A Review of Accessible & Multisensory Spatial Navigation for Persons with Vision Impairement

by

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Abstract

Cognitive scientists created a research on how humans remember and travel in familiar and unfamiliar locations. Humans pay more attention to contextual aspects of an area while exploring unfamiliar places, and less attention to details, and more to objectives and consequences when following a familiar route. Cities are designed to appeal to the senses. Elements of cities form a map elements. Institutions and society define where we live in with it's barriers and requirements of persons with disabilities. Humans travel with identity, experience and emotions. While the visually impaired use assistive devices to travel, blind persons need guidance on how to plan and discover an area. When travelling, people use their negative and positive appearances. Wayfinding aids for blind have examples of practical and aesthetic wayfinding tools. Maps products take into account the user experience from the designer standpoint. The emotional design of the products and the environment anticipates and responds to the demands of the user.

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1 Introduction

1.1 Background

When investigating an area, we are mainly detail-oriented; out of the five senses, vision provides the most detailed information(Arbib, 2020; Burgess, Maguire, and O'Keefe, 2002), but persons with impairments rely on their hearing, smell, and touch to explore and navigate(Hersh, 2015; Kuehn and Smethurst, 2015). Individuals with vision impairments learn how to navigate from one site to another from their immediate social circles or sighted guides in order to increase their knowledge of the area of interest and arrive at their destination on time and on schedule (Goffman, 1986b). Without sensory signals for location-based information, such as self-distance travelling to a specific site or distance between points or routes. If VI persons are unable to walk outside, it will limit them from engaging in social interactions (Nawaz, Khan, and Bashir, 2020).

Tactile, auditory, and olfactory cues and interaction are used to aid navigation (Cunningham and Weinel, 2016). According to current multisensory research, navigational devices consider specific senses and emotions in order to produce maps with sensorial routes (Cunningham and Weinel, 2016; Krylov, 2018). Tactile maps with multimodal capabilities increase handicapped people's ability to move in new areas(Albouys-Perrois et al., 2018; Kandalan and Namuduri, 2019; Meşhur, 2013). We conducted this literature study to discover spatial navigation, wayfinding, and accessible research in multidisciplinary domains for people with visual loss in order to get a thorough understanding of multisensory navigation.

Compared to more traditional ways of spatial navigation, such as the use of a ground plans, you-are-here maps and tactile maps, multiple studies revealed evidence that the use of multisensory elements for digital maps and tactile maps Assistive technology & Adaptive technology can enhance the wayfinding experience for unknown areas(Engel et al., 2020; Chibaudel et al., 2020; Cullen and Metatla, 2019).

1.2 Problem Statement

Understanding how to navigate in unfamiliar places requires to get familiar to cognitive mapping (Arbib, 2020; Burgess, Maguire, and O'Keefe, 2002), We looked for the barriers and gaps to allow or limit travelling independently for visually impaired population. Their needs are to travel more independently and feel less excluded in society (Engel and Weber, 2018).

While vision-impaired persons continue to adopt the adaptive technology to help them with their limitations, Assistive technology helps with using interfaces, such as screen readers, braille keypads, and speech-to-text. There are alternative methods for wayfinding applications in digital media for vision impaired users (Siebra et al., 2017).

Accessible information in roadmaps are limited, and it doesn't include the accessible & multisensory route information (Brock et al., 2010). For navigating in unfamiliar places, visually challenged people need mobility and navigation aids. (Cunningham and Weinel, 2016; Kueh, 2006; Cunningham and Weinel, 2016). During a journey access to areas; doors, stairs, elevator access, add to the complexity of mobility (Engel and Weber, 2018). The topic about how to make effective maps representing the essential and relevant information for surroundings through geographers, scientists and sociologists (Lynch, 2008; Norman, 2004; Taylor, 2005).

1.3 Research Objectives

To understand multisensory navigation, we looked at the interdisciplinary studies of wayfinding in cognitive science, sociology and geography, We wanted to understand the literature about how cities are seen from the eyes of travellers, cities and the world with the challenges faced by visually impaired persons.

Our objective was to understand the knowledge in the literature to create a conceptual framework to address accessible navigation for visually impaired persons. We looked what city offers, how the visually impaired travel and targeted population's abilities, to aid with the creation of sensorial, and positive experiences for navigation or environments. Our aim was to create an analysis of an wayfinding from a traveller's experience to apply a wayfinding solution for persons who depend on the use assistive devices as navigational aids.

We formed our main research question and it's subquestions based on our analysis.

1. What is the nature of design research being done in relation to wayfinding?
    - How can wayfinding relate to meaningful senses,emotions?
    - What are the social and physical challenges that visually impaired people face when wayfinding?

1.4 Contributions

This study examines navigational approaches and the social and physical barriers od people with vision disabilities travelling in their daily lives. The review highlights the human psychology, social factors, methods, and tools originating from wayfinding and travelling.

The needs for targeted group, the process of spatial navigation, how persons create identities and get attracted from environment in their wayfinding strategies. A visually impaired person's wayfinding was analyzed socially, cognitively and from geographic frameworks during the literature review.

1. This literature review provides an overview of spatial navigation and multisensory navigation, as well as the social barriers the targeted population face.
   (a) The study examines many sensory inputs and and outputs and how they adapted during finding familiar and unfamiliar routes,
2. The review discussed fundamentals of human wayfinding and spatial navigation and how VI persons perceive spatial navigation with senses,
   (a) Our analysis of the literature highlights the demands and difficulties of the target audience from the literature,
   (b) Reviews VI persons' travelling techniques, identified navigational, sensorial & emotional indicators of environments and examines complementary sensorial cues,
   (c) Provides abilities and challenges VI wayfinding experience;

   (d) The review identifies gaps and provides future directions for multisensory and inclusive navigation,
   (e) The review explains how VI travel experiences from literature analyzing with conceptual frameworks (Norman, 2004; Lynch, 2008)

3. The results of this literature study highlights the needs and ideas for designing navigational aids.

1.5 Document Structure

1. The introductory section describes the problem and lists research questions & contributions,
2. Research approach,
   (a) Problem area and research scope,
   (b) Process of conducting the literature,
3. Related work
   (a) An analysis of human spatial navigation,
   (b) An overview of wayfinding,
   (c) An analysis of the Lynch (2008)'s image of the city for wayfinding,
   (d) An analysis of environments related to spatial navigation and emotions,
   (e) An overview of spatial navigation for visually impaired persons,
   (f) An overview of human abilities, strategies, tools and processes of wayfinding,

(g) An overview of multisensory wayfinding,

(h) An analysis of emotional wayfinding (Norman, 2004),

(i) An overview of vision disabled's abilities, social and physical barriers and challenges,

(j) An analysis of Goffman (1986b)'s multiple identity and stigma,

(k) An analysis of Taylor (2005) framework,

(l) An overview of navigational and mobility aids,

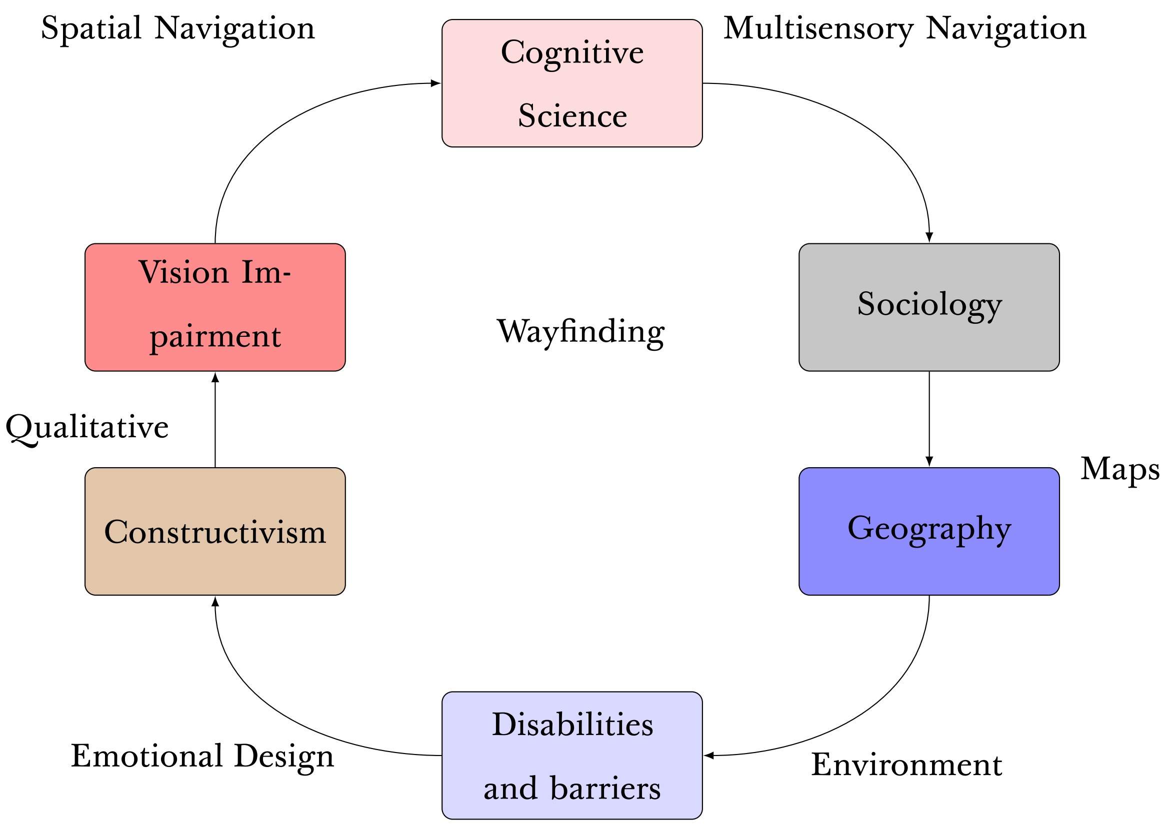
(m) An overview of multisensory solutions that are relevant to wayfinding.

4. The gap analysis section identifies and discusses gaps derived from the literature, and builds on these results to suggest future study areas,

5. The conclusion section responds to the research question and highlights issues and ideas of accessible multisensory navigation for VI people.

2 Research Approach

2.1 Theoretical Framework



We used the constructivist (Creswell and Poth, 2018; Charmaz, 2006) framework to construct our conceptual framework (See Figure 2.1). We also employed Latour (1999)'s Actor Network Theory (ANT), to be able to critic the point of view of the actors and the social world. This technique allows to critic the literature on different scales between a global framework and local framework. This technique of framework was used to explain the role of society and of the person in the context of navigation (Kueh, 2006).

Charmaz (2006) and Creswell and Poth (2018) was used in several areas to build subjective reality (Kueh, 2006; Brulé et al., 2018; Amedeo and Speicher, 1995). This knowledge is used in our research. In constructivism, contribution are not facts unlike natural sciences (Koskinen et al., 2013; Hatwell, 2006). The framework for constructional design research generates datasets includes researcher's creativity in an imagined world including the cognitive reality of cognitive science and the true reality of social scientists. For ethnographic research, we employed a qualitative analysis technique to analyse the experiences of the visually impaired. This technique has been identified (Creswell and Poth, 2018; Charmaz, 2006) and will improve navigation in earlier study findings. This will allow us to find emerging theories in data finding independent and nonlinear relationships(Levers, 2013). Grounded theory is known subjective collective method for capturing series of phenomenons from emerging data (Creswell and Poth, 2018; Glaser and Strauss, 2010; Strauss and Corbin, 1998). Emotional design (Norman, 2004) and the multiple identity framework (Goffman, 1986a) also played a role to understand the audience and their environments they travel, during the analysis of this research. In the case when data did not exist we employed (Lynch, 2008)'s map elements to construct with emotional processes(Norman, 2004).

2.2 Research Method

Exploring the literature will allow us to know which data to prioritize over any input and our influence in the research product. The literature research can be included or excluded in the grounded theory research. Our plan is to use this literature review for ehtnographic studies. In the later stages of our research technique, we will employ grounded theory technique as a method to research an ethnographic study.

We constructed specific research knowledge about experiences, products, cognitive, social and physical factors, user experience, emotions, and the social environment of design. Explanations are given when data did not exist in the reviewed paper. Cognitive skills and human skills were analyzed. If science is restrictive in concept, design may not have a fair chance of showing its benefits. Designers have the responsibility to redirect the language of product and looking for lucrative product tie-ins. Critical design's ability is building on multiple theories. Frameworks will allow us to reflect the designs with theories, debates, and the design process. Main ones are philosophy, humanities and social sciences.

During the survey we looked for usability criteria and design requirements, positive and negative experiences, from the qualitative analysis. We aimed to learn on how VI individuals travel with the use of digital navigational aids. Our goal was to learn about personal experiences and social factors for visually impaired persons to analyse navigation solutions that have been applied in spatial navigation for maps and wayfinding settings.

To gain a better understanding of the context of accessible interactions via digital maps, we performed a literature study. This analysis was based on current research and potential growth areas. We looked for accessible wayfinding and navigation solutions in academic journals and conference papers in the field of computer science and information technology, investigating the interaction models of digital and traditional solutions for maps and spatial navigation using a multisensory, accessible, and inclusive frameworks. The literature review analysis involved a series of research procedures (See Figure 2.1).

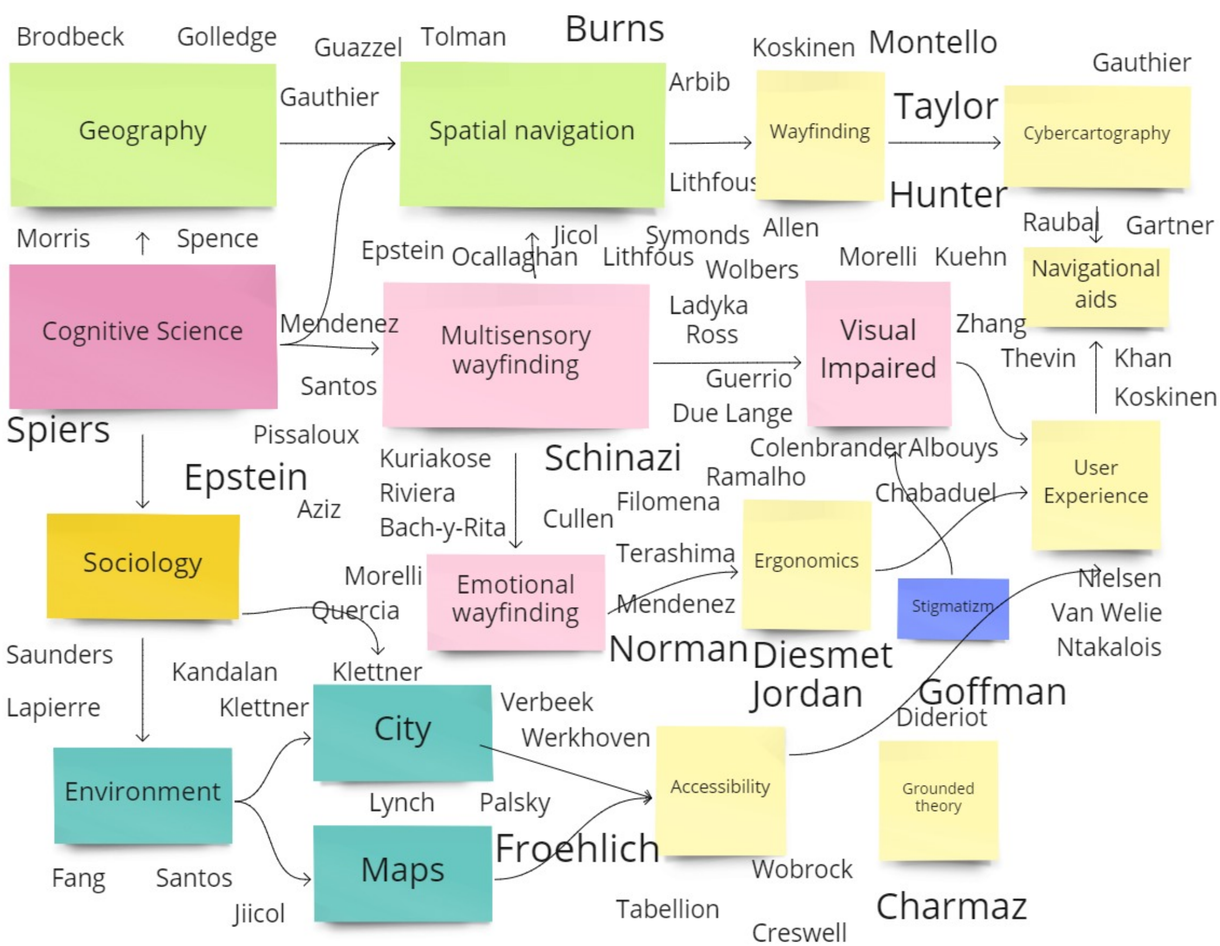


FIGURE 2.1: Conceptual framework

Cognitive scientists, sociologists, and geographers investigated spatial navigation. Wayfinding frameworks emphasize on humans, maps, and the environment, providing models that may be used to investigate wayfinding with VI. To discover relevant research from the resources we researched, we looked at each paper's references (forward snowballing) and applied backward snowballing to see if the research has evolved. (Wohlin, 2014).

In our literature review, we identified the main concerns and current solutions of visually impaired persons in the fields of psychology and sociology. We reviewed the literature about the design research for the interdisciplinary field.

To establish the adequacy of our literature review collection, we used four key factors to identify the papers that were suitable. Key factors are, navigation is highlighted in blue boxes, accessibility in orange boxes, multisensory in red boxes, and maps in yellow boxes.

We looked at journals, books, conferences, articles from digital libraries at Carleton University.

Because the focus of this review is human spatial navigation and wayfinding in physical world, it did not include the studies for virtual reality, artificial intelligence systems and the use of robot interactions.

In grounded theory, a phenomenon is the center of action in order to create abstract interpretative understanding of data. My focus is on user experience and the process, make analysis of observation of data available, analyze interaction, targeted population's goals, tools, and their level of engagement and emotions of sensory and navigation aids.

We organized a categorical schema of theories and concepts through a series of processes 2.1.

Throughout the analysis we compared the literature across the gathered data and made these comparisons:

- Categorize the data in concepts per analysis (See Figure 2.1)

– Compare categories per their importance which of these can act as major category what are the other categories

– Compare subcategories with general categories

– Compare concepts or conceptual categories (See Figure 2.2)

– Compare the entire analysis with existing literature

From the research question and the conducted literature subcategories arised, conditions, challenges, usability problems. Original theories were taken into account to understand multisensory navigation theories. A construrictivist motivation is being creative with ideas while keeping the interpretivist reality.

Our initial search was created using the keywords in the table below. (See table 2.1).

Keywords
Multisensory, spatial navigation, navigation, accessible, emotions, vision impairement, pedestrian, wayfinding, blind, maps, design, user experience

Table 2.1: Keywords used in literature survey

We looked at journals, publications, conferences and books from our findings using the keyword formula, we carefully read the literature and added the relevant information to our analysis.

Additionally, we created searches using formulas to find the number of researchers that was reviewed (See table 2.2).

Using our research questions and our scope we looked at current peer-reviewed solutions in information technology for VI persons in the fields of industrial design,

Multisensory	Navigation	Spatial	122
Impair*	Accessibil*	Map*	22
Sensory	Wayfinding	Environment	38
Vis* OR Visual	Impairment OR Impaired	Wayfinding AND Navigation	62
Vis*	Impairment	Navigation OR Wayfinding	61

TABLE 2.2: The number of publications reviewed for each keyword

computer science, and information technology We collected the research papers from digital libraries such as Scopus, Sage, Web of Science, Google Scholar, IEEE, ACM. As part of our survey search, we looked at relevant multimodal wayfinding solutions and compared them to human senses in the context of visually impaired persons

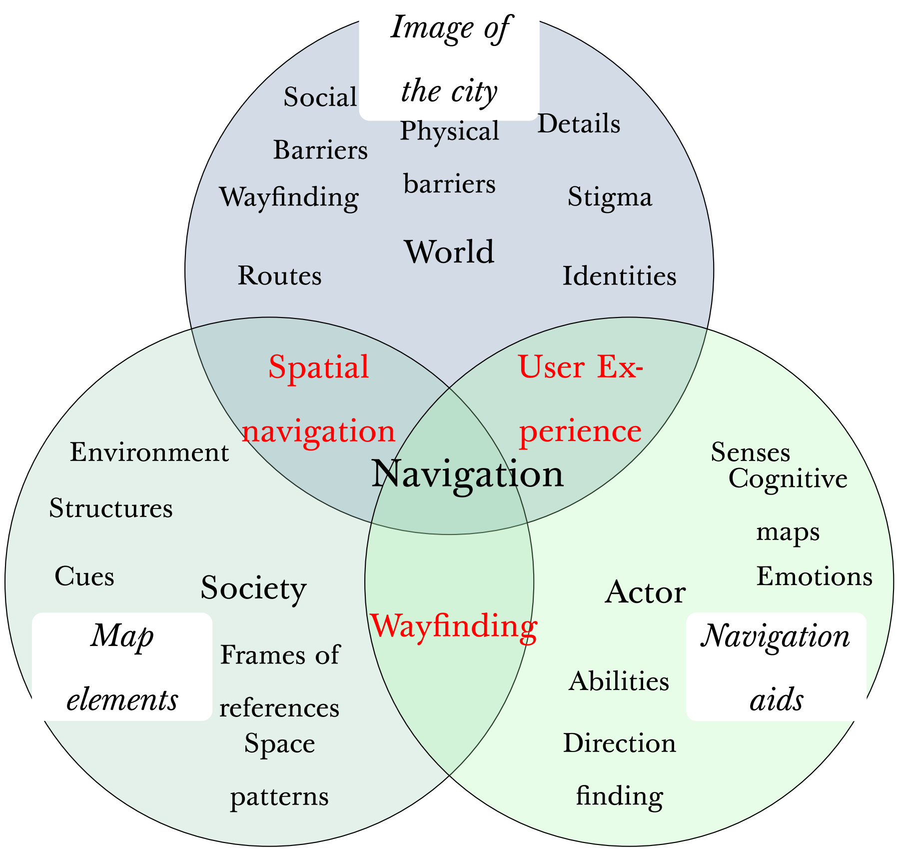


FIGURE 2.2: Subcategories with general categories

3 Literature Review

3.1 Spatial Navigation

There are three aspects of navigation, how humans navigate (spatial navigation), how humans navigate with using navigational aids (navigation), how humans navigate in environments (wayfinding), with physical and social barriers (stigma, emotions). Spatial navigation is to know where you are in relation to the environment(Burgess, Maguire, and O'Keefe, 2002).

Cognitive scientists have discovered that humans and animals can depend exclusively on their affordances when they are travelling in familiar routes. The theory is that navigational and spatial patterns are stored in long-term memory and a representation of a cognitive map is created in the short-term memory(Burgess, Recce, and O'Keefe, 1994).

According to Statistics Canada (Canada, 2019) people who are sixty-five and older are the %9.7 of the Canadians with seeing disability. Alzheimer patients have difficulty using long-term memory, which is why they frequently become disoriented. Cognitive scientists conducted spatial navigation studies for Alzheimer and epileptic patients (Davis, Ohman, and Weisbeck, 2017; Lithfous, Dufour, and Després, 2013). Humans use less cognitive skills when following routes than exploring new ones, as shown by a virtual reality driving game (Lin et al., 2009). Humans have two modalities for completing navigation tasks: active working memory and visuo-spatial memory, which can be used sequentially or concurrently. Passive tasks are the ability to use a familiar pattern, the ability to remember locations, and perceive orientation in an environment. Active tasks are the ability to recall or recreate a visual memory of an object or an environment (Cornoldi and Vecchi, 2003). Humans move based on their reasoning; they define their mood, tasks, and use emotions, whereas animals move based entirely on senses, instincts and consequences in a survival manner (See figure 3.1).

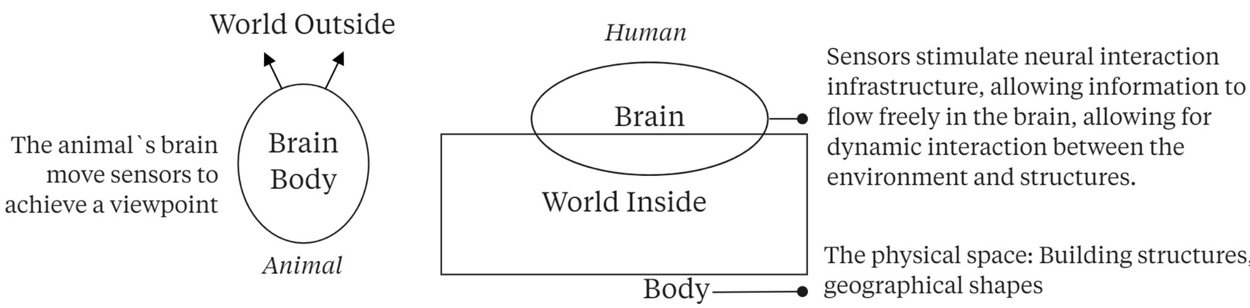


FIGURE 3.1: Animal thinking compared to human thinking - Adapted from (Arbib, 2021)'

Neuroscientists, O'Keefe and Dostrovsky (1971) has discovered that spatial navigation occurs independently of cognitive levels. The model illustrates that the animal brain operates independently of thoughts and perceptions at all times during spatial navigation. The parietal lobe controls senses of space, position, and movement with four types of cells. Place cells gives positional and dimensional cues. Grid cells form patterns from self centered motion cues. Head direction cells store self orientation. Border cells stores borders between places. Burgess, Maguire, and O'Keefe (2002) and Arbib (2020)'s improved Affordances Taxonomy and World Graph(TAM-WG) model (See figure 3.2) emphasizes two forms of navigation. When humans are travelling to places, they may either think of locations creating a mental cognitive map or they may choose to follow a familiar route exclusively from their thoughts by depending on their senses and affordances.

Cognitive scientists argue that spatial navigation and cognitive maps takes place in two separate regions in the human brain (Burgess, Maguire, and O'Keefe, 2002; Arbib, 2020). Long term memory stores navigational cues from personal frames of references in the hippocampus, whereas cognitive map process the in the visual region where it combines it on a cognitive map Arbib (2020) refers to cognitive map as "an ordinary map of a user."

When travelling down a straight path, a human's basic navigational ability is to divert their attention and filter the environment. When a journey begins, the major functions of cognitive space become emotions and sensations. The brain's visual cortex produces a mental image of the environment in the case of an unfamiliar place (Logie and Sala, 2005). To follow familiar routes, humans rely on their long-term memory (Guazzelli et al., 1998).

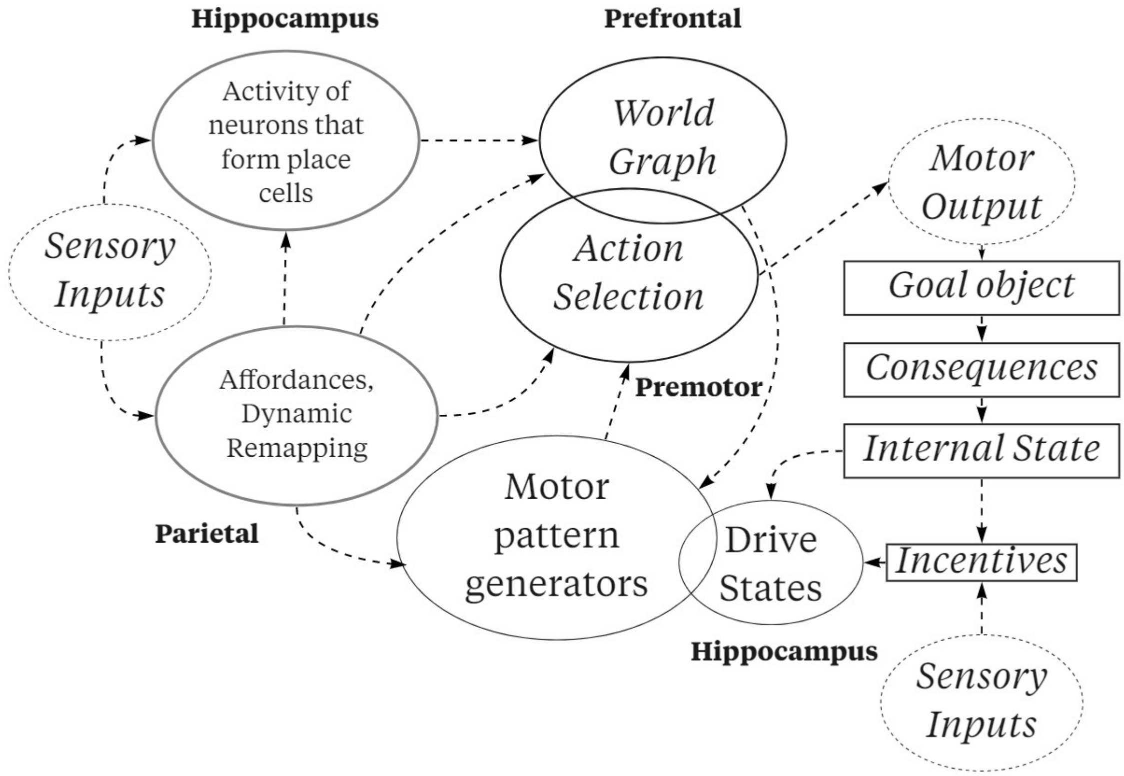


FIGURE 3.2: TAM-WG model for Spatial Navigation - Adapted from (Arbib, 2021)'

Human sensory inputs and behavioral outputs are linked with thoughts, which leads to revise journey routes. According to (Arbib, 2020) there are two states; internal and external. During a journey, internal state is considerations and consequences. External state is the way a person act in the real world. In the event of getting lost, a person refreshes his thoughts and creates a cognitive map from using both short-term and long-term memory (Klippel, 2019). In the event of getting lost, humans use their spatial representations to remember previous locations. When humans try to remember a location, they start with landmarks to create distance and orientation relations of locations. The prefrontal visual cortex encodes the distance relationship of familiar locations in wider real-world context, with the visuospatial imagination of a cognitive map (Burgess, Maguire, and O'Keefe, 2002)

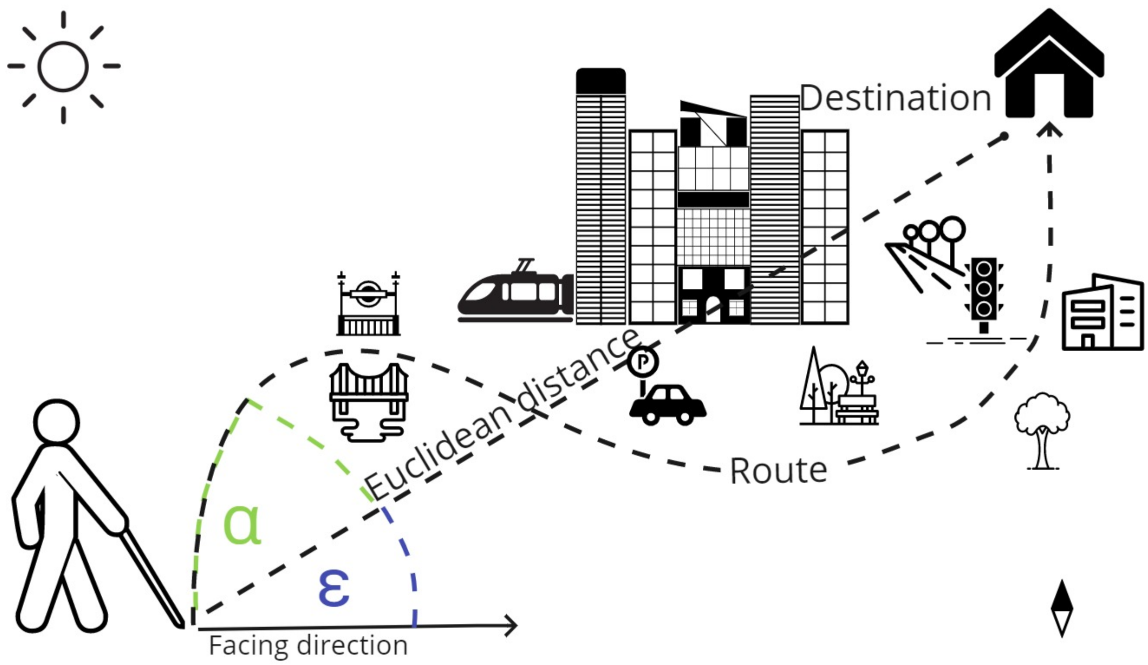


FIGURE 3.3: Author's interpretation of mental models of Allocentric and Egocentric frames

Humans have the ability to create cognitive maps using two frames of references. A person's placement and orientation to a landmark is an egocentric, whereas estimations between two landmarks are allocentric representations (Ekstrom et al., 2018) (See figure 3.3).

Between a traveller and a destination, there are four spatial relationships (Arbib, 2020; BurgeSmani and Wheelwright, 2004; Epstein et al., 2017). Allocentric direction (α) is an angle between a fixed direction and the euclidean distance. Allocentric directions are used to calculate distances between landmarks by determining their orientation using another point of references to guide us. Egocentric direction (ε) is angle between the traveller's facing direction, and the euclidean distance. Euclidean distance is the shortest line connecting a place. A route is a course that explains the direction a traveller will take to reach a destination.

To know a distance and orientation to a route or location, both egocentric, and allocentric representations are used. Allocentric cues are external cues with spatial features that helps with orientation, examples are cardinal directions, the sun, a train station facing north or a river facing east, or a taller building visible throughout the city. When humans travel, they remember traces of a route from optic flow and proprioception cues (Lithfous, Dufour, and Després, 2013; Knierim et al., 2006). Egocentric cues are directional and orientational indicators from one's own perspective with the environment (Burr and Gori, 2012). .

Humans collect multisensory information from landmarks and store in long time memory to build routes on a cognitive map. Route integration is a technique for identifying a sequence of directions and orientations based on recent spatial movement cues. A cognitive representation of a route is egocentric since it uses the body of the subject as a reference (Arbib, 2020).

When the environment is unfamiliar, humans can easily loose directions; turn-left or -right directions may lead to disorienting from the route (Chiesa et al., 2017). Our sensory skills help us remember essential points of interest and draw a route. Throughout the trip, humans align themselves with the destination's route orientation in order to reach the intended goal. To guide bodily movement through space, allocentric directions are translated to egocentric directions. (Spiers and Barry, 2015). When taking a route, the environment becomes less important because humans are constantly following the route with an attention of familiar patterns and self movement (Ellard and

Ellard, 2009).

Cognitive scientists studied human spatial navigation and established a scientific knowledge of spatial navigation. Golledge et al. (2000) classified cognitive maps into three categories. Route acquisition via publicly available sources, perceiving and visualizing the route in a wider context, and linking the route to a network that links to larger networks (ibid.).

When examined with (ibid.)'s description of the cognitive map, the research by cognitive scientists exposes uncovered areas for example when the description of a given direction is ambiguous, for instance when the description is verbally described or if in the case of travelling between countries or following nature trails. Despite their lack of vision acuity, VI people can use the sense of self positionining and creating spatial images between locations in the same sense as sighted people do(Cattaneo et al., 2008). Spatial navigation research for VI is limited, and neuroscientists are still learning about applying to solutions for Information Technology (Arbib, Ngoon, and Janes, n.d.).

3.1.1 Wayfinding

3.1.1.1 Definition

Navigation, as opposed to spatial navigation, examines the use of navigational aids and the environment setting, whereas spatial navigation is concerned with human affordances and direct reactions with environments. When travelling, navigation is the general name for the using the methods wayfinding and spatial abilities (Montello and Sas, 2006). Navigation term was used by sailors for following a route. They sailed around coastlines and followed the skies to find a way back to their ports.

Wayfinding, in contrast to spatial navigation (which focuses human's internal state and external behaviour) is about the outside world as where the human lives in and how humans interpret it. Wayfinding includes a strategy and reasoning and it is used in several domains (Arbib, 2020; Golledge, 1993; Lynch, 2008).

> Wayfinding is a self-intentioned, self-directed, and self-motivated navigation (Golledge and Klatzky, 1996).

Geologists see wayfinding as the capacity of a person's cognitive and behavioral abilities to find their ways in environmental structures (Golledge et al., 2000). During travelling, it is used as spatial information to determine the route between locations. According to Golledge and Klatzky (1996), humans advance in wayfinding by actively learning and thinking about the egocentric and allocentric relationships.

3.1.2 The Image of the City

Spatial navigation focuses in human perception, as opposed to Lynch (2008)'s theory where the environment is dominant. He explains wayfinding as reflecting the city's original functions. In Lynch's framework wayfinding cues are being constructed from the image of the city. Wayfinding becomes a culture in within the environments and people and society will learn and adapt to its architectural and contextual changes. While innovations in technology and engineering enhance the design of cities, it will also change what we used to know.

This concept may conflict with Goffman (1986a)'s stigma theory, because a moderately impaired person walking through electronic sliding doors may cause a stigma about disabled person, as a stigmatized person does not want to be recognized because it causes anxiety about their appearance.

Lynch (2008) sees wayfinding an act of an individual, when wayfinding, a traveller can attach his knowledge, other than simple instructions to a location. Lynch's theory includes institutional and social model of an image of the city constructed from a person's perspective. Lynch (ibid.) argues that a city is more than it's landmarks, routes and districts, its a social, cultural and geographical activity. Lynch explains how humans are oriented in a world designed for them, and human knowledge that includes the use of symbolic signs, diagrams, maps and tracking devices is the heuristics of wayfinding. The problem of VI wayfinding in the city can be explained with the lack of understanding of the city's image. Lynch refers to visual experiences when referring to navigational cues although Lynch also uses the term ”reference of frame” (ibid.) where we can assume human beings carry their emotions with them when they are travelling.

According to Lynch (ibid.), people discover wayfinding within the city's image. The city has five forms, routes, edges, corners, nodes, districts and landmarks (See 3.4). Lynch (ibid.) describes the wayfinding methods in urban places are systematic and visual.

A journey begins with a route and how the traveller interprets it.(Golledge and Klatzky, 1996). Therefore, the most significant asset in developing a a journey is the route, which is a decision-making process that creates the sequence of locations and orientations that make up the route.

In the city there are districts, edges, nodes and landmarks. Districts are abstract territories that may be recognized both from inside and outside. Routes are paths that have trails of human traces such as streets, sidewalks, coastlines a traveller takes into account.

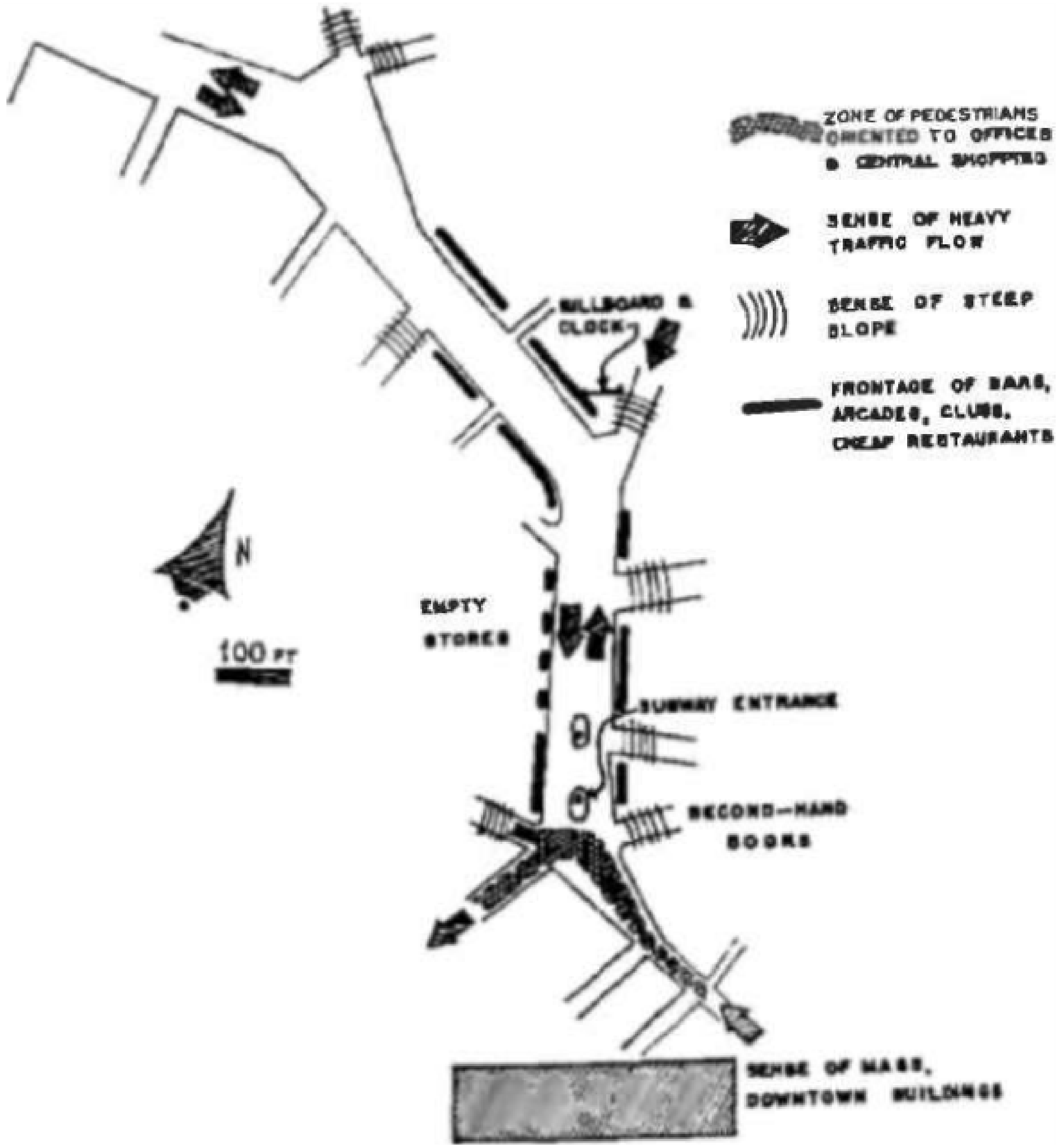


FIGURE 3.4: Visual elements of Scollar Square (Lynch, 2008)

Edges define geometry, such as the corners of buildings. There are two types of edges: barriers and walls that restrict mobility and long edges with sufficient area to follow as a path.

Nodes are intersections of cities where two routes intersect. Crossroads, clusters, street corners, and city squares are all considered nodes. Nodes can be found at local gathering places. Lines are linear components which interrupt continuity between nodes, for example, beaches, railroad tracks, development edges and walls.

Landmarks are what travellers can read and build based on their knowledge. Lynch classified landmarks into two categories. Distant landmarks can be seen from a distance, such as tall buildings. Local landmarks are nearby signs, symbols and signages, door frames, and city elements such as crossroads.

3.1.3 Environments with a meaningful sense

Navigation occurs in contextual environments. Sensory characteristics and structural aspects of structures impact the accessibility of finding a path around them. Knowing where you are (self-orientation) is a continuous phenomenon in navigation (Arbib, 2020). Find a route can be an issue when we attempt to bypass boundaries. In terms of navigation, the interplay between the city's elements is critical (Lynch, 2008).

When navigating in an environment, we begin by accumulating spatial information and structural representations that are compatible with our existing environmental knowledge. To navigate, we combine all of our senses, such as vision, hearing, touch, and sensory motor or proprioception. Environmental awareness is achieved through the environment and our senses while moving through an environment (Raubal and

Winter, 2002). When we travel, we observe three important pieces of exterior information; access to the environment, geographic knowledge, and barrier information (Golledge, 1993).

Roads and trails are designed to lower the cognitive load for travellers (Pigeon et al., 2019). Some of the environment choices offer rich attributes, such as a busy downtown corner, while others, such as a desert, have none.

The appearance of a landmark is measured with its attractiveness. The sensory characteristics are shape, color, visibility and texture (Raubal and Winter, 2002; Brodbeck and Tanninen, 2012) The significance of a landmark based is determined by on its resistance. As the resistance increases, it becomes more visible (Kallioniemi et al., 2013). A landmark can be find distant locations with distant senses such as vision and auxilary sense.

Norman (2004) describes the wayfinding experience is the person's reflected view of the world, what they know and how they perform, environments include the people, the technology that they are interacting.

Environments may be analysed using (ibid.)'s emotion design model.

A visceral environment is similar to an embodied experience. Pleasure is the emotional criterion for a visceral environment, as is the inner self of being happy while anticipating perfectionism.

Students in geography developed a series of workshops (Sensory of geographies) (Morris, 2020) to better grasp the embodied nature of route-taking. Students evaluated positive and negative elements of geography when they created a sense route with its multisensory elements. The findings indicate that multisensory landmarks are considered as genuinely meaningful reference points of routes.

A behavioral environment is when we can compare with the integrity of design,(Gestalt) organized roads and structure, as shopping malls. A reflective environment can be compared with the social perspective of different cities, where we feel special because of the multiple identities we create.

3.1.3.1 Strategies Tools and Processes

Wayfinding employs many strategies such as going from one landmark to another landmark, spatial exploration, imagination of the positioning of landmarks and routes, and most traditionally the user of celestial compasses.

According to Lithfous, Dufour, and Després (2013) Humans travel in three stages: first, use previous knowledge from perceived sensory cues from locations to build position with the location, discover the route, plan a sequential route from significant landmarks, and create a larger network of routes; second, use previous knowledge from perceived sensory cues from locations to build position with the location, discover the route, plan a sequential route from significant landmarks, and create a larger network of routes.

Geographers Golledge et al. (2000)discuss that cognitive mapping makes use of both long and short term memory to figure out how to get somewhere. Allen and Golledge (1999) characterizes wayfinding with two objectives; oriented search, which follows a predetermined path, or exploring for a landmark in all directions. Humans are more inclined to navigate through surroundings based on existing knowledge. When it comes to navigating in unfamiliar areas, knowledge and experience play a significant role.

The efficiency with wayfinding in unfamiliar environments is an ongoing research area in architectural design. Travelers were requested to make maps after getting to know an area in order to better understand their environmental cognition. Travellers identified a variety of environmental information, such as color schemes, spatial landmarks, spatial distances, plan configuration, signages, text and numbers they observed in unfamiliar environments (Baskaya, Wilson, and Özcan, 2004).

3.1.3.2 Abilities

Allen and Golledge (1999) defines visualization, speeded rotation, spatial orientation as navigational skills. Visulization ability to see and learn new places for wayfinding, Speeded rotation is the ability to create a a visuospatial cognitive map. For instance, a path is to the west and the building entrance is to the east. The capacity to know one's own direction towards objects is referred to as spatial orientation. Suppose the building's entrance is to the east and you are looking north.

Humans rely on their capacity to navigate in both left and right directions. The ability to predict the position of an object from a body relative directions is known as spatial orientation (Golledge et al., 2000). Persons use spatial orientation when referencing global landmarks such as a tall building or cardinal directions. This approach makes a person aware of and guided by the global landmark.(Golledge and Klatzky, 1996).

Wayfinding is a cognitive process that varies based on the person's ability and perception. (Allen and Golledge, 1999). People may choose to walk between places or other means of travel, depending on the qualities of the environment and their capabilities.

Another point to consider is that spatial architecture and unique environments are not always viewed in the same manner (Lynch, 2008; Norman, 2004) (See section 3.2.2 for Norman). A scientific observation is that men and women have a different sense of landmarks when it comes to spatial orientation and navigation; women search for landmarks more systematically, while men interpret geometry and other visual indicators for their wayfinding (Erdemli, 2018; Mendez-Lopez et al., 2020)

3.2 Multisensory navigation

3.2.1 Missing sense: Vision

Effective navigation involves the use multisensory sources of information. In an event of going to a familiar destination, most of these information is filtered because we navigate with a goal of following destinated path (Guazzelli et al., 1998).

When we are unfamiliar with an environment, we try to remember the visual, olfactory and physical and multisensory characteristics of surrounding objects (O'Callaghan, 2016). They can be considered as directional cues or intersection points, which is connected to our position by routes. Sounds or smells have a big influence on how we recognize and experience places in long-term memory (Cattaneo et al., 2008), whereas short-term visual memory recalls all visual linked forms, lines, points and visual characteristics such as color, layout and text or acoustic data reflecting the object's current location (Buzzi et al., 2011a).

Sensory cues can point to a fixed direction and they can be used as directional landmarks to orient face direction to a location. (Brodbeck and Tanninen, 2012). Visual perception can be used to locate objects that are out of reach of the touch and hearing senses. A person's visual recollection of the space around them, as well as their understanding of where they are in it, contribute to spatial memory (Morelli et al., 2020).

The combination of complementing senses and the use of multisensory landmarks helps to make the environment and the sites around us sensationally present (Klettner and Gartne, 2012). While spatial navigation requires the integration of input from a variety of sensory and motor systems (e.g., visual, tactile, and auditory), visual information is thought to be the most important cue (Gauthier et al., 2006). Visual perception gives sighted people a sense of how city structures are organized as cognitive maps (Golledge and Klatzky, 1996).

The functional senses, auditory, vision, and olfactory senses are used to identify sensory indications in the environment during navigation. To perceive spatial information our perception depends on depth associations of objects. Humans use both distal and proximal senses to get sense of the environment. In the case of vision impairement, tactile and haptic senses are used to identify closeby objects whereas auditory and olfactory senses play a role as auxiliary senses to contribute to the understand the environment with its multisensory context. Emotions and experiences have a part in the process of discovery (Norman, 2004).

The vestibular system in the ear is used for the recognition of self-motion and stabilization. From head rotation and linear acceleration, the canal system determines one's self-position (Mergner and Rosemeier, 1998). It's a standalone system that can work without the help of other senses.

Using hearing during navigation uses an attention-intented system, where the short term memory interprets the multisensory information in the visual cortex (Wallace and Murray, n.d.). There are less reference points to vision in comparison to vision auditory senses (ibid.). This reduces the ability to find landmarks for navigation. Environmental auditory indicators that are interpreted from echoes of walkyways to the sound of wooden, metal structures or the ambient noise help in the discovery of landmarks from noise levels (parks, railway stations) (Montuwy, Dommes, and

Cahour, 2019). In stressful circumstances, people do not focus on audio pulses that demonstrate emotions establish sensory barriers at the behavioural level (Mergner and Rosemeier, 1998). In a study (Baltenneck et al., 2012) hearing was the most useful modality for identifying events and allocentric locations when using a cane with tactile senses for VI travellers. The perceived sound level might be an indicator of a location distance. With hearing, environmental information in a single sensory modality that separates background and foreground (Spence and Santangelo, 2009).

Verbal directions are also a research topic for wayfinding. A route can be described by explaining its surroundings with rich and complex descriptions (allocentric) or described from the with a response to traveller's acting capacity to turn by turn based directions(Srikrishnan and Joshi, 2019). VI persons are interested to know visual occurrences around them, with rich verbal information, in details, size, color, distance. Details about the occurrences allow VI persons developing creating a mental image, including the imagery of the space and add to their experience. A narrative approach for explaning locations creates an descriptive wayfinding the experience better (ibid.).

Recent research presents that aural and olfaction interaction models can be used with Orientation and Mobility on maps to help orient a user's experience. Aural and olfaction interaction models with maps to help orient a user's experience for special needs (Kwan et al., 2016; Andreasen et al., 2019).

According to recent research, olfactory interaction is being used as a supplementary sense for indicating the quialitative information of landmarks (Ben-Elia, 2021) Smell was used to analyze for identifying sensory aspects of touristic routes (Quercia et al., 2015). Researchers studied the effect of scented and olfactory landmarks on tactile maps at geography classes for Visually Impaired (Brule et al., 2016).

3.2.2 Emotional wayfinding

According to cognitive scientist (Norman, 1990), people can distinguish between their thoughts and emotions and control their incentives through different levels. Donald A. Norman used three different levels of cognitive processing to describe emotions and emotional design (See Figure 3.5).

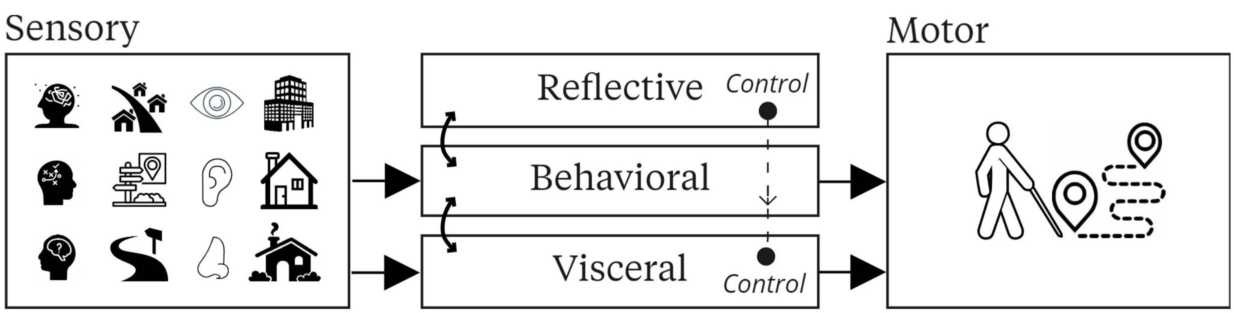


FIGURE 3.5: Author's Interpretation of Emotional Design's three levels - Adapted from Norman (2004)

Visceral level is the basic level that use senses and emotions to assess a situation and change behavioural level. to the fundamental thinking process of humans, where biological responses that include senses play a roleIt controls the natural activity of human body and motor skills. It occurs that emotions control human thinking and behaviours and change the way humans use their muscles.

Humans' senses and emotions contribute to their behaviour level. Humans use visceral to sense directions and behavioural to do simple tasks like walking down a corridor. Using the thoughts is an extra effort when following a familiar route that relies mostly on motor skills and senses.

Similar to the affordances taxonomy paradigm (Arbib, 2020), thoughts and activities are isolated so humans may concentrate on basic tasks. Behavior thinking occurs when we use our skills without reflecting on them. When a VI student walks to his weekly class, he can focus on the route by following familiar routes, using a cane to follow familiar patterns such as tactile pavements, and being able to isolate his attention.

Reflection level of thinking is isolated from the emotions and muscles. It's the state of being conscious and thinking about the choices. Thinking or planning a phase of a journey is a processing at reflective level.

Emotional design's design criteria for products is having functionality and shape, design and the look of the product that we use on a every day basis. Other than usability, satisfaction and attachment is an emotional advantage that boosts a users's mood. According to Norman, the physical design of a product increases its utility and user satisfaction. As a benefit of using the product, it should provide a pleasant experience. The feel of a product, regardless of its appearance, should not interfere with its outcomes, its usefulness; the design should enhance operability while still being appealing.

(Norman, 2004)'s theory explains user in product design, mentioning emotions, moods, and multiple personalities in the same manner with offers Goffman (1986b) that humans create multiple identities in multiple social groups.

Jordan (2005)'s definition for pleasure using a product differs from satisfaction element of usability standards of products's because design provides practical benefits over a product based on user control and his experience with the system's performance. Satisfaction is a metric that correlates user emotion ratings when with usability tasks (effectiveness, efficiency) (Nielsen, 1994). Using a product might be, for example, exciting, interesting, fun, satisfying or confidence enhancing. A computer game, for example, might be exciting and fun to use, whilst a stylish new dress may give the wearer a feeling of self-confidence.

A good product, according to Norman, must find the right balance between performance and satisfaction. Users prefer the enjoyment of items from three levels, each of which has its own pleasure qualifier. A product might be enjoyable due to a user's mood, user's emotional attachments, or products' functional features. A product may be chosen or used for a variety of reasons, including its functionality, appearance, and the image of the person. A product can influence a user's mood with it's emotional design. Using a product comes with product attachments that increase satisfaction, confidence, excitement and interest. Product design is linked to human thought and employs the three stages of the thinking process (See Figure 3.6).

$$VisceralDesign \longrightarrow BehavioralDesign \longrightarrow ReflectiveDesign$$

$$Appearance \qquad Pleasure, effectiveness \qquad Self-image, reflective, satisfaction$$

FIGURE 3.6: Adapted from Norman (2004)'s Emotional Design

Visceral design is the emotional reaction of a product. Product design elements, such as purpose and appearance, may generate emotional experiences. Sensory characteristics, form and feeling of a product will come with an enjoyable experience. A longer road decision could bring happiness and pleasure because of sight attraction.

A behavioural design is the logical design of the product. The usability and pleasure of a product is taken into account. When we get to a new place, finding a way to discover the address is a behavioural strategy.

Reflective design is concerned with the customer's self-image and his relationship to the outside environment. When selecting and using a product, reflective thought is required. If a person wants to attract attention by using a product, such as using a popular item, or if the product has a procedure that requires a high degree of thought to solve, such as tactile maps that give navigation. A decent map design must find a balance between practical design and and utility. A tactile maps should have a good visual design and tactile design. A good map design needs to aim for practical benefits and enjoyment, delight, gratification (Desmet, 2007) at the same time.

Norman (2004) addressed emotional responses with respect to the products, and he defined it by intercorporating one's environment. In a respect it is comparable to a traveller's experiences, as this research shows, that experience may simply refer to visceral responses but it was not obvious to have a greater understanding of three emotional phases. In the literature, however, the full spectrum of emotional design for wayfinding is not through (Norman, 2004; Norman, 2011).

A city's elements of Lynch (2008) may be analzyed from Norman's emotional design method. An emotional landmark can be visceral, giving a pleasant or negative impression, depending on the individual's senses and emotions. The actor model of Latour (1999) would be associated with the visceral navigation experience. When we follow a path, we use our senses to experience the feelings and pleasure that it brings. A visceral route might be a regular walk on a trail. Cities' edges can be visceral elements, such as the positive feeling about going to corner stores. A node might be a positive or bad example of a busy city centre that serves as the focus of attention. A positive example of a landmark is a beautiful city building with roman architecture.

The behavioural design of a landmark could be viewed from Latour's world view model because it is functional rather than aesthetic. It would be a matter of matching the city's image and layout. Borders, rivers, and bridges are examples of behavioural landmarks that define regions. A behavioural example of a city's edge is a junction where roads and walkways connect. A corner and an edge would help maintain the continuity of the city and give the traveller with instructions for the the city. Highways and main roads are a city's primary routes. A city's junction can be represented as behavioral highways. Highways may represent negative or positive traffic-related experiences.

It is observed from the actor's perspective since it is a self-reflection. An individual's image and confidence are enhanced at the reflection level of navigation. Reflective routes could be city streets, or roads where exploration and reflection take place at the same time. A specific street, an unknown meeting place, are reflective landmark experiences that might be pleasant or unpleasant.

3.3 Wayfinding for the Visually Impaired

3.3.1 VI Population

Eye doctors use a eyesight exam with the method of reading newsletters from a fair distance (See Table3.1) . People can avoid the use of glasses if they can read a newsletter from 80 cm distance (Colenbrander, 2013). At intermediate eyesight, people consider reading with glasses. Magnifiers or big print are used for reading by those with moderate to severe vision loss. For reading, people with profound vision loss require nonvisual, multisensory aids. Although near-blind persons lack vision, they can still perceive light and utilise vision to detect objects.

Level	Newsletter reading distance	Visual Acuity	Population (Millions)	Performance
Normal vision	160 cm - 80 cm (60” –32”)	20/20	441.5	Normal performance, with reserve
Mild vision	60 cm - 30 cm. (24” –12”)	20/40	188.5	Can perform most tasks with glasses
Moderate Loss	25 –12 (10” –5”)	20/100	217	Can perform with help magnifier, large print.
Severe Loss	10 - 4cm (4”-2”)	20/200	36	Slower performane, needs stronger magnifiers.
Profound Loss	Less than Between 4 - 2 cm (2”-1”)	20/500	826	Poor performance with the aid of maginifiers, multisensory aids
Near-blindness(Total Blindness)	2 cm -	20/1250	”	No visual performance; must rely on nonvisual means, can sense light
Blindness	0	0	”	No light perception. Relies on nonvisual aids.

Table 3.1: Levels of Visual Impairements - Adapted from (Colenbrander, 2013)

Visual impairment can range from being able to see objects close, distance or partly blind. A person’s capacity to see objects is called visual acuity, which is used for diagnosing a person with visual impairment. Visually impaired phrase is used if vision acuity is moderate to high (20/70 - 20/200). The word blind is used if there is less than 20/200 of a person’s visual acuity. Visually impaired people with severe to profound vision loss can use residual eyesight for mobility, but they are classified as blind in many countries. The table 3.1 shows levels of vision loss and their performance levels.

According to the World Health Organization, 285 million people worldwide are visually impaired, 246 million have moderate vision or less, and 39 million have severe loss and lower eye sight (Aziz et al., 2019).

In Canada %5.4(1.8 million) of the population (37.74 million) is diagnosed with normal vision and below levels (20/40). Of the Canadian population aged between 15 to 34 %6 have normal vision and below. Of the Canadians aged 35 to 64 %5.6 have normal vision and less. %9.7 of the Canadians 65 years and older reported with normal vision and less.

%77 Canadians is mild vision and above use eyeglasses to their correct vision, %26 needs stronger magnifiers to read, %18 can read large prints. %43 of the population with normal vision and less reported that their disability limits their daily activities.

%84 of this population is using one or more aids or assistive devices to travel (Canada, 2020).

Visually Impaired persons need to consider all the accessible information for transport, footpaths, accommodations, surroundings, and buildings. To complete a journey back and forth, they need to consider from a choice of routes, and whether to travel on public transportation, with a driver or by foot.

Engel et al. (2020) created a survey to consult the accessibility challenges for VI navigation. The participants were aged between 8-77 years old. The survey was conducted with one hundred and six participants with an equal division of genders. From 106 participants 43 participants had sight levels at profound loss(20/500) and belove. 63 participants had mild vision(20/40) and below. %63 of the of the participants used digital maps, %40 asked verbal descriptions from personal contacts. The main difference between the VI were that blind participants preferred to use sighted guides and used tactile maps more often than VI. This suggests the stigma's identification aspect. (See Table 3.2).

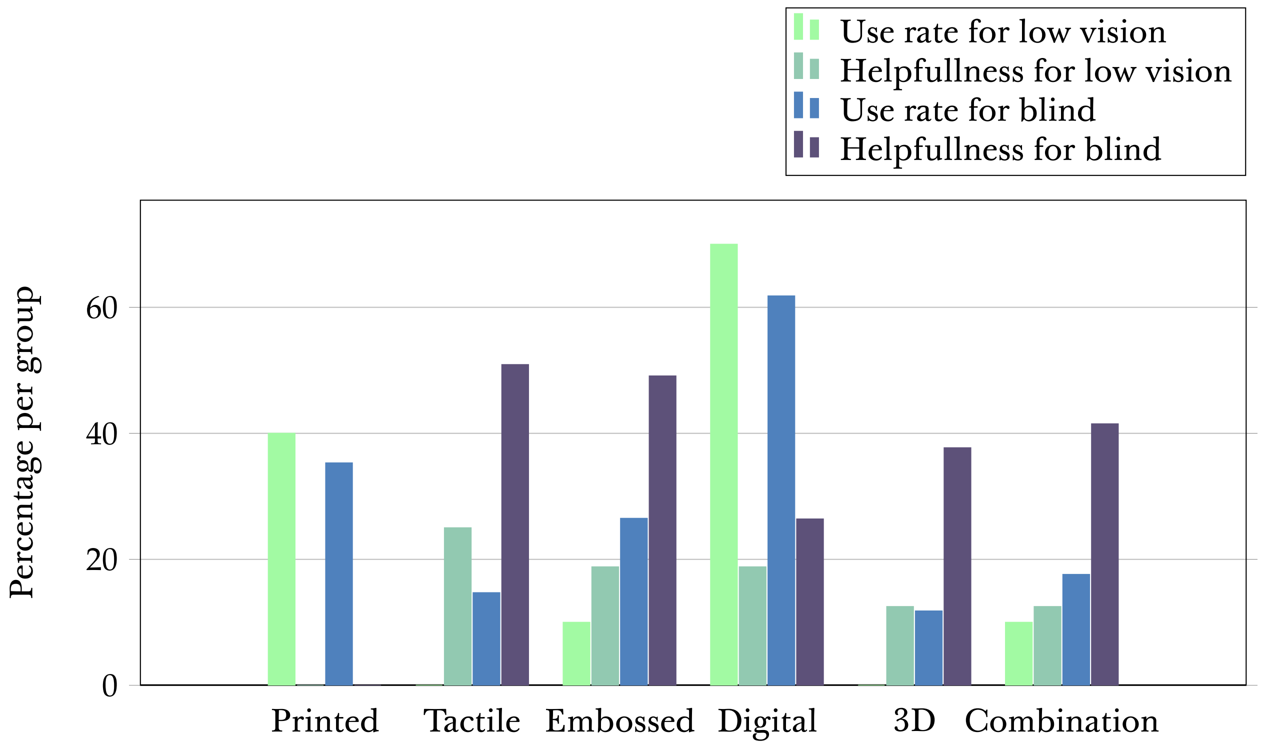


TABLE 3.2: Survey results of wayfinding methods for VI, adapted (Engel et al., 2020)

According to the survey (Engel et al., 2020), majority of individuals with low vision and blindness, rely on other individuals for instructions indoors. % 40 of VI people prefer asking the route to a guide prior to the journey. From sixty-four blind participants, tewnty-one of them have a sighted guide. Although asking for directions is the most common method of locating rooms or locations within buildings, it is not the most effective. The most preferred method was finding signs with textual descriptions from digital maps (%26 No vision, %10 Low vision), tactile maps (%10 No vision, %26 LV).

For the preference of maps, VI persons and persons who have no sight find digital maps useful but problematic for the use of blind people. Blind participants found the tactile and embossed maps helpful but not useful. These shows the gap for the design of tactile maps, digital apps for blind. Ongoing research created 3D model maps (Albouys-Perrois et al., 2018) and maps that use augmented reality (ibid.) to test with VI groups.

Engel et al. (2020)'s survey explains that VI persons with less than moderate sight(20/100 "legally blind") are using landmarks from those with physical and tactile properties such as intersections, doors, staircases, snack and drink equipment or accessible ramps and elevators (See figure 3.7). VI persons experience more architectural barriers as challenges than those with restricted vision (ibid.). Some examples of these barriers include missing signposting and labelling, missing speaker or voice technology on escalators, missing braille signs on elevator buttons. Insufficient lighting and signage lacking legible contrast also effect VI navigation in finding intersection points such as elevators, doors, and staircases landmarks such as parking lots, private places and temporary barriers, are problematic for VI persons (ibid.) (See figure 3.7).

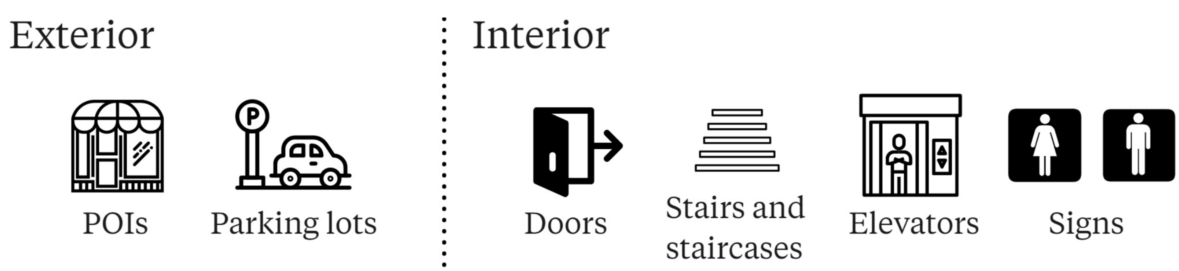


FIGURE 3.7: Authors interpretation of barriers and intersections (Engel et al., 2020)

Wayfinding signs must be accessible to those who are trained to use their haptic senses, for instance using braille, or using Assistive technology that provides auditory or olfactory feedback.

Labels and wayfinding signs could also be in braille for those with training to read it as braille. Audio or olfactory feedback provides an alternate method of sensory communication for persons who are unable to read braille. Another option is to increase flexibility by combining multimodal solutions with Assistive technologys.

3.3.2 Challenges

Early blindness creates differences in finding allocentric cues for wayfinding between blind and severely to moderately VI persons for space acquisition (Hatwell, 2006). Ruggiero, Ruotolo, and Iachini (2009) investigated the effect of visual experience on the capacity to build egocentric(person-to-object) and allocentric(object-to-object) spatial frames of reference. Early (congenital) and late (adventitious) development of blindness, short-term deprivation (blindfolded), and complete vision were compared with their method of wayfinding. Participants were given a spatial task that required them to make spatial evaluations of relative distance in regard to the subject or another object after a delay, requiring either egocentric or allocentric processing of measurement relationships. According to the findings, having access to object-to-object information improved performance, and measurement estimations between self to landmarks were more accurate than allocentric (object-to-object) estimations. Ruggiero, Ruotolo, and Iachini (ibid.) predicted VI individuals would score worse in allocentric estimates than sighted and partially sighted groups, but they did not predict significant differences in egocentric estimations.

VI persons that are VI use routes, but they struggle to locate allocentric navigational directions when given step-by-step instructions. When navigating, persons who have profound level of vision and less employ an integrated visual representation of spaces as visuals as information, instead depending on self-motion (Garcia et al., 2015).

Casey (1978) investigated how VI individuals used complimentary representations of navigational information, comparing methods of maps and verbal communication. Participants were given embossed maps with markers on them representing locations and actual structures for VI individuals. A navigational study for VI persons was created to better understand the sociocultural issues of VI. The most difficult part was directing the participants about the location of allocentric destinations in relation to one another. With given directions, the majority of the VI who had less then moderate sight participants adopted their egocentric direction rather than a following the directions for allocentric directions. Cattaneo et al. (2008) created study to conduct the correlation of survey-like and route-like tactile maps for VI and for sighted individuals. The participants with modarate loss and less did equally well with participants with less then profound loss with route-like maps.

Persons that have vision enjoy being independent and travel alone in their daily lives (Goffman, 1986b). Persons with visual impairments are critical of their public presence and their revealed identity (ibid.). A common strategy for people with vision impairements is to minimize their visibility in the society as a visually impaired person.

VI persons study an area or route, study an area to develop wayfinding skills (Brock et al., 2010; Golledge, 1993). In order to move independently and safely, VI persons plan ahead of time for new routes (Bandukda et al., 2019). Going to unknown places alone for VI requires planning with obtaining detailed qualitative information about the route and destination(Kueh, 2006). A study of experiences of VI in outdoor nature(parks and forests) alone, emerged the themes of interdependency, awareness of the environment, and sensory experiences (Bandukda et al., 2019).

Persons with VI must not only learn about a route before travelling to a destination, but they must also find accessible information and multisensory routes. A wayfinding design framework for mobile apps that has have five phases was built. To understand the VI needs, Kueh (2006) created a novel study for VI exploring in nature. There are five phases to create a wayfinding application for VI (ibid.) (See table 3.3). A journey for VI individuals includes a planning phase about their close circle, with whom they would be comfortable, to coop with and learn about a place before travelling. To distinguish the digital experience from a mobile app with environment, the research built a co-design with VI participants. During the planning phase, accessibility requires identifying entrances and spaces. The research was inclusive, with the concept that disability is a broad topic, and that persons with mobility issues, for example, may contribute to the map.The Engagement phase incorporates emotions and sensations; nature gives a pleasurable experience with navigation where VI individuals participate in activities. In a park field, ethnographic research was conducted. The researcher and a sighted guide were on hand to provide verbal comments. The lack of landmarks on the map's front end was an issue. One traveller said "There could be a screen you can touch it and it will show you where the cafes are or where you are, or there is a button to press that speaks." (ibid.) As recommended by Taylor (2005) cybercartographic applications for the blind can provide the map in various phases for each location to optimize the landmarks and display the key areas of a map sequentially.

Stage	Needs	Challenges and Strategies
Plan (PL)	• Where am I going? • Who am I going with? • What will I do there? • How will I get there? • How will I meet my friends there?	• Rely on sighted family members and companions • Use accessible navigation and public transport apps to plan their journeys
Access (A)	• How do I find the entrance? • How do I get to the areas I need to go to? • Where are the facilities (e.g. playground, café, auditory wayfinding information in parks. toilets, cycle rack, car parks? • How do I avoid falling?	• Challenging to access parks without sighted help due to the lack of tactile and auditory wayfnding information in parks • Prefer small size parks or no-fenced parks to overcome entrance and orientation challenges.
Contribute (C)	• How can I contribute to the plan? • How can I help others to access? • What abilities I have to ofer to others? • How can ensure all have exposure to an outdoor experience?	• Want to be part of the decision-making and sharing abilities with people with other disabilities.
Engage (E)	• What's around me? • What plants and animal life are in this space? • How can I make sense of the nature around me? • How do I build rich multisensory experiences?	• Rely on companions' visual sense to build mental pictures of their surroundings • Explore their surroundings through auditory tactile, and olfactory senses, helped by their sighted companions
Share and recollect (S)	• How can I capture the multisensory sensations and share them with others? • How can I share what I've learnt from my experience with other BPSP to help them plan?	• Desire to share their experience further with other BPSP and publicly over the internet but faced accessibility challenges. • Capture nature sounds for personal recollection and sharing with friends.

Table 3.3: Kueh (2006)'s SHAPE Framework

3.3.3 Abilities

For VI persons , touch is their primary sense when wayfinding and using maps (Garcia et al., 2015). In addition to asking to passersby, when lost, VI individuals can efficiently use location-based map applications on mobile devices to find the appropiate routes. People with visual impairments, like sighted persons, can ask passersby for directions if they get lost (Engel et al., 2020). Similar to the majority of the population, VI individuals use digital applications for learning a route to prepare their journey. They plan their trip in detail in terms by learning routes for getting directions for indoor and exterior locations, and they use tactile and braille maps to learn the tactile guideline routes (Bandukda et al., 2019). In addition to planning for a route, individuals with VI, before their journey, consult sighted guides for directions (Engel et al., 2020).

Touching is the sight of a blind person, it is to know what's around him, and what they rely on, it the sense of curiosity of wayfinding (Michalko, 1998). VI use white cane and touch techniques when receiving tactile and feedback from the tactile pavement to follow trail guidelines and pavement structures, but they are unable to orient themselves to the goal due to a lack of allocentric information. (Shah and Miyake, 2005)

VI persons use the ground's tactile structure when travelling. The cane primarily responds to haptic feedback, but it is also used also provide aural feedback about the floor's material (Due and Lange, 2018). Sensory characteristics available to someone with an extended body reach via touch, as well as distant senses like sound and scent indications of location. Specific landmarks involved in orientation when travelling in urban and non-urban environments are stored in their memory .

As knowledge creates better navigation, VI travellers use tactile maps to aid their cognitive maps to follow studied routes during a journey. Maps are used as navigation aids to prepare for travelling for VI population (Buzzi et al., 2011b; Calle-Jimenez and Luján-Mora, 2016). Research shows that map guidance was used by mobility and orientation professionals to help visually impaired people identify routes.

VI travellers use wayfinding strategies using their proximal senses, to follow routes, and distal senses,to find directions from the environment. With tactile systems structures they cross the street, they may use hearing to hear things further to recognize as landmarks such as the sound of an audible fountain(Ntakolia and Iakovidis, 2021). VI can learn explore, ask someone, or use maps to learn a location prior to travelling alone (Due and Lange, 2018; Engel et al., 2020) although learning about an takes time is slower and requires more effort with the use navigational aids. VI people with spatial navigation obstacles can learn spatial navigation methods with cane. Orientation and Mobility training for the VI. Depending on their vision acuity, (See 3.1).

VI individuals use their other hand to orient themselves on edges and follow a straight familiar route Tactile guiding system(Due and Lange, 2018). Like sighted people, blind persons may also use the environmental influences when travelling. Environmental influences include ambient sound, radiant energy(sun position), wind direction, and the sensation of the pavement (Cattaneo et al., 2008; Amedeo and Speicher, 1995).

3.3.4 Stigma

In ancient times, Stigmatism was a physical mark on a body for thepeople who are discredited from the society; currently, it is a metaphor for judging someone based on their identity and social aspects. Stigma is characterister in one's self or a sign seen from the outside. (Goffman, 1986b) describes the relation between one and one's own reflection from the perspective of the audience. Ordinary individuals, as well as those who are weaker or less-than-average. From the standpoint of the individual and society, defects such as diseases, statutes such as unemployment, or handicap will result in stigma. Other forms of stigma result from social vulnerabilities such as economic, racial, gender, and crime-related factors.

Goffman (1986a) believes that stigma is a result of norms established by people, society and the constitutions. Being blind is regarded as a physical disability, and it is associated with weak and in the need of help, with others who have poor status or aged. The image of a disabled persons is a harmless person who are incapable of looking after themselves (ibid.) .

The multiple identity theory of (ibid.) emphasizes that stigmatized persons prefer to build their own second identity, hiding their actual identity. Individuals are actors who adopt many identities in order to look more appropriate in social settings. Stigmatized persons create multiple identities of selves in consistent worlds, where they feel empathy. Stigmatized people have two identities: one in the outside world and one in their intimate social group. Stigmatized individuals make mates with other stigmatized people in order to form social engagement groups that are isolated from the outside world and the social institution. Individuals who know them in an ”every day sense,” such as blind people and their spouses, teachers, and school administration, make up the social group.

From a general standpoint, we are all stigmatized because we are always concerned with how we appear in society, and we want to present ourselves in the best light possible. Goffman (ibid.) defines appearance as a mirror of our own inner reality and existence.

In Diderot and Jourdain (1916)'s journal , a blind man imagines that he can extend his arms to a reach that sight has, then a pair of eyes, because he understands touch but not sight, and he is concerned about this ability because it will reveal the world and its barriers. A blind man says:

> I should think of myself a pitiable object in wanting those advantages which we enjoy, and that I should incline to consider myself as superior being (Diderot and Jourdain, 1916)

suggests that we should have empathy for them as people with VI, but admire them for their skills that are greater than our potential.

It is consistent with Goffman's "identity" hypothesis is that VI persons are cautious of sighted individuals wants to help them, but they have a desire to enjoy being independent. They are stigmatized and they have something to hide. Blind people have social circles where they know they are not criticised. Visually impaired individuals have constitutional custody in places like blind people's homes (Goffman, 1986b). Universities have orientation and mobility courses for VI (Abramo and Pierce, 2013).

3.3.5 Mobility aids

3.3.5.1 White cane

A white cane allows the individual to sense obstacles and around his/her surroundings. Vision impaired persons use touch techniques for scanning environments. There are various techniques and training for people with vision loss to be able to travel safely.

A cane is used as guidance and mobility equipment for visually impaired. Wayfinding, mobility, and orientation centres, such as *Orientation and Mobility (O and M) | CDE* (n.d.) , teach white cane methods and skills to those who have difficulties travelling alone. VI individuals use a cane to obtain tactile feedback from their environment and detecting Tactile guiding system and obstacles and travel to the best of their ability(Santos, 2009).

Tactile guiding system guide VI persons in urban environments such as travelling to a metro station. In the event of travelling in areas withour Tactile guiding system, tactile patterns on the pavements are used to assist VI navigate the use of sidewalks and stairs. Tactile patterns are blocks and domes. Straight routes are marked with blocks, whereas stops are marked with dots. Walking with a cane and detecting the roughness or smoothness of the surface to determine your position, such as the difference between asphalt and grass. Other structural surfaces, such as sidewalk edging and the rubber texture of tactile pavement, will identify two adjacent surfaces.

A VI person uses a number of methods when travelling with a white cane. These techniques are systematic procedures. When using the cane a rhythmic side-to-side technique is being used to clear the feet area from obstacles (Due, 2021). An auditory landmark can be used to provide allocentric direction. The side-to-side method is utilised when walking across open places. The cane can be used in this approach to walk in areas without tactile guidelines. Touch and slide technique is used to detect edges such as curbs and stairs. The tactile guideline system uses offsets to indicate 90-degree turns to help individuals follow the path. To follow braille guidelines for turn instructions and intersections, a touch method is being used. Walking on the ground with tactile guidance aids following a line with ground perception (Austin et al., 2020). To detect road structures, detect the height of curbs, or locate a sidewalk with tactile stribs, two point and three point methods are used.

When using the cane, visually disabled individuals move attentively and gradually, orient themselves to a waypoint every 40 metres, whereas visually impaired people self orient every 100 metres (Harper, 1998).

3.3.5.2 Value of Sighted Guides

VI person can consult others for directions to get to a place. The directions are given verbally about a point of interest or a destination location. Visually Impaired (VI) persons may request wayfinding information from other VI persons . In this care the given directions are more found more effective (Srikrishnan and Joshi, 2019). Despite the fact that it is a technique, blind people may find it hard to understand both written and verbal directions to a route or meeting spot (Santos, 2009).

When a person with an accidental vision impairment reveals his new identitiy, he or she may feel as if they feel under the impression of stigma (Hersh, 2015). Sighted guides are used as the most preferrable method for navigation in VI and blind groups (Engel and Weber, 2018) .

3.3.5.3 Seeing eye dogs

A guide dog (also known as a service dog or a seeing eye dog) is an assistance dog that has been trained to safely direct a visually impaired person to a location. Service animals are permitted anyplace that the general public is permitted in Canada. For the VI service guide dogs can create a less attentive travel. This way a traveller can focus on intersection points rather than depending on a guideline. Seeing eye dogs disattach the visually impaired from stigma and be more independent when travelling. while it attaches the responsibility that comes with owning a dog.

Worth (2013) highlighted that VI persons think service dogs are contributing to their navigation compared to white canes because VI do not have to concentrate on exploring and without pausing for wayfinding decisions.

3.3.6 Navigational aids

Golledge et al. (2000) categorized navigation aids in three categories; models, visual aids, and verbal aids. Models are tactual maps that maintain map features such as lines, forms, and structures Graphic aids are two-dimensional maps that use diagrams, graphics, sketches, and raised drawings to offer a tactile and visual sense of maps. Verbal aids are directly given or recorded audio directions for routes and landmarks are types of verbal assistance. It contains descriptions of routes, step-by-step instructions„ as turn left-right directions (ibid.).

When navigation occurs, a map is a convenient and transportable way to explore a new area. Because the map elements rely significantly on visual and tactile representations, making them accessible to a visually challenged population(Brock et al., 2010).

Vision impaired persons are capable of using non visual cartography, and creating cognitive maps that capture the relationship between themselves and objects either through cognitive or tactile maps(Santos, 2009).

3.3.6.1 Tactile maps

The most traditional maps for cognitive learning VI are tactile maps which is a hybrid application or sole representation of embossed, raised lines and braille techniques (Brock et al., 2010). . Tactile maps are processed sequentially, while visual maps are processed concurrently. Because visual systems are not multimodal, VI individuals must create a new organisational structure for navigating.

A spatial navigation test was conducted with 32 congenitally blind people and 34 blindfolded people. The exam was designed to assess spatial working memory The apparatus was a 5x5 wooden cube matrix (Heller et al., 1999) (See Figure 3.8). The targets marked on the different squares. The individuals blindfolded and VI (less than deep loss) utilised their fingers and maintained their finger in one matrix. It was requested that the first points of reference on the matrix be remembered. Second step was sliding the finger across the 5x5 matrix with following statements of direction. Proceed to the neighbouring matrixes by sliding forward or left after moving to a single matrix. Steps back to the previous location were then given. On the 5x5 matrix, participants were asked to identify their path.Participants in VI could effectively locate their paths by using touch on a single route. When compared to blinded participants, VI individuals were slower to recall be locations at a time. When asked to point to many places at once, they performed better than when they were blindfolded.

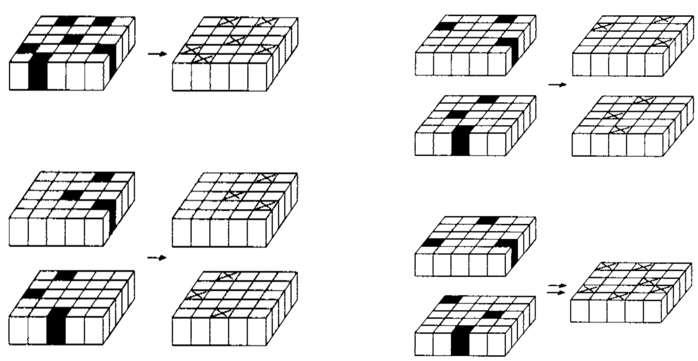


FIGURE 3.8: 5X5 matrix system for location memory (Heller et al., 1999)

A tactile map should be accurate, printed in large font, and labelled in both visual and braille. If the tactile map is displayed as signage or is put on a wall, the you-are-here icon should be the most prominent symbol on the map. It should point north with an arrow. A map legend is required to relate to textural and tactile symbols on the map. It is recommended to design a map for left or right handed users since maps include vertical and diagonal alignment of map components. Text may be used as a symbol to apply knowledge about the surroundings. For routes, a Tactile guiding system is used. The arrangement of routes and landmarks is consistent and continuous, with sequential fixed alignments. There are no elements that cross each other. Different materials, such as metal, are used as labels where there isn't enough area to place the naming, such as an indicator on a crossing. Grid systems for maps range from a two-dimensional X/Y coordinate system to a three-dimensional X/Y coordinate system (*Guidelines and Standards for Tactile Graphics* n.d.). (See Figure 3.9)

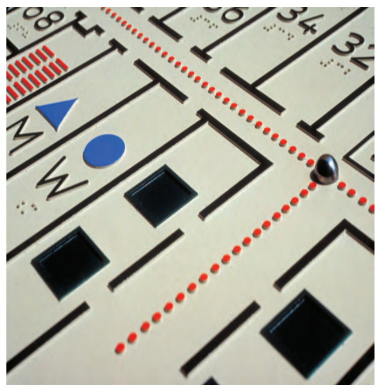


FIGURE 3.9: A tactile map of Lighthouse, NY (Chamberlain and Dieng, 2011)

A tactile map application, which can be interactive or tactile, enables VI persons to access spatial information and graphic elements on maps. VI persons , with knowing braille alphabet and using touch screen one can sense labels and navigate sites using tactile maps. A tactile map needs to be accessible, to do so it can combine a variety of complementing sensory or interactive features (Albouys-Perrois et al., 2018).

The main difficulty with tactile maps is considering how and what wayfinding information will be presented. Computer algorithms are incapable of detecting routes that we have previously explored by ourselves. Accessible maps offer the safest and fastest way but do not evaluate possible shortcuts as the environment changes. When the environment changes, the system is unable to take use of any shortcuts.

The tactile map uses four map components that describe urban plans as regions, borders, edges, and junctions. Areas represent grass, asphalt, pavement. Paths include sidewalks, streets, corridors. Edges are walls, fences, stairs, roads. Junctions are intersections, stairs, entrances, bus and metro stops. Although it is suggested that to use a universal sign for you-are-here indicator (D.R. Fraser Taylor, 2014), the use of icons and symbols are not used consistently in tactile map examples (de Almeida (Vasconcellos) and Tsuji, 2005).

A tactile map can be easy to navigate visually although it may be difficult to find a single object at a time sequentially. Icons must be available as multiple sets. Different sets are for a contrast between when labelling maps methodically. Symbols and labels should be simple and easy to understand. (Millar and AI-Attar, 2003)

Visual, tactual, and texture components should be used consistently across the map. Symbols must be clearly distinguishable from their context both tactually and visually Figure 3.10 shows a tactile representations of visual icons on a floor plan. On a floor layout, tactile equivalents of visual icons are shown. Previous icons seems to have been created by combining existing visual icons with semantic information. The exploration of the map is methodical for tactile map browsing. The form and width of lines become significant how they are connected and where they point. Symbols or labels should have enough space between them (3 mm, 1/8 inch) (Štampach and Mulíčková, 2016).

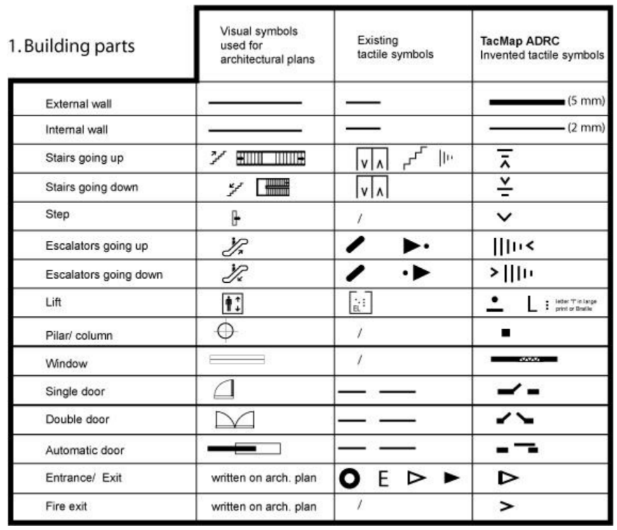


FIGURE 3.10: A set of tactile symbols (MDesRCA and Ma, n.d.)

A user can get confused when reading the map components. Tactile maps can be explored in two stages (D.R. Fraser Taylor, 2014). The first stage is to explore the elements of the environment. Second step is to create the map. A study conducted by Hamre et al. (2020) contrasted reading maps with and without route directions and discovered that people had a better understanding of relationships without the route directions.

Tangible research is being used in studies to look at the 3D models and tactile maps' interactions between VI and blind persons to understand the cognitive model for mapping (Ducasse et al., 2016).

Holloway, Marriott, and Butler (2018) explored 3D tangible maps by adding interactive audio labels to 3D tangible objects to test their effectiveness. The study compared 3D tangible maps to traditional navigation methods, using landmarks and labels with braille letters. The findings suggested that 3D maps with augmented audio can offer advantages over traditional maps.

In a classroom environment, researchers tested a preliminary map principles with twelve VI persons. (Holloway, Marriott, and Butler, 2018) evaluated combining a 3D landmark objects used on a 2D map. The use of 3D volumetric symbols and auditory signals considerably decreased locating time and identification inaccuracies on a spatial map (See 3.11).

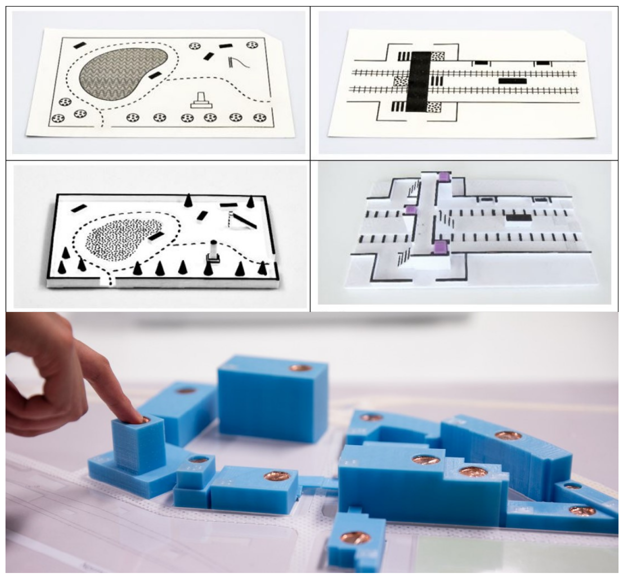


FIGURE 3.11: Comparison of traditional maps with volume maps (Holloway, Marriott, and Butler, 2018)

The results in the study indicate that 3D classic symbols and characteristics are more easily recognised than their 2D counterparts, models maps would be easier to interpret than tactile maps. The relative height of items in a 3D model may be easier to recognise and will provide a performance boost for activities that need this support. To build a detailed model using a 3D map, studying the area and adding the map elements with additional tactile and auditory components demonstrated an increase in satisfaction, usability and design (ibid.).

Ten congenitally blind and twenty blindfolded high school students crafted tactile maps of the school campus to investigate VI persons' cognitive mapping ability.

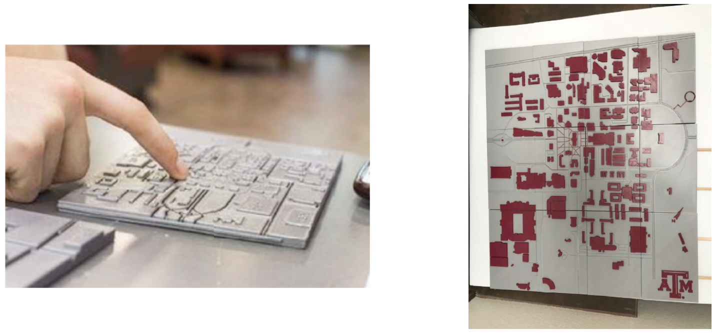


FIGURE 3.12: Portable braille campus map (Wilson and Wooten, 2017)

When the maps made by blind students were compared to those by blindfolded, the results indicated that while blind students may generate a complete campus map with the right sequence of things, the majority of the map pieces were disorganised and missing navigational components (Szubielska, Möhring, and Szewczyk, 2019).

The use of multisensory cues for an interactive map could be difficult to adjust. For example, olfactometers are used by researchers to interpret scent characteristics measuring them with frequency, intensity, and duration (Cunningham and Weinel, 2016; Jacobs, 2017). Researchers (Cunningham and Weinel, 2016; Jacobs, 2017) measured the effect of additional multimodal components in tactile maps when learning geography. Five cognetilly blind, three VI who had moderate vision(20/40) subjects used a tactile global map, that consisted of a custom tactile paper map with an overlay of a touch screen map. The map had landmark elements for recognizing smell or taste as a landmark. Participants encountered landmarks that were filled with food or scented fragrances while exploring the map. The feedback was provided with audio assistance.

The tactile world map was a custom tactile paper map with overlays during the prototype testing (See figure 3.13). Furthermore, VI children used tangible and scent objects as markers to learn about ocean's names with audio, such as the names of the oceans, audio cues and narrative recording of a surroundings. Findings showed that not only multisensory landmark assets could help VI children remember in addition audio can help the understand spatial data (Brule et al., 2016).

FIGURE 3.13: Tactile maps with tangible objects (Brule et al., 2016)

3.3.6.2 Visual maps

A visual map has simple, clear and distinguishable elements that helps to perceive the contents. The map information can change from public transport to sidewalks, traffic lights and crosspaths and indoor environments.

According to Golledge (1993), a map is a conceptual representation and visual representation of a geographical surface. The visual aspects of maps are represent the city's elements, landmarks, routes, edges, corners and nodes the (Lynch, 2008). Maps are creations of the constitution and of the institutions. Maps should be designed for people and their needs by using the frame of references from the city and a traveller (ibid.).

The size, value, texture, colour, orientation, and form of a map element are its visual properties (Taylor, 2005). Tactile and visual maps, as well as how they should be represented on maps, were investigated (See 3.4).

Graphic variables	Map variables	Tactile variables
Size	Area	Dimension
Value	Icons, text	Label, braille
Texture	Geometry	Texture
Color	Terrain	Elevation
Orientation	Pinned indicators	Landmarks
Shape	Environment	Facets

TABLE 3.4: Semiotics of elements in visual maps, adapted from (Palsky, 2019)

Labels are indexical symbols, which means that they don't have to match a meaning. When a user read a map he thinks about the meaning of symbols. For a sighted person, detailed visual information can be complex and overwhelming. A map element should be indicated with a less inductive approach. Icons and symbols should be built exclusively for visually impaired people (Santos, 2009).

The area of a visual map is generally two-dimensional, but tactile and model maps have three-dimensional elements. The third dimension distinguishes one region from another. The descriptive components, labels, icons, and text can be provided in their current form (Holloway, Marriott, and Butler, 2018). Blind persons are considered to be better at reading braille. Latin alphabets create a difficulty for those who are congregationally blind while they perform better then others reading braille letters

(Thevin et al., 2019; Holloway, Marriott, and Butler, 2018; Cattaneo et al., 2008).Typography contains spacing (kerning, leading), appearance (serif non-serif) criteria, whereas braille has only spacing criteria. The spacing and size of the dots must be uniform.

A visual map's geometry (edges and curves) is used to provide structural information about the area. Color is a diverse element that is provided in a number of ways as an elevation for the blind and colour impaired. The you-are-here indicator is used as a pinned indicator on both tactile and visual maps (MacEachren and Taylor, 1994).

The interface of digital maps were found problematic when compared to user interface criteria Khazravi and Karimipour (2012) and Nair and Smith (2020). Navigational, cartographic, and cognitive categories were used to assess digital navigation apps (See 3.5).

Category	Issues	Solutions
Cartographic	Location and orientation aware through geovisualization system functionality	A fixed local landmark (Rideau river) for smaller maps,
Cognitive	Lack of history, Lack of orientation cues, Lack of explicit coordinate display, Cognitive load of zoom functionality; Fit to screen.	Learn the important features of an area.
Navigational	Representation of information, Use of geographic features on routes, Labeling of routes, Match between map model and cognitive map, Interaction, Design.	Define route selection, Create user-oriented model from mental map, Design accurate and simple visualization.

TABLE 3.5: Cartographic issues of navigational maps (Khazravi and Karimipour, 2012)

The cartographic category includes the placement of the you-are-here sign. In digital maps, a fixed global landmark (north) is a standard. In smaller areas, global directives are ineffective. In smaller areas, a local landmark might serve as a second point of reference.

The cognitive category identifies issues of user experience and ergonomics. Digital maps lack history. A user browsing a map can not prevent an error in case of browsing a location on map. Landmarks are problematic because of the screen size. Zoom functionality can lead a user to lose his previous position. For the user, exploring a large area on a map is problematic. One solution is to create a map that just shows the important landmarks and routes for navigation.

The concerns with navigational components are visual issues. The problems are with the map layout and the arrangement of map elements, aesthetic aspects, as well as information design and interaction design. For route selection, the solutions advised using a design with the best amount and quality of data.

3.3.6.3 Cybercartography

The interactive atlas framework for cybercartography is a framework that focuses on solutions for orientation and mobility. The framework employs both actor and social world-based methods. Example of maps that use the world model were created by using narrative techniques to represent historical events. The information of narrative maps is presented in a variety of timeframes. Presenting a journey in stages ables to choose from scenes that optimizing and explorable map area with significant landmarks. An example of bringing the actor's viewpoint into design is a map (Nunaliit) that employs native cities names and native's ancient routes for indigeous wayfinding.

The cybercartographic framework promotes an interdisciplinary approach. The system uses both sides of the system to build meaningful representations and to create multisensory experiences. Its objective is to get a better understanding of the user's perspective in order to design maps from a social and cultural standpoint.

An ethnographic research with small groups is recommended to build a navigation aid for VI. It is emphasized that VI group's social networks, as well as how they discover places and have experiences, should be studied with empathy. For diverse minority(social) groups, qualitative mapping approaches were used. Cybercarographic maps are used as a social model for VI wayfinding, with sighted, visually impaired and blind user groups.

People travel in a number of ways, depending on whether they are unfamiliar with the area, depending on what they learned about the area, and their intentions. According to the three stages of the cybercartography concept, a journey is an engagement with what you know, perceive, and think (See figure 3.14).

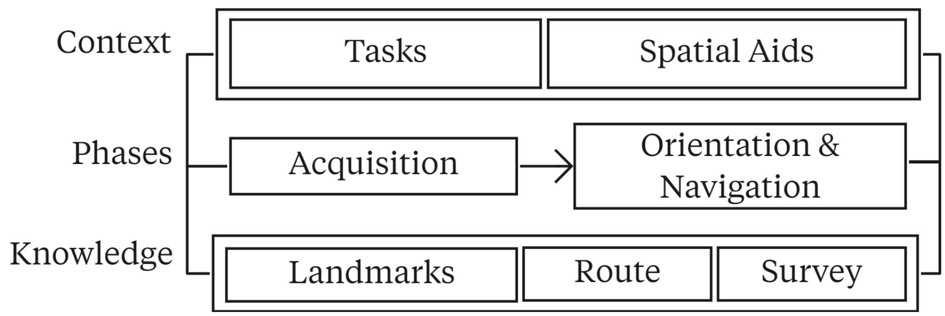


FIGURE 3.14: Conceptual framework of cybercartography adapted from (Taylor, 2005)

There are two types of tasks for navigation, open tasks are exploratory because we don't have a goal in mind. Closed tasks have a clear objective. Landmarks, route instructions, and cognitive maps are all orientation and navigation tools that aid in the acquisition of route and survey information (Taylor, 2005).

Landmarks are recognizable in an environment and easy to distinguish from their background. When people think of locations(orientation) or finding directions(wayfinding), landmarks are the primary focus of attention. When taking directions on a familiar route a clear design of a landmark can reduce the workload required to use of a mental map and in the same manner to read and interpret a real maps. Landmarks creates the structure of wayfinding information; when a person is lost, and start think of significant locations. Landmarks are noticeable cues that help with following routes, that are referred as nodes, points or pages.

Routes are created by connecting landmarks. If people travel with routes, they travel with a sense of embodied,centering their focus on wayfinding cues. A route's criteria is its readability, clarity, completeness, and convenience.

A survey is more than just a route; it's the entire experience that comes as a result of a journey. A journey to take public transport for example, would include routes, stops, transfers. Cybercartography recommends that map elements to be clear and distinct. Unclear representation of an environment creates cognitive load with active tasks (D.R. Fraser Taylor, Erik Anonby, and Kumiko Murasugi, 2019; Cornoldi and Vecchi, 2003).

Taylor (2005) describes social and technological challenges for VI communities and approaches as novel solutions. Sounds maps were created with cybercarographic framework for the VI. A map built with sound, according to Fraser, might be difficult due to the large amount of sources, thus it must be presented in small windows to filter sound elements (MacEachren and Taylor, 1994) . The suggested method is to combine audio and visual components to create hybrid maps because of the complexity of sound and its single dimension space. The cognitive load of map design is more noticeable for audio than it is for tactile.

3.3.6.4 Digital maps

In digital maps, researchers are addressing two accessibility issues. Accessibility problems for navigation & Accessibility problems for digital maps (Brock et al., 2018;

Froehlich et al., 2019). Digital media provides potential solutions for disabled persons as they navigate daily through a variety environments. Digital maps may serve as an effective planning application (Bolten and Caspi, 2019; Hosokawa, Yamamoto, and Nakazawa, 2015). A preview of a given location has many uses such as viewing the destination to anticipate obstacles or points of interest for pedestrians before going there (Erdemli, 2018; Hoelzl and Marie, 2014; Spoonauer, May 15, and Pm, n.d.).

Digital maps have features such as screen readers, which allow users to translate a visual environment to an audio format for visually impaired users. Digital maps therefore improve the capability of disabled people to traverse unfamiliar areas(Kandalan and Namuduri, 2019; Meşhur, 2013). The arrival of interactive digital maps in the recent decade provide an inclusive and accessible and multimodal solutions. GPS-based voice navigation apps are effective and efficient as route knowledge acquisition aids (Mai, 2015).

The use of accessible design of products is identifiable in the public. The Audiotactile (AT) Adaptive technology used are essential for their daily travel. Mobility aids such as a white cane brings an ironic or unusual image that creates embodiment with stigma. Unlike a white cane, apps are popular products that are inclusive, such as smartphones and tablets, have a positive image. From the society's perspective, the accessibility standards that institutes created to access public places do not appeal to a positive image to the majority of society.

Touch displays with multi-touch interfaces are available on mobile phones. It lets you to zoom in on a map using multitouch gestures. For commands to access the system's database, it uses speech to text as an input. When travelling on roads, mobile phones automatically detect body motion, record audio, and capture photographs.

These directions can also be approved using glsgps specifications. A braille keyboard is one way to use a mobile phone entry, while screen magnifiers are another. The screen of a mobile app allows for a multimodal design in which the visual data is combined with audio. Using gestures like rotating the frame on the map to navigate the visual components of a map can be exhausting. Using movements like rotating the frame on the map to navigate the visual components of a map can be exhausting. Mobile phones provide notifications in a variety of ways, including vibration, light, and sound. Sonification is used in hearing aid navigation to receive distant sounds by leveraging the depth of sound and alert sound to signal when approaching junctions (Doush et al., 2020).(See Table 3.6).

Communication direction	Interaction modality	Hearing	Visual	Motor	Cognitive
Input	Voice recognition	X	X	X	X
	Touch screen		X	X	X
	Voice to text	X			X
	Gesture		X	X	X
	Body motion detection	X	X	X	
	Braille keyboard	X	X		
Output	Text to voice	X	X	X	
	Display screen	X	X	X	
	Notifications	X	X	X	X
	Sonification	X		X	X
	Alert sound	X	X	X	X

TABLE 3.6: A Survey on Accessible Context-Aware Systems Adapted from - Doush

The primary issues for digital maps with touchscreen problems are is the visual presentation of maps on small screens (Poupyrev and Maruyama, 2003) For sighted audiences, a digital map was built as an emotional map. The map uses a visual tactile interface (Gartner, 2018) (See figure 3.15). Users were able to communicate their subjective relationships in particular using the app. Emotional reactions directly acquired from the user, with electronical physiology recording from wearables. Users could also share their emotions for others if they thought a particular place was happy, distressing, or practical while on a journey. This concept is quite similar to the emotional process of product development. In terms of primary and secondary users, it captures visceral and behavioural processing. During a journey, while the primary user keeps track of their feelings, the secondary users of the app can utilise the app for practical reasons, such as receiving subjective input from the route and analysing it using behavioural processing.

FIGURE 3.15: EmoMap keeps track of emotions- Adapted from (Gartner, 2018)

Recommendations: Enlarging text, Voice commands Head-mounted real-time text recognition

3.3.6.5 Accessibility of Maps

Disability is not defined by personal impairments but by the barriers people face in society. Accessibility refers to design of products, devices, services or environment for people who experience disabilities. Criteria and heuristics are created by expert evaluations to create guidelines and standards. Digital standards has been standards to support the social inclusion of Persons with Developmental Disabilities (Canada, 2018). Some criteria were beneficial to institutions for accessible construction requirements, but there is a social world side that highlights emotional challenges that disabled people confront in society. The integration of accessibility is progressing, but at a fair rate.

Assistive technology can help visually impaired persons with non-visual multisensory integration, in problematic areas; to get egocentric directions cues and to access allocentric information. People with vision can use maps to improve their visual memory to obtain knowledge about landmarks and envision their proximity. People who have no vision do not have a thorough representation of maps and landmarks, they acquire the information with audio and use buttons for landmarks and the application develops a route in relation to their position and the destination(Garcia et al., 2015).

The main objective of accessibility in the digital map area is improving visual user interfaces. The goal is to increase the inclusivity of the target audience with assistive auditory feedback, haptic and tangible interactions with mobile phones. The majority of visual-based research focuses on improving the accessibility of digital maps with screen-readers (Constantinescu et al., 2020).

Despite the fact that universal and inclusive design is primarily concerned with accessibility standards to be used and evaluated by screen-readers; accessible and spatial navigation studies are requirements must be carefully considered and focus on the VI persons ' abilities with their surroundings and environment.

Designers should examine an optimal system by focusing on what impaired persons are experiencing, and what they can achieve with information technology while also taking into account their abilities. Instead of considering disabilities as impairments, users' abilities should be viewed as using complementary senses and sensations. User's abilities and the surrounding environments are essential factors to consider with sociological factors and emotional design. To ensure that it is functioning and accessible to everyone, accessibility features and Assistive technology and Adaptive technology products should be designed with emphasizing the needs of people (Goffman, 1986b) and their emotions (Norman, 2010) and as an Inclusive Design approach.

3.3.6.6 Hearing aids

The majority of digital apps for VI persons feature auditory feedback for hearing spoken directions that only give navigational advice at predefined intersections. When compared to spoken turn-by-turn directions, SoundScape provides more frequent input on Orientation and Mobility (May et al., 2020). The beacon's signals are given in various tracks of audio layers to offer Orientation and Mobility cues towards the direction of a landmark and junction notifications using Three dimensional audio sound cues. Nair and Smith (2020)'s work is a different example of IT enviromental interfaces which can be used a game controller stick that allows hearing the items around by selectively using only the navigational game controller stick.

Microsoft Soundscape makes use of acoustic Beacon strategy to let VI identify hear the distance between landmarks through sounds. Participants were given a series of landmarks connected by line segments, allowing them to turn in a certain direction using navigational data derived from spatialized sounds around them. At landmarks, spoken directions are also given, recommending the correct orientation.

Audio feedback were used to test accessible maps on a mobile phone (Thevin et al., 2019). Developers used accessible web standards as criteria for assessing if the labelling of the map language and navigation features; if it is usable and functional for users, and if it applies Adaptive technology and Assistive technology.

A user commented about his experiences using the auditory navigation aid. The AT used two sounds of references, an allocentric cue that gives fixed directions and egocentric cues that are turn-by-turn based directions Assistive technology (McGill et al., 2020).

> The use of the beacons builds a richer awareness of the surroundings. By being able to scan directional spatial sound visual impaired users feel more independent and confident exploring the world beyond what they know.

When he was using auditory feedback system allowed him to follow fixed allocentric locations while listening turn-by-turn instrusctions on intersections. Being aware of the distance between landmarks, VI users feel more indendent and enjoy exploring their surroundings. It gives satisfaction when feeling the distal range of audio, because of the feeling of feeling independent. It is functional since it uses turn-by-turn based instructions and sonic waves for egocentric and allocentric directions.

Congenital Visually Impaired persons can travel without depending on their visual skills.

4 Gap Analysis and Insights

4.1 Summary of findings

Humans use cognitive mapping for solving wayfinding problems (Arbib, 2020). Significant landmarks form spatial relationships in our visual memory, which includes spatial relationships. Humans take route approach, and use turn-by-turn navigation. VI travel sequentially in the same way as others, but checking orientation more often then sighted. The maps for VI are designed in a very specific way for their travel. The map elements for the visually impaired is less aesthetic then visual maps.

Perceived spatial information creates a contextual meaning to the image of city (Lynch, 2008) could be more emotional, where the as a map design aids are behavioral, from a global perspective. In this review, understanding the function of cities and its elements (ibid.) and our role in terms of response to city features, elements contextually; subjectively or objectively (Norman, 2010) were analyzed.

How to view the world from the actor's and the society's view(Latour, 1999) depends on a person's identity (Goffman, 1986b). The main objective of both frameworks is to address such basic issues as how individuals experience environments, the way in which these experiences enter into' behavioral,reflective or visceral episodes(Norman, 2010), and the manner by which individuals establish durable relationships with their environments.

The attributes of the city are its elements. City structures are defined by society and institutions, we perceive the world from the world's point of view with its aesthetics, social and cultural factors and history(Lynch, 2008). When travelling in an area, environments provide social and structural cues for cognitive mapping (Hosokawa, Yamamoto, and Nakazawa, 2015; Lynch, 2008). Navigational aids cities elements for a general audience. Disabled persons navigate daily through a variety environments. Emotional apps may reflect emotional levels of a person taking routes, this cause may serve as a visceral wayfinding application (Gartner, 2018).

People will create their own identities as they travel and behave appropriately for the place of occasion (Goffman, 1986a) they will have moods, goals and consequences (Norman, 2004). In the actual world, navigation may be complex and but compatible, emphasizing users makes it possible to relate to emotions and consequences. The integration of maps as multisensory products can serve persons with impairments. People with VI plan and study their surroundings with the help of navigational aids in order to anticipate obstacles or plan for their travelling phases (Kueh, 2006; D.R. Fraser Taylor, 2014).

Researchers have examined maps for the user of vision impaired for spatial exploration. Researchers tested additional elements to be used with other senses. Such as landmark figures that could be filled with parfumes and mixed methods of using tactile maps with braille (Brulé et al., 2018).

Researchers looked at how vision-impaired persons may use spatial maps and spatial exploration. Tangible interaction was tested with different senses and found to improve efficiency of spatial exploration for VI. For example, landmark figures that might be filled with perfumes and tactile maps combined with braille(Holloway, Marriott, and Butler, 2018).

4.2 Key findings

When travelling, the most complex personal condition for vision-impaired people is being independent and relying on others for support (Goffman, 1986b). People who are visually impaired have access to Orientation and Mobility training for learning how to travel with the use white canes (Due and Lange, 2018), although research does not show evidence of a digital navigation application system designed for the use of cane. A VI person enjoys being self-sufficient and travelling whenever they desire (Engel et al., 2020) .

When help is unavailable, VI persons employ information technology to learn about an unknown area. They explore an area before travelling(Engel and Weber, 2018). Assistive technologies allow VI persons to travel independently. It has been proven to be useful for them to know how to read accessible maps with olfactory, auditory, 3D volume printed and braille features(Albouys-Perrois et al., 2018). Tactile maps are used on sensorial map elements and and sensorial routes with a visceral design, with narrative structure (Cullen and Metatla, 2018), sensory routes (Aiello, 2016). and maps with a visceral design (Albouys-Perrois et al., 2018; Thevin et al., 2019).

According to (Engel et al., 2020), using maps and digital media will help in wayfinding and planning for a travel for the VI. Current issue in design is how the city accessible maps(Nielsen, 1994). Recent studies attempt to employ accessibility in digital map systems (Biggs, 2019); research shows that tactile maps have accessible examples (Holloway, Marriott, and Butler, 2018). The interaction approach must be simultaneous and error-free, according to the criteria (Nielsen and Molich, 1990).

Although blind people may use their short-term memory, their visual perception is degraded. According to research, blind persons have good spatial memory of recalling an initial point of travel (Heller et al., 1999). According to research, vision-impaired persons who use conventional methods or digital assistive devices are still reliant on others because they lack access to sufficient information (Engel et al., 2020).

Cognitive scientists suggest a link between accessibility and sensations and emotions (Guazzelli et al., 1998; Morelli et al., 2020; Wallace and Murray, n.d.), however current IT research on practising wayfinding skills in response to sensorial cues is limited.

4.3 Interdisciplinary insights

Sociologists'(Goffman, 1986b) studies suggest that navigation is dependent on the existence of images, representations, districts, and scenes, which explains a long-term interaction that encourages learning and enhancing wayfinding interaction.

Cognitive scientist Norman (2004) argues that the environment changes with emotions, and sociologists (Lynch, 2008) argue that technology and culture will create changes of the frames of references to the the city and to the travellers. Current studies indicate that navigation research focuses on improving wayfinding experience with including the experiences of environmental and emotional design (Raubal and Winter, 2002; Gartner, 2018).

The findings of human cognitive researchers use the terms mood, thoughts and pleasure. This viewpoint is evident of products and environments. Emotions activate behaviours motivating human decision, moods, thoughts and enjoyment are timely manners. Current study reveals that people make choices based on moods and emotions on their journeys (Gartner, 2018).

Cognitive, emotional and practical experiences, and digital and conventional navigational solutions using accessible and multisensory routes for persons with VI were explored. Advances in technology were analyzed and new navigation solutions using digital maps as assistive technology looked to aid navigation solutions for travel and blind paths.

Some of the studies carried out ethnographic studies travelling with the use of cane. Due and Lange (2018) tested to see how VI persons could use the cane following a Tactile guiding system and in open areas. VI persons have been put into test with using various conventional cane techniques (Kueh, 2006). VI persons have been evaluated using a variety of standard techniques, allowing researchers to learn their travelling experience with canes (Hersh, 2015).

Recent studies has shown how the lack of awareness about accessible transport choices might impair the independence and mobility of people (Hara and Froehlich, 2015). A navigational map can be used to provide rich sensorial information with Assistive technology using Spatial Augmented Reality with Tactile Map to the Visually Impaired persons (Holloway, Marriott, and Butler, 2018; Thevin et al., 2019). A variety of research in the fields of human computer interaction looks Tactile Map the use of Spatial Augmented Reality with tactile maps. The work on tactile maps enhanced the efficiency of using maps by combining embossed maps with multisensory input.

4.4 Identified knowledge/research gaps

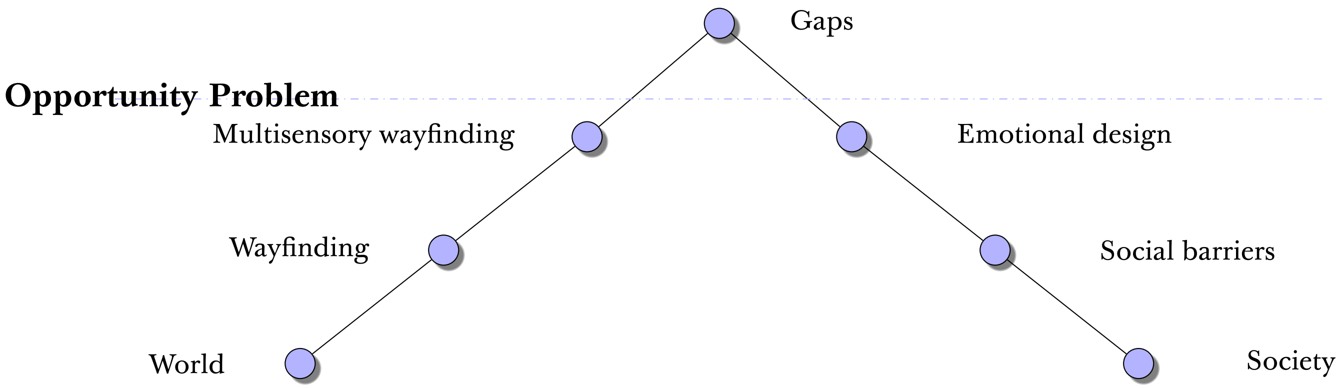


FIGURE 4.1: Problem space

The problem space figure illustrates how the interdisciplinary studies intersects and the potential problem space for enchanging accessible wayfinding experiences for VI (See Figure 4.1).

1. DIGITAL APPS WITH VISCERAL DESIGN

   VI persons use many navigational aids such as white cane, seeing eye dogs and tactile maps to travel, but they prefer digital apps in the public in order not to get stigmatized, a visceral approach of an inclusive map application can be designed in order to remove the location of the stigma, What you want to do? Create a model for Visceral/Behavioral/Reflection apps, (Positive and negative experiences) How you want to do it? Creating apps with giving Route information or Map information or Both Why you want to do that? I want to measure the cognitive load(a person's attention) of following familiar patterns and routes with tactile information vs using cognitive maps What value would it add? Create emotional models of digital maps using accesories for phones (e.g. linear routes with apple watch's knob)

2. MIXED MAPS WITH STUDYING MAP/TEXTURE/GRAPHIC VARIABLES Although VI persons may use digital maps, the routes on the maps are inaccessible to them. The combination of technology with material maps is more accessible than using digital or paper maps alone (Holloway, Marriott, and Butler, 2018; Thevin et al., 2019), What you want to do? Use materials with maps that allows multisensory feedback inclusing tactile, olfactory How you want to do it? Test multisensory materials with their texture, graphic, and map elements Why you want to do that? To create a framework for using multisensory elements What value would it add? A tactile or multisensory criteria for mixed maps

3. QUALITATIVE STUDY TO DEFINE EMOTIONAL ROUTES LANDMARKS AS MAPS Recent study shows that people have been motivated to participate in creating emotional routes which can reveal rich semantic and sensory information for unfamiliar places (Gartner, 2018), What you want to do? Use existing emotional data or create emotional routes to add semantic value, How you want to do it? Create a digital app that records Micro level, measure hear rotation, self motion, movement, blood pressure, heart rate, stress levels, how your influence in a space effects your thoughts and your feelings Why you want to do that? To understand the psychological challenges that VI people have with travelling What value would it add? Add maps sensorial and emotional routes that gives sensorial and emotional cues for accessibility of maps

4. PSYCHOLOGICAL PERCEPTION/REPRESENTATION OF EMOTIONAL LANDMARKS AND CUES

Emotional maps are visceral, but they lack behavioral (Norman, 2004) wayfinding functionalities of a map, e.g. emotions to be used as allocentric indicators to places or routes to follow, What you want to do? Use emotional landmarks e.g. perceived districts, areas, Rideau Canal & River, Library, as landmarks How you want to do it? (e.g. classes that take place inside many campus buildings, related to the field or emotional activity on the time of the day) Why you want to do that? Humans Represent Large-scale of space, perception and imagination. Geometers, A to B, we straighten curves, change angle, we chunk together large regions of space that may not necessarily look belong together. What value would it add? Optimize wayfinding with an understanding the psychology and perceived emotions of places.

5. LEARN IF SENSORY ROUTES CAN BE EFFECTIVE FOR WAYFINDING

   Emotional maps is a new concept (Gartner, 2018). As far as we are aware, in Ottawa there are no emotional maps for an inclusive use of population with VI, What you want to do? Record emotional trails for Ottawa for recreational visits How you want to do it? Use surveys, use user input and sensorial data to reflect the routes in Ottawa, Why you want to do that? If multisensory routes can add to the accessibility of routes or not, What value would it add? To contribute to the field of multisensory routes to be used for learning about routes with information of multisensory wayfinding,

6. CLUSTER AND PLAN PHASES OF AREAS OF MULTISENSORY ROUTES FOR OPEN AREAS

   Visually impaired persons have to plan for exploring a location before travelling (Engel and Weber, 2018), therefore a tactile map that could help to explore an area before arrival (Worth, 2013). What you want to do? Many places lack of maps that give the information as tactile, there are small places such as the school campus to discover before travel, Why you want to do that? A map that gives the information based on the findings of VI haptic mental model for travelling and tactile maps is clustering the spatial structure by systematically analyzing them(examine by touch, memorize to some extent, mental construct together) How you want to do it? Create tactile maps that are specifically designed to explore areas that contain navigational info and sensorial cues for areas What value would it add? Using SPACE framework for open areas without TGS, to allow VI to plan from beginning to back home, including areas for accessible information and finding entrances.

7. A STUDY ADDING MEANINGUL SENSORY/NAVIGATIONAL INFORMATION FROM VISUAL/AUDIO RECORDED MEDIA

   Before the journey, VI persons are interested to use descriptive information aids in the location of points of interest for safe trips. As far as we know, there is no example of multisensory routes for positive experiences that can lead motivating VI people to visit in real. Having the ability to explore recreational areas encourages VI people to travel, What you want to do? A map for exploring the trails in a forest, How you want to do it? Create multisensory maps of recreational areas to explore before visiting (e.g. my Master's thesis) Why you want to do that? To explore a space with maps and preview capabilities of recorded routes to give be able to navigate the space, What value would it add? Accessible information with using enviromental sounds, and information about the objects in the environment

8. DIGITAL APPS WITH MULTISENSORY ALLO/EGO CUES VI uses digital

media to learn about locations with textual information, (Engel et al., 2020). Global maps do not capture the tactile information. What you want to do? Create a map that gives detailed texture information of sidewalks, including the cracks and the tactile surface of the sidewalk as tactile cues and distance, How you want to do it? Give the tactile information on maps with two modalities, egocentric and allocentric directions Why you want to do that? To test if the environmental design the cognition of space and construction elements of buildings or spatial structures can be used by touch, sound and What value would it add? To create textual information of the tactile surface of the ground and if TGS is available,

9. NARRATIVE APPROACH WITH TACTILE MAPS TO Tactile maps show only small areas, where digital maps can be scaled to a global scale (Holloway, Marriott, and Butler, 2018). A research may be applied to design maps that include a fixed scale zooming method for VI mental models with cybercartography framework(Taylor, 2005) as an narrative approach of giving high detail areas for locations, What you want to do? Narrative maps that gives rich env info - size, color, distance, World Model - Histroical timeframes, Actor - Model UX, Qualitative Study How you want to do it? Creating maps sequentially, the journey phases that VI uses, explaining each step one by one, to learn about a place or the world, Why you want to do that? I want to understand how VI can create their own narratives based on spaces, What value would it add? Allow VI community to create their own narratives to understand spaces,

10. STUDY SYMBOLS ON A SPACE DEFINED BY A GRID SYSTEM OF A TACTILE COGNITIVE MODEL OF SPACES

    Landmark information on tactile maps are designed with visual cues. Researchers are studying how to improve the tactile design of symbols with structural cues that replicate visual symbols (See Figure 3.10)(Chamberlain and Dieng, 2011), What you want to do? Use other material for symbol specifically designer for VI audience, How you want to do it? Use parts that can assemble with each other that gives navigational cues with landmarks, routes (e.g. create puzzle maps that connect to each other with routes connecting to nodes and landmarks) (e.g. using braille legos that includes brailles, numbers and ordinary legos for creating maps) Why you want to do that? To learn the cognetive models for navigation and encourage VI for learning at school with braille systems, What value would it add?

11. CREATE A MAP GUIDING VI IN PUBLIC TRANSPORTATION WHERE THEY HAVE TGS

VI are interested in various physical and social activities, although they rely on their inner circle groups to learn about locations. The society have a negative look for disabled appearance but VI want to be independent and be a part of decision-making activities. Tactile maps can might help VI to plan for trips for discovering new areas or learning routes such as Tactile guiding system. What you want to do? Create tactile maps that are specifically designed to explore areas that tactile guiding systems info and add sensorial cues for areas How you want to do it? Create tactile or haptic maps specifically designed to plan journeys, taking public transportation and getting back. Why you want to do that? To use of multimedia can create a virtual environment that gives cues visually on routes that could be described with audio as given information about the environment from the photos of social events What value would it add? This could add a inclusive value to virtual environments to be translated to other means of audio and tactile information.

4.5 Directions for future research

Design has a timely manner, so as the tools it provides to us. The cues from the cities are visual because our design choices. Ability based designs creates opportunities for emotional design. Visual maps are reflective designs because they suggest many meanings. Tactile maps meaning are more structural and reflective since it gives many cues. The elements of maps represent the city's structures. City's structures reveal cues and emotions. The city has its emotional phases. Maps are generally behavioral, they are practical uses of navigational aids. Positive experiences of maps suggest many themes, such to be used as a part of the journey. A journey has its phases, a route is the most significant part of our journey. To create navigational aids for VI, like other ethnographical studies(Due and Lange, 2018; Kueh, 2006) suggest we need to understand their routes and design with their ability.

Visually impaired persons can define their own sensory pathways and localize them using tactile maps. How can tactile maps be more inclusive? Or how can digital maps be less visual? The social factor is important and reflects identities, therefore such as environments navigational aids and mobile aids also have multiple identities depending on their environment. Students need more information on accessible routes to classrooms, learning about their classrooms and planning the intersections. Navigational aids can help with a positive experience at the campus, with a behavioral process of positive design.

5 Conclusion

Wayfinding reflects the environment in which we live. The society and the world in which we live define our setting and our skills as well as our own identity. We live in a visual world where we can view things from afar and get lost with information. Visually impaired persons are curious of their surroundings and they use digital technologies as a matter of choice to get this information. The nature of design of wayfinding emerges from the themes of the cities. Current design trends are aimed for the majority and use with visual mental models of maps. Design of tactile maps to serve targeted audiences and their needs. Researchers and designer offer accessible frameworks for wayfinding. We all have strengths and weaknesses. Our senses and emotions play a part in our navigational decisions.

Although multisensory navigation may help with spatial wayfinding in a number of ways, we must also consider social, emotional and physical variables including social behaviours and cooperative strategies. While developing an accessible navigation aid, we must take into account travleler's journey that includes many phases as aspects from emotional, social, and physical demands (Wobbrock et al., 2011).

This review looked at the physical and cultural barriers that VI face for wayfinding to understand the nature of design. This review demonstrates an analysis on how we can focus of design can shift from map elements to the user and create emotional meanings of wayfinding experience. This review outlined the design criteria for navigational aids and compared them for the needs of the VI.

A Glossaries

A.1 Acronyms

2D Two dimensional

3D Three dimensional

AT Audiotactile

IT Information Technology

VI Visually Impaired

A.2 Glossary

The glossary was built by looking up the definitions of words in Oxford English Dictionary (*Oxford English Dictionary* n.d.) , the accessibility terminology online resources from Colorado University's accessibility studies department (*Orientation and Mobility (O and M) | CDE* n.d.) and Ladyka-Wojcik and Barense (2020)'s article "Reframing spatial frames of reference" . The additional terms that are not included in the above mentioned dictionaries are referenced individually. The dictionary consists of the terminology of familiar spatial navigation terms in three main areas: accessibility, and wayfinding and orientation & mobility for persons with vision impairment.

Adaptive technology Specifically designed for where existing tools are adapted for individuals with disabilities. Screen readers, magnifiers, braille embossers, reading device scanners, braille displays.

Assistive technology	Any type of technology, device or tool that assists to maintain or increase of performance. Wheelchairs, walkers, hearing aids for the hearing impaired and special walking canes for the blind.
Beacon strategy	A response strategy when navigating to a single landmark that does not require a representation of space in memory, and involves only moving toward or away from a recognized target.
Inclusive Design	A design method that recognizes the user with disabilities as personas within the user-centered design process. Inclusive design is proactive, assistive technology is reactive.
Orientation and Mobility	Knowing one's spatial relationships to the features of the travel environment and keeping track of those relationships (e.g. mental or spatial mapping, familiarization with the layout of a room, etc.) while moving safely, efficiently, and comfortably within that environment.

proprioception	The ability of the mind to perceive the location or relationship of parts of the body in stationary positions without the need to use any other sense to check.
Spatial Augmented Reality	In virtual reality systems, SAR is a projection-based augmented model. It can recognize and engage with three-dimensional physical models that seem like computer images, as well as interface with other projected assets to form extended virtual reality.
Tactile Map	A three dimensional or raised line representation of a specific location in the environment (e.g., a map of a residential training area, school campus.
Tactile guiding system	A system of tactile paving was first instituted in Asia, starting at Okayama in Japan at pedestrian crossings and other hazardous road situations. Tactile warnings provide a distinctive surface pattern of truncated domes, cones or bars, detectable by a long cane or underfoot, which are used to alert the vision-impaired of approaching streets and hazardous surface or grade changes. There is disagreement between the design and user community as to whether installing the aid inside buildings may cause a tripping hazard.

Three dimensional audio Audio perceived with depth of volume relation to its distance in 3D space *Soundscape LinkedIn Accessibility Demo - YouTube* n.d.

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