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The Application of the Eye Tracking Technique in Understanding Users' Visual Perception of Urban Streets; Case Study: Shiraz's Afif Abad Street*

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ABSTRACT

This study investigated how the eye-tracking technique could be employed to help understand users' immediate visual perception of urban streets. For this, Afif-Abad Street in Shiraz City was selected as the case study. After acquiring applicable 360° photos at a virtual reality laboratory, a special headset and the FOVE software were used to record the visual exposure of fifteen Architecture and Urban Planning students to the images, as data were summarized and analyzed using the Gaze Software. Meanwhile, urban designers and policy-makers must understand citizens' visual encounters with these urban spaces and evaluate their visual preferences in analyzing and redesigning streetscapes based on users' cognitive preferences". Also, to enhance the validity of the technique, a questionnaire was developed, which was completed by the statistical population, after a field visit and a guided tour in the earlier stage. Findings led to an analysis of users' visual perception of the Shiraz Afif Abad Street and a comparison of various sections (sequences) of this street, indicating the capacity of the eye-tracking technique in understanding citizens' immediate visual perception of urban spaces, which could be employed in analyzing various dimensions of urban spaces in terms of citizens' visual perception. The findings also indicated the significance of the presence of sign-based buildings within the process of perceiving urban streets, attention to contrasts and differences and emphasis on street walls, the effects of ground-floor walls on the individual's exposure and interaction with the street body, and the effects of vegetation design and arrangement in the process of perceiving urban streets. The results of this study underscored the significance of using immediate techniques of understanding visual perception as a complementary technique of previous methods while helping urban planners and policy-makers to organize the landscape and redesign urban streets.

Keywords: Eye Tracking, Virtual Reality, Visual Perception, Urban Street.

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1. INTRODUCTION

Regarding citizens' perception of urban spaces, a key component of streets as an urban space is the edges whose quality, in conjunction with their spatial dimensions and social activities, may greatly influence the experience of citizens' exposure to urban streets (Simpson et al. 2019; Kickert 2016). This section of the street is viewed as a social-spatial realm and is influenced by both physical dimensions and citizens' daily social life (Simpson 2018; Simpson et al. 2019; Dovey and Wood 2015). Meantime, it is crucial for urban designers and policy-makers to understand citizens' visual encounters with these urban spaces and evaluate their visual preferences in analyzing and redesigning streetscapes based on users' cognitive preferences.

One of the key concepts in urban design literature is "visual perception", which is concerned with the users' sense of vision interacting with the process of perceiving space. Vision is the most important gateway from which environmental information is received, thus playing a major role in the perception process. Hence, it is increasingly important to understand the visual perception process of the space and the factors involved in it to understand the man-environment relationship. The majority of the research conducted on citizens' exposure to urban street edges has employed interview and observation techniques (Gehl and Svarre 2013; Heffernan et al. 2014). Despite their useful applications, these two techniques suffer from some limitations in describing the real, immediate, and subliminal experiences of people in the urban environment. It seems like users' subliminal exposure to street edges could help them gain a more accurate and deeper understanding of their experiences of interactions with urban spaces and their visual perception processes. The eye-tracking technique, which has widely been applied in the last two decades in cognitive, psychological, gaming and leisure, marketing, and commercial sciences, utilizes software and hardware and examines the subliminal behavior of the eye pupil to address the human eye's attention to visual stimuli in the environment (Hollanders et al. 2019). Because this technique concerns the eye's subliminal behavior, it may increase the validity of research in this regard.

The goal of the present study was to explore how the eye-tracking technique can be used to understand users' visual perception of urban streets. This goal was examined both from the perspective of testing the application of this method to understanding citizens' visual perception of urban street edges and the perspective of the content dimension of how visual perception is understood and the components considered by the human eye.

2. RESEARCH LITERATURE

Over the past years, the eye-tracking technique has been used to evaluate the visual quality of urban landscapes and perceptions by examining visual behavior (Wang et al. 2022; Hollanders et al. 2019; Dupont et al. 2015; Gao et al. 2020). Some studies have applied this technique to understand the way landscape elements affect visual quality (Zhou et al. 2022; Gholami et al. 2021), while others have used it to examine how arrangements of green elements, forms, and their colours affect users' visual attention of urban spaces (Zheng et al. 2022; Chen et al. 2023). Yang and Li (2021) also employed the eye-tracking technique to examine visual attention in the process of map-reading and map-cognitive behavior. Lavdas et al. (2021) employed the eye-tracking technique as an instrument to understand the subliminal experience of a built environment, while Li et al. (2022) used it to understand visual behavior when users are exposed to works of architecture (Li et al. 2022).

Some research has used this technique to investigate how people may behave and the way they are exposed to a built environment. Noland et al. (2017) employed the eye-tracking technique to evaluate how components of urban spaces are visually preferred by users. Simpson et al. (2019) applied this technique to evaluate how users are visually engaged with urban street edges and how social-spatial indexes affect this exposure. Susman and Hollanders (2015) used the technique to explain designs to meet users' responses to a built environment, introducing five principles of design: shapes, edges, patterns, and bilateral symmetrical forms in a biophilic design, which are the same principles of design provided by this study. Using the eye-tracking technology, they found that users provided positive cognitive reactions to the urban environments where the principles had been met, feeling more comfortable and being more willing to stay there in such environments.

A review of previous literature indicated that the application of this technique in understanding urban design and citizens' visual perception of streets could represent a novel perspective, warranting more research to help how to enhance the validity and reliability of this technique. This technique is less recognized in Iranian literature and its application has been less examined in analyzing users' visual perception. In sum, the present study aimed to explain how this technique could be applied to understand citizens' visual perception of urban streets and how it could be incorporated into deeper layers of the urban design profession.

3. THEORETICAL FOUNDATIONS

3.1. Visual Perception (Eye-Tracking)

The eye-tracking technique helps investigate how visual attention is concentrated over a visual stimulus (Holmqvist et al. 2011). The overall advantage of this technique is producing data that describe the subliminal movement patterns of people's eyes. These data are measured at higher tracking frequencies, as the quality of the data is so good that they extract visual attention patterns (Blasckeck 2015). The eye-tracking technology is used to specify how people visually attend to or prefer environmental characteristics. Meanwhile, greater levels of environmental element attractiveness could draw visual attention and increase the number of gazes (Zheng 2022).

Regarding various eye movement measures, there is a primary classification that concerns those most correlated to visual attention, those most correlated to emotional arousal, and those that best serve a cognitive workload (Skaramagkas et al. 2021).

People's visual observation behaviour is also influenced by the scene of view complexity. For example, the less the building is within the [field] of view, the less the intensity of visual exploration will be (Dupont et al. 2017). Eye movement patterns usually concentrate on the general arrangement of visual centres, major volumes, and contrasts rather than on the buildings' geometric characteristics (Li et al. 2022).

Various landscape characteristics represent distinct patterns of eye movements and consequently influence perceptions (Batool et al. 2022). The aesthetic value of a landscape helps a greater level of eye fixation and exploration (Zhang et al. 2009; Guo et al. 2021). Visual exploration is also influenced by a combination of landscape elements, with people concentrating their attention more on landscapes that arouse their interest (Kerimova et al. 2022).

Visual attention refers to a process where the user opts for a specific element from among all information available for further examination; put simply, the term "visual attention" refers to a set of various cognitive operations distinguishing relevant information from irrelevant information in visual scenes (McMains and Kastner 2008).

Saccades are rapid eye movements used to shift the focus on a new location within the visual environment. Borrowed from an outdated French word, a saccade denotes sail waving. Saccadic movements involve both voluntary and involuntary movements (Gregory 1990). Meanwhile, fixations are eye movements that fixate the retina on a fixed object of interest. Fixations are characterized by miniaturized eye movements such as tremors, drift, and micro-saccades. Fixations help to focus an object of interest within the visual concentration, as longer fixations indicate more effortful processing and shorter fixations indicate less effortful processing (Hollanders et al. 2019).

The eye normally tends to fixate on a subject and moves again towards the next fixation (saccade). As interest in a stimulus grows, the eye tends to have a greater fixation and thus reduces blinking. Meanwhile, saccade duration and its general length change further with the tendency to exploration (Hollanders et al. 2019).

An area of interest is part of a visual stimulus that is highly important in terms of visual attention. Relevant components can also be determined before or after performing eye-tracking experiments. Areas of interest are commonly created by the stimulus' semantic information. A part of the saccadic movement transfer occurs from one area to another, with the temporal concentration of fixations formed within an area of interest or AOI (Kerimova et al. 2022).

4. AREA UNDER STUDY

This study was conducted in Afif Abad Street of Shiraz, in the Iranian province of Fars. Afif Abad Street measures approximately 940 m long and is located in Shiraz's District 1 (Fig. 1). Bordered by two main linking roads of the city (Ghasr-e-Dasht St., and Sattar Khan Blvd.), this street enjoys a good location and capacity for social, commercial, recreational, and tourism activities. On its western side are the Afif Abad Garden and its Museum, which is considered one of the main centres of tourism in Shiraz. The flourishing business activities along this axis and the increasingly important residential, administrative, recreational, therapeutic, and entertainment roles have made this street receive a wide range of citizens and tourists alike, accounting for a larger share of social interactions in the city. Despite its advantages, this axis suffers from some weaknesses due to its visual configuration and urban landscape, sparking a review of redesign processes involving urban landscape configuration projects. In considering that this space allows for more [citizen] presence and features a significantly important role in Shiraz's spatial-perceptual structure, along with its weaknesses and challenges that require future design reviews, this street was selected as the case of the study to help measure the users' visual exposure to urban spaces within a virtual setting using the eye-tracking technique.

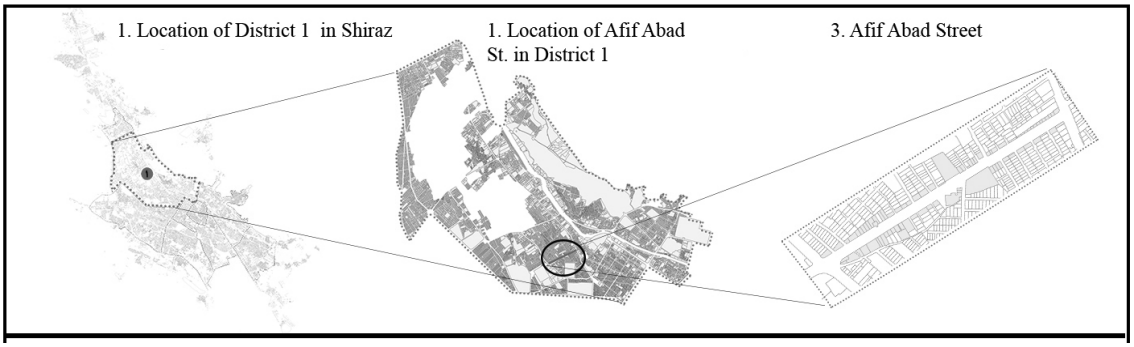

Fig. 1. Location of the Shiraz Afif Abad Street

5. METHODOLOGY

As stated earlier, this study employed the eye-tracking technique to measure the users' visual perception of urban spaces. To strengthen its validity, the study used field visits and a physical (in-person) survey via a questionnaire. To meet its goals, the study conducted theoretical studies to select Afif Abad Street as the case study. To use the eye-tracking technique, there was a need for 360° images. To this end and to increase the accuracy of understanding and analyzing the space, the street was divided into three sequences (Fig. 2).

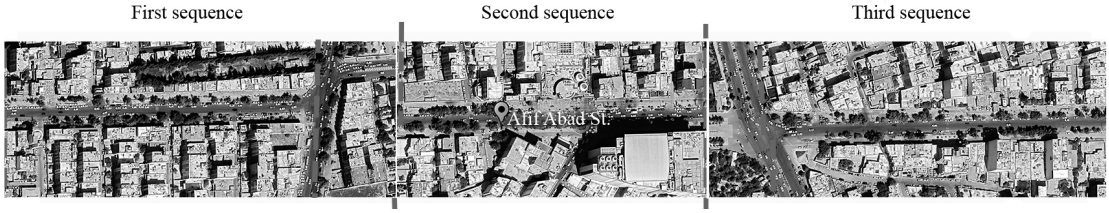

Fig. 2. Sequencing the Street for the Careful Examination of the Understanding and Analysing Process

The street was sequenced by its distribution of land uses and activities, physical characteristics, city image, and urban landscape. The first section starts from the beginning of the street (entering from Ghasr-e-Dasht) to Alley 6, the second section from Alley 6 to Alley 16, and the third section from Alley 16 to the end of the street (exiting towards Sattar Khan). Each section (sequence) comprises a wall on two sides of the street (Fig. 2). From each sequence three images of the main areas are taken using a camera with a special 360° photography lens, as demonstrated in Figure 3. The images were taken from the beginning until the end of the street in the morning in the middle of the week using a camera stand of the same height.

A total of 15 B.A. and M.A. students majoring in Urban Development (9 male and 6 female students) were selected to perform the eye-tracking test at a laboratory using the eye-tracking technique. They averaged 20-24 years of age, as the number, age interval, and selection of the students were based on previous experiences. Many similar studies had opted for 18-30-year-old academic youth, with the number of participating subjects amounting to 12 to 30 people (Torralba et al. 2006; Ehinger et al. 2009; Hollanders et al. 2019; Simpson et al. 2019; Li et al. 2022).

Fig. 3. 360° Images for Laboratory Testing and Their Location on Afif Abad Street

After the subjects were selected for the test, they were provided with the necessary explanations to carry out the test, and a pretest on the feasibility of using the technique was given. The test was performed at the Tech Lab of the Art and Architecture Faculty of the Shiraz University. To conduct the test at the lab, each subject was asked to wear the Virtual Reality headset equipped with the FOVE Eye-Tracking System and to stand in the Virtual Reality Room. After this, the calibration process was performed for the careful examination and accuracy of the users' eye movements using the eye-tracking system. The FOVE software was then used to separately display each of the nine 360° images to the subjects, as the headset was used to record the information obtained from each subject's eye movements. Following the conduct of the virtual test and observation of the images in each sequence, each person was asked a series of questions in the form of a questionnaire about the extent to which they perceived the space displayed. After the tests were conducted, the data were processed using the Gaze Software (Web version) to extract the indexes required. This software shows the information related to the distribution of the fixations and saccades on the images. As stated above, this study used the "visual attention" index to understand users' visual perception which can be evaluated in similar research by such measures as "fixations" and "saccades". The measures used for the index are given in Table 1.

Table 1. Indexes and Measures of Eye-Tracking Technique in the Present Study

Indexes	Measures	Description	Research
Fixation	Total Fixation Time	The more fixation time, the more the user pays attention to the visual stimulus.	(Winter et al. 2020; Li 2022)
	Average Fixation Time	The areas where the average fixation time is higher feature a greater level of users' mental preferences.	(Chu Chen et al. 2022; Simpson 2022; Li 2022)

Indexes	Measures	Description	Research
Fixation	Number of Fixations	The number of fixations reflects the users' ability to process the scene, the scene complexity, and their interest in the content they look at. The areas that feature more fixations are commonly more interesting areas for the users.	(Zheng et al. 2022; Winter et al. 2020; Yang 2021; Chu Chen et al. 2022; Hollander 2019; Li 2022)
	Fixation Duration	The longer the fixation duration, the harder it gets to perceive the image and the more it becomes attractive for the user.	(Zheng et al. 2022; Yang 2021; Chu Chen et al. 2022; Hollander 2019; Li 2022)
Saccade	Number of Saccades	The number of saccades refers to the number of eye movements between the fixations.	(Zheng et al. 2022; Li 2022)
	Saccade Amplitude	The saccade amplitude refers to the distance between saccades and is measured as the angle of view.	(Zheng et al. 2022; Hollander 2019; Li 2022)

Also, to increase validity, a survey involving a questionnaire was considered while making the field visit. The questionnaire was adjusted in three sections. The first section asked about the subjects' demographic data, the second section measured their extent of attention to the main components of the street (areas of interest) by each sequence based on a Likert scale (15 items), and the third section measured the perception of the sequences by two questions (the extent to which the sequences could be remembered and the extent of the clarity of the mental image). This questionnaire was completed by the statistical population in the earlier stage, after a field visit involving a guided tour to Afif Abad Street.

6. FINDINGS

Eye-Tracking Technique-Related Findings: To analyze the data from the Gaze Software, the areas of interest were specified by analyzing the eye movements of 15 users who observed the representative images. These areas comprised five items: buildings, urban furniture, vegetation, the sky, and flooring. Then, the measures of fixations and saccades indexes were analyzed to help determine the extent to which the subjects paid attention to each of the AOIs in each sequence.

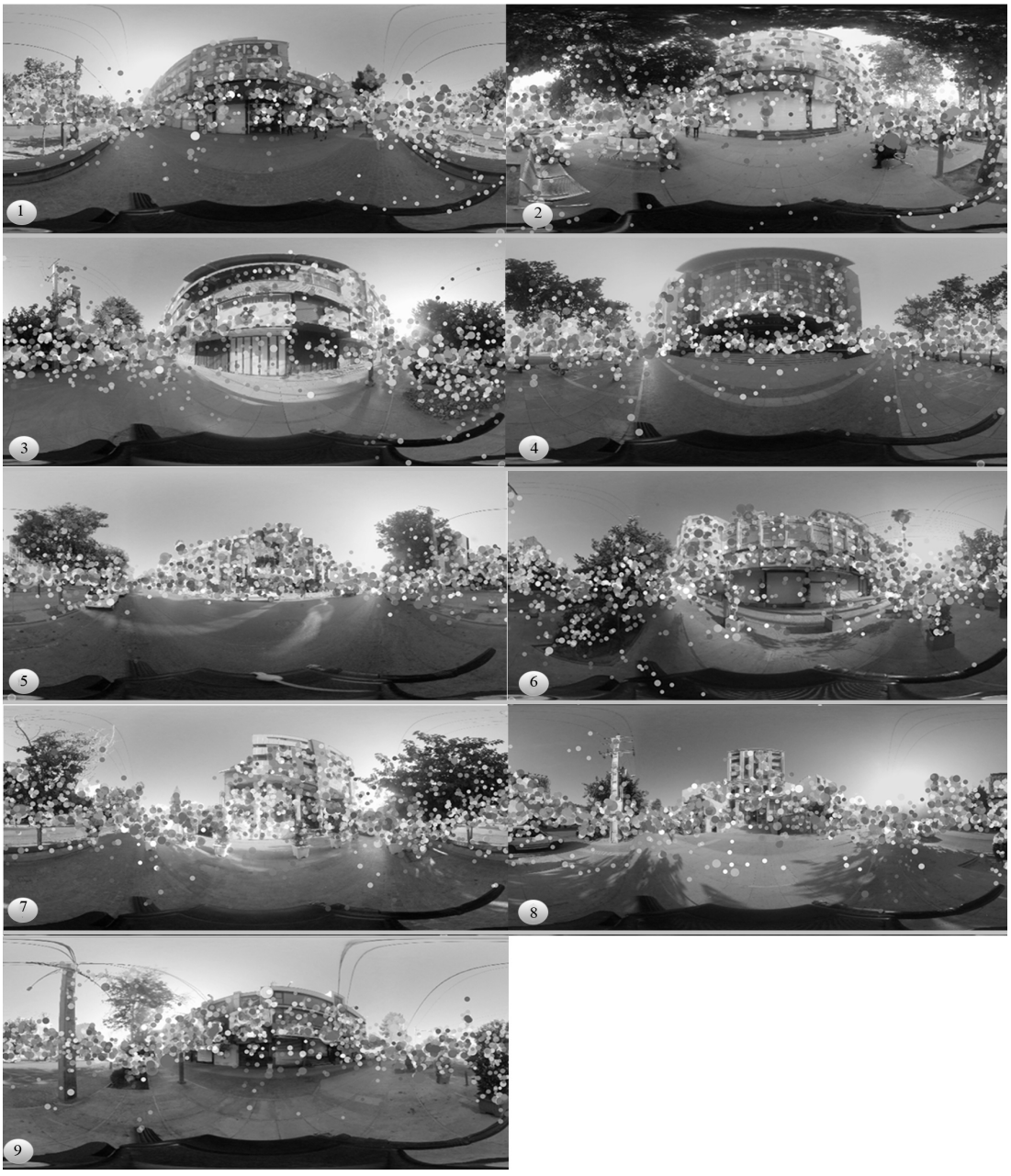

Fig. 4. Heat Map of the Fixations across the Street

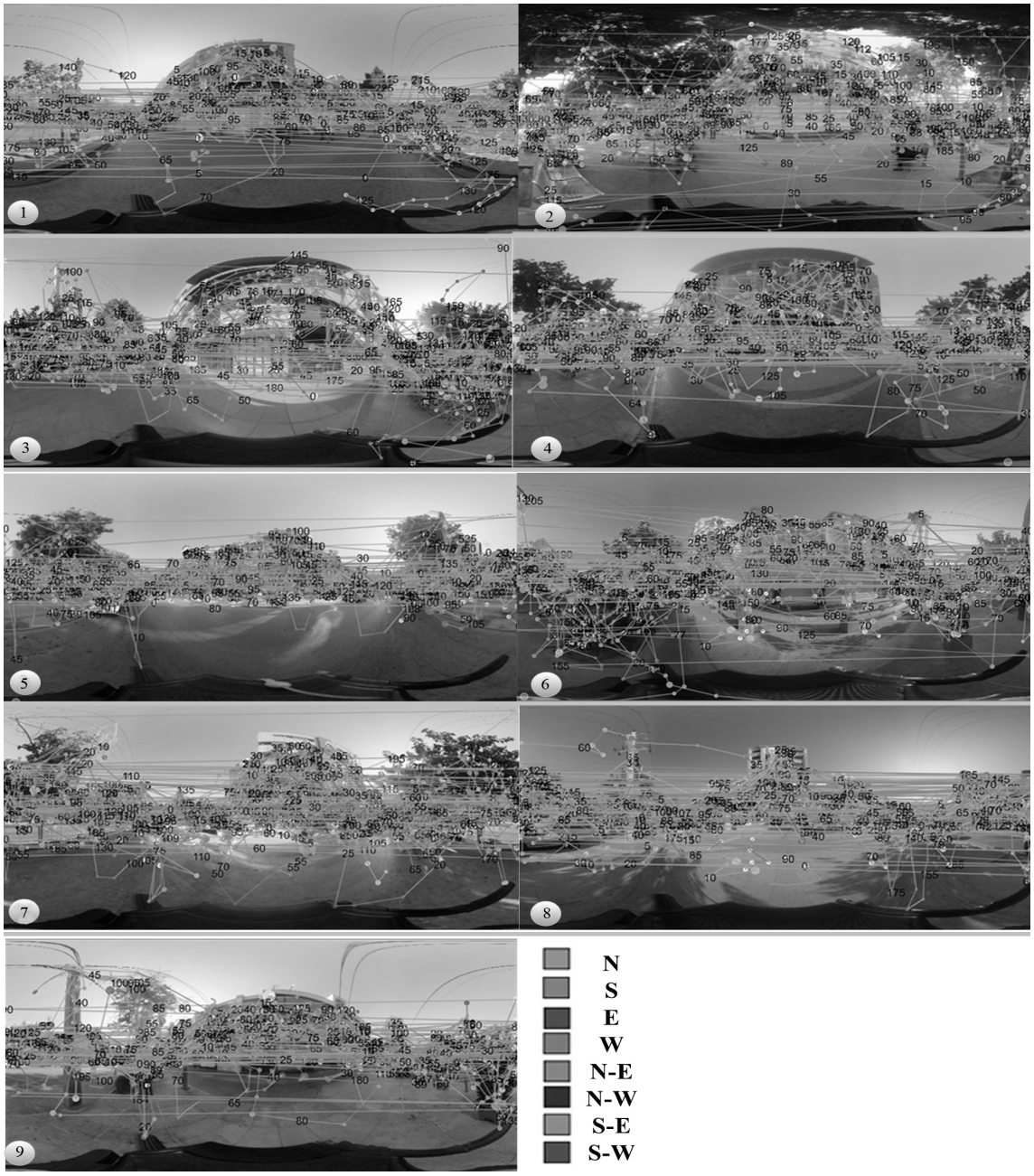

Fig. 5. Heat Map of the Saccades across the Street

Table 2. Number of Fixations and Saccades in 9 Images of Afif Abad Street

	Image 1	Image 2	Image 3	Image 4	Image 5	Image 6	Image 7	Image 8	Image 9
Number of Fixations	1884	1893	1753	2005	2090	2105	2221	1991	1934
Number of Saccades	1854	1866	172	1977	2062	2077	2196	1968	1907

Table 2 gives the number of fixations and saccades in the nine images of Afif Abad Street. The images reveal a slight difference between the number of fixations and saccades, indicating the scattering of the points and attention to all parts of the image. The images also feature that the number of saccade lines that pertain to the eastern direction is greater than that of other directions, indicating the horizontal extension of façades and the attention to the walls of the adjacent buildings.

According to Figure 4, there is a scattering of fixation points in the first sequence, as exhibited by the heat map of Image 1. No outstanding point is seen on which the fixations are concentrated. The environment is actually a neutral one, suggesting that there is no outstanding element in the image. As exhibited by the heat map of Image 2, the fixations are seen to have concentrated more on the building of the Mir Hospital and the ambulance next to it on the side of the street. As exhibited by the heat map of Image 3, the fixations are seen to be scattered all around the image, as they are more concentrated on the building and vegetation. This map features no outstanding point where the number of its fixations is more than others.

As exhibited by Image 4 in the second sequence, the points are seen to have concentrated more on the buildings and vegetation than the rest of other areas. The number of fixations on the entrance to the Afif Abad Complex is higher than those on the upper floors, as the skyline receives less attention. Image 5 shows a rising number of fixations than in the previous images, with the fixations being more concentrated on the buildings, especially the Setar-e-Fars and Fars Complexes, indicating the greater level of attention of people. Image 6 also features a rising number of fixations than the previous images, though the point scattering is higher and no fixation concentration is seen over any other specific component (Fig. 4).

In the third sequence, Image 7 shows that the number of fixations is greater than those of other images, with vegetation and flower vases, as well as lower floors rather than upper floors, receiving more attention. Image 8 features that the buildings receive a greater number of fixations than other images, as vegetation and vases, as well as upper floors rather than lower floors, receive much attention. Image 8 shows that the majority of the fixations are concentrated over the buildings; however, the scattering of the points of fixations is higher. More attention has been paid to the Sepehr Complex, with people, unlike in previous images, paying much more attention to the upper floors of this building. Image 9 shows a falling rate of fixations compared to the other two images (Images 7 and 8) (Fig. 4). All images feature the horizontal view as one that dominated (Fig. 5).

Table 3. Measures of Fixations by Sequences and Areas of Interest (AOIs)

Sequencing	AOIs	Total Fixation Time	Fixation Time Percentage	Number of Fixations	Number of Visits
First Sequence	Buildings	877561	45.17	2498	322
	Urban Furniture	91544	4.66	249	130
	Vegetation	581727	30.07	1597	444
	The Sky	51389	2.63	166	73
	Flooring	125806	6.53	426	131
Second Sequence	Buildings	1076398	46.63	2933	401
	Urban Furniture	11841	1.62	28	16
	Vegetation	857828	37.6	2309	494
	The Sky	31406	1.41	77	48
	Flooring	130432	5.38	370	157
Third Sequence	Buildings	1066005	47.47	2879	518
	Urban Furniture	27736	1.82	74	36
	Vegetation	907905	39.8	2470	748
	The Sky	84938	3.82	246	148
	Flooring	86572	3.86	258	100

Table 3 gives the measures of the index of fixation generally by sequence and areas of interest in each sequence, as Figure 6 compares the three sequences in the areas of interest by the measure of the number of fixations.

As exhibited in the table and the diagram, the highest fixations primarily pertain to the buildings and then to vegetation in all three sequences. The second and third sequences feature a greater level of attention to the buildings, with the first sequence showing a lesser rate. This is due to the presence of sign-based buildings in the two sequences with different heights and physical structures. Accordingly, the first sequence shows weak sign elements, which is confirmed by the scattering of the fixations across the heat map. As exhibited by the heat map, the saccades feature a horizontal (eastern-western) extension in the first sequence compared to the other two.

In the third sequence, the Sepehr Building has drawn significant attention in its vertical saccades due to its

façade and wall design distinction, with the ground floor of other similar commercial complexes on the street (in the second sequence) receiving more eye attention.

In the second and third sequences, vegetation receives more attention from the users. The first sequence of Afif Abad Street reveals some weaknesses compared to the other two sequences in terms of tree arrangement and green space designs.

More interestingly, the extent of attention to the sky is higher in the third sequence than in the other two sequences, which is due to the open space of this sequence, the reduced size of volumes, the diversity of land uses in the sequence, and the relative reduction in the population visiting this section of the street. In addition, special building architecture tends to invite the user to pay more attention to the sky and the skyline in this area.

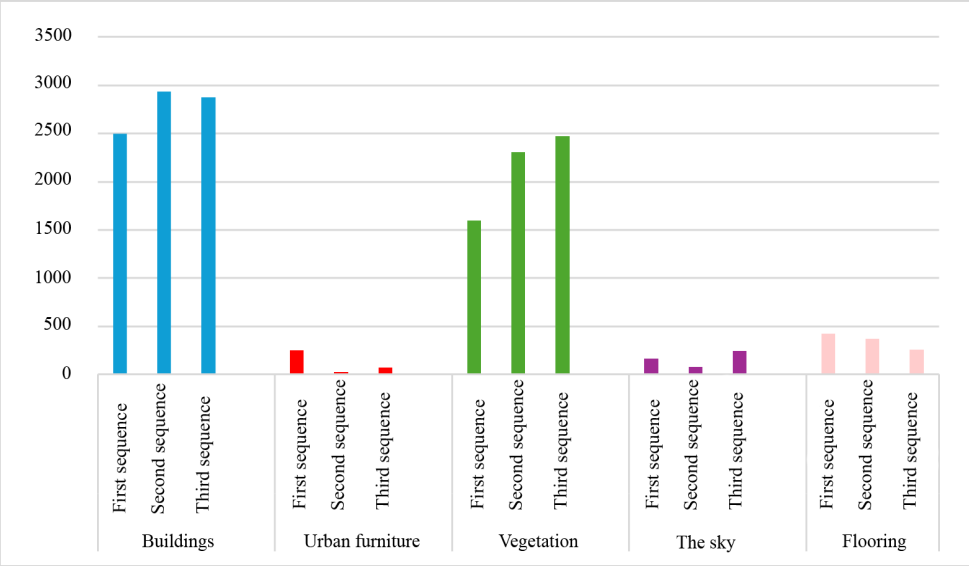

Fig. 6. The Number of Fixations for all Areas of Interest (AOIs) in the Three Sequences

Figure 7 demonstrates the extent of attention to the areas of interest across the entire street based on the number of fixations, indicating the noticeable contribution of the buildings and vegetation to the users' and pedestrians' visual perception.

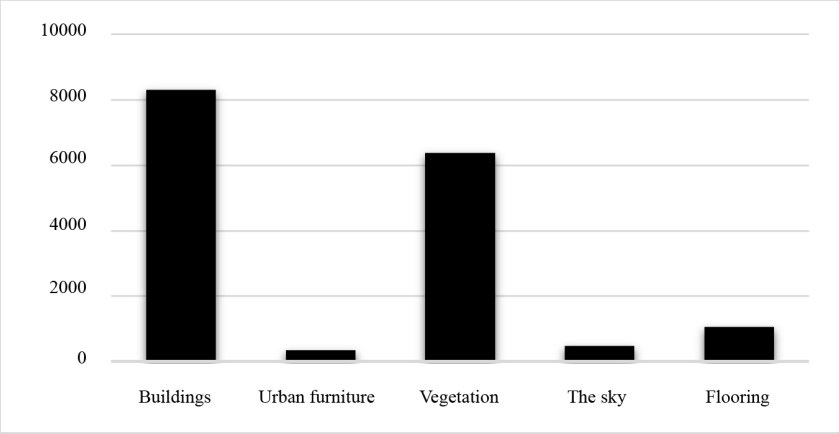

Fig. 7. Number of Fixations for all Areas of Interest across the Street

As stated earlier, after displaying the images and recording the eye-tracking data, for every sequence, the extent to which the user perceived the space was determined using a questionnaire based on two indexes, namely the clarity of the space image in the mind (a clear mental image) and the ability to remember the space in the mind. Figure 8 shows the results of this questionnaire by sequence. As exhibited by the image, and based on the observers' statements, the second sequence could create a clearer and more lasting mental image in the subjects' minds. When compared with eye-tracking findings, this can be considered consistent with the intensity of the fixations on the building walls in the second

sequence (compared to the other two sequences), especially the sign-based buildings in this section of the street (e.g., commercial complexes of Afif Abad, Hafez, and Setareh). This underscored the effects of these complexes and sign buildings on users' visual perception.

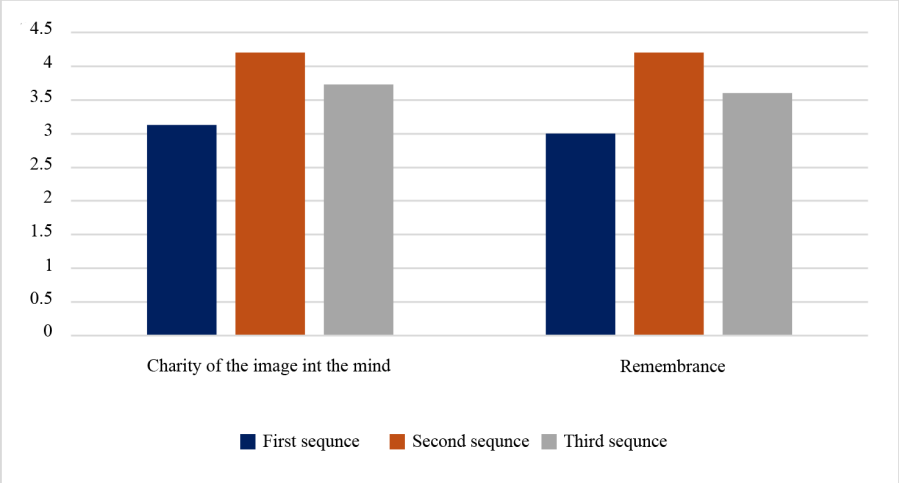

Fig. 8. User's Perception of the Street for every Sequence (based on the Virtual Questionnaire)

- Field Questionnaire Findings

As stated, to increase the study's validity, the statistical population completed the intended questionnaire while on a field visit and a guided tour to Afif Abad Street, as a survey in the laboratory environment was performed using the eye-tracking technique.

The questionnaire findings are given in Table 4. As noted, among the areas of interest, the buildings accounted for the highest attention, which was also mentioned in analyzing the heat maps of the fixations. Also, for the sequences, the buildings in the second sequence received more attention than the other sequences. This was in line with the eye-tracking technique findings, which were specifically due to the presence of large-scale commercial complexes in the second sequence. Concerning the greater attention to the sky and vegetation in the third sequence compared to the other two sequences, the findings were similar to the eye-tracking findings, which were also explained in the same section. The field survey findings and the eye-tracking findings differed over the extent of attention to the furniture and flooring in the first sequence, with the eye-tracking technique allowing for more attention to them.

Table 4. Extent of Attention to the Areas of Interest for every Sequence based on the Field Visit Questionnaire

Areas of Interest (AOIs)	Extent of Attention (Average Likert Spectrum)		
	First Sequence	Second Sequence	Third Sequence
Buildings	3.3	4.1	3.7
Furniture	3.3	3.5	3.4
Vegetation	3.4	3.3	3.5
The Sky	3.5	3.3	3.8
Flooring	3.5	3.8	3.7
Sequence Remembrance	3	3.7	3
Sequence Mental Image Clarity	3	3.6	2.7

Concerning the two final questions of the questionnaire that generally measured the extent to which each sequence was perceived, Figure 9 shows that the second sequence, followed by the first and third sequences, generally encouraged better user perception, which was also underscored by the eye-tracking technique data.

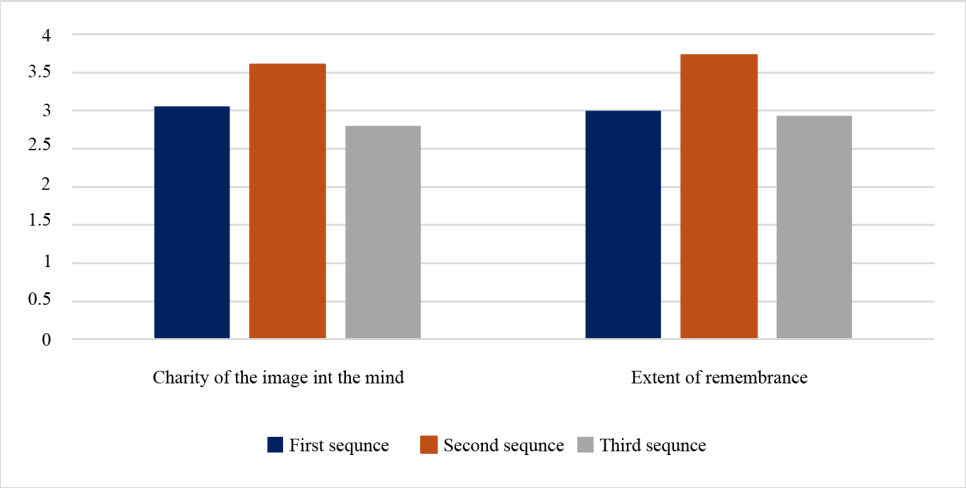

Fig. 9. User's Perception of the Street for every Sequence (based on the Face-to-Face Questionnaire)

7. DISCUSSION

The results of employing the eye-tracking technique in understanding the visual perception of spaces can be concluded as follows:

First: The significance of the effects of wall buildings on users' visual perception of streets. While seemingly a clear subject, this concerns subtler issues such as the effects of the ground floor of the walls, especially in commercial complexes (higher number of fixations in the sections) (Kickert 2016) and the significance of façade designs in these buildings (higher fixations on the facades of the Sepehr Building and the Namak Food Complex, as well as higher vertical saccades on these two facades). The research by Hollanders and Susmun also demonstrated the way the eye-tracking technique had been applied, as façade and pattern designs on space walls could form one of the main five elements underlying the man-environment relationship (Hollanders and Susmun 2015). As stated in previous research, building walls significantly contributed to users' visual perception of urban spaces. Previous research had suggested that the effects of the edges were not just due to their physical features; rather, current activities on those edges could influence the perception process, also (Simpson et al. 2019; Kickert 2016).

Second: The significance of attention to such qualities as contrasts and emphasis along street walls to avoid uniformity and to present a clear and readable image of urban streets in the mind of users. The comparison of observers' type of exposure to the images of the first, second, and third sequences on the studied street in terms of both indexes of fixation and saccade indicated that the uniformity and neutrality of wall designs in the first sequence had influenced the number of fixations and horizontal saccades. From a comparison of perception (the clarity and permanence of the mental image), this sequence, as stated by the users, received the lowest scores.

Third: The significance of vegetation and how it is arranged in the visual perception of urban streets. This study drew more visual attention to flooring and urban furniture. This subject, tested using the eye-tracking technique in prior research (Zheng et al. 2022; Chen et al. 2023), indicated the importance of attention to designing vegetation along the street in line with the behavioral and activity patterns of the space. In the third sequence of Afif Abad Street, where vegetation is seen along with the behavioral patterns of pause and stop due to the presence of dining shops (cafes, and restaurants), more visual attention was paid.

In sum, the study noted the importance of employing the immediate eye-tracking technique, along with such methods as observation, questioning, and interview, in understanding space users' visual perception. This technique proved to provide a novel and usable cognitive layer for a more accurate understanding of urban spaces within the urban design process. Using this cognitive layer to analyze visual perception relations with urban design cognitive dimensions, such as citizens' behaviors, as well as the examination of such qualities as identification, a sense of place, presence, vitality, etc. could provide useful and credible outputs.

8. CONCLUSION

The goal of this study was to investigate citizens' visual perception of urban streets using the eye-tracking technique in terms of two procedural and content dimensions. To this end, Shiraz's Afif Abad Street was selected as the case study. Meanwhile, 360° images involving three street sequences were captured. This was followed by testing the type of users' virtual exposure to the images using the laboratory eye-tracking technique. The findings not only underscored the importance of using eye-

tracking methods in recording the eye's immediate behavior in the visual perception process but also compared the various sections of Afif Abad Street based on users' perception processes. The results showed that using the eye-tracking methods, along with other field methods and face-to-face (physical) survey methods, could help provide more accurate information about users' visual behaviors in urban spaces, as well as their perception of urban streets.

Evaluating the index of "visual attention" by examining the two measures of "fixation" and "saccade" using eye-tracking tools and developing heat maps, as well as comparative diagrams, could provide areas of interest as cognitive layers for citizens in urban spaces in a more acceptable accuracy. These layers can also be used to provide more complex and deeper analyses and understand the space and its relevant correlates with the behavior, activity, and presence of citizens, which would help examine such qualities as readability, vitality, a sense of belonging to a place, etc. The results of this study can be generalized to future research to help increase the validity of the findings and their methodologies while advancing urban landscape configuration plans and street redesign processes by urban policy-makers and planners.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

MORAL APPROVAL

The authors commit to observe all the ethical principles of the publication of the scientific work based on the ethical principles of COPE. In case of any violation of the ethical principles, even after the publication of the article, they give the journal the right to delete the article and follow up on the matter.

PARTICIPATION PERCENTAGE

The authors state that they have directly participated in the stages of conducting research and writing the article.

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