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SEEING THE ENVIRONMENT FROM THE EYE OF BLINDS

Didem Kan Kilic İzmir University of Economics didem.kan@ieu.edu.tr

Fehmi Dogan İzmir Institute of Technology fehmidogan@gmail.com

ABSTRACT

Blind people perceive space with their heightened sense of hearing, smell, and touch focusing exclusively on non-visual constituents of space. Everybody perceive space multidimensionally however blind people are more conscientious of the non-visual constituents of space. There is an extensive amount of research on mobility, perception, and wayfinding of blind people (Gaunet and Briffault, 2005; Saerberg, 2010; Passini and Proulx, 1988; Leonard and Newman, 1967; Dodds et al., 1982, Herman et al., 1983), however, there are fewer work showing which aspects of built environment they focus on and they use as cues in relating to the spatial environment. The study highlights the holistic and multidimensional perception of space by asking blind people to mark those places that they find particularly important in complex urban environments by verbally describing the features in the environment they attend to. Their verbal reports are recorded during wayfinding process. Decoding is made according to egocentric (memory) and environment based (sensory) inputs of environment that they mention. The study was conducted with 7 blind participants of whom three are congenitally blind in the Kemeralti District in İzmir, which is a complex urban environment. The district provides rich sensory information for blind people in the form of non-visual sensory inputs. It is found that holistic perception of the urban environment has great significance for blind people and the multidimensional sensory inputs help them in their wayfinding strategies in a complex environment.

Keywords: blindness, sense, multidimensional perception, complex urban environment

1 INTRODUCTION

Blind people perceive space with their heightened sense of hearing, smell, and touch focusing exclusively on non-visual constituents of space. Everybody, blind and non-blind, perceive space multidimensionally however blind people are more conscientious of the non-visual constituents of space.

In this study, the main research question is *"which specific aspects of built environment blind people focus on and they use as cues in relating to the spatial environment".* The research question is mostly open-ended. The study highlights the holistic and multidimensional perception of space by asking blind people to mark those places that they find particularly important in wayfinding in an urban fabric by verbally describing the features in the environment they attend to. This study also tries to understand the ability of blind people to mentally represent space and their movement.

The urban environment is mostly not designed to meet the needs of blind people. In fact, we know very little about these needs and we know very little about the wayfinding abilities of blind people and their limitations. Although there is an extensive amount of research on mobility, perception, and wayfinding of blind people (Gaunet and Briffault, 2005; Saerberg, 2010; Passini and Proulx, 1988; Leonard and Newman, 1967; Dodds et al., 1982, Herman et al., 1983), there has been no work to show which specific aspects of built environment they focus on and they use as cues in the way they relate to the urban space. These studies on blind people are generally limited to short routes and simple environments like a room, a corridor, or a building (Tellevik, 1992; Passini and Proulx, 1988; Passini et al., 1990) and only focus on one advanced sense of blind people in wayfinding process.

2 WAYFINDING PROCESS OF BLIND INDIVIDUALS

Passini and Proulx (1988) state that "to move freely in the large scale architectural and urban environment can be a difficult task for any person; but it can be an exasperating one for the visually impaired" (p. 228). Blind people require extensive storage of information regarding their environment because they cannot use visual sensory inputs to understand the spatial organization of their environment. Strelow (1985) claimed that blind people have disadvantages compared to sighted individuals because vision provides important and unique information about the location and motion of the traveller as well as cues regarding the spatial layout of the space. Nonetheless, blinds are able to perform cognitive-mapping tasks, that is they can learn mutual spatial relations between locations in the environment in order to reach destinations. Thus, it appears that blinds are able to generate a cognitive map from non-visual sequential information sources (Steyvers and Kooijman, 2009).

Verbal descriptions are shown to help blind people to orient themselves (Gaunet and Briffault, 2005). Verbal description is also beneficial for blinds to form a

mental image of what they cannot see. Besides, the ability to construct a cognitive map from verbal descriptions was recently demonstrated by Giudice et al. (2007) to be a valid technique, who showed that normally sighted people are able to convert a non-visual verbal description into a cognitive map that can be used to solve wayfinding problems.

The majority of blind people cannot easily find their own way in unfamiliar areas because of the lack of adequate information to guide them (Golledge et al., 1998). In an unfamiliar environment, a blind person faces a number of difficulties such as accessing spatial information from a distance, obtaining directional cues to distant locations, keeping track of one's orientation and location and obtaining positive identification once a location is reached, whereas sighted persons use visual landmarks and signs in order to orient themselves (Coughlan and Manduchi, 2009).

2.1 SENSES OF BLIND INDIVIDUALS DURING WAYFINDING

Klatzky et al. (1998) state that "Exceptions notwithstanding, there is general understanding that in an egocentric reference frame, locations are represented with respect to the particular perspective of a perceiver, whereas an allocentric reference frame locates points within a framework external to the holder of the representation and independent of his or her position". In this study, both egocentric and allocentric reference frame of blind individuals are inquired. Blind people depend on their other senses and develop them to higher than normal levels because of the lack of visual information (Gougoux et al., 2005), such as the localization of sound, the discrimination of pitch, memory and selective attention involving words, and the discrimination of texture (Lessard et al., 1998).

When visual information is missing, the environment is perceived through hearing, smelling, touching and being touched, and path integration (Gaunet, 2006). In the case of blind individuals, the use of sounds is essential because the perception and interpretation of auditory cues are vital for wayfinding (Koutsoklenis and Papadopoulos, 2011). Hearing facilitates the appreciation of depth and distance and enables the understanding of environmental features (Wiener and Lawson, 1997). By using auditory cues, blind people can also gain information about landmarks and points of information and can use this information to determine and maintain their orientation within an environment (Jansson, 2000). It has long been known that blind people use reflected sound to navigate within space. For example, this echolocation ability facilitates these

individuals' ability to walk parallel to a wall, since the echo of sound on the wall creates a "wall of sound" on one side of the traveler (Ashmead and Wall, 1999). The interpretation of echoes also provides individuals with visual impairments with information regarding the size, shape, and composition of specific objects (Kellogg, 1962; Rice, 1967).

Compared to vision and hearing, the sense of smell seems to play a less prominent role in humans (Hummel and Nordin, 2005). Similarly, persons who are blind use mainly hearing and touch to gather information about their environment (Hatwell, 2003). Some people who are blind have also reported using olfaction, in addition to touch and hearing, to recognize objects and persons (Hatwell, 2003). Porteous (1985) argued that smells are not randomly distributed: they are located with reference to their source and the direction and distance from the source. In the absence of vision, the sense of smell has an increased ecological value for the evaluation of the quality of food and the detection of odors that yield information about the environment (Ferdenzi et al., 2010).

Information provided by the skin can also be used in wayfinding process of blind people. Feeling the sun's heat associated with the time of the day provides clues about the geographical direction (Foulke, 1982; Guth and Rieser, 1997). Sunshine appearing and disappearing, gusts of wind as one rounds a street corner can be felt by the skin and provide information about crossroads (Gaunet and Briffault, 2005). Millar (1994) suggested that early blind people's spatial knowledge would rely on more body-centered proprioceptive and kinaesthetic information than other less precise sources of distance cues. That may account for congenitally blind persons' tendency to use spatial information organized as routes rather than maps. In contrast, late blind people would continue to organize nonvisual landmarks as visual ones.

3 METHODOLOGY

3.1 PARTICIPANTS

There were 7 participants in the study (4 men and 3 women; 3 congenitally blind and 4 late blind; mean age is 28). The participants had a self-sustaining life and were good travellers. They can easily get on and off public buses, go around familiar and unfamiliar environments. Three of them were employed and four of them were university students. All had to use a long cane in their wayfinding process. All participants were informed about the scope of the study.

3.2 PROCEDURE

This study took place in a complex urban district, namely Kemeralti in İzmir. Kemeralti provides rich sensory information for blind people in the form of non-visual sensory inputs such as sound, smell, and touch (see figure 1-2-3).

Figure 1: Sense of Sound in Kemeralti

Figure 2: Sense of Smell in Kemeralti

Figure 3: Sense of Touch in Kemeralti

On the other hand, there are complications because of obstacles, other people, and unexpected diversions and barriers (see figures 4-5).

Figure 4: Distractions and complications in Kemeralti

Figure 5: Barriers in Kemeralti

The participants were tested individually in different days. Each trial was performed at the same time of a different week day and in similar weather conditions between 12.00 p.m. to 16.00 p.m. A predefined route, starting with the Clock Tower and ending at Hisar Mosque, was given. Before each trial, each participant walked the route only once to become familiar with it. Later they were asked to rewalk the path. They were asked to verbally describe important reference points for them and the interviews were led through think-aloud approach while walking in Kemeralti. Their verbal reports were recorded during wayfinding. Transcripts of the video was coded according to egocentric (memory) and allocentric (sensory) inputs of the environment. Sensory inputs included the followings *'sound, air movement, texture, kinesthetic, temperature and smell'.*

3.3 RESULTS AND DISCUSSION

3.3.1 ***Findings of Congenitally Blind Participants***

Finding 1: Sound (29,8%) and air movement (29,8%) were the most used senses by the congenitally blind participants. As Jansson (2000) states auditory information is key in orientation. The echo of a sound help them to interpret the shape and size of the objects that they come across (Kellogg, 1962; Rice, 1967). Air movement helps blind individuals to locate crossroads and street corners. They also get information about the source of smell and its distance to the subject by the help of air movement (Gaunet and Briffault, 2005). Below, some excerpts from congenitally blind participants underlying significance of hearing and touch are included.

A: *Woman wearing high-heeled shoes is passing by me. The sound of heels help me to understand the place of the wall around me. And also I feel the person carrying the bag in his left hand. The sound of heels and the sound of the bag help us to orient ourselves in such a crowding environment.*

A: *There are streets on three sides of me. I understood it because there is a gap now around me. The echo reflected from the wall while walking had stopped.*

Finding 2: It was found that texture (15,2%) was also significant. They also relied on kinesthetic (6,6%) information like the slope of a route and holes in the crossroads. Martnor and Zaback (1976) showed that congenitally blind subjects were able to mentally rotate an object that was previously experienced by touch. Below, I include two statements from the congenitally blind participant highlighting the importance of sense of touch.

B: *Look! There is a hole in the right side of the floor. Did you notice it? When you find this hole, you understand where you should turn.*

C: *The sound is not significant for me during wayfinding. Sidewalks, intersection points and the texture of a street are the references for me. By following drain inlets I can locate the end of street and crossroads as well.*

Finding 3: It was found that smell (12,6%) was used more than temperature (6%). The sense of smell (28,9%) was the most used sense by one of the congenitally blind participant. He stated that:

C: *When I need extra information for wayfinding in such a crowded environment, I follow the olfactory sensory inputs such as coffee, corn and new cloths.*

On the other hand, one of the congenitally blind participant didn't rely on any olfactory references because he thought that smell can change easily with the wind direction, therefore he followed the air movement (41,5%).

B: *The wind blew strong. I could notice the smell of coffee. But, I can't understand the place of it. When the wind died out, the effect of the coffee smell decreased. Therefore, I don't rely on the olfactory sensory inputs during wayfinding process.*

Finding 4: It was found that kinesthetic (6,6%) and temperature (6%) were not as significant inputs as sound and air movement. One of the congenitally blind participant stated that:

A: *For a straight walk, we need drain inlets in such a crowded environment. If we don't follow the drain inlet, we are sliding to the middle of the street and can found ourselves in unexpected situations. For example, we can hit the hawkers' stands in the middle of the street.*

A: *There is a building with a long façade against me. How did I understand it? I could tell the dimension of the building from the bird flying towards the edge of the roof.*

Finding 5: It was found that only one of the congenitally blind participants mostly used his memory in wayfinding. He walked the route only once to become familiar with it. However, he memorized many details such as the crossroads, building facades and specific places with its sound. He perceived the space with his all senses. Lynch (1960) states that "wayfinding is related to the process of forming cognitive maps of our environmental surroundings based on sensation and memory".

A: *We are walking to the Hisar Mosque. It is the third street that I counted. I should count and memorize these gaps.*

CONGENITALLY BLINDS	**URBAN FABRIC KEMERALTI**						
Participant	Sound	Air Movement	Texture	Kinesthetic	Temperature	Smell	Memory
1	29 (47,5%)	18 (29,5%)	7 (11,5%)	0 (0%)	2 (3,3%)	5 (8,2%)	11
2	10 (18,9%)	22 (41,5%)	6 (11,3%)	8 (15,1%)	6 (11,3%)	1 (1,9%)	2
3	6 (15,8%)	8 (21%)	10 (26,4%)	2 (5,3%)	1 (2,6%)	11 (28,9%)	2

Table 1 – Senses of Congenitally Blind Participant Individually

CONGENITALLY	**URBAN FABRIC**

BLINDS (3 PEOPLE)	**KEMERALTI**						
	Sound	Air movement	Texture	Kinesthetic	Temperature	Smell	Memory
TOTAL	45 (29,8%)	45 (29,8%)	23 (15,2%)	10 (6,6%)	9 (6%)	19 (12,6%)	16

Table 2 – Senses of Congenitally Blind Participants in Total

3.3.2 ***Findings of Late Blind Participants***

Finding 1: It was found that sound (30,9%) was the most used sense by late blind participants like congenitally blind participants. As cited in Koutsoklenis and Papadopoulos (2011), the use of sounds is essential because the perception and interpretation of auditory cues are vital for wayfinding. Below, I include some excerpts from congenitally blind participants' statements underlying the significance of sense of hearing.

A: *There were hawkers selling cloths on the left side. I could hear the sound of hangers. On the right side, I heard the sound of refrigerator. Then, I noticed that I can turn here to reach the end point.*

A: *Is there an ATM on the right side? I heard the sound of bill. And I heard the sound of a card game. I think I am passing in front of a café.*

Finding 2: It was found that kinesthetic (2,4%) and temperature (5,9%) were not as significant inputs as the other senses for late blind people like congenitally blind participants. Millar (1994) suggested that early blind people's spatial knowledge would rely on more body-centered proprioceptive and kinesthetic information than other less precise sources of distance (e.g., auditory) cues. On the other hand one of the late blind participants relied more on touch (35%) and stated that:

B: *One of the most significant criteria for me is the drain inlets, sidewalks and difference in the floor pattern. I follow these differences under my feet.*

Finding 3: Late blind participants used their memory more than congenitally blind participants. They can memorize the references better than congenitally blind people. However, they can't concentrate on the non-visual constituents of space as good as congenitally blind participants.

A: *There is a street on the right side. It is just the memorization. I always visit Kemeralti for shopping and use the same stores. Therefore, mostly, I don't notice anything and directly go to the target. For example, there are jewelry*

stores on the right side. Don't ask me how I can understand. As I said, it is the memorization.

Finding 4: It was found that smell (28,6%) was used more than air movement (15,5%) and texture (16,7%). Some people who are blind have also reported using olfaction, in addition to touch and hearing, to recognize objects and persons (Hatwell, 2003). The sense of smell was the most used sense (46,9%) for one of the late blind participant who underlied the significance of smell as follows:

C: *Usually I am more sensitive to the smell of food and drink. Especially the smell of coffee. There is a coffee shop at the bus stop in front of my house. When I get off the bus and notice the smell of coffee, I feel relax because it is the right stop for me to get off. But now, I only notice the smell of sweat.*
...In this street, there should be a spice shop. For example, if I would like to buy fish, I concentrate on fish smell. However, if the wind blows, I confuse the shops that I would like to go.
...Now we are approaching Kızlar-ağası Khan. I am noticing the smell of fish and pickle on the right side of me.

LATE BLINDS	**URBAN FABRIC** **KEMERALTI**						
Participants	*Sound*	*Air movement*	*Texture*	*Kinesthetic*	*Temperature*	*Smell*	Memory
1	10 (52,6%)	2 (10,5%)	4 (21%)	0 (0%)	1 (5,4%)	2 (10,5%)	15
2	5 (25%)	3 (15%)	7 (35%)	1 (5%)	0 (0%)	4 (20%)	0
3	8 (25%)	5 (15,6%)	2 (6,25%)	1 (3,1%)	1 (3,1%)	15 (46,9%)	6
4	3 (21,4%)	3 (21,4%)	1 (7,2%)	0 (0%)	3 (21,4%)	4 (28,6%)	5

Table 3- Senses of Late Blind Participants Individually

LATE BLINDS (4 PEOPLE)	**URBAN FABRIC KEMERALTI**						
	Sound	*Air movement*	*Texture*	*Kinesthetic*	*Temperature*	*Smell*	Memory
TOTAL	26 (30,9%)	13 (15,5%)	14 (16,7%)	2 (2,4%)	5 (5,9%)	24 (28,6%)	26

Table 4- Senses of Late Blind Participants in Total

Finding 5: It was found that late blind participants used less sensory information than congenitally blind participants and used their memory more than congenitally blind participants. Congenitally blind participants' mental representations include abstract perceptual patterns such as crosswalks, slopes indicating crosswalk entrance, or the sound of cars or crowd. Late blind participants' mental representations include categorization of objects such as building, tree, car, etc. Therefore, congenitally blind participants rely more on sensory information than the late blind participants.

	URBAN FABRIC KEMERALTI	
	Sensory	Memory
Congenitally Blind Participants (3 people)	151	16
Late Blind Participants (4 people)	84	26

Table 5 – Sensory and Memory Relationship of Blind Participants

4 CONCLUSION

Sound is the most used sense both for congentinally blind and late blind participants during wayfinding in this complex urban district. Late blind participants can memorize landmarks and crossroads easier than the congenitally blind participants. Congentinally blind participants use the non-visual sensory inputs such as sound, wind, smell more than the late blinds.

Urban design includes the consideration of sensory inputs beyond the visual. The results of the study have significant implications to understand which specific aspects of built environment blind people focus on and how their senses compensate each other in perceiving their environment. The study suggests that spatial experience could be healed for blind people and for sighted people as well if the multidimensional aspect of spatial perception is understood better.

5 REFERENCES

Coughlan, J. and Manduchi, R., 2009. Functional assessment of a camera phone-based wayfinding system operated by blind and visually impaired users. *International Journal on Artificial Intelligence Tools, Special Issue on Artificial Intelligence Based Assistive Technologies: Methods and Systems for People with Disabilities*, 18, pp. 379-397.

Dodds, A.G., Howarth, C.I. and Carter, D.C., 1982. The mental maps of the blind. *Journal of Visual Impairment and Blindness*, 76, pp. 5-12.

Ferdenzi, C., Coureaud, G., Camos, V. and Schaal, B., 2010. Attitudes toward everyday odors for children with visual impairments: A pilot study. *Journal of Visual Impairment & Blindness*, 104, pp. 55–59.

Foulke, E., 1982. Perception, cognition and mobility of blind pedestrians. In M. Potegal (Ed.), *Spatial abilities: Development and physiological foundations*. New York: Academic Press, pp. 55-76.

Gaunet, F., 2006. Verbal guidance rules for a localized wayfinding aid intended for blind-pedestrians in urban areas. *Universal Access in the Information Society*, 4, pp. 338-353.

Gaunet, F. and Briffault, X., 2005. Exploring the functional specifications of a localized wayfinding verbal aid for blind pedestrians: Simple and structured urban areas, *Human-Computer Interaction*, 20, pp. 267–314.

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

Golledge, R.G., Marston, J.R. and Costanzo, C.M., 1998. *Assistive devices and services for the disabled: auditory signage and the accessible city for blind and vision impaired traveler*. In: California PATH 276.

Gougoux, F., Zatorre, R. J., Lassonde, M., Voss, P. and Lepore, F., 2005. A functional neuroimaging study of sound localization: Visual cortex activity predicts performance in early-blind individuals. *PloS Biology, 3*(2), pp. 324–333.

Guth, D. A. and Rieser, J. J., 1997. Perception and the control of locomotion by blind and visually impaired pedestrians. In B. Blasch, W. Wiener, & R. Welsh (Eds.), *Foundations of orientation and mobility* (2nd ed.). New York: AFB Press, pp. 9-38.

Hatwell, I., 2003. *Psychologie cognitive de a ce´cite´ pre´coce*. Cognitive psychology of early blindness. Paris: Dunod.

Herman, J.F., Chatman, S.P. and Roth, S.F., 1983. Cognitive mapping in blind people: acquisition of spatial relationships in a large scale environment. *Journal of Visual Impairment and Blindness*, 77, pp. 161-166.

Hummel, T. and Nordin, S., 2005. Olfactory disorders and their consequences for quality of life. *Acta Oto-Laryngologica*, 125, pp. 116-121.

Jansson, G., 2000. Spatial orientation and mobility of people with visual impairment. In B. Silverstone, M. A. Lang, B. Rosenthal, & E. E. Faye (Eds.), *The Lighthouse handbook on visual impairment and rehabilitation.* New York: Oxford University Press, pp. 379-397.

Kellogg, W.N., 1962. Sonar system of the blind. *Science*, 137, pp. 399–404.

Klatzky, R.L., 1998. Allocentric and egocentric spatial representations: Definitions, distinctions, and interconnections. In C. Freksa, C. Habel, & K. F. Wender (Eds.), *Spatial cognition – interdisciplinary approach to representation and processing of spatial knowledge*. Berlin. Springer-Verlag, pp. 1-17.

Koutsoklenis, A. and Papadopoulos, K., 2011. Olfactory cues used for wayfinding in urban environments by individuals with visual impairments. *Journal of Visual Impairment & Blindness*, October-November Issue, pp. 692-702.

Leonard, J.A. and Newman, R.C., 1967. Spatial orientation in the blind. *Nature*, p. 215.

Lessard, N., Lepore, F. and Lassonde, M., 1998. Early-blind human subjects localize sound sources better than sighted subjects. *Nature*, 395, pp. 278–280.

Lynch, K. (1960). The image of the city. Cambridge, MA: MIT Press.

Martnor, G. S., & Zaback, L. A. (1976). Mental rotation by the blind: Does mental rotation depend on visual imagery? *Journal of Experimental Experimental Psychology: Human Perception and Performance, 2,* 515- 521.

Millar, S., 1994. *Understanding and representing space. Theory and evidence from studies with blind and sighted children*. Oxford, England: Clarendon Press.

Passini, R. and Proulx, G., 1988. Wayfinding without vision. *Environment and Behavior,* 20 (2), pp. 227-252.

Passini, R., Proulx, G. and Rainville, C., 1990. The spatio-cognitive abilities of the visually impaired population*. Environment and Behavior*, 22 (1), 91-118.

Porteous, J. D., 1985. Smellscape. *Progress in Human Geography, 9*, pp. 356–378.

Rice, C.E., 1967. Human echo perception. *Science*, 155(763), pp. 656–664.

Saerberg, S., 2010. How blind and sighted pedestrians negotiate space. *Senses & Society*, 5 (3), pp. 364-381.

Steyvers, F.J.J.M and Kooijman, A. C., 2009. Using route and survey information to generate cognitive maps: differences between normally sighted and visually impaired individuals. *Applied Cognitive Psychology*, 23 (2), pp. 223-235.

Strelow, E. R., 1985. What is needed for a theory of mobility: Direct perception and cognitive maps—Lessons from the blind. *Psychological Review*, 92, pp. 226–248

Tellevik, M., 1992. Influence of spatial exploration patterns on cognitive mapping by blindfolded sighted persons. *Journal of Visual Impairment & Blindness*, 86, pp. 221-224.

Wiener, W. R. and Lawson, G., 1997. Audition for the traveller who is visually important. In B. Blasch, W. Wiener, & R. Welch. (Eds.), *Foundations of orientation and mobility*. New York: American Foundation for the Blind, pp. 104-169.