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Analysis of wayfinding strategies of blind people using tactile maps

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Abstract

The current work aims to analyse the wayfinding strategies for blind people when interacting with a tactile map so as to plan an unfamiliar route. It results from reflections carried out as from research on the support to navigation by blind pedestrians whose study objective was the guided decision-making of 4 congenital blind, 4 adventitious blind and 4 low-vision blind in the process of route finding. The field study took place at the Education Faculty of the Federal University of Pernambuco – Recife – Brazil. The proposed experiment has been divided in 2 phases: learning and experimentation. Each one of them consisted of 3 steps with the following tasks for each user: plan a route, perform and represent it. A map was made upon a wooden structure covered by cardboard, upon which acetate was laid on the circulation areas. Different textures indicating the route to be followed by volunteers as well as the architectonic elements of the space to be experienced were placed upon them. Two reading strategies were used by the blind people to understand the space and plan a route: one based, exclusively, on the tracking of the route to be followed; and another devised as from the tracking of the general map. Those who limited their knowledge of the environment through the route, tended to memorize a lot of the decision-making orientation, thus causing hesitations and route deviation. Those who tracked the whole map, developed a panoramic idea of the space, generally related to some of the elements in the environment connected to the route structure, thus facilitating their spatial orientation. Due to the complexity of the wayfinding task for blind people, it is suggested that the tactile map is not studied in isolation but as from an ergonomic systemic view which considers it as an integral part of the information system which favours the decision-making orientation.

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Keywords: Tactile map; Wayfinding; Ergonomic system; Public buildings

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1. Introduction

Facing the blind person's problem of not knowing where they are or where to go in public buildings such as airports, bus stations, hospitals, schools and malls, it can be concluded that vision becomes necessary to acquire spatial concepts. However, "the finding that some early blind participants in a number of studies perform within the sighted range indicates that lack visual experience per se is not sufficient to explain the common finding of spatial difficulties" Ungar [1]. It is noted, however, that blind people are able to have environmental concepts, and it lacks an appropriate environmental information adapted to their abilities and limitations in public spaces which causes so many difficulties.

Conscious of the cognitive spatial ability of the blind person and in order to fill the needs of visual information, other researchers, as Jacobson, Espinosa et al.,[2] [3] highlight the importance of the assistance of the orientation tactile map to facilitate the process of wayfinding. It is noted that through this informational instrument, the blind person has an anticipated and panoramic idea of the environment that can ease the perception, the planning and the performance of an unfamiliar route. However, it is noted that there is a great limitation of the tactile map when the blind person applies inefficient strategies during the haptic reading of the map.

A series of studies in the last decade has shown that the strategies taken by blind people while interacting with the tactile map when facing spatial tasks represents an important role on determining its performance. It was found out that the performance of blind people could be increased from the strategies used to learn a new route attesting that the decisions are related to the haptic reading strategies of the tactile map and they determine the performance of the user. Ungar, Simpson and Blades ,Blades et al. [4, 5].

The word strategy has two meanings. It can be related to the way the information is coded in the memory or to the behavioral aspect embraced by the person when exploring a spatial layout or environment [6,7]. Although this two strategy categories are clearly inter-related, in this paper it was chosen to evaluate the behavioral aspect of the blind pedestrian in the haptic reading of the tactile map. The meaning of the word strategy, in this context, refers to the sequence of behaviors in the process of tracking the tactile map and make decisions with the intent of perform the route.

Due to the sensory restriction, Proulx and Passini [8] attest that during the wayfinding process the blind person need more details and a larger number of environmental information adapted to their abilities and limitations. They emphasizes that the blind person is capable of learning a relatively complex route, performing them by themselves, mapping it and comprehend the experienced space in a way it they can acquire a complete representation of the layout, allowing them to perform a complex spatial operation, such as using shortcuts. In addition, they tend to reject the theory that blind people found difficulties to develop spatial concepts, and praise the theory that they use different strategies in the process of understanding space, needing, in this case, of accessible guiding points.

Aware of the spatial cognitive ability of the blind person, of their limitations and based on the ergonomy and informational systems principles, that also refers to the communication human-task-machine in other supports that not the computers, it is possible to conclude that understanding the "blind person – tactile map" interface is a pre-requirement in the wayfinding process to ensure efficacy and efficiency of this environmental information system. Knowing the target audience and the context in which the information will be used, including a better knowledge of the activities of the tasks that will be performed by the users of that information, Padovani [9] says that this understanding will led us to create better informational systems and interfaces, improving the communication process.

Corroborating with this reasoning, the present study intent to understand the problems in the "blind person – tactile map" interface during the tasks activities such as decoding the information in the map to plan an unfamiliar route and the performance of the user to perform it and describe it. It presents itself as an object of study the haptic reading strategies of the tactile map associated to the performance of the blind person from the spatial cognition during the route fulfilling. The paper is a result of a master's degree dissertation about assistance in navigation of blind pedestrians through the tactile map [10].

2. Experimental study

Conscious that the environment perception of the blind person varies according to the person characteristics (age, cognitive development, perceptual mode, used to code the spatial information) and also factors related to the environment characteristics (size, structure and familiarity) and related to the learning process (strategies to acquire knowledge, conditions of learning, ways to communicate the information) Ochaíta and Huertas, [11] Espinosa [12] Ochaíta et al [13], it was selected a group of 12 (twelve) blind people with proximate ages and similar cognitive development to perform the same unfamiliar route with the help of the tactile map in the Education Center of the Federal University of Pernambuco.

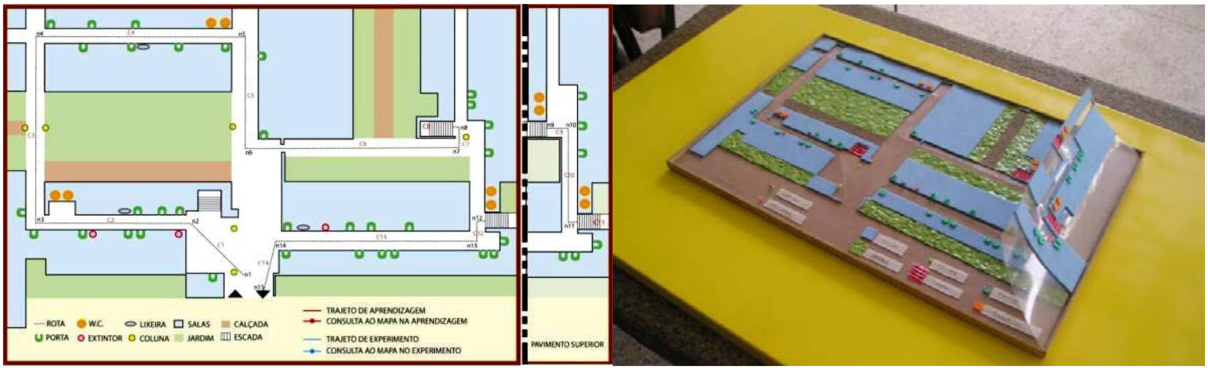
The sample was chosen randomly, however it intended to choose four total congenitally blind, named ct1, ct2, ct3, ct4, four adventitious blind, which means that they acquired the blindness at adult age, having visual memories, considered ca1, ca2, ca3, ca4, and four of low vision, bv1, bv2, bv3, bv4. The criteria was that they were adults, with practice in using the long cane, without other limitations, physic, mental or psychological, that prevent their translation. It was not the interest of the present work to evaluate the alterations occurred in the orientation decisions by the users, because some participants had visual remainder. Therefore, it was necessary to blindfold them, to neutralize them, so that it would not interfere in the studied phenomenon. If the congenitally total blind people had similar or superior performance over the low vision or adventitious blind people, that would indicate that different strategies were used to solve the problem, excluding the memory or visual remainder.

The building where the experiment was performed is characterized for two floors facing an intern patio with paths between gardens. The learning of the route was through the tactile map, the building did not have an informational system for blind people. From the main access of the building, it was proposed a route that was represented in the tactile map by linear points in high relief indicating the course that the volunteers should do. The route passed among the internal hallways of the building in the ground floor and sidewalks among the gardens of the central patio towards a stair that would lead them to the first floor, proposing to pass some hallways of the first floor and return to the initial point through a stair.

The experiment was purposed in two stages, learning and experiment. Each one of them had three stages, with the following tasks for each user , plan an unfamiliar route through the tactile map, perform the route and describe the route. A tactile map of 0,30m by 0,47m in the scale of 1:100 was manufactured over the wood structure, covered with cardboard and then acetate. Over it, several different textures were set, meaning besides the route to be performed, doors, bathroom, fire extinguisher, trashcans fixed on the wall, columns, rooms, garden, sidewalk and stairs. To assure the understanding of the symbols, the subtitles were in Braille.

During the task of planning an unfamiliar route with the assistance of the tactile map, due to the fact that the informational instrument was unknown by the participants, it was explained the goal to understand the information in high relief, their meaning through a Braille subtitle and to realize the course to be followed before planning the route. Because it was a complex route, it was asked, after the understanding of the information on the map, that each participant read the map again without determined time with the goal of planning and verbalize their orientation decisions. This process was recorded in video and in audio so the researcher could analyze the finger movements during the information capture of the tactile map while the orientation decisions were verbalized. This way, it was possible to associate the reading strategy with the performance of the volunteer in implementation of the route and in the graphic representation of the course, and also evaluate the spatial cognitive aspects of each person.

Figure 1.a shows a schematic print of the tactile map printed for the researcher's use with the intend to graphic represent the route performed by each volunteer during the implementation of the route to compare with the designated one. The dotted black line represents the route structure to be performed by the users with the nodes (n), which means the corners of the hallways or decision making points, and the paths (c) to record the locale and the moment of the verbalization of the orientation decisions. Figure 2.a is a picture of the tactile map that was used in the experiment indicating the high relief representation of the architectonic elements of the building, the subtitle informing their meanings and the route that each volunteer would perform. The fixed part over the wood structure represents the ground floor and the acetate sheet fixed only in one of its side in the same structure, represents the



a b

Fig. 1 (a) schematic print of the tactile map; (b) tactile map

first floor where the participant should perform the route. The acetate surface when rotated by the blind person during the experiment contribute to the perception of the floor changing through the stairs that was represented with a red texture.

3. Analysis of the "blind person – tactile map" interface

People's ability of generate the representation of an environment is designed cognitive map. The blind person can develop this representation in three ways. One of them can be constructed from the direct experience in an environment and the other one is indirect by verbal or written description in the locale or by three dimensional graphic representation, as an example, the tactile map [14].

Espinosa et al [15] considers that the tactile map is significantly the best way to develop the cognitive map of blind people compared to the other ways quoted above. Corroborating with Espinosa et al [15] idea and agreeing with Hampson & Daly [16] when affirming that tactile reading strategies are a potential variable source that reverberate in the performance of the individuals in ambient tasks. It was verified that, in this study, the importance of evaluate which tactile maps haptic reading strategies can improve the development of the cognitive map in an easy way using wayfinding to plan and perform a route.

Studying spatial cognition with the tactile map requires the previous introduction to some notions on types of spatial knowledge. Hirtle and Jonides [17] say that people acquire spatial knowledge through the use of "referential marks", "knowledge of routes" and "area knowledge". The authors above define referential marks, as a highlight place in the route. The knowledge of routes is the understanding of the environment by walks among the striking features and the knowledge of the area is when the user is able to recognize the space as in a panoramic view. These kinds of spatial knowledge can be acquired in an indirect way by the haptic reading of the map and in a direct way by performing the route.

4. Results of the "user – tactile map" interface

In each of the performed routes it was possible to verify the relation between the haptic reading of the tactile map and the accomplishment of each volunteer in the act of perform and develop a mental representation of the environment and the ability to make a graphic representation of the fulfilled route. The term "reading the map" in this research correspond to the haptic reading in order to realize the form, size and texture of the map. The term "trace a route", meant to perform the haptic reading of the tactile graphic representation of the route with the intention of noticing the path in the constructed environment, before even walk the path. And "tracing the environment layout" or "tracing the map" is to perform a haptic reading of the map at large. An analogy can be made of the fingers "walking" in the environment and "look" the referential elements that can help their route without sight. Next, it will be presented the strategies applied by the volunteers to understand the map, planning the route and the implications in perceiving the environment that help or not the implementation of the route.

4.1 Strategies used by full blind people

All the volunteers of the research, in distinct moments, sat in a same bench, starting point of the route (n1), located next to the interior access door of the building where they were asked to understand the map, planning and perform an unfamiliar route with the help of the tactile map that was placed in a table in front of them. The Braille subtitle presented in the map help the understanding of the tactile graphic representation.

To understand the tactile map, the fully blind volunteers, Ct1, Ct2, realized the environment by applying the strategy of tracking the route first, identifying the referential marks during the walk from the starting point (n1) to the end of the route (n15). In order to achieve that, Ct1 overlaid his fore fingers on the starting point (n1), then while one of them, with the help of the others started to know the route and the marks in the environment, in clockwise direction and returning to the starting point (n1). Unsatisfied, the volunteers decided to track the map as a complete layout, curious about the environment to be known and the route to be performed. However, volunteers Ct3 and Ct4 realized the environment only by applying the strategy of tracking the route to be performed describing everything they noticed but without tracking the total layout of the environment.

To plan the route, volunteers, Ct1 and Ct2 used the strategy of choosing the referential marks that could ease their decision-making process in corners or "spin points", denominated by volunteer Ct1. They make a link between the referential elements of the route and decision points realized in the reading of the map.

To achieve that, they fixed one of the fingers in the starting point of the route (n1), while the other fingers searched for referential marks along the path to plan the route, without missing the starting point (n1) until reaching the finishing point (n15). This way, they related the referential marks of the route with the decision-making points, which helped their orientation in each corner of the hallways. However, the volunteers Ct3 and Ct4, even with the knowledge of the elements in the environment, while tracking the route, used the strategy of memorizing and describing what they found without finding guiding points to their orientation.

The strategies used by volunteers Ct1 and Ct2 to understand and planning the route helped the total spatial comprehension in the wayfinding process. Ct1, as an example, founded the route quite simple, because he had the notion that he would walk through the building in the clockwise direction, finishing the route in a hallway that would lead him to the finishing point that was the starting point. He also noticed the possibility of shortcuts in the route. Being able to identify that he would need to climb two flights of stairs doing a 180° spin in that floor to arrive in the ground floor. He really enjoyed the textures presented in the map and verbalized how pretty it looked. Ct2, during the performance of the route, anticipated the decision making process before reach the end of hallways. He preferred to be guided by the wall that were in the same direction that he should follow in the next corner. Such strategies showed a good spatial understanding and made it easier the orientation decisions in the decision-making points. Both volunteers, Ct1 and Ct2, noticed that the direct experience with the tactile map during the learning process, improved and reinforced the "good" strategies used in the experiment to planning the route and also helping the general comprehension of the environment.

The strategies used by volunteers Ct3 and Ct4 contributed to informing the existing elements of the route, but did not helped the wayfinding process. Due to the quantity of information noticed by them without a referential while performing the route, they searched the memorized elements during the reading of the map, but, when they could not remember where to find them, they were lost or felt insecure to continue the route. Those factors provided a fragmented comprehension of the environment. They knew that they would find some referential elements but they did not know where and how to reach them. Volunteer Ct4 recognized the flaw in his strategy and created new strategies in the experiment to improve the memorizing the referential marks from his own hesitations and mistakes during the learning process.

4.2 Strategies used by adventitious blind people

In order to understand the map, volunteer Ca2, noticed the environment applying the strategy of tracking the whole map. To achieve that, he did the reading with quick movements on the tactile map using all fingers, sometimes together, sometimes apart, as if he wanted to feel all the texture of the surface. After the panoramic perception of the map, he used the strategy of tracking the route from n1 to n15, coming and going several times.

During that walk, he stopped many time with a finger on the decision point while the others noticed what was surrounding him. Volunteer Ca3 noticed the environment by applying the strategy of focusing in the decision points to ensure his orientation. To achieve that, he fixed his index fingers on the starting point (n1) and then used the other one to find the next decision point. The finger on the “n1” moved to meet the one on “n2”, while that finger searched for the “n3” and so on until arriving at “n15”. However, to achieve a wider perception of the environment, the fingers moved other ways founded in each decision point without losing the place where he stooped and his route. Volunteers Ca1 and Ca4 noticed the environment by applying the strategy of knowing the route dismissing the architectonic elements with the building context.

To plan the route, volunteers, Ca2 and Ca3, noticed the environment using the strategy of planning the route foreseeing solutions to assist the decision making in the hallway corners. They did not worried in identify and inform the obstacles that they meet in the route. They passed doors without any interest of counting or even identifying them. The goal of their routes was to find the end of the hallways and take the right decisions to find their way. To endure that, they decided to use as orientation parameter the walls or the floor contour. They predicted the direction they should follow in the corner, right or left, or in the same direction. To help such process, they used some fixed element of the building as a referential. Volunteers Ca1 and Ca4 used the strategy of knowing the route without identifying referential marks.

The strategies used by volunteer Ca2 made him realize the central internal garden and the route that would make him pass through it, and he was able to verbalize what was inside and outside of the route. Both Ca2 and Ca3 had a general notion of the environment, managed to plan the route foreseeing solutions that needed to be taken in the end of each hallway and perform the route without any difficulties. The way of planning the route made it easier to perform. However, Ca1 and Ca4 had the notion of what they would find in the environment, but could not get there, creating insecurity to move through the path.

4.3 Strategies used by the low vision blind person

In order to understand the tactile map, volunteers Bv1, Bv2 and Bv4, noticed the map by applying the strategy of knowing the environment from learning of the route, identifying only what was in the route. Volunteer Bv3 used the strategy of tracking the route first noticing the referential marks in the route and relating them to the map layout. However, he used a different strategy when naming new functions to the symbology of the rooms represented in the tactile map by terms created by him, such as auditorium, library, secretariat, left border, tension point in order to ease the processor of locating the referential marks. He was alert to always identifying if a referential mark was on the wall of the places pictured by him.

To plan the route, volunteers Bv1, Bv2 and Bv4 applied the strategy of identify all of the symbology founded on the route, quantifying them and trying to memorize many architectural elements unnecessary to their orientation, turning the task more difficult. Volunteer Bv3, however, verbalized in detailed way, sometimes repeated, the referential marks founded in the route using the rooms named by him, auditorium, secretariat as informational parameters to locate the referential marks.

Strategies used by volunteers Bv1, Bv2 and Bv4 were important to know the architectural elements founded in the route, but did not offered guidance parameters to inform them where and when to find them. They could not anticipate the decision making process to their orientation and mobility because they got confused. They acquired a fragmented representation of the environment. Many times, they confused the laterality of the decision-making points and the excess of useless information overloaded the short-term memory. They got lost. On the other hand, Bv3 task became fun because of the new designation of the simbology of the represented rooms of the tactile map, such as auditorium, library secretariat, that became guidance points to the orientation, to locate the referential marks and the decision-making points, that he called tension points.

5. Final considerations

Performing an unfamiliar route with the assistance of the tactile map demanded from the user not only to understand the meaning of each texture and each high relief picture with the help of the Braille subtitle, but also to apply strategies that helped the development of the mental representation of the building to be known and the route to be performed. To this end, there were two strategies that interfered in the planning and execution of the route: the understanding of space based, exclusively, on tracking the route or on the environmental perception from all the tracking map. Those who have developed an idea of space, generally, triggered some elements of the environment in relation to the structure of the route, hence facilitating their spatial orientation. Those who have limited knowledge of the environment through directions tended to memorize decisions making, thus causing more hesitations and route deviations. It is concluded that the decisions were related to the strategies of how they used the tactile map and the same determined the user performance, corroborating with the reasoning of Ungar, Simpson and Blades [14]

It was also noted, that three strategies have been applied of haptic reading to the map to get an early idea of the environment equal to those used for space knowledge through the identification of benchmarks, route recognition or knowledge of the area quoted by Hirtle and Jonides [17]. It was found that those who had perceived the environment and planned the route using the three types of spatial knowledge developed an idea of ordered space from a panoramic perception with guiding points or benchmarks, that facilitated the decisions making on the corners, hallways or decision points. The ones who somehow disregarded one of three forms of spatial knowledge had a fragmented idea of the environment this harming the process of knowing where they were and where to go. It is concluded that most had a tendency to plan the route using the same strategy applied to understand the map.

Because of the complexity of the task of wayfinding for blind people, it is suggested that the tactile map is not studied in isolation but rather from a systemic view of ergonomics that puts it as part of an information system that favors decisions making across the map. To this end, it is essential to include orientation and mobility parameters early in the design process of concomitant wayfinding systems to architectural project for such parameters will facilitate the development of the mental representation of the environment and the decisions of blind people respecting their needs, abilities, and limitations as well as facilitate planning and running a route with autonomy, security and satisfaction.

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