated into spatial information such as distances, configurations, etc. at the conceptual level (Lahav & Mioduser, 2008). Thus, at the conceptual level, the focus is on strategies used to encode and cognitively map space (Lahav & Mioduser, 2008).

Two fundamental strategies are utilized to explore and encode space: route strategy and map strategy. Route strategy involves the granular linear and sequential exploration, while map strategy refers to multi-perspective management of spatial components (Fletcher, 1980). Developing a multi-perspective spatial knowledge may require advanced cognitive spatial skills, such as mental rotation and spatial translation processes (Gunzelmann & Anderson, 2004). Poor spatial skills may lead an individual to rely on non-spatial strategies such as object imagery or verbalizing (Blazhenkova & Kozhevnikov, 2009; Kozhevnikov, Kosslyn, & Shephard, 2005).

Route and map strategies lead in turn to route knowledge and configurational or survey knowledge of space, respectively (Kitchin & Jacobson, 1997). Route knowledge concerns the mental representation of the route that someone can follow to travel from point A to point B, and includes the constant engagement of one’s own body as his/her point of reference (Tinti, Adenzato, Tamietto, & Cornoldi, 2006). This type of spatial knowledge could lead to the respective representation (route-like representation) when asked (Postma, Zuidhoek, Noordzij, & Kappers, 2007), which is an egocentric representation. On the other hand, configurational knowledge is connected to mental representations according to environmental components' interrelation (orientation, distances, etc.) and an allocentric encoding system (Tinti et al., 2006), which could entail a respective, allocentric, survey representation (Loomis, Klatzky, Golledge, Cicinelli, Pellegrino, & Fry, 1993).

Egocentric and allocentric are strategies that can be used to encode and represent space. Different orientation and mobility aids may entail different encoding strategies and, by extension, differences in knowledge, and performance in spatial tasks. Verbal descriptions are normally body-referenced which means that complicated cognitive processes such as rotations and transformations may be required. Since verbal descriptions are body-referenced (egocentric), they predispose individuals to route knowledge (Thorndyke & Hayes-Roth, 1982). Similarly to verbal descriptions, a tactile map can be read sequentially leading to an egocentric representation with the egocenter here to be the user's fingers, and the egocentric cues to be the proprioceptive information (Habel et al., 2010).

However, both verbal descriptions and tactile maps might direct an individual to survey knowledge. If verbal descriptions are formed in a way to provide survey cues then the subject could present survey knowledge (Taylor & Tversky, 1992). The way language is used in a verbal description can draw on either intrinsic or extrinsic frames of reference (Taylor & Tversky, 1996). On the other hand, tactile maps enable the use of tactile cues, for instance the contour, which constitutes a stable frame of reference (Rice, Jacobson, Golledge, & Jones, 2005) and allows for object-to-object interrelation inference. Accordingly, Thorndyke and Hayes-Roth (1982) suggested that map exploration leads to the acquisition of survey knowledge.

Ungar, Blades, and Spencer (1997) showed that individuals with visual impairments can use a variety of strategies to read a tactile map, which affects their performance. In accordance with this, research results have indicated that individuals with visual impairments may exploit external spatial cues when these are available and performed better in small-scale space encoding (Papadopoulos & Koustriava, 2011; Papadopoulos, Koustriava, & Kartasidou, 2011).

The main question arising at this point is whether verbal descriptions, which are mainly egocentric representations, better enable individuals with visual impairments who present the tendency to use self-referent strategies in spatial tasks (Cornoldi, Fastame, & Vecchi, 2003; Millar, 1988), or whether tactile maps could evoke a better performance, because of the allocentric mental representation and possible support through the depiction of their components' interrelation, and according to Catteneo and Vecchi (2011) they are stored better in long-term memory. On the other hand, when an individual with visual impairments – who gets knowledge of an area through the reading of a tactile map and has the ability to use frames of reference – visits the physical environment, he/she is asked to translate his/her frame-referenced cognitive map in an environment with no respective frames of reference. So, if allocentric representation is in a way prohibited it could be hypothesized that acquiring an egocentric, route-like representation up front would be more efficient in orientation tasks.

Most studies have examined the development of cognitive maps using indoor assessment tools such as the creation of a tactile model, answering corresponding questions (distance estimates, objects' orientation, etc.), drawing a map, etc. (for a review see Kitchin & Jacobson, 1997 and Ungar, Blades & Spencer, 1996). For instance, Jacobson (1998) developed an audio-tactile map that could be used with a touchpad device and examined participants' cognitive map through verbal descriptions and tactile drawing. However, both of these methods have been criticized for their questionable results (Blades, 1990; Fletcher, 1980).

Kitchin and Jacobson (1997) mentioned that the conclusions derived from such assessment methods are of weak validity since they highlight the content and the accuracy of the cognitive map but not the utility, i.e. walking in a large geographical space. A distinction between "practical" space knowledge – i.e. knowing how to manage and act in real conditions – and "conceptual" space knowledge – i.e. being able to represent space (Piaget & Inhelder, 1956). Which knowledge antedates the other probably depends on the cognitive map and mostly on the task's requirements. After all cognitive maps seem to be dynamic and task-specific (for a review see Kitchin, 1994).

However, the supreme goal should be individuals' independent and autonomous movement having sufficient orientation and mobility skills. Hence, the assessment of the cognitive map developed through a passive aid should be completed in the actual environment. Besides, transferring the knowledge of an audio-/tactile map or a verbal description in a large geographic environment may require additional and complex cognitive processes – such as translating distances, understanding scale differences, changing perspective – that elude when both the coding face and the assessment face are based on a tool of the same scale.

Only a few research studies have focused on the utility of a cognitive map acquired through an indoor process on the physical environment. Herman, Herman, and Chatman (1983) examined the ability of individuals with visual impairments to walk among four locations after having examined a table-top model. The results showed that the model appeared to be useful for navigation in the actual environment. In another research (Brambring & Weber, 1981), 27 individuals with blindness were asked to encode an area through direct experience, verbal description, and a tactile map. After the assessment in the area, it was found that the tactile-map condition led to a more rapid learning and a better wayfinding performance that in the two other conditions. Holmes, Jansson and Jansson (1996) examined the ability of four individuals with visual impairments to form a cognitive map of a route after the subjects had studied the route using a tactile overlay on a touch tablet with verbal information delivered through synthetic speech. The subjects were able to present considerable spatial knowledge that presented the respective tool to be a significant aid for individuals with visual impairments in planning traveling.

The present study is part of an extended research which aims at examining whether spatial knowledge structured after an individual with blindness has 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 an area. From this research a series of published works has emerged

(Koustriava, Papadopoulos, Koukourikos, & Barouti, 2016; Papadopoulos, Koukourikos, Koustriava, Misiou, Varveris, & Valari, 2015; Papadopoulos et al., 2016).

In the study of Papadopoulos and his colleagues (2016), it was examined whether spatial knowledge structured after an individual with blindness had studied a map of an urban area, delivered through 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 detecting specific points of interest in the real environment. The results revealed the superiority of the audio-tactile map as well as the audio-haptic map over the verbal description. However, a basic restriction of this study (Papadopoulos et al., 2016) was the small sample, which is highlighted as a limitation by the authors of the article. The present study developed as a progressive step from the study of Papadopoulos et al. (2016). In essence, the tests have been replicated in a sample twice the size of the previous one, excluding, however, the test concerning the audio-haptic maps. Thus, the main data concerning the participants, the instruments, the procedures, the variables used in the statistical analysis, as well as the methods of analysis should be the same.

Moreover, in the work of Koustriava and her colleagues (2016) part of the results of the present study have been presented. As a result, these two works are similar as far as the participants, the instruments, and the procedures are concerned. The aim of the study of Koustriava et al. (2016), was to examine if a verbal description or an audio-tactile map would support the development of an effective (or perfect) cognitive route of an urban area that could be used consequently for detecting specific points of interest in the actual area. The "perfect" route was defined as the one that, if followed, the participant would have met all 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 (Koustriava et al., 2016). The findings indicated that the participants followed the perfect route fewer times after they had listened to the verbal description than after they had read the audio-tactile map. Moreover, the number of participants who 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 (Koustriava et al., 2016).

Study

The aim of the present research was to examine whether spatial knowledge structured after an individual with blindness had listened to the verbal description of an urban area or had read an audio-tactile map, could be used for detecting specific points of interest in the area. Moreover, the present study compared the effectiveness of the two mobility aids in orientation and points of interest' detection tasks. The assessment process took place in the actual physical environment.

Participants

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). A basic criterion to include a participant in the study was not to have a hearing impairment or other disabilities, apart from visual impairment. The visual impairment was congenital for 9 participants and acquired for the remaining 11 participants – in 4 out of these 11 participants vision loss occurred in the first year of life. With respect to their level of education, 11 participants were university graduates, 7 were university students, and 2 were high school graduates. Moreover, the participants were asked to indicate the main reading media they used (i.e., Braille, Text-to-Speech systems). Seventeen out of 20 participants used Text-to-Speech (TtS) systems (i.e. systems that convert language texts into speech through computer hardware or software) as the basic reading medium, and 3 participants used Braille.

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 duration of training for 12 out of those 15 participants was from 10 to 100 hours in total, while just 3 of the participants have been trained in O&M for more than 100 hours. Moreover, 7 participants declared that they have "never" read tactile graphics or maps, 10 participants that they have "rarely" read tactile graphics, 2 participants that they have read tactile graphics "a few times" and 1 participant that he/she has "many times" read tactile graphics. None of the participants had ever used an audio-tactile map.

The participants were asked to state their daily method of moving in outdoor places, by choosing one of the following: a) with the assistance of a sighted guide, b) sometimes by myself and sometimes with the assistance of a sighted guide, and c) by myself, without any assistance. None of the participants is a guide dog user. 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 by themselves. Moreover, 10 participants stated that they "always" move independently, 8 stated "usually," 1 participant stated "sometimes," and 1 participant stated "seldom."

Instruments – materials

Two O&M aids were developed for the aims of the experiment: a verbal description, and an audio-tactile map readable with the use of a touchpad device. Each one included three maps (or the verbal description of a map) referring to three different areas of Thessaloniki city (areas around the city center with apartment buildings and stores). All areas had approximately the same dimensions 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 the same on each map. Two points of interest referred to audio information (e.g. coffee house, supermarket), 2 to haptic (e.g. pillar, tree, kiosk) and 2 points of interest referred to olfactory information (e.g. bakery, perfume shop), resulting in six points of interest for each map. The 3 maps were slightly different concerning the degree of difficulty depending on the amount of extra information available to the participants. More specifically, the first map (first area) was considered to be the easiest, and consisted of 9 streets (17 street sections), 6 points of interest, and 0 dangerous locations. Street sections were technically the parts of a street from intersection to intersection. The second map (second area), which was considered to be of medium difficulty, consisted of 8 streets (17 street sections), 6 points of interest, and 2 dangerous locations. Lastly, the third map (third area), considered the most difficult, consisted of 8 streets (16 street sections), 6 points of interest, and 7 dangerous locations.

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 (in Greek). Headphones connected to a personal computer were used for listening to the verbal descriptions. The verbal description of each map referred to the corresponding residential area, including information on a) the streets, b) the six points of interest, c) the dangerous locations, and d) the boundaries of the map. The verbal protocol used for the above four types of information (streets, points of interest, dangerous locations, boundaries) was based on the following guidelines. At the beginning of each verbal description, the starting point of the area was defined and subsequently vertical, horizontal, and diagonal streets of the area were verbally defined with reference to their names and their orientation. Then, the six points of interest were defined with reference to the street and their relative position on the street. Subsequently, the verbal description included the dangerous locations in the area in the same way as the points of interest (i.e. with reference to the street and their relative position on the street). Finally, the boundaries of the area were also defined, as an outline of the map was verbally described. The description began from the starting point and continued cyclically from intersection to intersection until the starting point was met again. A full verbal description (third area) is provided as a sample in Appendix A.

For the study of the audio-tactile maps, an 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 dimensions of the device are: length 17 inches (423 mm), width 14 inches (355 mm), height 1.5 inches (38 mm), and the device is supplied via the USB port. Adapted tactile material (e.g. tactile map) can be properly positioned on the surface of the IVEO Touchpad. While reading tactile material on the device surface through active touch, the tactile and audio stimuli of the aid are simultaneously received.

The audio-tactile aid consisted of three tactile maps, one for each area, and the corresponding computer files (SVG files). The dimensions of the tactile maps were 360 mm x 285 mm, making the most of the dimensions of the IVEO Touchpad. Maps were printed on microcapsule paper using a PIAF machine. Audio-tactile maps included streets, points of interest, dangerous locations, and soundscape for intersections. Streets were tactile presented as thick continuous lines, points of interest as dots, and dangerous locations as thin continuous lines. The soundscape of intersections was recorded in real time using a Stereo Dat-Mic microphone (TELINGA) and a ZOOM H4n-Handy Recorder. SVG files were created, using IVEO Creator software, in order to present the audio information for each map, and could be viewed using IVEO Viewer software. For the study of the audio-tactile maps, a personal computer was connected to the touch-tablet.

Procedure

Initially, the researcher explained in detail the procedure to the participant, and this was followed by a short period of time (5 minutes) for the participant to become familiar with the procedure. The procedure of the experiment consisted of two phases for each aid.

The first phase took place in a quiet place (indoors) located close to the actual area depicted on the map, and the second phase was executed in the same area (in the physical environment) depicted on the map. During the first phase, each participant tried to form a cognitive map that would help him/her in seeking and precisely locating 6 points of interest within each area during the second phase. The participant had 15 minutes at his/her disposal in order to read the aid, but he/she could stop reading earlier if he/she considered that he/she had fully finished his/her study.

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 (“easy map”) and reading the audio-tactile map of the second area (“medium map”), the second participant listening to the verbal description of the second area (“medium map”) and reading the audio-tactile map of the third area (“difficult map”), and so on. Moreover, not all the participants started the process by listening to the verbal description. On the contrary, half of them started by reading the audio-tactile map first. 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.

For the verbal description, the participant sat comfortably on a chair in front of a table and a personal computer was placed in front of him/her. He/she was also given headphones in order to receive the verbal description of the map. The participant could listen to the description as many times as he/she wanted either entirely or just a segment of the description (streets, points of interest, dangerous locations, boundaries).

For the study of the second aid (touchpad), the participant sat comfortably on a chair in front of a table, and a touchpad with a connected computer were placed in front of him/her. He/she was also given headphones in order to receive all the audio stimuli. While studying the audio-tactile map, the participant received simultaneously audio and tactile information. The information on the map referred to a) the streets, b) the six points of interest, and c) the dangerous locations in the area. When the participant pressed a street, he/she heard its name, and if he/she pressed an intersection, he/she heard the soundscape of the intersection. Moreover, when the participant pressed one of the six points of interest, he/she heard a short audio message that identified the point (e.g. bakery). An audio message was also received for dangerous locations (e.g. steps downwards).

The time span available for the study of each aid (i.e. either for repeated listening of the verbal description or for studying the audio-tactile map) was 900 sec. The time span participants spent for listening to the verbal description ranged from 314 sec to 874 sec, while the time span spent for the audio-tactile map study ranged from 300 sec to 835 sec. None of the participants spent the total available time span in any case – verbal description or audio-tactile map.

The second phase of the procedure began 10 minutes 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 and name of as many of the six points of interest as he/she could. The participants were using a white cane during their movement within the area.

The researcher followed the participant and noted on an A4 page that depicted the map, the precise route that the participant had gone through. The researcher also noted the points of interest that the participant had defined as well as the exact time. Whenever the participant defined a spot, he/she was given feedback on whether his/her definition was correct or incorrect. When the participant correctly named the point of interest and the distance from it was less than or equal to 2 meters, the definition was counted as correct, otherwise it was counted as incorrect. In cases of emergency, and only when the blind participant was in danger, the code word “freeze” was spoken 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 would take him/her 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 participant had at his/her disposal a maximum time span of 20 minutes 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 she/he had formed during the first phase.

Results

Initially, the scores of the following six variables were calculated: 1) the number of points of interest in the area detected by each participant (Found), 2) the number of points of interest in the area that were not detected or were added by each participant but did not actually exist in the area (Errors), 3) the number of auditory points of interest detected by each participant (Found Auditory), 4) the number of haptic points of interest detected by each participant (Found Haptic), 5) the number of olfactory points of interest detected by each participant (Found Olfactory), and 6) the number of times each participant walked outside the borders of the area (Out of Area). 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. Concerning the number of points of interest, if a participant had detected all the points of interest correctly, his/her score would be equal to 6. Moreover, if a participant had detected all the auditory, haptic, and olfactory points of interest correctly, his/her score would be equal to 2 in each case.

<Insert Table 1 about here>

Repeated-measures ANOVAs were conducted to examine the differences in performance after: a) the use of verbal description, and b) reading the audio-tactile map with the use of a touchpad device. Repeated-measures ANOVAs were conducted for the variables presented in Table 1.

The implementation of repeated-measures ANOVAs revealed significant differences for the variables: Found [F (1, 19) = 32.111, $p < .01$], Errors [F (1, 19) = 23.841, $p < .01$], Found Auditory [F (1, 19) = 30.032, $p < .01$], Found Haptic [F (1, 19) = 13.113, $p < .01$], and Found Olfactory [F (1, 19) = 5.516, $p < .05$].

The participants detected significantly fewer points of interest (information) after having listened to the verbal description than having read the audio-tactile map, with reference to all the above-mentioned variables.

The findings are very interesting concerning the differences in the number of participants that found all the information using the verbal description and the audio-tactile map. In the condition of the verbal description, none of the participants found all 6 points of interest, while just 2 participants detected 5 points of interest. In the condition of the audio-tactile map, 8 out of the 20 participants detected all 6 points of interest, and 6 of the remaining 12 participants found 5 points of interest.

In addition, correlation analysis has been applied to examine the influence of vision loss on the participants' performance. The results are presented in Table 2. According to these results, there seems to be a tendency of a better performance with the increase of age of vision loss. This tendency appears to be more intense in the case of audio-tactile map. However, these correlations are not statistically significant. It should be noted, though, that in the case of audio-tactile map the correlation of the age of vision loss with the variable "Found" was close to significant (r = .441, p = .052).

<Insert Table 2 about here>

The mean of listening to the verbal description and reading the audio-tactile map was 568.7 (*SD* = 176.47) seconds, and 591.1 (*SD* = 147.44) seconds, respectively. Moreover, the mean time of walking within the area in order to detect points of interest after having used the verbal description and the audio-tactile map was 789.4 (*SD* = 150.47) seconds, and 820 (*SD* = 147.12) seconds, respectively. It should be noted that the shorter walking time in the case of the verbal description does not imply an advantage of the verbal description since the participants completed the procedure more quickly due to their inability to detect any more points of interest.

Conclusions

In the present study, specific aspects of the cognitive map of individuals with blindness were examined after the participants had listened to a recorded verbal description and they had explored an audio-tactile map using a touchpad device. The assessment method focused on wayfinding and detection of predefined points of interest. The above research appears to be the first trial to examine in the physical environment the cognitive maps derived from an audio-tactile map of individuals with visual impairment. Only recently, the efficiency of the cognitive map derived from a multimodal map through the use of a force-feedback haptic device was examined in the real environment (Papadopoulos et al., 2015).

The results of the present research suggest that an individual with blindness can acquire and use a functional cognitive map through the use of an audio-tactile map, while relying on a verbal description entails challenges when he/she comes into the actual location. Participants found more haptic, auditory, and olfactory points of interests during the process of wayfinding after they had explored the audio-tactile map than they did after they had listened to the verbal description. This indicates not only that audio-tactile maps constitute an effective orientation and mobility aid but, also, that they could be more supportive compared to verbal descriptions in locating points of interest in the physical environment.

Although no other similar result has been detected, our results are in line with other research studies' findings concerning spatial knowledge derived from a tactile map. Brambring and Weber (1981) showed that the tactile map can be a better orientation and mobility aid than a verbal description when it comes to the real environment. Ungar, Blades and Spencer (1996) also mentioned that according to their review of research studies, it becomes obvious that tactile maps provide a more integrated and global representation of the spatial environment.

Taking these results into consideration, it could be assumed that audio-tactile maps combining the significant advantages of tactile maps (configurational presentation of spatial components and salient points of reference leading to an allocentic encoding) with the solutions brought with the inclusion of auditory information (simultaneous perception of auditory and tactile information, spatial relations inference provided auditorily, soundscape cues) enable an individual with blindness to navigate more efficiently when he/she arrives in the physical environment. Verbal description appears to be a weaker tool for wayfinding and points of interest detection in the physical environment.

Another finding derived from the analysis concerns the relation between age of vision loss and performance. A non-statistically-significant correlation has emerged between age of vision low and participants’ performance, which was more salient in participants’ performance after they had used the audio-tactile map. This finding is considered interesting enough, and as such it needs to be further investigated in the context of a future research. This research should engage a larger sample that will permit the comparison between the group of individuals with congenital visual impairment and the group of individuals with adventitious vision loss.

Undoubtedly, the conclusions of the current research could transform the O&M support delivered either by specialists in the field or by entities that aim at ensuring accessibility for individuals with visual impairments. Similarly, O&M aids need to result in the most functional spatial encoding and representation possible. In order to successfully provide functional O&M solutions and services, audio-tactile maps should be an indivisible part of the relevant tools.

Independent movement of individuals with visual impairments is a major issue that needs thorough examination since it not only encapsulates significant restraints, but is also directly linked to quality of life. Knowing how and under what conditions spatial encoding becomes a quicker and easier procedure for an individual with visual impairments, prior to his/her arrival in the physical environment, could result in a reorganization of the content and the type of mobility aids as well as of wayfinding and orientation training.

Future research should focus on whether the spatial knowledge acquired through the use of audio-tactile aids is time unalterable or not, and on what exactly are the cognitive processes that occur during geographic space management so as to align the mobility aids according to these processes. Furthermore, it would be interesting to realize the same study in a larger area with more points of interest, as well as to collect data as the participants' feedback concerning which method of learning a route they prefer and why, what other information they need and would be useful either in the verbal description or on the audio-tactile map.

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References

Bentzen, B. L. (1997). Orientation aids. In B. B. Blash, W. R. Wiener & R. L. Welsh (Eds), *Foundations of Orientation and Mobility* (2nd ed. pp.284-316). New York: AFB Press.

Blades, M. (1990). The reliability of data collected from sketch maps. *Journal of Environmental Psychology, 10,* 327-339.

Blazhenkova, O., & Kozhevnikov, M. (2009). The new object-spatial-verbal cognitive style model: Theory and measurement. *Applied cognitive psychology*, *23*(5), 638-663.

Brambring, M. & Weber, C. (1981). Taktile, verbale und motorische Informationen zur geographischen Orientierung Blinder. *Zeitschrift fόr Experimentelle und*

Angewandte Psychologie, 28, 23-37.

Brock, A., Truillet, P., Oriola, B., & Jouffrais, C. (2010). Usage of multimodal maps for blind people: why and how. In *Proceedings of ACM international conference on Interactive Tabletops and Surfaces* (pp. 247-248), Saarbrücken, Germany: ACM, November 7-10.

Caddeo, P., Fornara, F., Nenci, A. M., & Piroddi, A. (2006). Wayfinding tasks in visually impaired people: the role of tactile maps. *Cognitive Processing*, *7*(1), 168-169.

Cattaneo, Z. & Vecchi, T. (2011). *Blind vision: The neuroscience of visual impairment*. MIT Press

Cattaneo, Z., Vecchi, T., Cornoldi, C., Mammarella, I., Bonino, D., Ricciardi, E., & Pietrini, P. (2008). Imagery and spatial processes in blindness and visual impairment. *Neuroscience and Biobehavioral Reviews, 32*, 1346-1360.

Connors, E. C., Chrastil, E. R., Sánchez, J., & Merabet, L. B. (2014a). Action video game play and transfer of navigation and spatial cognition skills in adolescents who are blind. *Frontiers in Human Neuroscience*, *8*(133).

Connors, E. C., Chrastil, E. R., Sánchez, J., & Merabet, L. B. (2014b). Virtual environments for the transfer of navigational skills in blind: A comparison of directed instruction vs. video game based learning approaches. *Frontiers in Human Neuroscience*, *8*(223).

Cornoldi, C., Fastame, M. C., & Vecchi, T. (2003). Congenitally blindness and spatial mental imagery. In Y. Hatwell, A. Streri, & E. Gentaz (Eds.), *Touching for Knowing: Cognitive psychology of haptic manual perception* (pp. 173-187). Amsterdam, Philadelphia: John Benjamins Publishing Company.

Dulin, D., Hatwell, Y., Pylyshyn, Z., & Chokron, S. (2008). Effects of peripheral and central visual impairment on mental imagery capacity. *Neuroscience and Biobehavioral Reviews, 32,* 1396-1408.

Fletcher, J. F. (1980). Spatial Representation in Blind Children. 1: Development Compared to Sighted Children. *Journal of Visual Impairment and Blindness*, *74*(10), 381-85.

Holmes, E., Jansson, G., & Jansson, A. (1996). Exploring auditorily enhanced tactile maps for travel in new environments. *New Technologies in the Education of the Visually Handicapped, 237*, 191-196.

Espinosa, M. A. & Ochaita, E. (1998). Using tactile maps to improve the practical spatial knowledge of adults who are blind. *Journal of Visual Impairment and Blindness*, *92*(5), 338-345.

Espinosa, A., Ungar, S., Ochaita, E., Blades, M., & Spencer, C. (1998). Comparing methods for introducing blind and visually impaired people to unfamiliar urban environments. *Journal of Environmental Psychology, 18*(3), 277-287.

Giudice, N. A., Bakdash, J. Z., & Legge, G. E. (2007). Wayfinding with words: Spatial learning and navigation using dynamically-updated verbal descriptions. *Psychological Research, 71*(3), 347-358.

Giudice, N. A., & Tietz, J. D. (2008). Learning with virtual verbal displays: Effects of interface fidelity on cognitive map development. In C. Freksa, S. N. Newcombe, P. Gärdenfors, & S. Wölfl (Eds.), *Spatial Cognition VI: Lecture Notes in Artificial Intelligence* (Vol. 5248, pp. 121-137). Berlin: Springer.

Golledge, R. G. (1993). Geography and the disabled: a survey with special reference to vision impaired and blind populations. *Transactions of the Institute of British Geographers*, *18,* 63-85.

Gunzelmann, G., & Anderson, J. R. (2004). Spatial orientation using map displays: A model of the influence of target location. In *Proceedings of the Cognitive Science Society* (Vol. 26, pp.517-522). Illinois, Chicago, August 4-7.

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.

Harder, A. & Michel, R. (2002). The target-route map: evaluating its usability for visually impaired persons. *Journal of Visual Impairment & Blindness, 96*(10), 711-723.

Herman, J. F., Herman, T. G., & Chatman, S. P. (1983). Constructing cognitive maps from partial information: A demonstration study with congenitally blind subjects.

Journal of Visual Impairment and Blindness, 77, 195-198.

Hill, E. W., Rieser, J. J., Hill, M. M., & Hill, M. (1993). How persons with visual impairments explore novel spaces: Strategies of good and poor performers. *Journal of visual impairment & blindness*, *78*(8), 295-301.

Holmes, E. & Jansson, G. (1997). A touch tablet enhanced with synthetic speech as a display for visually impaired people's reading of virtual maps. Retrieved from http://www.dinf.ne.jp/doc/english/Us_Eu/conf/csun_97/csun97_060.html

Jacobson, R. D. (1998). Navigating maps with little or no sight: An audio-tactile approach. In *Proceedings of the workshop on Content Visualization and Intermedia Representations (CVIR)* (pp. 95-102), Montreal, Canada: ACL, August 15.

Kitchin, R. M. (1994). Cognitive maps: What are they and why study them? *Journal of environmental psychology*, *14*(1), 1-19.

Kitchin, R. M. & Jacobson, R. D. (1997). Techniques to collect and analyze the cognitive map knowledge of persons with visual impairment or blindness: Issues of validity. *Journal of Visual Impairment and Blindness*, *91*, 360-376.

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 M. Antona & C. Stephanidis (Eds.), UAHCI, 2016, Part III, *Lecture Notes in Computer Science, 9739,* (pp. 577–585). Switzerland: Springer.

Kozhevnikov, M., Kosslyn, S., & Shephard, J. (2005). Spatial versus object visualizers: A new characterization of visual cognitive style. *Memory & cognition*, *33*(4), 710-726.

Lahav, O. & Mioduser, D. (2008). Haptic-feedback support for cognitive mapping of unknown spaces by people who are blind. *International Journal of Human-Computer Studies*, *66*(1), 23-35.

Landau, S., Russell, M., & Erin, J. N. (2006). Using the talking tactile tablet as a testing accommodation. *RE: view*, *38*(1), 7-21.

Loomis, M. J., Klatzky, L. R., Golledge, G. R., Cicinelli, G. J., Pellegrino, W. J., & Fry, A. P. (1993). Nonvisual navigation by blind and sighted: Assessment of path integration ability. *Journal of Experimental Psychology: General, 122*(1)*,* 73-91.

MICOLE (2006). Deliverable D6: Report of the Design and Evaluation of Basic Multimodal Navigation Tools. Retrieved from http://micole.cs.uta.fi/deliverables_public/index.html

Millar, S. (1988). Models of sensory deprivation: The nature/nurture dichotomy and spatial representation in the blind. *International Journal of Behavioral Development, 11*(1), 69-87.

O'Modhrain, S., Giudice, N. A., Gardner, J. A., & Legge, G. E. (2015). Designing media for visually-impaired users of refreshable touch displays: Possibilities and pitfalls. *IEEE Transactions on Haptics, 8*(3), 248-257.

Papadopoulos, K. S. (2005). On the theoretical basis of tactile cartography for the haptic transformation of historic maps. *e-Perimetron*, *1*(1), 81-87.

Papadopoulos, K. & Karanikolas, N. (2009). Tactile maps provide location-based services for individuals with visual impairments. *Journal of Location Based Services*, *3*(3), 150-164.

Papadopoulos, K., Koukourikos P., Koustriava E., Misiou M., Varveris, A., & Valari, E. (2015). Audio-haptic map: An orientation and mobility aid for individuals with blindness. *Procedia Computer Science, 67,* 223-230.

Papadopoulos, K. & Koustriava, E. (2011). The impact of vision in spatial coding. *Research in developmental disabilities*, *32*(6), 2084-2091.

Papadopoulos, K., Koustriava, E., & Kartasidou, L. (2011). The impact of residual vision in spatial skills of individuals with visual impairments. *The Journal of Special Education*, *45*(2), 118-127.

Papadopoulos, K., Papadimitriou, K., & Koutsoklenis, A. (2012). The role of auditory cues in the spatial knowledge of blind individuals. *International Journal of Special Education*, *27*(2), 169-180.

Papadopoulos, K., Koustriava, E., Koukourikos, P., Kartasidou, L., Barouti, M., Varveris, A., Misiou, M., Zacharogeorga, T., & Anastasiadis T. (2016). “Comparison of three orientation & mobility aids for individuals with blindness: verbal description, audio-tactile map and audio-haptic map”. *Assistive technology.* Advance online publication. doi: 10.1080/10400435.2016.1171809

Parkes, D. (1988). "NOMAD": An audio-tactile tool for the acquisition, use and management of spatially distributed information by partially sighted and blind persons. In A. F. Tatham & A. G. Dodds (Eds.), *Proceedings of the Second International Symposium on Maps and Graphics for Visually Handicapped People* (pp. 54-64). King's College, London, April 20-22.

Passini, R., Duprés, A., & Langlois, C. (1986). Spatial mobility of the visually handicapped active person: A descriptive study. *Journal of Visual Impairment & Blindness*, *80*(8), 904-907.

Piaget, J. & Inhelder, B. (1956). The child's concept of space. *New York: Humanities Press.*

Postma, A., Zuidhoek, S., Noordzij, M. L., & Kappers A. M. L. (2007). Differences between early-blind, late-blind, and blindfolded-sighted people in haptic spatial-configuration learning and resulting memory traces. *Perception,* 36, 1253-1265.

Rener, R. (1993). Tactile cartography: another view of tactile cartographic symbols. *The Cartographic Journal*, *30*(2), 195-198.

Rice, M. T., Jacobson, R. D., Golledge, R. G., & Jones, D. (2005). Design considerations for haptic and auditory map interfaces. *Cartography and Geographic Information Science*, *32*, 381-391.

Taylor, H. A., & Tversky, B. (1992). Spatial mental models derived from survey and route descriptions. *Journal of Memory and Language, 31*(2), 261-292. doi:10.1016/0749-596X(92)90014-O

Taylor, H. A., & Tversky, B. (1996). Perspective in spatial descriptions. *Journal of Memory and Language*, *35*(3), 371-391.

Thinus-Blanc, C. & Gaunet, F. (1997). Representation of space in blind persons : Vision as a spatial sense? *Psychological Bulletin, 121*(1), 20-42.

Thorndyke, P. W. & Hayes-Roth, B. (1982). Differences in spatial knowledge acquired from maps and navigation. *Cognitive psychology*, *14*(4), 560-589.

Tinti, C., Adenzato, M., Tamietto, M., & Cornoldi, C. (2006). Visual experience is not necessary for efficient survey spatial cognition: Evidence from blindness. *The Quarterly Journal of Experimental Psychology*, 59(7), 1306-1328.

Ungar, S., Blades, M., & Spencer, C. (1993). The role of tactile maps in mobility training. British Journal of Visual Impairment, *11*(2), 59-62.

Ungar, S., Blades, M., & Spencer, C. (1996). The construction of cognitive maps by children with visual impairments. In Portugali, J., (Ed.) (1996). The construction of cognitive maps. Dordrecht: Kluwer Academic Publishing.

Ungar, S., Blades, M., & Spencer, C. (1997). Strategies for knowledge acquisition from cartographic maps by blind and visually impaired adults. *The Cartographic Journal*, *34*(2), 93-110.

Wang, Z., Li, B., Hedgpeth, T., & Haven, T. (2009). Instant tactile-audio map: Enabling access to digital maps for people with visual impairment. In *Proceedings of the 11th International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 43–50), Pittsburgh, PA, USA, October 25-28.

Table 1

Mean and standard deviation (SD) of the detected points of interest and the times each participant walked outside the area borders for each one of the two aids

	Verbal description		Audio-tactile map	
	Mean	SD	Mean	SD
Found	3.15	.99	4.85	1.35
Errors	3.05	1.19	1.20	1.51
Found Auditory	.80	.52	1.50	.61
Found Haptic	.85	.67	1.55	.69
Found Olfactory	1.50	.51	1.80	.41
Out of Area	.35	.49	.35	.81

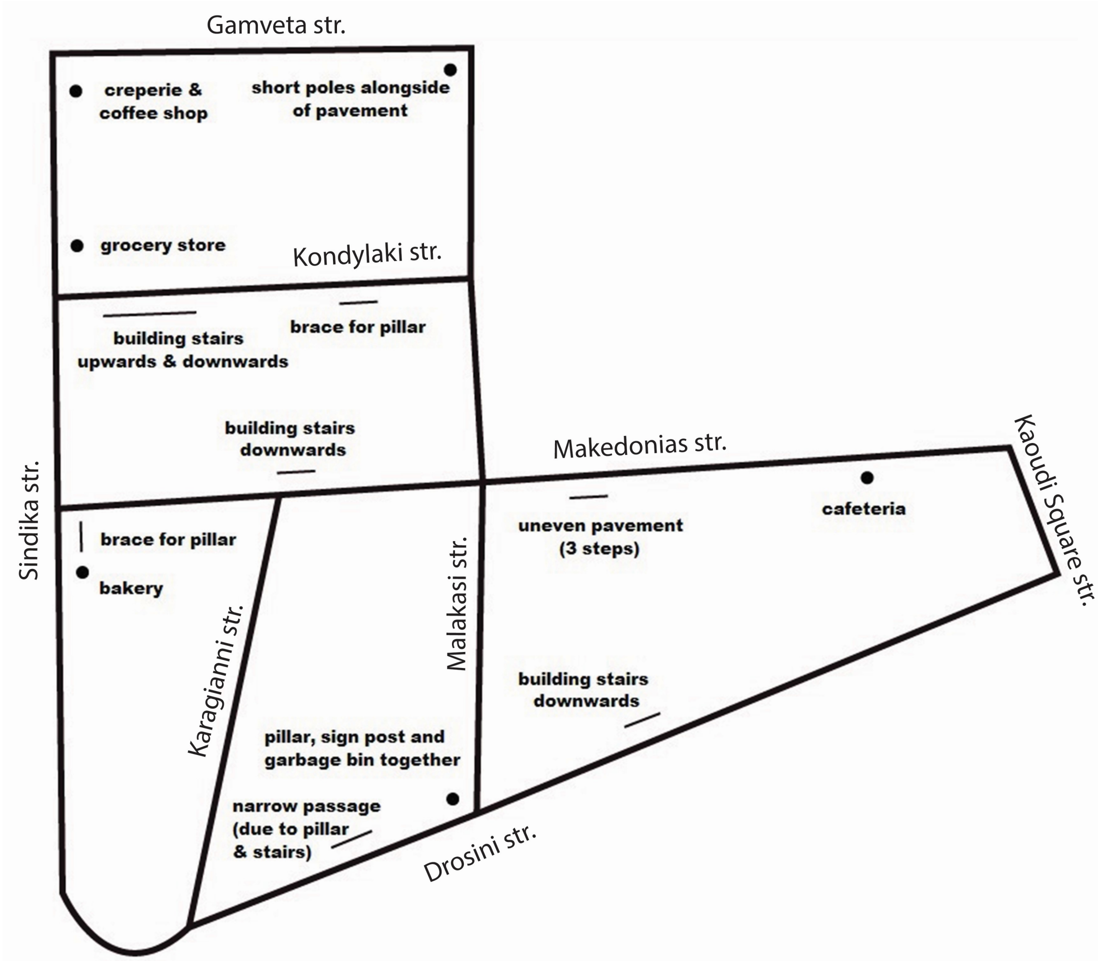
Table 2

Pearson's product-moment correlation coefficients between age of vision loss and the six variables for verbal description (VD) and audio-tactile map (AT)

	Age of vision loss
Found (VD)	.310
Errors (VD)	-.246
Found Auditory (VD)	.268
Found Haptic (VD)	.253
Found Olfactory (VD)	-.006
Out Of Area (VD)	-.107
Found (AT)	.441*
Errors (AT)	-.417
Found Auditory (AT)	.419
Found Haptic (AT)	.301
Found Olfactory (AT)	.326
Out Of Area (AT)	-.278

* close to significant

Appendix A: Verbal description of the third area



The starting point of the area is the intersection of Sindika and Drosini Streets. You are standing at the starting point and you are looking ahead at the route on Sindika Street. Following the direction from left to right there are four vertical streets named Sindika (the street you are standing on), Karagianni, Malakasi, and Kaoudi Square respectively. Following the direction from the position where you are standing and going forward there are four horizontal streets named Drosini (the street you are standing on), Macedonias, Kondilaki, and Gamveta respectively.

The six Points Of Interest (POIs) of the area are located in the following streets or intersections: On Sindika Street, following the direction from the position where you are standing on and going forward, on the right side of the street, just before the intersection with Macedonias Street, there is a POI called the Bakery. On Sindika Street, following the direction from where you are standing and going forward, on the right side of the street, shortly after the intersection with Kondilaki Street, there is a POI called the Grocery Store. On the corner of the intersection of Sindika Street and Gamveta Street, there is a POI called the Creperie & Coffee Shop. On the corner of the intersection of Drosini Street and Malakasi Street, there is a POI called Pillar, Signpost & Garbage bin together. On the corner of the intersection of Gamveta Street and Malakasi Street there is a POI called Short Poles alongside of Pavement. On Macedonias Street, following the direction from the intersection with Malakasi Street to the intersection with Kaoudi Street, on the right side of the street and specifically three quarters of the way along, there is a POI called Cafeteria.

Dangerous locations in the area are located in the following streets or intersections: On Sindika Street, following the direction from the position where you are standing and going forward, on the right side of the street, just before the intersection with Macedonias Street, there is a dangerous location called Brace for Pillar (the wire ropes that connect an electricity pillar with the ground). On Drosini Street, following the direction from the intersection with Karagianni Street to the intersection with Malakasi Street, on the left side of the street and specifically halfway along, there is a dangerous location named Narrow Passage (due to a pillar & steps). On Drosini Street, following the direction from the intersection with Malakasi Street to the intersection with Kaoudi Square Street, on the left side of the street and specifically one quarter of the way along, there is a dangerous location called Building Steps Downwards. On Macedonias Street, following the direction from the intersection with Sindika Street to the intersection with Malakasi Street, on the left side of the street and specifically halfway along, there is a dangerous location called Building Steps Downwards. On Macedonias Street, following the direction from the intersection with Malakasi Street to the intersection with Kaoudi Square Street, on the right side of the street and specifically at the beginning of this route, there is a dangerous location called Uneven Pavement (3 steps). On Kondilaki Street, following direction from the intersection with Sindika Street to the intersection with Malakasi Street, on the right side of the street and specifically from the beginning to the middle of this route, there is a dangerous location called Building Steps Upwards & Downwards. On Kondilaki Street, following the direction from the intersection with Malakasi Street to the intersection with Kaoudi Square Street, on the left side of the street and specifically three quarters of the way along, there is a dangerous location called Brace for Pillar.

The boundaries of the area are the following intersections in series: Drosini and Sindika intersection (your starting point). Move forward. Sindika and Gamveta intersection. Turn right and move forward. Gamveta and Malakasi intersection. Turn right and move forward. Malakasi and Macedonias intersection. Turn left and move forward. Macedonias and Kaoudi Square intersection. Turn right and move forward. Kaoudi Square and Drosini intersection. Turn right and move forward. Drosini and Karagianni intersection. Move left to the roundabout. Drosini and Sindika intersection (your starting point).