Comparison of three orientation & mobility aids for individuals with blindness: verbal description, audio-tactile map and audio-haptic map

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Abstract

Disorientation and inability of wayfinding are phenomena with a great frequency for individuals with visual impairments during the process of travelling novel environments. Orientation and mobility aids could suggest important tools for the preparation of a more secure and cognitively mapped travelling. The aim of the present study was to examine if spatial knowledge structured after an individual with blindness had studied the map of an urban area that was delivered through a verbal description, an audio-tactile map or an audio-haptic map, could be used for detecting in the area specific points of interest. The effectiveness of the three aids with reference to each other was also examined. The results of the present study highlight the effectiveness of the audio-tactile and the audio-haptic maps as orientation and mobility aids, especially when these are compared to verbal descriptions.

Keywords: blindness, spatial knowledge, audio-tactile map and audio-haptic map

Introduction

Individuals with visual impairments face incremental challenges as they travel from familiar to unfamiliar places. Exploring novel environments may entail disorientation and getting lost that bring in turn to individuals with severe visual impairments feelings of fear, stress and panic (Golledge, 1993; Hill, Rieser, Hill, Halpin & Halpin, 1993). Orientation, wayfinding and cognitive mapping are prerequisite skills to manage novel spatial environments. Wayfinding involves the ability to learn and recall a route as well as to update one's orientation as he/she moves along the route (Blades, 1991). Wayfinding is one aspect of the spatial knowledge arisen from cognitive mapping (Golledge, 1999; Kitchin & Blades, 2001). Cognitive mapping refers to the process during which someone consciously or subconsciously acquires, codes, stores, recalls and decodes the data of his/her everyday geographic environment, and the knowledge resulting from this process (Downs & Stea, 1973).

Studying the cognitive maps of individuals with visual impairments might shed light into their 'mental landscapes' (Kitchin, Blades & Golledge, 1997), which possibly are not organised like a cartographic map (Downs & Stea, 1973; Montello, 2001), but as fragmented, augmented, schematized, or distorted representations (Downs & Stea, 1973). Since cognitive maps constitute the knowledge based on which people take spatial decisions and make respective choices (Kitchin, 1994), or, to restate, cognitive maps are the basis of every spatial behaviour (Downs & Stea, 1973), their studying is of great importance. It is, also, extremely significant in the case of individuals with visual impairments who miss the greater or the total piece of visual information of space and the cognitive mapping becomes a very difficult process supported only by the other sensorial channels (Lahav & Mioduser, 2008).

Existing assistive technology can be used as orientation and mobility aids that support the other sensorial channels, especially hearing with auditory stimuli and touch with tactile stimuli. Lahav and Mioduser (2008) categorised orientation and mobility aids in two types: the passive and the active ones. The former category includes all those tools that are used by an individual before his/her contact with the actual environment, while the latter consists of the aids that are used during someone's contact with the spatial environment. In the former category belong aids, such as verbal descriptions, tactile maps, audio-tactile maps and audio-haptic maps, which aim at supporting the formation of cognitive maps and prepare someone for the processes of orientation and wayfinding when he/she travel into actual environment (Lahav & Mioduser, 2008).

Audio-tactile maps that can be used through a touchpad device appear to compensate for the limitations ascribed to tactile maps. Tactile aids seem to necessitate extended Braille labelling (for a review see Jacobson, 1998), while the abundance of the information and the complex graphics require greater memory load (Ungar, Blades & Spencer, 1993) which influences spatial coding and representation (Papadopoulos, Koustriava & Kartasidou, 2012). Including soundscape (Papadopoulos, Papadimitriou & Koutsoklenis, 2012) and audio information concerning names of locations (cities, streets etc), spatial relations, descriptions of buildings (Habel, Kerzel & Lohmann, 2010), significant landmarks, for instance traffic lights (Wang, Li, Hedgpeth & Haven, 2009) or impediments into a tactile map, can help individuals with visual impairments significantly. It has been suggested that combining auditory and tactile information may present information in a more efficient way (MICOLE, 2006) resulting in a more complete concept (Landau, Russell & Erin, 2006). Moreover, considering that touch pads give the ability to use environmental auditory cues incorporating the soundscape into the tactile map, they could promote an individual's orientation, since individuals with visual impairments are proved to use auditory cues to determine and maintain orientation within an environment (Koutsoklenis & Papadopoulos, 2011; Jansson, 2000) and to associate the soundscape with the structural and spatial configuration of the landscape and, finally, create cognitive maps (Landau et al., 2006). Research has provided evidences that using an audio-tactile map with a touchpad device, individuals with visual impairments can develop a cognitive map (Papadopoulos & Barouti, 2015).

Moreover, many researchers have previously studied the abilities of haptic technology in transferring spatial and geometrical concepts to individuals with visual impairments. Rice, Jacobson, Golledge and Jones (2005) develop a map combing auditory cues with haptic feedback, while the user could scan the map using a force-feedback mouse. Kaklanis and his colleagues (2013) used a force feedback haptic device on a digital map that compounded haptic interaction with a sonification system and Text to Speech (TtS) module. Parente and Bishop (2003) used auditory icons, TtS and haptic feedback to deliver spatial information to individuals with visual impairments.

Furthermore, a few researchers created an audio-haptic map and then examined the development or improvement of spatial knowledge. Lahav and Mioduser (2008) designed a virtual spatial environment and then examined the construction of cognitive maps. The participants in the same study were individuals with blindness who studied the virtual environment using a force feedback joystick. According to the results, the participants presented a thorough and comprehensive knowledge of the virtual space and were able to use this knowledge to apply complex spatial skill and perform orientation and mobility tasks in the real space. In another research, a tablet application providing vibration and auditory stimuli, used by one participant with blindness to explore an interactive map. The participant was then asked to draw a map to depict the mental representation. The researchers pointed out that the drawn map was surprisingly precise (Simonnet, Bothorel, Maximiano & Thepaut, 2012).

Many of such methods used to enable individuals with visual impairments to develop a cognitive map appeared to be more or less effective. However, to decide the efficiency of a method or a tool, the assessment technique should be taken into consideration. Kitchin and Jacobson (1997), and Jacobson and Kitchin (1995) review the techniques used to assess cognitive maps of individuals with visual impairments. All those assessment tests that examine either route knowledge (retracing, distance, direction) or configurational knowledge (how a points of interests are spatially related to each other) by constructing models, sketching a map, or answering to respective questions, focus on content comprehensiveness and accuracy, than on utility (Kitchin & Jacobson, 1997). However, the objective value of an orientation and mobility passive aid should be determined when the acquired knowledge after its usage can be transferred in real space in an actually productive way, that is the ability of an individual to travel from point A to point, orient him-/herself and locate specific landmarks or points of interest.

Study

The aim of the present research was to examine whether spatial knowledge structured after an individual with blindness had studied a map of an urban area, delivered through different aids, could be used for detecting in the area specific points of interest.

The map was provided through: 1) a verbal description, 2) an audio-tactile map with the use of a touchpad device, and 3) an audio-haptic map with the use of a force feedback haptic device. An additional aim of the present study was the comparison of the three aids with reference to their effectiveness.

Participants

Twelve adults with blindness (total blindness or only light perception) took part in the research. The sample consisted of 9 males and 3 females. The age ranged from 19 years to 46 years (*M* = 28.33, *SD* = 7.73). A basic criterion to include a participant in the study was not to have a hearing impairment or other disabilities, apart from visual impairments. The visual impairment was congenital for 8 participants and acquired for the rest 4 participants – in 3 out of these 4 participants vision loss occurred at the first year of life, and in the other one participant at the age of two. With respect to their level of education, 5 participants were university graduates, 5 were university students, and 2 were high school graduates.

Nine out of the 12 participants use the computer for more than 20 hours a week, 1 participant uses the computer 10 hours a week approximately, 1 participant uses the computer 5 hours a week approximately and 1 participant uses the computer for less than 5 hours a week. Moreover, the participants were asked to indicate the main reading media they used (i.e., Braille, TtS systems). Ten out of the 12 participants used TtS systems as the basic reading medium, and 2 participants used Braille.

As far as their Orientation and Mobility (O&M) training is concerned, 10 participants stated that they have participated in O&M training sessions, while 2 participant have never been trained in O&M. The training for 7 out of those 10 participants endured from 20 to 100 hours in total, while just 3 of the participants have been trained in O&M for more than 100 hours. Moreover, 4 participants declared that they have “never” read tactile graphics or maps, 7 participants that they “rarely” have read tactile graphics, and 1 participant that he/she has read “many times” tactile graphics. None of the participants had ever used and audio-tactile map.

The participants were asked to state the way of their daily move in outdoor places, by choosing one of the following: a) with the assistance of a sighted guide, b) sometimes myself and sometimes with the assistance of a sighted guide, and c) myself, without any assistance. Moreover, the participants were asked to indicate the frequency of their independent movement using a 5-point likert scale: always, usually, sometimes, seldom, or never. According to their answers, 7 participants move without the assistance of a sighted guide and 5 participants sometimes with assistance, sometimes all by themselves. Moreover, 4 participants stated that they “always” move independently, 6 participants stated “usually” and 2 participants “sometimes”.

Instruments - materials

Three O&M aids were developed for the aims of the experiment: a verbal description, an audio-tactile map readable with the use of a touchpad device, and an audio-haptic map readable with the use of a force feedback haptic device (Phantom Omni). Each one included three maps (or the verbal description of a map) referring to three different areas of the Thessaloniki city (areas around the city center with apartment buildings and stores). All areas had approximately the same extend and included 5 blocks each. Maps consisted of streets, points of interest and the extremely dangerous for blind people locations of each area. The amount of points of interest was the same on each map. Two points of interest referred to audio (e.g. coffee house, super market), two to haptic (e.g. pillar, tree, kiosk) and two points of interest referred to olfactory information (e.g. bakery, perfume shop), resulting to six points of interest for each map. The 3 maps were slightly different concerning the degree of difficulty depending on the extra amount of information which could be received by the participants. More specifically, the first map (first area), considered to be the easy one consisting 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. For example, if there were three intersections on a street, the street was divided into two street sections, and so on. The second map (second area) was considered to be of medium difficulty, consisting of 8 streets (17 street sections), 6 points of interest and 2 dangerous locations. Lastly, the third map (third area), considered to be the most difficult consisting 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 (greek voice). Headphones connected to a computer were used for the listening of verbal descriptions. The verbal description of each map referred to the corresponding residential area, including information of a) the streets, b) the six points of interest, c) the dangerous locations and d) the boundaries of the map. 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 of the area in the same way as to points of interest (i.e. with reference to the street and their relative position on the street). Finally, 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 starting point was met again.

For the study of audio-tactile maps (touchpad), IVEO (ViewPlus) Touchpad tactile device was used. Touchpad is an educational tool for individuals with visual impairments. 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, 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 360mm x 285mm, making the most of the dimensions of IVEO Touchpad. Maps were printed on microcapsule paper using the 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 (see Figure 1). 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 audio-tactile maps a personal computer was connected to the touch-tablet.

For the audio-haptic aid the haptic device Geomagic Touch was used. The device is also known as Phantom Omni and it is widely used for research and educational purposes for the tactile rendering of three-dimensional models (Sjöström, Danielsson, Magnusson, & Rassmus-Gröhn, 2003). It has six degrees of freedom (6 DOF) and has an approximately 6.4 Width x 4.8 Height x 2.8 Depth inches workspace. Geomagic Touch consists of a “base”, a “body” and an “arm”. The “arm” ends up in a handle, similar to a pen, and has two buttons of which only one was used for the experiment. The handle can move in three dimensions: up - down, left - right and front – back. Only two dimensions were used for the needs of the experiment (front - back was locked).

The audio-haptic aid consisted of 3 maps referring respectively to the three areas. The maps were set up in C++ programming language and more specifically in programming framework OpenGL which was responsible for the graphic rendering of the maps. For the haptic interconnection with the Geomagic Touch haptic device the H3DApi programming framework was used. The audio-haptic aid was accessible through the use of the haptic device. The mean for loading the maps of the audio-haptic aid was a personal computer connected to the haptic device. When a map was loaded on the computer and the haptic device was calibrated the audio-haptic aid was ready for use.

The maps of the audio-haptic aid consisted of streets, points of interest, dangerous locations and soundscape for intersections, and they were accessible with the use of the haptic device. Audio messages for street names, points of interest and dangerous locations were created using TextAloud software. The soundscape of intersections was recorded in real time using a Stereo Dat-Mic microphone (TELINGA) and a ZOOM H4n-Handy Recorder. Streets were technically implemented as grooves and the haptic device could freely move only through them. Moreover, vibration was added on intersections.

<Insert Figure 1 about here>

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 (indoor) 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 the 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"), reading the audio-tactile map of the second area ("medium map") and exploring the audio-haptic map of the third area ("difficult map"), second participant listening to the verbal description of the second area ("medium map"), reading the audio-tactile map of the third area ("difficult map"), and exploring the audio-haptic map of the first area ("easy map"), and so on. Furthermore, not all the participants started the procedure by listening to the verbal description. It should be noted that not only the map to be studied each time was addressed in a cyclic way from one participant to the other but also the aid (verbal description, audio-tactile aid and audio-haptic aid). The cyclic procedure was followed so as to decrease the potential effect due to the ease or the difficulty of the studied map.

For the phase of verbal description aid, the participant sat comfortably on a chair in front of a table, and a 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.

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

During the administration of the third aid (Geomagic Touch), the participant sat comfortably on a chair in front of a table and the Geomagic Touch haptic device was placed on the table right in front of him/her. He/she was also given headphones in order to receive all the audio stimuli. The researcher placed the handle of the haptic device at the starting point of the map. By controlling the handle in two dimensions (up – down and left – right), the participant could move through the streets, receive haptic and audio stimuli and form a cognitive map of the area. The third dimension (front – back) of the haptic device was locked.

There were four different types of audio messages the participant could listen to his/her headphones: a) While navigating through the streets and every time he/she approximated an information spot, an audio-message informed him/her which one it was and the side of the street the spot was on. For example, if there was a bakery on the left side of the street and the participant approximated the bakery, he/she listened to the audio message "bakery on left side". b) A similar audio message was listened when the participant approximated a dangerous location on the streets of the map. c) In the case of an intersection, when approximated, there was a short vibration on the handle and if the participant pressed the handle button he/she could listen to the soundscape of that specific intersection. The soundscape audio message lasted approximately 30 seconds, but it could be stopped earlier by pressing the handle button once again. d) Lastly, at any point of the map, if the participant pressed the button, an audio message with the name of the street was heard. The participant could listen to the same audio message as many times as he/she wished by pressing the button repeatedly. Every time an audio message was heard, the handle was locked and could not move until the message completed. Hence, the participant would not lose his/her location on the 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 more 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 depicting 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 definition time. Whenever the participant defined a spot, he/she was given feedback whether his/her definition was correct or incorrect. In cases of emergency and only when the blind participant was on danger the code word “freeze” was told by the researcher in order to freeze the navigation of the participant. Moreover, the researcher did not provide any assistance to the participant in relation to his/her navigation, unless the participant chose a direction in a street that set himself/herself out of the area of the map. In that case, the researcher relocated the participant back into the specified area, noted the mistake and the participant continued his/her navigation.

The participant had at his 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 he/she had formed during the first phase.

Results

Initially, the scores of the following 6 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 that were added by each participant but did not actually exist in the area (Add

More), 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 three 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>

As it appears on Table 1, the participants detected 50% of the points of interest after having listened to the verbal description, 75% after having read the audio-tactile map, while they detected 78% of the points of interest after having read the audio-haptic map.

Furthermore, repeated-measures ANOVAs were conducted to examine the differences in performance after the: a) use of verbal description, b) reading the audio-tactile map with the use of a touchpad device, and 3) reading the audio-haptic map with the use of a force feedback haptic device. Repeated-measures ANOVAs were conducted for the variables presented on the Table 1.

The implementation of repeated-measures ANOVAs revealed significant differences for the variables: Found [F (2, 22) = 11.247, $p < .01$], Found Auditory [F (2, 22) = 6.522, $p < .01$], and Found Haptic [F (2, 22) = 4.808, $p < .05$].

Moreover, the implementation of the LSD post-hoc test ($p < .05$) indicated that the participants detected significantly fewer points of interest (information) after having listened to the verbal description than having read the audio-tactile map as well as read the audio-haptic map, with reference to all the above mentioned variables.

Table 1 shows that the participants detected relatively fewer points of interest after having read the audio-tactile map than having read the audio-haptic map. However, this difference in performance was not statistically significant.

The superiority of the audio-tactile map as well as the audio-haptic map over the verbal description with reference to their effectiveness also emerges from the number of the participants that detected all the 6 points of interest using each aid. In the case of the verbal description none of the participants detected all the 6 points of interest. On the contrary, in the cases of the audio-tactile map and the audio-haptic map the number of the participants that detected all the 6 points of interest was 3 and 2, respectively.

The mean of listening to the verbal description, reading the audio-tactile map and reading the audio-haptic map was 647 (*SD* = 177.01) seconds, 609 (*SD* = 148.13) seconds, and 800 (*SD* = 75.34) seconds, respectively. Moreover, the mean time of walking within the area in order to detect points of interest after having used the verbal description, the audio-tactile map and the audio-haptic map, was 775 (*SD* = 164.06) seconds, 838 (*SD* = 171.71) seconds, and 876 (*SD* = 117.01) seconds, respectively. It should be noted that the shorter walking time in the case of verbal description does not imply an advantage of the verbal description since the participants completed the procedure more quickly due to their inability of detecting any more points of interest.

Conclusions

The present research assessed the spatial knowledge developed through three different types of orientation and mobility aids: a verbal description, an audio-tactile map and an audio-haptic map. The assessment process was based on examining if the participants could transfer the acquired knowledge on physical environment completing independent walking within the mapped area and detecting the predefined points of interest. The methodology was decided on the base of utility, which means that any orientation and mobility aid used for cognitive mapping should be examined in realistic conditions, i.e. the actual geographical space, instead of relying simply on the comprehensiveness and accuracy of indoor tests (Kitchin & Jacobson, 1997).

The results of the present study highlight the effectiveness of audio-tactile and audio-haptic maps as an orientation and mobility aid, especially when these are compared to verbal descriptions. Participants' performance in walking through the area and detecting the points of interests was significantly better when they had read the audio-tactile aid or when they had explored the audio-haptic map than when they had listened to the recorded verbal description.

Research results of previous studies support the finding of the present study concerning either the efficiency of audio-tactile or the importance of audio-haptic maps. Papadopoulos and Barouti (2015) proved that audio-tactile maps in use with a touchpad device result in cognitive mapping. Similarly, Lahav and Mioduser (2008) found that participants who had explored an indoor place using a force feedback joystick presented consequently a thorough and comprehensive spatial knowledge when they were transferred to the actual place. Simonnet, Bothorel, Maximiano and Thepaut (2012) showed that the participant in their study was able to draw a surprisingly precise map after having a explored an interactive map using a tablet application of audio and vibrating stimuli. However, this specific research included only one participant and thus the results should merely be considered as a simple indication. With the present study it is proved for the first time that an individual with visual impairment can actually walk and orient him-/herself in the real space after having studied an audio-haptic map using a force-feedback haptic device.

Moreover, the superiority of audio-tactile and audio-haptic maps over verbal descriptions could alter orientation and mobility training as well as the means of cognitive mapping provided when this is necessary. The results of the present study could have significant implications on the design of orientation and mobility aids that aim at supporting the creation of an enduring mental representation of space before an individual with visual impairment visit the physical environment. Contributing to independent movement of visual impaired individuals is a crystallized demand since it influences their quality of life.

Future research should make focus on whether the spatial knowledge acquired through the use of audio-tactile or audio-haptic aids is labile as time passes compared to spatial knowledge derived from other orientation and mobility aids.

In addition, future research should examine if a verbal description of an area results in a better performance compared to no previous support with any aid but rather a direct contact with the physical environment. This comparison was beyond the scope of the present research, though it could be considered a significant dimension. A basic limitation of the present study is the small sample size and, thus, future research should try to involve a larger number of participants.

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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 three aids

	Verbal description	Touchpad	Haptic device

	Mean	SD	Mean	SD	Mean	SD
Found	3.00	1.04	4.50	1.45	4.67	.78
Add More	.17	.39	.08	.29	.00	.00
Found Auditory	.75	.62	1.33	.65	1.50	.52
Found Haptic	.75	.62	1.42	.67	1.50	.52
Found Olfactory	1.50	.52	1.75	.45	1.67	.49
Out Of Area	.42	.52	.50	1.00	.50	.80

Figure 1

The map of third area