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Wayfinding Performance of Visually Impaired Pedestrians in an Urban Area

Aida E. Afrooz, Toktam Hanaee, Bruno Parolin

(Aida E. Afrooz, Faculty of the Built Environment, University of New South Wales, Sydney, Australia, a.eslamiafrooz@student.unsw.edu.au)
(Toktam Hanaee, Faculty of Art and Architecture, Science and Research Branch Islamic Azad University, Tehran, Iran, toktamhanaee@yahoo.com)
(Dr. Bruno Parolin, Faculty of the Built Environment, University of New South Wales, Sydney, Australia, b.parolin@unsw.edu.au)

1 ABSTRACT

Movement from an origin to a destination within a city is an inevitable activity for all inhabitants, especially for those who are commuters. For the visually impaired, this movement task is a difficult activity, given inability to use visual properties and hence reliance on hearing and smell for navigation. This study seeks to determine the type of information that is acquired by the visually impaired to navigate from an origin to a destination. In essence the study is attempting to determine the wayfinding process in familiar environments among the visually impaired. An experiment with 12 totally visually impaired and 12 partially visually impaired students was conducted in Mashhad city. Our method is based on an analysis of wayfinding from a school for the visually impaired to a familiar destination in the urban area of the city. Questionnaire survey methods were used to determine reference points, which senses (hearing, touch, smell) were used and problems experienced in reaching the destination by walking. The key findings show that there are differences between the two groups in terms of their use of reference points, use of the senses and problems encountered on the wayfinding trip to the destination. The totally visually impaired displayed a reliance on touch, smell and hearing for gaining information from the environment, as opposed to the partially visually impaired who could rely on sight and other senses for their information. As a result of the study it is suggested that those who design aids for the visually impaired should have stronger experiences of the perceptions of the needs and problems encountered by the visually impaired during the wayfinding process. For urban planners and designers the results suggest the need for greater consideration of the problems and needs of the visually impaired in terms of street layout and pattern, pavement slope and material, and safety and security.

2 INTRODUCTION

Finding one‘s way is a significant task for individuals engaged in daily activities. However, being oriented in a place with regard to objects and knowing where to go next, and ultimately how to return, is a main concern for inhabitants and, in particular, the visually impaired. Orientation refers to an individual’s awareness of his/her position in the environment by maintaining the relationship to other objects (Hersh and Johnson, 2008). Sighted people in an airport would be aware of their position at that moment, similarly for the visually impaired who can hear the verbal announcement of the flights. But what about being in a large public space where there are no verbal announcements for blind users. Lack of information for the visually impaired about the potential to encounter different temporary obstacles or hazards, as well as deficiency in gaining information about distant landmarks, make wayfinding a serious problem for this target group (Loomis et al. 2001). This leads to not making independent journeys outside their neighborhood areas, or only to restricted or familiar areas (Clark-Carter, et. al, 1986).

The present study addresses path integration in a wayfinding process among a sample of blind and visually impaired students in a familiar area as regards both navigation-based and resource-based learning strategies. The questions the present study attempts to answer are whether blind and low-vision persons keep reference points in mind instead of visual cues, as opposed to those who are sighted. What are the characteristics of these reference points such as the type and frequency of usage of them among the blind and low-vision users separately? What sort of visual cues, if any, do low-vision students use? What are the other kinds of aids they may use? What is the dominant sense for the target group in deficiency of vision? How can street pattern influence the wayfinding process? And finally, how do blind students differ from low-vision students in their wayfinding process? To grasp the importance of information in visually impaired wayfinding, we hypothesize that one’s wayfinding process and, in particular, the reference points that are used depend on his/her ability of vision. In other words, if the user is visually impaired (either blind or low-vision), then reference points are used to obtain information in familiar environments. Accordingly, the main hypothesis could break down to a sub-hypothesis; if the user is blind, then the dominant sense is to rely on familiar

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urban areas as a tactile experience. If the user is low-vision impaired, then visual cues similar to those used by sighted people are used for wayfinding. If the user is visually impaired, we argue that the grid street pattern is clearer and more legible for him/her in their wayfinding process. To test the hypotheses, we surveyed visually impaired students in a setting with which they are familiar in terms of the variety of landmarks and where they have a higher likelihood of using different senses. Furthermore, we clarify some definitions and related theories in wayfinding performance. In section 4, visual characteristics of the study area and respondents are presented. The relationship between reference points, familiarity, street layout and, ultimately, the problems encountered in the area are categorized in Section 5. The final section provides conclusions and directions for future work.

3 LITERATURE REVIEW

3.1 Wayfinding concepts

Wayfinding is the ability of travelling between locations either with an internal or external map of the environment (Kalia, 2009) as purposeful and directed movement from an origin to a specific distant destination (Allen (1999) and Golledge, 1999). Such behavior involve interactions between the traveler and the environment (Raubal, 2001). Further, wayfinding is a behavior (Bechtel and Churchman, 2002, p, 427) which cannot be successful unless you know where you are, know your destination and follow the best route to your destination, recognizing your destination and finally being able to find your way back (Carpman and Grant 1993). Thus, it is the process of collecting information from our built environment, to know where we are related to where we want to go and how to get there (Woyciechowicz and Shliselberg, 2005). In addition, wayfinding is one aspect of people's cognitive map knowledge which includes all aspects of encoding, processing, and gaining information about the environment (Blades et. al. 2002). Basically, two components of wayfinding are movement and decision-making (Xia et. al, 2008). Seamless integration of movement, perception and memory are required for successful wayfinding (Kalia, 2009). Indeed, path integration - obtaining information while walking- is one source of information for humans which assist them in determining their location in urban areas (Kalia 2009). Thus, wayfinding, a cognitive process (Golledge, 1999), can be defined as spatial behavior (Julian, 2010) that involves the ability to learn a route and retrace it from memory (Blades et. al. 2002), to move from an origin to a destination while maintaining orientation in and around objects, people, and spaces.

3.2 Commuters and the level of familiarity with the environment

Wayfinding or being oriented within an urban area is an important task which involves interaction among people and the environment while undertaking daily activities. It is of high importance especially when travelers are commuters -those who travel back and forth on a regular basis- and require frequent navigation within cities. Commuting enables people to live in areas and work in a place spatially separated from their living places (Heinen et. al, 2011). This would increase their familiarity with the environment through which they are travelling as they regularly travel to and from a particular place. As familiarity with an environment increases, performance in wayfinding and spatial orientation tasks improves (O'Neill, 1992). Understanding and awareness of surroundings provides a sense of security for individuals (Kaplan, et. al, 1998 and Cutting, 1996). Therefore, users' feelings of safety follow from understanding a place, and familiarity, in turn, can increase this feeling. Commuters regularly follow the same order of routes or use the same reference points to recognize their ways. Nevertheless, people may choose different reference points, and landmarks may vary depending on the environment they are moving through (xia, et. al, 2008).

3.3 Reference points

According to Lynch (1960) inhabitants have a shared image of their resident area. A clear image of the city makes it possible for the users to navigate freely within urban areas. Familiarity with a neighborhood can be defined as having a "clear image". A clear image of the environment makes it possible for individuals to know the spatial position of places they are traveling through. Hong (2007) notes an interesting point on the five elements Lynch proposed- edges, nodes, landmarks, districts, paths. He stated that one similar function among all the five elements is geo-referencing. This indicates the role of image these elements have in a users' cognitive map to be utilized as a "reference point" (Hong, 2007). In other words, to have a clear image of the environment one requires knowing and storing the spatial relations among the five elements within an

urban area that is similar to the "anchor point" theory of Golledge (1999). "Anchor point" theory indicates spatial relations of landmarks, familiar districts and path segments as laying the foundation on which other information is anchored in cognitive maps. As an image develops based on a two-way process between man and environment (Lynch, 1960), it can be strengthened by either the perceiver to be retrained or the surrounding be reshaped. In addition, disorientation can take place when landmarks are unavailable (Dudchenko, 2010). But what if the user cannot see the surroundings properly?

3.4 Visually impaired and spatial information

Regardless of loss of vision or being visually impaired, obtaining information from the environment through which navigation is performed is important for commuters and would be a prerequisite for them. One needs to know the spatial relations between self and object as well as updating that to perform an efficient wayfinding (Turano et al. 2005). This information can be taken in two different ways, either from knowledge in the environment or knowledge in one's head (Raubal, 2001). Nonetheless, vision plays a primary role and provides plentiful information for helping the wayfinder to orient oneself in regard to spatial relations among objects. Previous studies on the visually impaired show that there are two main levels that the blind and visually impaired use to attain knowledge for orientation and mobility, namely perceptual and conceptual (Ungar et. al, 1996; Schloerb et. al, 2011). "Mobility" refers to being able to move from one point to another safely and efficiently (Hersh and Johnson, 2008). Hill and Ponder (1976) define it as the capacity to move, the readiness and the facility to move. This will involve negotiating any obstacle in sidewalks which would be temporary or any unexpected change in direction. "Navigation"refers to travelling from one place to another by using mobility skills while keeping oriented in relation to the purposeful course (Hersh and Johnson, 2008). At the perceptual level, other senses perceive information due to lack of vision or certain ability to overcome the impairment in the best way (Schloerb et. al, 2011; Goldstein 1999). The conceptual level focuses on developing strategies for mapping of space and generating an orientation path (Schloerb et. al, 2011). Furthermore, according to Hersh and Johnson (2008), and related studies, there are two perspectives for gaining spatial information; navigation-based learning and resource-based learning strategies. The difference between these two processes lies in experiencing the environment. Whereas in navigation-based learning the user experiences the environment directly, in resource-based learning information is acquired from diverse sources like TV, maps, asking others, or for the visually impaired from tactile maps, braille newspapers and so on. In spite of this, however, visually impaired users express their spatial knowledge differently in comparison to sighted people. As an example, Bradley and Dunlop (2003) stated that visually impaired provide more information while they were describing a path they have taken in comparison with sighted people. This difference in expression also differs among different visual impairments (ie. peripheral vision loss, central vision loss and so on) (Bradley and Dunlop, 2003 and 2004). Blind participants and central vision loss, for instance, asked more questions regarding steps, distance, and obstacles along their way in comparison with peripheral vision loss participants (Bradley and Dunlop, 2004).

To recapitulate, the present study addresses path integration regarding navigation-based learning and resource-based learning among a sample of visually impaired students at a perceptual level of orientation in a familiar urban area.

3.5 Street patterns

Zannaras (1976) suggested that city structure has an important role in urban images. On the other hand, Appleyard (1970) and Lynch (1960) declared paths as the main elements and organizer of a city. A street pattern has diverse forms and varies from star-like, linear, circular, treelike, radial, grid to an irregular pattern (Heinzle et. al 2006, Marshall 2005, Zhang, 2004,). A grid pattern makes the block similar and Hall & Poterfield (2001) stated that a feature of the grid network that makes it successful is the predictability of intersections. They noted this feature as providing cues and reference points for users in wayfinding processes. From an urban planning view point, the grid layout provides permeability in addition to preventing rotating districts (Design guide, 2005). The grid pattern has some privileges as it is also characterized by highly connected streets with shorter distances, and more route choices (Southworth and Ben-Joseph, 2004).

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4 DATA AND METHODS

In Iran unlike many other countries (e.g. Finland) visually impaired children without additional handicaps are educated in special schools distinctively designed for them. The respondents in the present study are students from such a school - a school for the visually impaired. The selected study area (Fig. 1) includes the educational area of a visually impaired high school in Mashhad City. The setting encompasses the school as the central focus, and approximately 500 meters away from the school is a well-known intersection named "Faramarz Intersection" (Fig. 2). There are three strip malls close to the intersection in addition to a clinic, two banks and several retail shops such as a bakery, fruit shop and supermarkets. In general, medium-income citizens are living in Faramarz district.

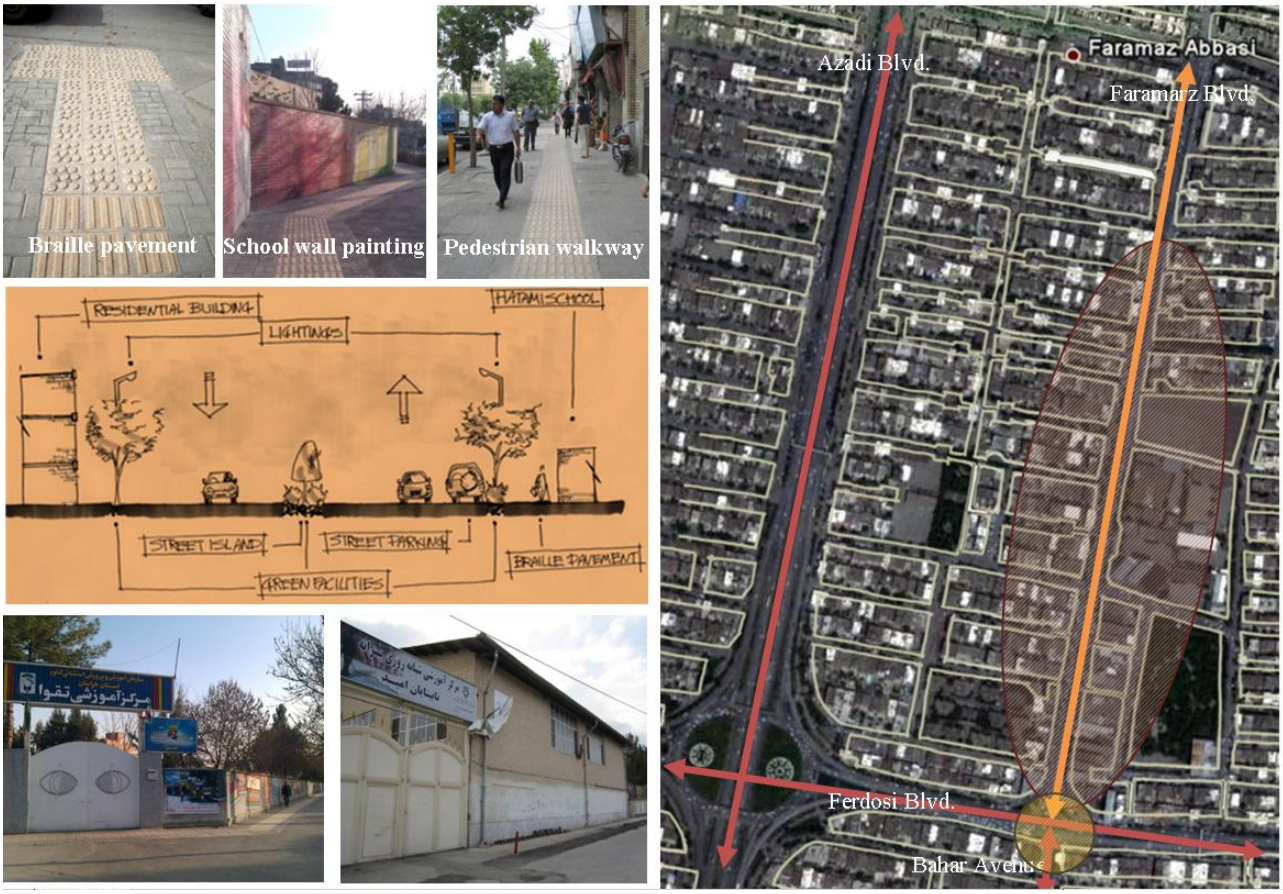

Fig. 1: The setting

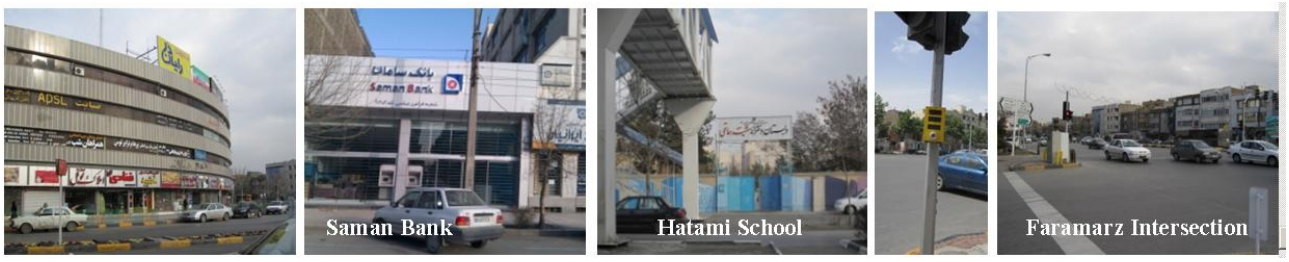

Fig. 2: Reference Points

The street pattern in the surrounding area of the school is a typical rectangular street in a "grid-like" pattern which is converted to cul-de-sacs for vehicles. This pattern supports row houses and low-rise apartments in the Faramarz district. Faramarz Boulevard functions as a "Connector"route type, which is a main road in a connective grid network of the district that brings the stream of traffic in a hierarchy from the "cul-de-sacs" and "spines" to the "Fredosi Arterial Collector" (Fig. 1). Thus, the area consists of similar blocks and intersections. The education area is approximately one hectare which includes two schools for girls and boys, with separate dormitory facilities for those who come from rural areas or the suburbs.

4.1 Respondents and procedure

The survey's target participants were students in the Blind and Low Vision school of "Taghva" and "Omid "- two high schools for visually impaired students for females and males respectively. A group of twelve 15 to 18 year old girls and an equal number of boys within the same age range were selected for the study. Half the students from each group were totally blind and the others were low-vision impaired (N=12 blind, N=12 low sighted). All respondents were asked to come to the school library individually and answer a questionnaire survey. It was conducted in Persian and divided into 4 parts; selected socio-economic characteristics (age, gender and education), questions regarding landmarks or reference point for the target group, questions regarding wayfinding performance which, in turn, consisted of questions based on path preferences and their behavior in a new environment as well as finding their way in difficult situations without any aids and, finally, questions about the use of their senses to figure out how they are performing wayfinding given their deficiency of vision. A pilot survey was initially undertaken at the same schools to better develop the questionnaire survey. Having completed the interviews, the researchers took photos of the reference points that respondents mentioned and then categorized these with respect to height, color, and function.

Gender	Visual impairment	Frequency	Age		Years of Education		Years of blindness	
			Mean	Age	Mean	School level	Mean	Years(min-max)
Female	Blind	6	18	15-21	3.2	1-4	7.35	0[1]-21
	Low-vision	6	16.5	14-19	2.8	1-4	12.25	10-19
Male	Blind	6	18.5	15-22	3.5	1-4	6.5	0-22
	Low-vision	6	17.5	15-20	3.1	1-4	14.30	13-20

Table 1: Characteristics of respondents

Table 1 shows the characteristics of sample respondents. A diverse group of blind and low-vision sample respondents allow us to investigate hypotheses regarding relationships between visual impairment and reference points as well as the utilization of different senses. The average age of the sample is similar with a mean age of 17.6, as is the frequency of male and female visual impairments. Sample respondents were fairly homogeneous with respect to age and education. For example, they were all high school students from level one to four and the mean school level was 3.1 which indicates most of them were in their third year of high school. Years of blindness depicts the minimum and maximum years that respondents have suffered visual impairments. It varies from birth to four years for the female low-vision students and from birth to two years for the male low-vision students. For the blind respondents visual disability mainly appeared after birth.

5 RESULTS

This section describes the relationships among reference points, street layout and familiarity revealed by the sample of blind and visually impaired students. We find that the level of visual impairment among the sample, plus previous familiarity with the setting, generates differences in how they behave and perform wayfinding in an urban environment. Descriptive statistics (Chi-Square and Cramer's V) are used to test for association and correlation on predominantly categorical data.

5.1 Reference points

There were several reference points that the visually impaired sample students utilized, and were presented to them as visual cues in wayfinding performance including a Braille pavement, bakery, strip Mall, supermarket and fruit shop, bank, and finally school walls (table 2). We note here that the sidewalk in Faramarz Street is facilitated with the Braille pavement from the intersection to both "Taghva" and "Omid" schools. Interestingly, the reference points differ in how they are used by blind or low-vision students. Around 67% of low-vision students indicated the "Braille Pavement" as a reference point in comparison with the blind students (33.3%). However, the blind students, and most of the low-vision students, preferred not to walk on the "Braille Pavement" because of the uncomfortable feeling that it generated as a result of harsh materials and breaks and bumps on the surface. The smell (aroma) emanating from a bakery was one of the main guides for students, particularly for the blind students (60%). Strip malls (8.3%), the supermarket (12.5%) and school walls (12.5%) were other cues for both groups. Approximately 67% of the blind students, in comparison with the low-vision sample, made use of the school walls by touching them when

[1] (0) denotes being blind from birth.

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getting closer to their school. They find it different from other walls due to the painting on the wall that makes the brick walls become smooth and even; therefore, they used tactile senses (Fig. 1). Among all the elements mentioned by the student sample, the "Bank" was one of the main landmarks they indicated (25% of blind and 41.7% of low-vision students) followed by the bakery, Braille pavement, supermarket, and school walls. ATM's were also a reference point for them particularly for the low-vision sample as they stated that the queue of people is a clue for them. It is also worth noting that the "Bakery" and "Bank" were cues mentioned by about half (50%) of the blind student sample, this was followed by the supermarket and school walls. It appears from the data that the reference points the target group can use to pinpoint their location in the urban area are more related to senses other than vision. Even though low-vision students named banks (41.7%) as cues, (which have different forms and functions in comparison to residential buildings that can be distinctive for them), they rely more on hearing people's sound. In other words, it is not the façade or the shape of the building that is functioning as a clue for them but the sound of crowds of passing people or people passing along commercial buildings such as the strip malls.

Our data highlights a significant finding - while all the blind respondents find using the Braille pavement helpful, most of the low-vision respondents (66.7%) did not find it practical. Further analysis shows that they prefer to have different colours on the pavement to help them get around the city. Some visual impairment leads to not being able to see some colors like white and gray. Thus, respondents made requests for the use of colors in urban areas; for example, at stairs to guide them to find out where the steps are. This suggests the use of suitable colors in walkways to be used as a guide for the visually impaired. Colour should be distinguishable even in the high light at noon or the lower light during night time. Therefore, this would require the sidewalks to have a high contrast with the environment and background, and indeed avoid using colours that are not suitable for color blind people. The most common type of colour blindness is "red-green" such that dark green, for instance, may appear black to them (Hersh and Johnson, 2008).

The respondents were asked to describe what they imagine in the selected study area around their school to focus on the cues they utilize as reference points for their wayfinding. The researchers categorized the elements indicated by respondents in terms of frequency and types (table 3). Among all the respondents 75% named "Hatami primary school" and "street trees" in Faramarz Avenue. "Hatami School" is a primary school located close to the "Taghva" and "Omid" school (Fig. 2). Almost half of both blind and low-vision respondents mentioned "Hatami School" because of the sounds of playing at school in the morning before entering the school, or at noon when they are going back home. Another obvious element for the respondents was street trees. Faramarz Avenue is green with trees on both sides of the street as well as the middle island (Fig.1). Trees, in general, are ideal elements for the target group.

They can feel the freshness and smell of trees or grass and enjoy walking in walkways equipped with green facilities. People waiting in line at a bus stop are another cue for the low-vision respondents in the area surrounding their school. In addition, they experienced other alternative cues like the bleeping sound at pedestrian crossing walkways which inform them of safety to cross the street (Fig. 2). This suggests that this target group should be equipped with devices focusing on the hearing sense. On balance, an urban area should also have a plentiful distribution of green facilities for the target group. There are two major reasons for this; first, the good feeling they get while walking along a green walkway results in a sense of security, and second; green facilities function as an insulator of sounds from vehicles and according to what the respondents stated, they get confused in a busy area full of vehicle noises and cannot continue walking.

What are the reference points you keep in mind when finding your way between Faramarz junction and the school?			
	Blind (%)	Low-vision (%)	Total (%)
Braille pavement	33.3[2] - 8.3	66.7 - 16.7	100 - 12.5
Bakery	60 - 25	40 - 16.7	100 - 20.8
Strip Mall	50 - 8.3	50 - 8.3	100 - 8.3
Supermarket	66.7 - 16.7	33.3 - 8.3	100 - 12.5
Bank/ATM	37.5 - 25	62.5 - 41.7	100 - 33.3
School walls	66.7 - 16.7	33.3 - 8.3	100 - 12.5

Table 2: Landmarks and reference points

[2] Note: The first percentage value represents the row percent; the second percentage value represents the column percent.

Describe your imagination during your way when finding your way between Faramarz junction and the school?			
	Blind (%)	Low-vision (%)	Total (%)
Park	66.7 - 16.7	33.3 - 8.3	100 - 12.5
Shops	100 - 8.3		100 - 4.2
Hatami School	44.4 - 33.3	55.6 - 41.7	100 - 37.5
People waiting at bus stop		100 - 16.7	100 - 8.3
Street trees in Faramarz st.	55.6 - 41.7	44.4 - 33.3	100 - 37.5

Table 3: Cues utilised as main reference points

Table 4 highlights that bus stops (50%) and counting junctions (33.3%) as a cue for the blind respondents in contrast to high buildings (41.7%) and shops (50%) for the low-vision respondents. It is significant that the blind student respondents rely on cues that are more related to other senses like hearing the sound of people waiting in line for the bus as opposed to low-vision student respondents who try to rely on their vision but also need to use other senses. As an example, low-vision student respondents were not able to see the height of buildings but they can see the buildings shadow and felt cool in the shade. In addition they heard about the specific strip mall, for instance, that is located close to the intersection. So they knew the approximate location of some buildings. Most of the respondents, whether blind or low-vision, had some familiarity with different buildings, besides residential ones, in the area as their friends or parents accompanied them only for the first or second trips there. Most were afraid of entering a new area and heavily rely on their parents for describing the area to them as part of their first timid steps in visiting a new environment. Gradually they try to understand the whole area but still do not have the confidence to perform an individual trip. Although gender differences are not a focus of this study, it is likely that the fear of entering a new area decreases more among boys as they have more confidence in exploring new areas.

Which factors help you more to find your way?			
	Blind (%)	Low-vision (%)	Total (%)
High buildings		100 - 41.7	100 - 20.8
Bus stop	85.7 - 50	14.3 - 8.3	100 - 29.2
Counting junctions	100 - 33.3		100 - 16.7
Shops	25 - 16.7	75 - 50	100 - 33.3

Table 4: Factors that assist in wayfinding

5.2 Wayfinding process

A chi-square test was performed to find the relationship between being blind or low-vision and the approach respondents would take to find their way when they get lost. In order to reduce the options for the question of "How would you find your way when you get lost?" there was a pre-test which summarized responses into the two categories - "asking residents" and "keeping in mind some elements as clues". As highlighted in Table 5 the chi-square value is 6.171 with p-value of 0.018; this implies a statistically significant relationship between the two groups we are comparing. Those with total blindness are being used to asking residents in these situations (83.3%) while different pattern is repeated for the low-vision students. Most of them try to keep in mind some landmarks or reference points as visual cues to assist them find their way (66.7%). The overall pattern seems being based on social matters. On the whole, it seems best that neither of the respondents want to ask others. They prefer to perform independent trip however, those who are blind got more stresses and cannot remind the clues they had previously used in such situations. Low-vision students seems to be more confident and try not to ask anybody but keep going to reach to their visual cues. Not using any devices like the white cane, has such drawbacks for them but calming down the car noises, utilizing suitable materials in the Braille pavement, using tactile graphics on walls, using reasonable size characters on the signs with high contrasts in colour would be definitely helpful for the target group.

How would you find your way when you get lost?			
	Blind (%)	Low-vision (%)	Total (%)
Ask residents	71.4 - 83.3	28.6 - 33.3	100 - 58.3
Keep in mind some elements	20 - 16.7	80 - 66.7	100 - 41.7

Table 5: Association between level of blindness and reference points to find the way

To be able to obtain the exact reference points used by the target group, other than understanding the differences in their wayfinding performance, we asked some similar questions but in a different way. For instance, in addition to the previous questions which were based on landmarks the following question was asked in another way to find out the cues they refer to (table 6). It is amazing that only 25% of the blind

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respondents reported that they rely on the Braille Pavement; however, they all mentioned it as a practical and useful element in their wayfinding process. This finding suggest that the blind respondents do rely on the Braille pavement but they do not want others to believe they have a disability and are therefore inclined to be more independent. Table 6 reveals that the majority of respondents (87%) rely on their sense of hearing in getting closer to their school. This includes either the sounds of children playing or the pedestrian bridge beside the "Hatmai" primary school. The reason for mentioning the pedestrian bridge is that they hear people going up and down the bridge when they get closer to it.

How do you understand when you are getting closer or reaching to school?			
	Blind (%)	Low-vision (%)	Total (%)
Braille pavement	100 - 25		100 - 12.5
pedestrian bridge	50 - 25	50 - 25	100 - 25
children's noise in the Hatami school	40 - 50	60 - 75	100 - 62.5

5.3 Senses

To answer the question of which senses do the target group rely on with a deficiency of vision, some parallel questions were asked of the respondents. To figure out whether they use the sense of smell, all the respondents trust their sense of smell (100%). They recognize the bakery before passing it or the fruit shop and the flower shop as well. It is noteworthy to mention that these shops function as cues for them in their trips as being commuters. The two principal factors the target group realizes by entering an open space or intersection in the city are the sound of a crowd sound and the noise of vehicles, and at the same time feeling a vacant or open space (table 7).

Table 8 highlights that, among those who answered 'yes', the overwhelming majority are blind respondents who indicated that vehicle noise helps them in their wayfinding. Among those who answered 'no', the differences between the blind and low vision respondents are less marked. For these latter respondents, vehicle noise meant they were not able to concentrate as well on their current location and perform wayfinding within a busy environment. This was true among almost all the low-vision respondents (91.7%) and most of the blind respondents (66.7%). In contrast, these two target groups were satisfied with the crowd sounds 100% and 58.3% respectively (table 8). Crowd sounds would only become devastating for them when it becomes too high or noisy that would confuse them of understanding their spatial location. Otherwise, it helps them understanding where the others are to make decision of what space it would be (i.e. for example, whether they are passing a mall or it is a school they are passing).

How do you understand when you reach a junction or an open space in the city?			
	Blind (%)	Low-vision (%)	Total (%)
noise of vehicles and the sound of a crowd	54.5 - 50	45.5 - 41.7	100 - 45.8
feel a vacant and open space	46.2 - 50	53.8 - 58.3	100 -54.2

Table 7: Reliance on sense of hearing

Do noises from vehicles and the sound from crowds help you in wayfinding?						
	Blind (%)		Low-vision (%)		Total (%)	
	Vehicles noise	Crowd sound	Vehicles noise	Crowd sound	Vehicles noise	Crowd sound
Yes	80 - 33.3	63.2 - 100	20 - 8.3	36.8 - 58.3	100 - 20.8	100 - 79.2
No	42.1 - 66.7		57.9 - 91.7	100 - 41.7	100 - 79.2	100 - 20.8

Table 8: Use of vehicle noise and crowd sound in wayfinding

To sum up, hearing is a sense that a sizeable proportion of the respondents get help from. It follows that devices which make use of hearing sense would be ideal for these respondents; however, we did not test different devices on respondents, that is the subject of a future study.

5.4 Problems

Table 9 illustrates the problems that blind and low-vision student respondents have in the selected study area. A comparison between the two groups indicates that the blind generally feel unsafe and did not find the walkway to be of good quality. Unevenness, inundations and steps of pathways were three often mentioned problems (most of these are due to poor maintenance). On the other hand, low-vision respondents, in most cases, were not satisfied with signage (83%) and barrels on the pedestrian walkways (67%). The problems encountered by the low-vision respondents were the result unexpected and temporary obstacles on the sidewalk such as temporary digging for water pipes or even cars that are parked in front of houses. They

indicated that they are afraid of not recognizing these obstacles or of colliding with them while walking as part of the wayfinding process. Generally, the blind student respondents require a flat sidewalk while low-vision respondents have a need for special signage with larger letters and suitable colors to be placed in advance of the obstacles. Further, the visually impaired respondents indicated that they do not intend to use any aids such as a white cane, thereby enabling them to be just like other pedestrians. The absence of a cane means they are not recognized as being visually impaired. However, non use of a cane can become a high risk for this group when they are crossing streets.

What problems do you have on pedestrian pathways?			
	Blind (%)	Low-vision (%)	Total (%)
unsuitable walkway	72.7 - 66.7	27.3 - 25	100 - 45.8
barrels on the pedestrian pathways	33.3 - 16.7	66.7 - 33.3	100 - 25
unsafely	100 - 8.3		100 - 4.2
lack of suitable signage for visually impaired	16.7 - 8.3	83.3 - 41.7	100 - 25

Table 9: Visually impaired and problems encountered on pedestrian pathways

5.5 Street pattern

With regard to street pattern most of the respondents prefer to pass through straight streets (table 10). A grid pattern or straight street pattern is generally a much easier pattern to learn and experience; however, the low vision respondents in particular seem to like to walk through curvilinear paths, thereby adding an element of mystery and exploration (of diverse alleys) to the wayfinding process.

Do you prefer to walk through a curvilinear path or a straight one?			
	Blind (%)	Low-vision (%)	Total (%)
curvilinear	20 - 8.3	80 - 33.3	100 - 20.8
straight	57.9 - 91.7	42.1 - 66.7	100 - 79.2

Table 10: Visual impairment and path preference

We used Cramer's V test to indicate if there is a relationship between the level of disability of visually impaired (blindness or low-vision) respondents and taking the same or different path. The test statistic for Cramer's V is 0.458 with a p-value of 0.025. In other words, being blind or of low-vision has an effect on choosing the same or different path. Table 11 indicates that a high proportion of blind student (92%) respondents always use the same path while is the reverse tends to be true for low-vision respondents. Half of the low-vision students take either of the paths; however, compared with the blind students almost 86% of the low-vision students take a different path in going to and returning from the school.

Do you prefer to walk through a different path or the same path?			
	Blind (%)	Low-vision (%)	Total (%)
same	64.7 - 91.7	35.3 - 50	100 -70.8
different	14.3 - 8.3	85.7 - 50	100 - 29.2

Table 11: Visual impairment and path preference

6 CONCLUSION

This study underscores the relationships between visual impairment- being either blind or low-vision- and the reference points the target group utilizes in comparison with the visual cues used by people with sight. The reference points the target group have utilized in our study –bakery, diverse retail shops like the flower shop or fruit shops, ATM's, "Hatami" school, street trees, school wall, pedestrian bridge, and the Braille pavement- were all related to those senses other than that of vision. Low-vision student respondents and showed similarity to the blind respondents in selecting some common cues such as the bakery, flower shop, crowd noise, street trees, and "Hatami" school. Moreover, the principal sense that both groups relied on was hearing. The sense of hearing was the principal sense they utilized and this is in contrast to our hypothesis that the sense of touch would be predominantly used. Further, smell emanating from particular shops such as the bakery and flower shop proved very practical in guiding them to understand their current position in relation to other elements in the area. It can be concluded that wayfinding aids for the visually impaired were based primarily on reference points that one can hear such as the cluster of people at a mall, and in some cases smell such as that emanating from a bakery.

Our findings suggest enhancements to the quality of life of the target group in the selected study area regarding reference points they gain information from to continue their walking and wayfinding. One immediate outcome is the need to insulate walkways with green facilities to reduce the problem of noise.

Sound-proof green facilities allow the target group to be relaxed as well as to feel safe while concentrating on their walking. In terms of street pattern, the target group indicated they were afraid of exploring curvilinear paths even though some of them, particularly among the low-vision student respondents- were inclined to experience different paths. Based on this finding, one suggestion is for city planning officials to avoid designing complicated curvilinear paths, especially in areas which are likely to be used by the visually impaired.

6.1 Future works

This paper serves to assist those who design aids for the visually impaired to understand their behavior in the simple case of a familiar environment. They can plan for methods to be utilized that make use of the dominant sense of hearing to assist the visually impaired in their daily trips and in experiencing new environments. Future study will need to focus on diverse tools the target group could use to support their movement in unfamiliar settings. More research is required on signage -size and characters– and considerations for the color-blind and various low-vision users. Urban Planners and designers should consider the needs of the target group in performing not only daily trips but also exploring new settings through facilitating walkways free from unexpected obstacles or barrels. Designers should consider the size and color of the signage for low-vision or color blind pedestrians.

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