User-oriented nightscape lighting (UONL)

Maedeh Pourfathollah[1], Mohammadhavad Mahdavinejad[1,*], Mojtaba Ansari[1], Hosna Shams dolatabadi[2], Maryam Arbab[1]

[1]Department of Art and Architectural, Tarbiat Modares University, Tehran, Iran
[2]Department of Art and Architectural, Isfahan University, Isfahan, Iran

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Abstract

User-oriented design is a method in which user's needs and comfort are met along with his comfort in design process. Lighting of some buildings and urban elements is done for the purpose of attracting audiences in urban nightscape, however the expectations of the users are not thoroughly met. In this paper, user expectations from nightscape are investigated through visual and perceptual attention approach and it's far beyond visual comfort. Therefore, the key question is around; what are the factors affecting user oriented nightscape lighting based on attention?
To answer the research question, two places of nightscape with different visual elements in Ab va Atash park are selected. Using survey and eye-tracking techniques, the relationship between different variables of visual attention and attention restoration as perceptual dimension was obtained. Also, by determining the visual preferences, the relation between lighting the elements of landscape with promoting the nightscape based on attention approach was investigated. Finally, a conceptual model of user oriented nightscape based on user attention is presented.

Keywords: User oriented nightscape lighting (UONL), Attention, Visual perception, Attention restoration theory

1 Introduction

Every day in the urban atmosphere, an area is experienced by people from morning to night by moving in the urban atmosphere causing comprehension of sequential scenes. [1] This comprehension creates a bilateral connection with the humans mind. For residency and life, a city is a big house and it should have the characteristics for providing luxury, convenience and security. [2] Light, as one of the indicators which shapes the quality of environment; plays a significant role in designing of cities' nightscape. Lighting design can effect desirability and sense of pleasant to viewer. [3]Recognizing its perceptual and psychological effects and determining visual preferences can provide a proper design (which is far from negative effects).

Today, eye tracking technique is one of the visual attention and visual prioritization tools. In fact, eye movement and eye fixation analysis have a direct relationship with attracting visual attention[4]. On the other hand, the attention restoration theory introduces valuable variables to measure the relationship between psychology and environment. According to this theory, the focused attention capacity (conscious) ends and is likely to be renewed trough attention (unconscious) to the attractive stimuli for a period of time. In fact, mental effort or conscious concentration cause tiredness and need restoration to be effective again. According to researches based on attention restoration theory, understanding certain qualities of environment results in returning the direct attention. The attention restoration theory introduces valuable variables to investigate the role of lighting in psychology and restoring attention. In this exploratory study, visual tracking technique and perceptual attention and visual questionnaire of nightscape are used to determine the preferences and priorities of lighting in the form of an auxiliary design model.

* Mahdavinejad M, Tel.: +989122142250
E-mail address: Mahdavinejad@modares.ac.ir

2 UONL and Attention Restoration Theory (ART)

The attention restoration theory was first proposed by Kaplan[5] and as it divided attention to two groups, the self-conscious and the self-unconscious, it suggests that the conscious mind becomes tired and needs renewing and certain environments can ease the direct renewing ability or the concentration. A restoring space can cause distance from work and mind pre occupation. So, what we see is related to the minds way of perception and can affect the conscious and unconscious mind. The attention restoration theory has proved that certain environments have helped to increase people's ability to pay attention directly or to concentrate [6].

Based on ART (attention restoration theory) the quality of a restoration environment is defined by being away, fascination, coherence and compatibility. A restoration environment creates physical and psychological distance from everyday work, a quality called being away. It supports the use of effortless attention (fascination), it promotes the use of involuntary attention and thus recovery from mental fatigue. [7] And if environmental contact supports intended activities the quality is called compatibility. According to the four factors of ART there are little factors for measuring an environment in which these amounts generally have positive correlation with sense of well-being [8]. The psychological studies of this topic have been vast. For example, in a study done by Gonzalez the relation between the two factors which are being away and fascination on treating depression have been measured [9]. As a result, this theory can provide useful indicators to determine UONL, which is attention based and consider visual utility alongside with visual comfort.

3 UONL and Eye Tracker Technique

Eye tracking technique is among the effective techniques to understand the user's attention to different elements and phenomena of an urban landscape. Motion and fixation eye analysis, assist in understanding the visual attention[4] and has been applied in various studies [10–12].

One of the UONL goals, is to set visual priorities according to user's visual needs. The eye tracker analyzes these priorities and requirements by accepting the relevant information and rejecting the irrelevant ones. In the current paper, this technique is applied to develop a conceptual model of planning user-oriented nightscape based on attention.

4 Research Methodology

The method of this research is descriptive-analytical and the technique for gathering information is by surveying by the use of questioning and eye tracking. So, the research based approach is qualitative-quantitative. The way in which users conceptualize the environment is quite important. The unconscious levels of the audience's perception are captured using the eye-tracking technique. This complementary test shows the visual preferences of the nightscape. In this study, a fifteen-meter-long track in Ab va Atash park is selected as one of the live urban spaces in Tehran. The prominent feature of this route is the diversity of the nightscape elements. This diversity creates different environmental experiences for space users. Two points were selected along this path and questionnaires were completed at each point by people walking along the route. At the end, one hundred questionnaires were analyzed. The analysis is done through spss20 software. The role of different factors is determined, using correlation test between variables of attention restoration theory with technical factors and lighting design. Then, for the complementary results, the same two points are displayed in the laboratory environment and data are analyzed to determine visual preferences, attractiveness, and cohesion.

4.1 Test process and data analysis

The first test is a survey which is done in the environment. The following image (Figure 1) shows the points from which the observers respond. This route includes various nightscape elements including vegetation, buildings and urban elements.

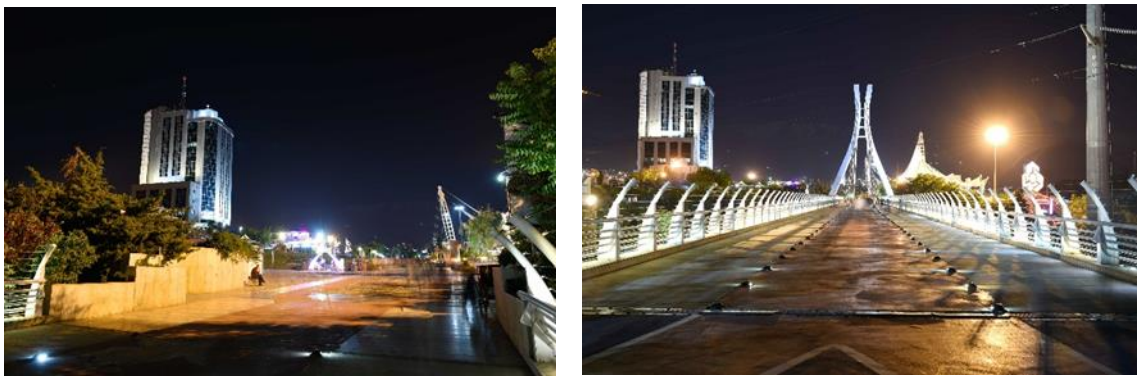

Figure 1: first point (right) and second point (left)

The visual weight of the landscape elements including tree, path, building and sky is measured. SPCONV and GeoCity software are used to determine the visual weight of each nightscape element. In This software, visual weight of elements is determined by counting the number of points that cover the element (Figure 2).

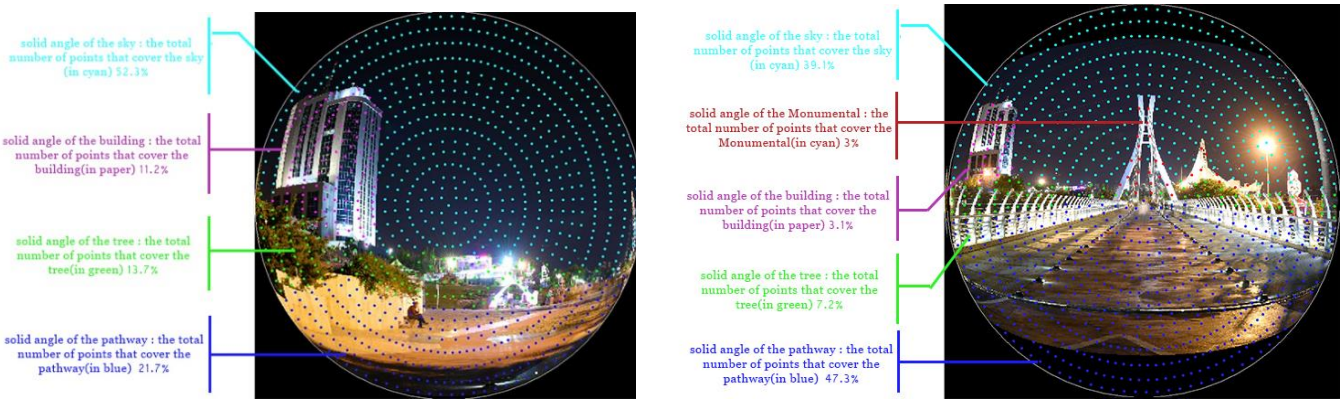

Figure 2: Determination of Visual Weight of landscape elements, Point 1 (Top) and Point 2 (Bottom)

Accordingly, the percentage of important elements of the nightscape are determined in these two points. Figure 3 shows the ratios and percentages of the main elements including; vegetation, built environment, and path.

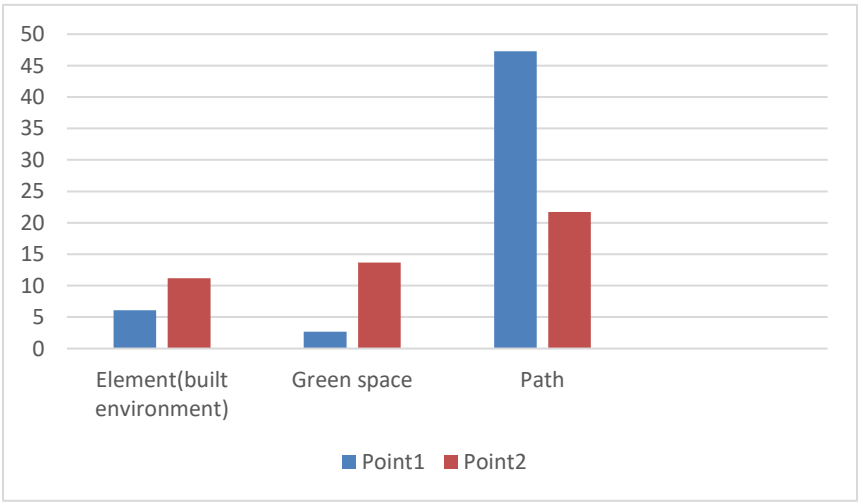

Figure 3: Ratio of the main elements forming the nightscape in paths at points 1 and 2

4.2 Questionnaire Design

In order to reply to the questions of the study, a questionnaire is constructed of all questions of measuring technical, design and ART factors. Questions were developed based on ART and perception of users by using the Nikunen questionnaire [10], which he had used for understanding attention restoration and lighting pedestrian routes in his research in locations close to residential areas. After developing the initial design of questionnaires, the amount of validity and reliability of them were determined. In this research in order to determine the validity of the test, the method of Cronbach's Alpha was used. This method is used for calculating the inner coordination of measuring tools which measure different features. By surveying professionals in this subject some of these items were eliminated so that a functional questionnaire was made. In this study the answers of the questions were anticipated based on the 5 spectrum Likert method.

5 Analyzing

After completing the questionnaires, the average questions which are related to technical factors of lighting (CCT, CRI) and questions related to the designing method of technical factors such as altering CCT on the route and the surrounding walkway in order to create contrast and balance of brightness led to creating the variables for designing technical factors and the sum of questions related to the variables of ART resulted in a single variable for assessing the surface of effectiveness and the relation between the technical factors and ART. In table 1 the average of the parametric test in the population is shown (Figure 4).

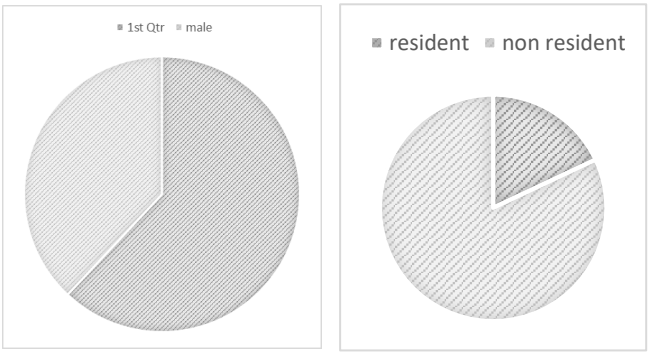

Figure 4: Indicates the average of the population

Table 1. Sorting questions and the definition of variable unit

Attention restoration theory	Lighting design	Technical aspects
Being away	balance	Color of light
compatibility	desirability	CCT(correlated color temperature)
coherence	contrast	CRI(color rendering index)
fascination	safety	brightness

In this research the average statistical indicators and the standard deviation are with a confidence interval of 95%(SD2) and the error of the study is measured based on (p-value<0.05). The table number 2 indicates that between lighting design and technical factors of lighting with attention restoration variable, coherence exists. (Table 2) Also the design of lighting with altering technical factors has more effect compared to technical factors of self-conscious attention restoration (Table 3).

Table 2. One sample test

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
art	36.051	89	.000	3.47222	3.2808	3.6636
design	30.630	89	.000	2.94167	2.7508	3.1325
technical	31.947	89	.000	2.98333	2.7978	3.1689

Table 3. The relation between lighting design and technical factors of self-conscious attention restoration.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.135	.249		4.553	.000
design	.480	.106	.479	4.506	.000
technical	.310	.110	.301	2.832	.006

a. Dependent Variable: art

Due to the existence of coherence relation between the variables, for more precise surveying, the variables in the ART for lighting design and technical factors are measured.

Table 4. The coherence between variables and lighting design

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.642	0.294		2.181	0.00
Being away	0.236	0.080	0.333	2.948	0.004
Fascination	0.195	0.081	0.219	2.397	0.019
Extent	0.002	0.091	0.003	0.o24	0.981
compatibility	0.244	0.075	0.316	3.251	0.002

The results show that the existence of lighting design has a direct relation with variables such as being away and compatibility. (Table 4) So, the use of technical factors capacity in creating a suitable walkway for pedestrian walk that keeps away humans from everyday struggles and causes conscious attention restoration in humans is effective. Table 5 shows the relation between variables and technical factors. The results show that technical factors have also a direct relation with variables such as being away, fascination and compatibility.

Table 5. The relation between variables and technical factors

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.127	0.288		3.910	0.00
Being away	0.440	0.079	0.637	5.601	0.00
Fascination	0.045	0.080	0.052	0.560	0.577
Extent	-0.031	0.089	-0.38	-0.342	0.733
compatibility	0.085	0.073	0.113	1.156	0.251

Regarding the effective and appropriate technical factors, CCT, CRI and brightness except for the variable of being away does not have a meaningful relation with ART variables.

Figure 5 shows the average of obtained statistical data of appropriate lighting design and attention restoration at different points of the path.

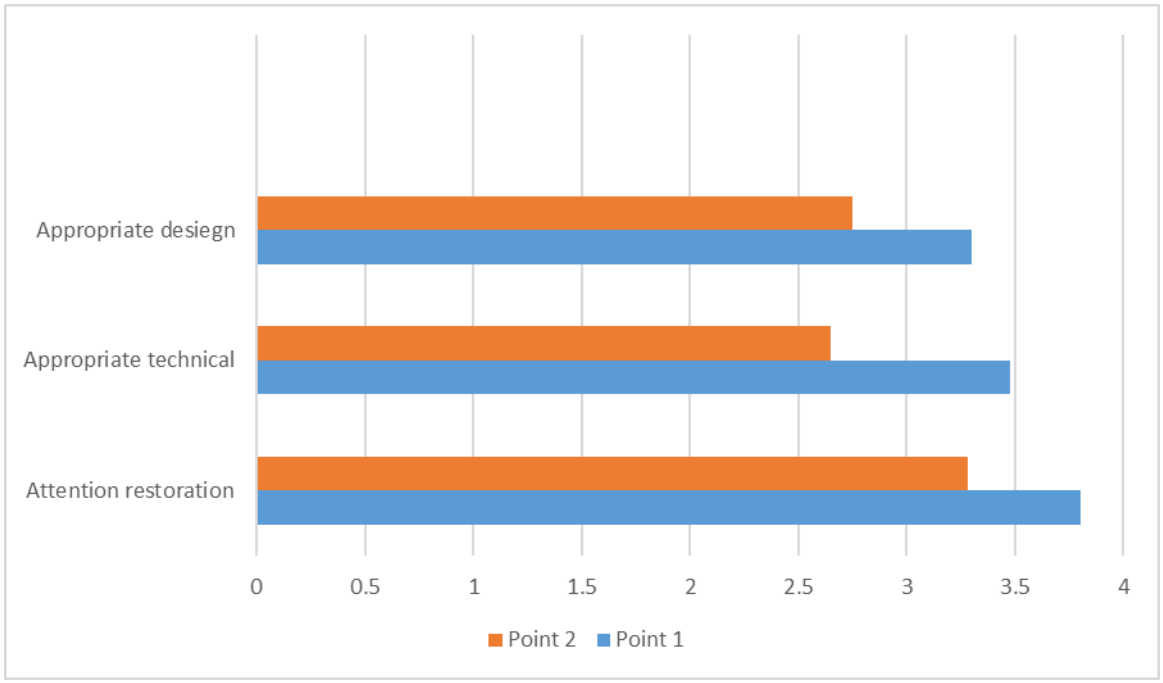

Figure 5: The Average of variables of; technical factors, lighting design and attention restoration at different points in the path

As it's shown in the diagram, the determined variables vary at different points of the route. Point 1 is recognized the most appropriate place according to technical and design factors from the respondents' point of view. Regarding appropriate and desirable application of technical factors such as; color temperature, light color, color display index and appropriate light intensity, no significant relationship is observed with variables of attention restoration theory, except for distance variable. As a result, the attractiveness which arouse conscious and unconscious attention, depends on other attributes. Since the first test is not able to measure the unconscious aspects; the eye tracking technique is used in the following practice. Therefore, a complementary test is applied to determine visual preferences based on attractiveness and visual cohesion for different elements of the nightscape.

5.1 Experiment 2, Visual Priority Analysis

17 persons (9 females, 8 males) with a mean age of 34.5 participate in this test. They participated voluntarily to get familiar with the cognitive science tests. Volunteers seated on a fixed chair which was 65 cm away from the monitor screen. For each participant, the stimuli were randomly displayed on a 17-inch monitor with a resolution of 1600 x 900 pixels. Each stimulus was monitored for ten seconds (standard time based on eye mechanism). Neutral screen (A gray plate with a white cross in the middle) appeared before and after that for two seconds. Eye movements were recorded using eye detector model SMI RED250.To prevent specific information from affecting test result, participants were unaware of the research topic. The lab employee described the test steps, including display of images to them. Also, prior of starting the test, a nine-point calibration process for each participant was used to validate the test. After displaying the images, participants were asked to complete a questionnaire about their visual preferences for light temperature.

After performing the test, a total of 478 absent of eye movements (moments when eyes were closed), 10231 fixations (fixations above 100 milliseconds), and 11138 SACADs (jumps to register new points) were recorded. Since the subject of the test is visual attention and eye fixations, the analysis was performed on fixations.

The recorded eye movements' data for the interesting areas were extracted through BeGazeTM software. The data was categorized in to; total fixation durability, image duration average, and the first recorded moment of eye movement. Table 6, shows the criteria of the audience's visual attention based on an observational approach. It measures the relationship between light temperatures with visual attention to building.

Table 6. Data from the analysis of mean eye tracking data in specified areas (Element (built environments)-Path-Green Space) in images

point	Area of interest	Entry Time(ET)	dwell time(DT)	number of fixation	Revisits	Revisitors	Average fixation (Av F)	First fixation (FF)
1	element	3478.50	1290.00	4.60	2.20	9.00	272.20	230.40
1	path	3718.90	968.30	2.70	1.30	7.00	299.30	294.20
1	Green spaces	3447.60	1033.20	4.00	1.40	5.00	245.00	205.40
2	element	2815.20	1199.30	4.00	2.00	7.00	267.00	212.20
2	path	3125.60	1480.70	4.40	1.30	6.00	3326.00	249.30
2	Green spaces	166900	495.40	4.10	1.70	6.00	387.60	446.20

According to the obtained data, the average fixation time represent attractive nightscape variables that provide the attraction trait. The lesser time it takes to see the area, shows the attraction of that area for unconscious attention. Diagram below shows the location of different elements of the nightscape; in terms of attractiveness (longer fixation time) for two different points.

It is important to note that at point 1, a large percentage of the image is dedicated to the track, but the level of eye stabilization is quite low. This can be due to the various and different urban elements at that point. The elements have a lower range of visual weight in compare to point 2. Due to this diversity, the degree of fixation on urban elements in point 2.

Despite this variation, the green space (that its visual weight is equivalent to the elements in both images), has more eye-stabilization. Finally, the green space is one of the most important visual priorities. Also the presence of urban elements in the path, the monumental elements (the second visual priority) and the path itself provides the attraction for the audiences (Figure6).

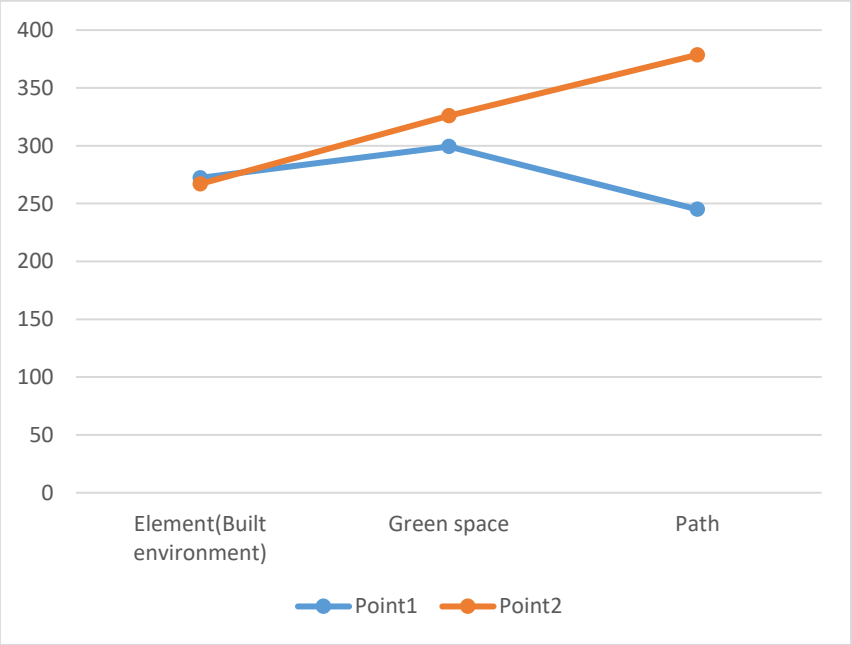

Figure 6: Average eye fixation for different landscape elements for the points 1 and 2

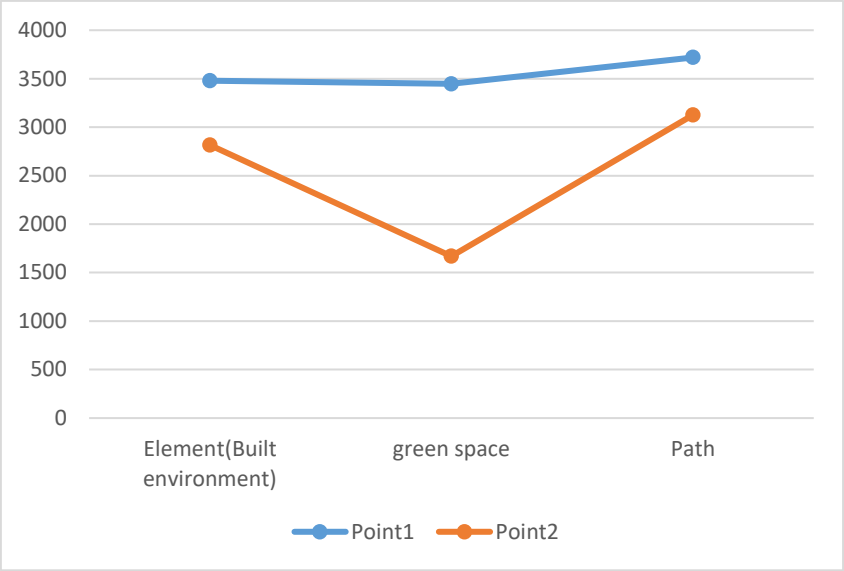

Figure 7: The Time of first glance on the different landscape elements for points 1 and 2

Examination of the first glance to the various landscape elements (Figure 7) shows that the greenery and vegetation are the most attractive elements of the nightscape which grasp the attention before any other elements.

To analyze visual cohesion, eye movement tracking is examined in both images and according to the outputs of the software, analysis of all participants' eye movements is obtained for each image (Figure 8). As it can be seen at point 1, there is a visual cohesion where a particular element is placed in the path. As a result, attractive and coherent area in the pathway can create the necessary visual cohesion. It also, influences the attention restoration which is associated with mental relaxation.

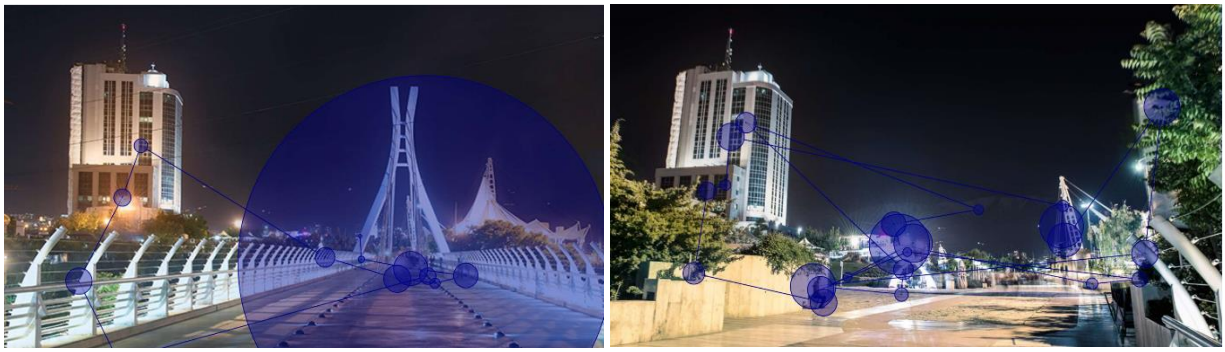

Figure 8: resultant of participants' eye movement for points 1 and 2

6 Conclusion

In planning for nightscape based on attention theory, the attributes and variables of this theory should be considered. These variables, by their very nature, include the conscious and unconscious aspects of perception and visual attention.

One way to measure attractiveness and compatibility based on visual perception is to use an eye tracking device. Visual priorities and visual cohesion are determined using laboratory analysis which can be applied to plan for similar activities. Based on the analysis, the following diagram (Figure 9) can be presented as a conceptual model of attention-based urban planning. Future studies can also analyze and investigate the different variables in relation with urban landscape element and lighting design methods in order to promote attention restoration more precisely.

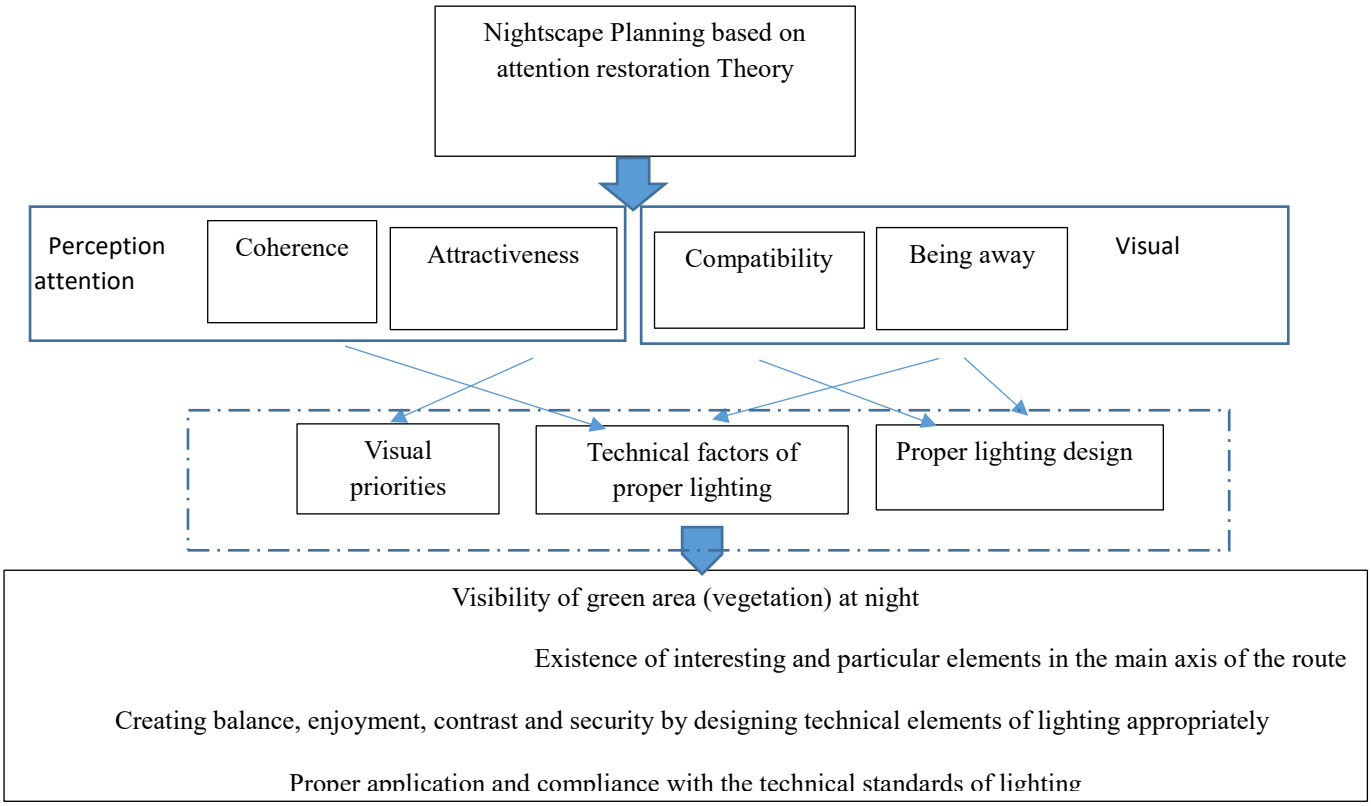

Figure 9: Conceptual Model of Urban Landscape Planning Based on the attention restoration theory

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