A NIGHTSCAPE PREFERENCE STUDY USING EYE MOVEMENT ANALYSIS

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Abstract

The results of a nightscape preference study combining traditional survey methods and eye movement analysis are summarized. The relationship between eye movements and degree of preference for a nightscape (i.e., nighttime landscape) was analyzed. While wearing eye tracking equipment, participants (N = 23) were shown images of three landscape settings types: a spatially open setting, an enclosed setting, and a setting dominated by a path. For each landscape setting, the images were provided at four different brightness levels. Participants were also given a traditional preference survey and asked to rate each image. A significant relationship was found between participant's eye movements and preference ratings. Results showed that people preferred brighter images of open landscapes to darker images of enclosed landscapes. These results can be explained by prospect and refuge theory. People prefer to see (prospect) dangers after dark, thus preferring brighter, more open landscape images. Participants spent more time looking at preferred images than nonpreferred images, and also spent more time looking not at light fixtures directly but at the areas surrounding them. Consistent with the affordance theory, the participants spent more time looking at objects that could be used. They also looked at images starting from the upper left and moving to the center of the images. The eye tracking study provided a detailed understanding of people's eye movement patterns and showed great potential for use in preference studies.

Keywords: *nightscape, preference, eye movement tracking*

1 INTRODUCTION

The goal of this study was to investigate people's preferences regarding different nightscapes (i.e., nighttime landscapes) using both survey methods and eye tracking technology. Interest in nightscapes has risen for various reasons, including concerns for light pollution and safety. However, past visual preference studies have focused mainly on daytime landscapes, ignoring the fact that people spend a large percentage of their time outdoors at night. Most of these preference studies have focused on parks, streets, and other urban public spaces (DeLucio & Mugica, 1994; Jorgensen et al., 2002; Ozguner & Kendle, 2006; Jaal & Abdullah, 2011; Zhang et al., 2013) in the daytime. These studies have usually focused on people's visual preferences, perceptions of safety, and behavior in order to develop design guidelines. Of the relatively small number of perception studies dealing with nighttime landscapes, most have focused on people's perceptions of danger and risk (e.g., Warr, 1990; Nasar & Fisher, 1993; Houtkamp & Toet, 2012; Yatmo, 2009). As a result, our understanding of people's nightscape preferences is limited.

In addition, little is known about other factors that contribute to people's nightscape preferences, such as level of brightness or the presence of specific landscape elements such as lights, buildings, and trees. Few of the nightscape preference studies have examined the effects of lighting conditions on affective appraisals of outdoor environments. For example, Hanyu (1997) found that brightness and uniformity of lighting are related to nightscape preferences—a finding consistent with the work of Flynn et al. (1973), Hendrick et al. (1977), and Flynn (1988).

The published research has also had relatively little to say on the topic of how people examine nightscapes. Technology limitations have, in part, contributed to this lack of research. Past preference studies using slides and image booklets were limited to the analysis of whole images, making it difficult at best to focus the analysis on particular areas of or elements within an image. Recent advances in eye tracking technology have provided a means of identifying particular areas within an image on which individuals focus, in what order, and for how long (Kim, 2004; Cho, 2009; Maier, Fedel, & Battisto, 2009; Kwon, 2011). The current study adds to this body of research by examining the following three aspects.

1.1 Overall Nightscape Preferences Focusing on Brightness

This study tests whether brightness affects nightscape preferences for three landscape settings: a spatially open setting, an enclosed setting, and a setting dominated by a path.

1.2 Preference and Eye Movement

This study also examines whether eye movement patterns have any relationship to nightscape preference.

First, this study examines whether the relationship between the total time spent viewing an image, the total length of eye movement paths, the total fixation duration, and pupil size have any relationship to nightscape preferences. Previous studies using eye tracking methods (Just & Carpenter, 1976; Goldberg & Kotval, 1999; Poole et al., 2004) found fixation durations tended to be longer for preferred images. None of these studies, however, found a relationship between eye movement and preferences. Second, this study examines specific eye movement patterns for each image. It examines how eye moves through each image, such as area of first fixation, the order of fixations, and the areas that get most attention.

1.3 Correlation between Eye Movement and Nightscape Preference Ratings

This study examines whether eye movement and nightscape preference ratings are related statistically. The presence of a correlation would help establish the value of eye tracking technology in nightscape preference studies.

2 METHODOLOGY

2.1 Survey Instrument

A survey instrument containing twelve digital photographs depicting three different nightscape settings was developed. Each nightscape setting was composed of four photos of differing levels of brightness (see Figure 1). The first set of photos (E1, E2, E3, and E4) depicted an enclosed setting in which trees frame the scene. The second set of photographs (O1, O2, O3, and O4) depicted an open setting, and the third set (P1, P2, P3, and P4) depicted a setting dominated by a concrete path. The numbers 1-4 indicate the level of brightness in each image, with 1 being the darkest image of the set and 4 being the brightest. For example, image E4 is the brightest among the four enclosed setting images. All photos were taken in the fall on the Virginia Tech campus in Blacksburg, Virginia.

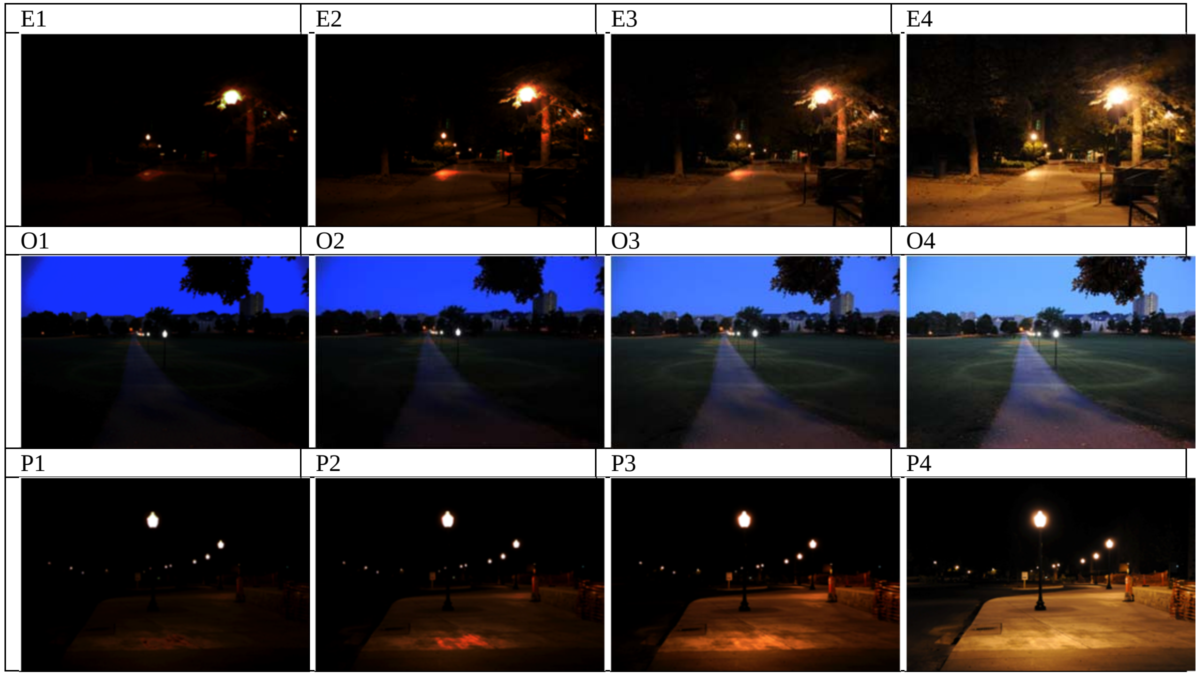


Figure 1: The visual preference survey instrument consisted of twelve images depicting three different nightscape scenes: an enclosed setting (E), an open setting (O), and a path-dominated setting (P). Each scene is depicted at four different levels of brightness, with 1 being the darkest and 4 being the brightest

2.2 Eye Tracking Apparatus

This study used a video-based, pupil/corneal reflection eye tracking apparatus that included an infrared eye movement camera and recording system (Red 250) manufactured by SensoMotoric Instruments (SMI) of Germany (Figure 2). The infrared sensor was positioned directly below the monitor. As participants viewed a photograph on the monitor, the eye tracking apparatus tracked and recorded points of fixation or gaze (also called areas of interest; AOIs), fixation duration, and saccades (eye movements between points of fixation). The system used the Begaze2 software that is part of SMI'seye-tracking system. Figures 3 and 4 show examples of participants' eye movements as detected and recorded by the apparatus.

The research was conducted at the School of Visual Arts' Perception and Usability Testing Laboratory at Virginia Tech in Blacksburg, Virginia. While the survey was conducted, only an investigator and a participant were present in the lab to minimize distractions for participants. In order to simulate the nighttime environment, all lights in the lab were turned off during each session. The laboratory does not have windows.

Figure 2: Eye tracking equipment in the Perception and Usability Testing Laboratory at Virginia Tech, Blacksburg, Virginia. An operator controls the foreground computer, and a participant sits in front of the screen in the back

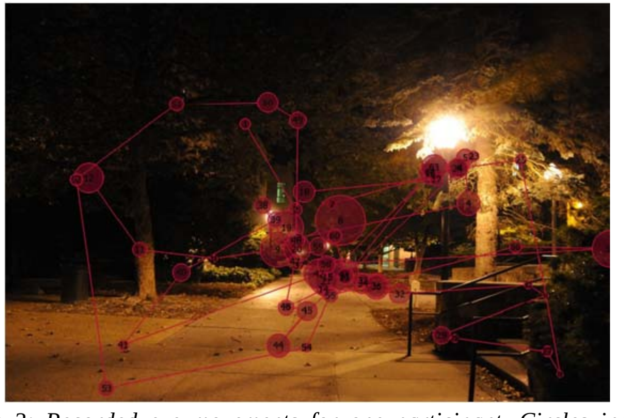


Figure 3: Recorded eye movements for one participant. Circles indicate AOIs, and the numbers in the circles denote the order in which each AOI was viewed. The relative size of the circles indicates the amount of time spent fixed on a spot, and the lines indicate the eye movement paths

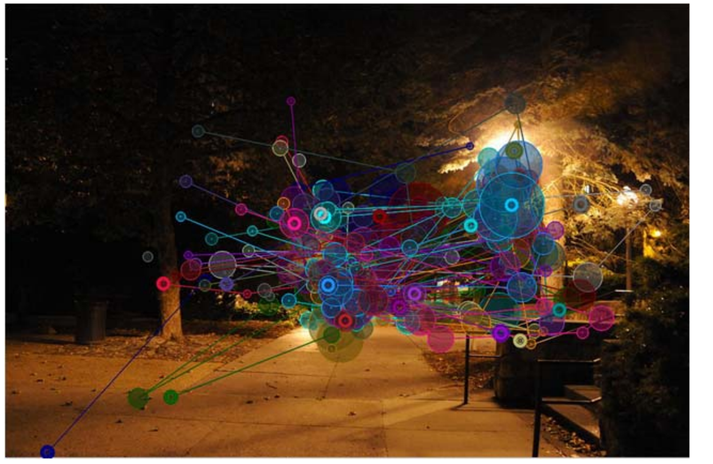


Figure 4: Compilation of all participants' eye movements as detected by the equipment

2.3 Participants

Participants were 15 men and 11 women affiliated with Virginia Tech between the ages of 20 and 40. Two men and one woman were eliminated from the study as a result of irregularities, leaving a total of 23 experiment participants. According to Kim (2006), 5 to 10 subjects are needed, generally, in experimental research involving people's physical functioning. The authors also selected participants with similar educational and cultural backgrounds who came from regions with similar environmental characteristics based on the results of Yu (1995), who found that variations in these characteristics could affect individuals' landscape preferences. Pre-surveys were conducted with three participants to identify potential problems in the survey procedure or contents.

2.4 Procedure

Participants were tested individually, with sessions lasting about 30 minutes. At the beginning of each session, participants were informed about the study purpose and procedures in detail and were positioned in front of a monitor fitted with the eye tracker. Each participant was then asked to follow a red circle on the monitor with his or her eyes in order to calibrate the eye tracker.

Participants were shown twelve digital photographs (Figure 1) in random order. As participants viewed each image, they were asked by a researcher to rate their level of preference on a 7-point Likert-type scale from 1 (very displeasing) to 7 (very pleasing). No further elaboration on these instructions was given by the investigator. Participants were permitted to view each image for as long as they wanted before pressing the spacebar to rate their preference level on the screen. Once they recorded this number, the monitor automatically advanced to the next randomly selected image. During the experiment, an investigator watched a video monitor to ensure that the eye tracker was working and recording properly. After viewing each image and rating their preference level for each, participants provided basic demographic information such as gender and age.

2.5 Measurement

To analyze the eye movement data for each image, the investigators examined the total viewing duration, the fixation duration, saccade counts, scan paths, pupil size, heat map, and area of interests (see Table 1 for a summary of terms used in the paper). The total viewing duration measured the total time a participant spent looking at an image before moving to the next image. Fixation duration measured the time spent looking at particular points or AOIs within a single image. Saccade counts accounted for eye movements between fixation points. Heat maps (Reeder, Pirolli, & Card, 2001), which are similar to shadow maps and use a color spectrum to reveal intensity, are one visualization technique for analyzing eye tracking data. Heat maps are currently part of the Eyetools commercial eye tracking analysis software.

To analyze preferences and eye movement differences, an analysis of variance (ANOVA) was performed for the twelve images. Additionally a Pearson's correlation was carried out to determine correlations between preference levels and eye movements.

Table 1: Summary of Terms Used

Terms	Description
Total viewing duration	Total time a participant spent viewing each image
Fixation duration	Duration of all fixations (no eye movement) per participant
Saccades	Quick eye movements as the gaze travels from one fixation point to another
Scan paths	Gaze positions and eye movements plotted on the stimulus image
Pupil size	Average size of a pupil
Heat map	Gaze positions plotted on the fixation areas
Gridded AOIs Dwell	Gridded AOIs main view visualizes the selected trial data set as a rectangular AOIs grid over the stimulus image. Gridded AOIs Dwell measures how much time is spent to examine each grid.
Gridded AOIs entry	Gridded AOIs show in what order of a participant's foci move through grids.

Note. Definitions follow SensoMotoric Instruments (2012). AOI = area of interest

3 RESULTS

The study results are presented in four parts: (1) preference ratings for each image; (2) a summary of the eye movement data collected; (3) more detailed analysis of specific eye movement patterns; and (4) a discussion of correlations found between the eye movement data and the preference ratings.

3.1 Overall Nightscape Preference Ratings, Focusing on Brightness

A comparison of preference level means for the twelve images showed that most participants preferred viewing the brightest nightscape for all three settings (enclosed, open, and path; see Table 2 and Figure 5). Image O3, however, was an exception. Image O3, the second brightest image in the open setting, was the most preferred image (M = 5.39) (See Figure 1). Image E1 (the darkest in the enclosed setting) was the least preferred (M =

2.48). To understand the differences among each setting, an analysis of variance (ANOVA) was run. Significant differences among the three settings were found regarding preference level means ($F(2,20) = 98.435$, $p < 0.00$). As a result, the authors concluded that the open setting was most preferred by participants.

An additional ANOVA was conducted to determine whether preference levels were affected by brightness levels. The results indicated that there were significant differences among the three settings (enclosed setting: $F(2,20) = 260.467$, $p < 0.000$, open setting: $F(2,20) = 256.728$, $p < 0.000$, path setting: $F(2,20) = 157.826$, $p < 0.000$). The authors learned that the higher the brightness level, the greater the preference for the image (with the exception of O3, which was preferred to O4).

Table 2: Mean Preference Ratings and Standard Deviations for Each Image

	E1	E2	E3	E4	O1	O2	O3	O4	P1	P2	P3	P4
M	2.48	3.13	4.43	5.13	3.65	4.91	5.39	5.17	2.57	3.61	3.65	4.09
SD	1.47	1.39	0.84	1.60	1.67	1.44	1.08	1.27	1.34	1.23	1.30	1.20

Note. Participants reported their level of preference for each image on a 7-point Likert-type scale from 1 (very displeasing) to 7 (very pleasing)

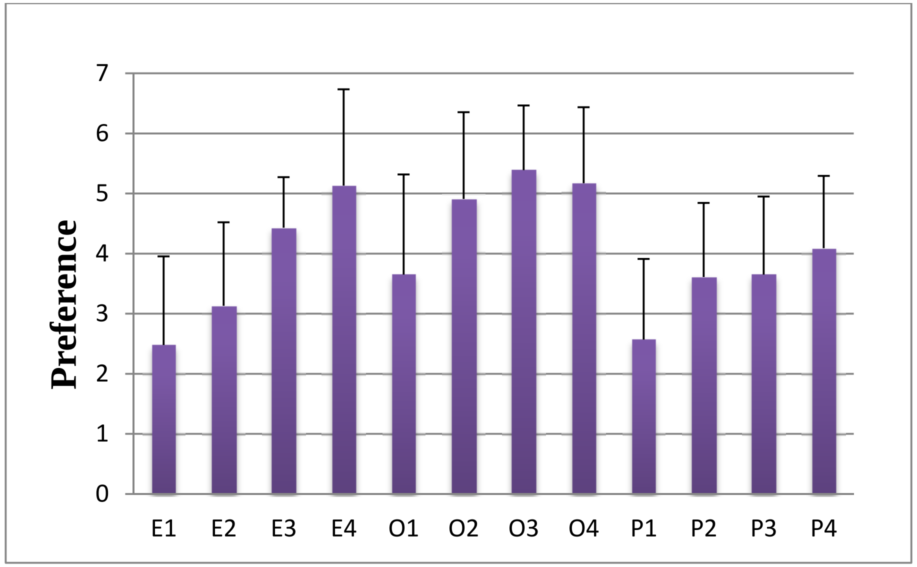


Figure 5: Participant preference ratings for each image. All settings showed increased preference as image brightness increased. Image O4 was the only exception to this, as O3 (slightly darker than O4) was most preferred in this setting

3.2 *Preference and Eye Movement: Examining Total Eye Movement Parameters*

In addition to the preference survey, an analysis was conducted in order to understand the relationship between eye movements and the preferred brightness levels. The eye tracking results for the three landscape settings are summarized in Table 3. The numbers presented in the table are sums of all eye-movement measurements. For example, total fixation duration is sum of all separate fixation for an image. The next section analyzes in greater detail the specific eye movement patterns recorded. Consistent with prior studies (Just & Carpenter, 1976; Goldberg & Kotval, 1999; Poole et al., 2004), this study analyzed participants' eye movements using fixation duration (ms), scan path length (pixels), total viewing duration (ms), and pupil size (pixels).

Enclosed Nightscape Setting

First, the analysis revealed a relationship between image brightness and fixation duration: the brighter the image, the higher the fixation duration. Fixation durations in each image had a positive relationship to preference rating results. Scan path results showed participants' fixations were more scattered in a brighter image than in a darker one. Total viewing duration per image was generally longer when brightness was higher. In addition, the authors analyzed pupil size to understand whether preference differs from one image to another. When the preference score was higher, pupil size was smaller.

Table 3: Results of Eye Movement Analysis for Each Image

Image setting	Image brightness	Fixation duration (ms)	Total scan path length (px)	Total viewing duration (ms)	Pupil size (px)	Preference rating
E1	1	2795.71	2152.61	3793.61	16.12	2.48
E2	2	2799.88	2185.22	3865.04	16.23	3.13
E3	3	2822.90	2200.13	3916.83	15.80	4.43
E4	4	4648.86	3422.48	5858.43	15.67	5.13
O1	1	4165.43	2681.96	5495.30	15.77	3.65
O2	2	4051.16	2582.26	5113.65	15.89	4.91
O3	3	3324.85	2157.78	4188.48	15.05	5.39
O4	4	2727.20	1976.52	3623.74	14.19	5.17
P1	1	2547.40	1714.30	3531.04	16.19	2.57
P2	2	2885.42	2195.67	3785.39	17.16	3.61
P3	3	3149.34	2379.30	4492.04	15.97	3.65
P4	4	3134.17	2776.30	4228.91	15.12	4.09

**Image brightness: 1 = darkest, 4 = brightest*

Open Nightscape Setting

The eye movement trends for the open setting were the opposite of those found in the enclosed setting. For example, when the image was brighter, the fixation duration was shorter. Moreover, the brighter that image, the shorter the scan path length. In other words, the preference scores did not correspond to fixation duration and scan path length in this setting as well as in other settings. Total duration decreased—as did pupil size—as the images became brighter.

Path Setting

These results were similar to those for the enclosed setting, and contrasted with those of the open setting. As in the enclosed setting, the image fixation duration was higher when the image was brighter (P4). P4 showed the longest scan path length. It was determined that the higher the preference score, the higher fixation duration and scan path length. Also, the increase in fixation duration corresponds to the increase in scan path length. What is notable about the results is that P3 had the longest fixation duration as well as the longest total duration, even though the preference score was not higher than P4. This indicates that participants' preferences do not necessarily correspond to their eye movements.

3.3 Preference and Specific Eye Movement Patterns: Scan Path and Areas of Interest

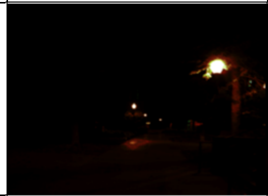
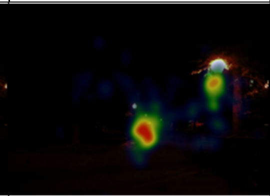
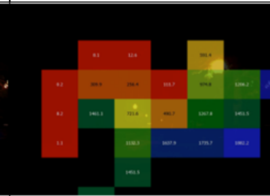
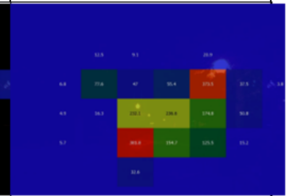
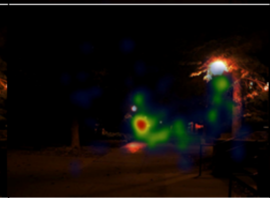
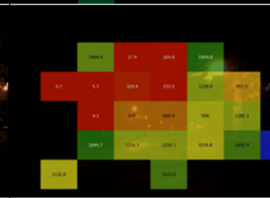
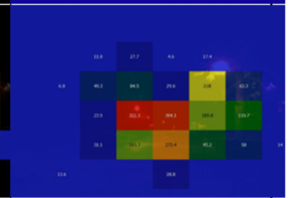
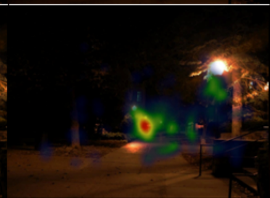
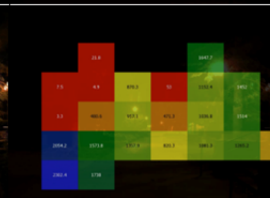
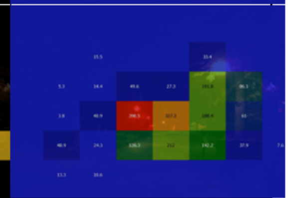
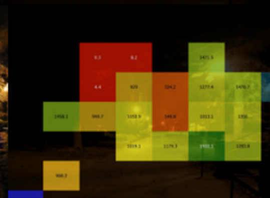
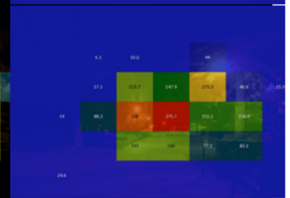
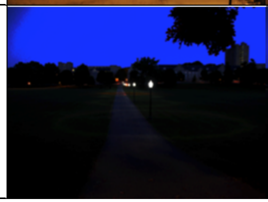
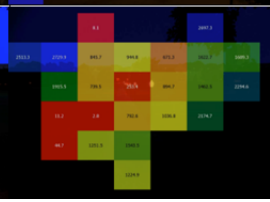
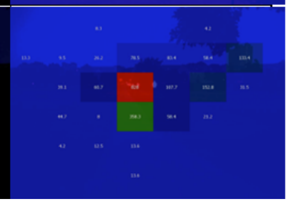
This section summarizes specific eye movement patterns including scan paths and areas of interest (AOIs) within each image. The effect of light fixtures in each image is examined as well. Byrne et al. (1999) suggested that the first few seconds that a viewer fixates on an object or image usually indicates the object or area of main interests. Based on this finding, this study examined the eye movement patterns displayed during the first three seconds of viewing for each nightscape image. This data allowed the authors to determine which parts of each image or elements within each image were preferred over others.

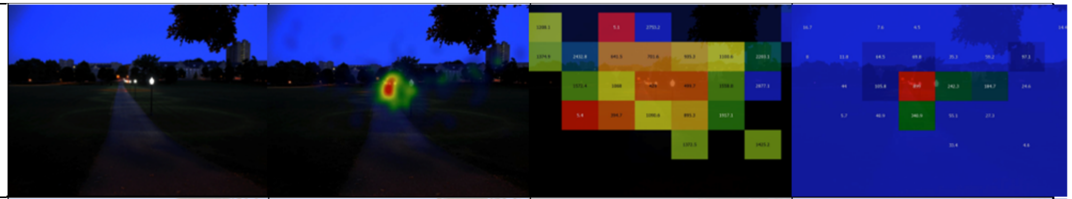
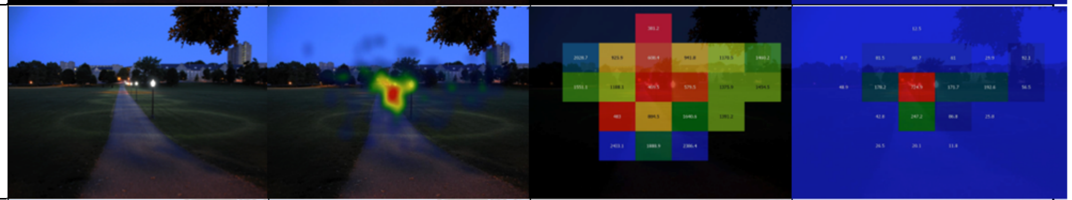
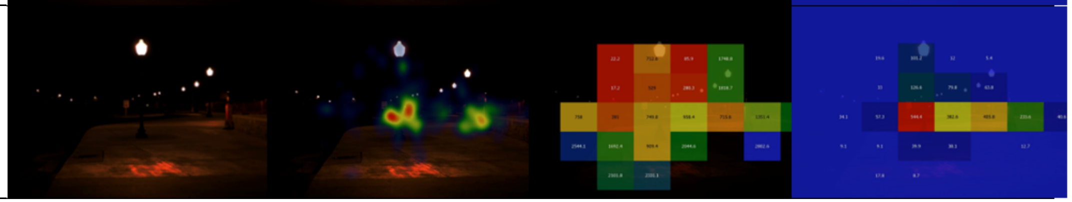
For the enclosed nightscape setting, participants focused on the center of each image regardless of brightness. Also, participants showed a strong tendency to focus on the area below the lamps on light fixtures on the right side of each image. Fixation duration was longer in dark images like E1. To understand the direction of participants' eye movements, the authors created grids for each image and analyzed the gridded AOIs (see column 4 of Table 4). The red in the images shown in column 4 (Gridded AOIs entry) mark the area viewed first (first AOI). Yellow and green show the subsequent AOIs, and blue marks the last AOI. These grids indicate that participants tended to look at the upper left part of each image first. After that, the gaze moved to the center of the images and then to the right. However, participants spent most of their time looking at the center of each image (see column 5, Gridded AOIs Dwell). This means that the areas participants looked at first were not necessarily the same as the areas participants focused on overall.

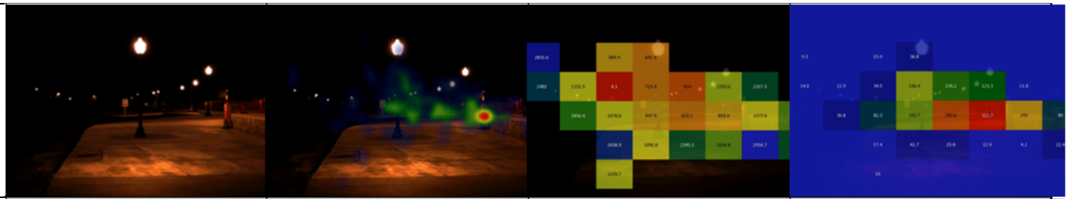
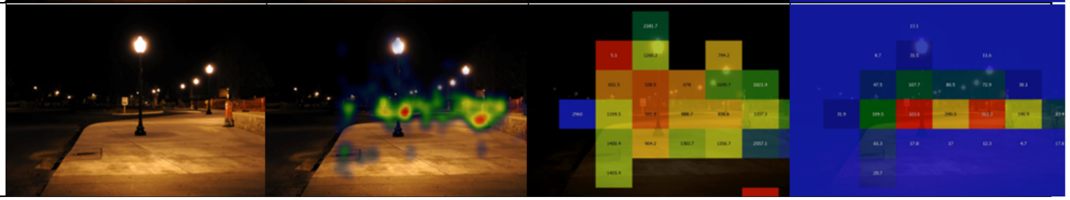
For the open setting, participants, in general fixated on upper left area of the images as shown in images O1, O2, and O3. For image O4, however, the first fixation was the center. As in the enclosed setting, participants focused on the central area of each image intensively in the open setting (see Gridded AOIs Dwell column). The tall building on the right side of each image was also a point of fixation. It can be assumed that viewers fixate on the unique elements in an image more than others. While the area of first fixation in images O1, O2, and O3 had two separate locations for the area of the first sight (Gridded AOIs Entry) and the area of intense gaze (Gridded AOIS Dwell), the two were the same for image O4.

For the path setting, participants' first fixation was roughly on the left side of the image. Then their gaze moved to the center of each image. The area on which participants focused the longest (Gridded AOIs Dwell) did not correspond to the area of first fixation (Gridded AOIs Entry). Overall, participants tended to look at the left side of each image first and then moved to the area where they gazed the longest (Gridded AOIs Dwell) in their second or third sight. In general, participants focused on the center of each image the longest. Interestingly, participants did not start to examine the images by looking at the lights the first or the longest. Also, they focused on the area below the light on the slight right side of the light. It appeared that the AOIs were getting expanded as the images became brighter as shown in E4 and P4. Perhaps, participants dwelt on lighted areas the most.

Table 4: Areas of Interest (AOIs) within Each Image

Image Setting	Original Image	Heat Map	Gridded AOIs Entry	Gridded AOIs Dwell
E1				
E2				
E3				
E4				
O1				

O2	
O3	
O4	
P1	
P2	

P3	
P4	

Note. The heat maps (column 3) show the general distribution of gazes, with red being the areas of the longest fixation. The Gridded AOIs Entry (column 4) displays the order of fixation, with red indicating the first fixation and yellow, green, and blue indicating subsequent fixations. Gridded AOIs Dwell (column 5) is the fixation duration. Red indicates the longest fixation times, with colors changing from yellow to green to blue as fixation time decreases

3.4 Correlation Between Eye-Movement and Nightscape Preference Rating

In order to determine how helpful eye tracking methods could be in assessing landscape preferences, the authors conducted a Pearson's correlation analysis between eye movements and preference ratings (Table 5). Focusing on preference, there were positive correlations with fixation duration (Pearson's r = .229, p = .000), scan path length (Pearson's r = .189, p = .002), and total duration (Pearson's r = .207, p = .001). No correlation between preferences and pupil size were found. As there were positive correlations, we speculate that the higher the preference scores, the higher fixation duration, scan path length, and total duration will be. However, Pearson's correlation was not high compared to other similar studies (Kaltenborn & Bjerke, T., 2002; Sevenant & Antrop, 2009). This indicates that correlations were not very strong. The correlations among eye movement variables were significant as expected. Among them, the highest correlation was found between fixation duration and total viewing duration (r = .867, p = .000). Also, there were positive correlations between fixation duration and scan path length (r = .861, p = .000) and between scan path length and total viewing duration (r = .856, p = .000).

4 DISCUSSION AND CONCLUSION

The results of the study provide a few insights about nightscape preferences and the use of eye movement tracking. The major findings of the study are discussed below.

4.1 Overall Nightscape Preference

The survey results indicate that participants tended to prefer the brighter nightscapes in all three settings. Perhaps participants preferred brighter images because they depict fewer places of concealment. This is consistent with the findings of Flynn et al. (1973), Hendrick et al. (1977), Flynn (1988), and Hanyu (1997). They all found lighting brightness and uniformity to be related to preference, despite the fact that lighting conditions can vary daily, seasonally, and meteorologically Hanyu (1997). Likewise, Warr (1990) suggested darkness and the unknown were important factors influencing fear. Results for the open setting, however, showed that participants did not prefer the brightest image. Instead they preferred the next bright image (O3). This finding suggests that lighting nightscapes with an appropriate level of brightness is more desirable than lighting them as brightly as possible. The authors also concluded that factors other than lighting affect nightscape preferences. Future studies might focus on identifying appropriate brightness levels for different environmental settings as well as identifying other variables that may affect people's nighttime visual preferences.

Table 5: Correlations between Eye Movement and Preference Ratings

		Preference rating	Fixation duration	Scan path length	Total viewing duration	Pupil size
Preference rating	*r*	1	.229**	.189**	.207**	-.071
	Significance		.000	.002	.001	.241
Fixation duration	*r*	.229**	1	.861**	.867**	.226**
	Significance	.000		.000	.000	.000
Scan path length	*r*	.189**	.861**	1	.856**	.184**
	Significance	.002	.000		.000	.002
Total viewing duration	*r*	.207**	.867**	.856**	1	.228**
	Significance	.001	.000	.000		.000
Pupil size	*r*	-.071	.226**	.184**	.228**	1
	Significance	.241	.000	.002	.000	

*N = 276; **p < .001.*

Participants also preferred the open setting (no visual obstructions) to the other two settings (i.e., enclosed and path). We suspect that participants preferred nightscape views of larger expanses free of obstructions because they elicit less fear. Among the three setting types, open ones had the fewest landscape elements. Fisher and Nasar (1992) and Nasar, Fisher, & Grannis (1993) found that the physical conditions of a landscape, such as the presence of trees and shrubs, and obstructed vistas, also affect preferences after dark. One theory that may account for these preferences for brightness and open spaces is Appleton's (1975) prospect and refuge theory, which posits that humans prefer physical conditions that afford them prospect (an unobstructed view) and refuge. Nasar et al. suggested that "reductions in places of concealment, increases in prospect, and reductions in obstructions to escapability may make an area less fearful" (p. 176). Applying this theory to design guidelines could improve both daytime and nighttime landscapes by minimizing obstructed views caused by landscape elements such as large trees located close to pathways.

4.2 Preference and Eye Movement

The study found that eye-movement patterns were inconsistent through the three settings. For example, total fixation duration, total scan path length, and total time spent on images were higher when preference was higher in the enclosed and path settings. However, the open setting showed the opposite trend. Here, fixation duration, total scan path length, and total time spent viewing an image were shorter when image preference was higher. This suggests that these parameters are not perfect indicators of nightscape preferences. These results were different from those of Just and Carpenter (1976), Goldberg and Kotval (1999), and Poole et al. (2004) where they examined only daytime images. Perhaps darkness of nightscape affects people's preference differently because the scenes show limited views, and people spend their time differently in examining the images. Pupil size was smaller when preference was high, perhaps because the images were brighter.

When we analyzed the heat maps, the center of each image and the lower right side of the lighted area in each image was the area of the longest fixation duration. Interestingly, the heat maps showed that participants fixated on the darker periphery of the lighted areas, rather than the central bright spot. Parasuraman (1985) suggested that people's attention is stimulated by size, color, location, uniqueness, and movement. The present study suggests that brightness should be added to this list. This study also found that participants fixated on different areas of the image for different durations based on brightness levels. This is possibly because brighter images show objects that are not visible in darker images.

Participants almost invariably fixated first on the left side of images, then moved on to the center of the image, then to the right side, and finally back to center. This result is different from Lanyon & Denham (2004) and Parasuraman's (1985) studies, which found that people fixated on the center of an image first and then moved to other places on the image. Parasuraman argued that when viewing graphic images, participants fixated on the center of the image, but when viewing text, tended to fixate first on the upper left and then move toward the right. The authors suspect that scan path patterns may vary according to the overall level of brightness when people view nightscapes.

In the open setting, participants fixated on the tall building. According to Gibson's theory of affordance (1977), people respond preferably to those images that include objects or areas that they can potentially use. Likewise, the results of the study also suggested that participants tended to focus on the things that can be used, such as paths and buildings. Josephson and Holmes (2002) suggested that people tend to "fixate on unique areas of visual scenes sooner and more frequently and for longer durations than any other area of the visual scene" (p. 44). However, this study found that people did not directly fixate on lights. They rather fixated on areas below the lights.

4.3 Correlation between Eye Movement and Nightscape Preference Rating

This study also found that the correlation between eye movement data and survey-based preferences was statistically significant. However, the Pearson's correlation values were not high (around 20%). Therefore, this study does not indicate that either the survey method or eye movement method is better.

Although the authors find that eye movement tracking adds to the visual preference research, we strongly think that eye tracking alone should not be used without a preference survey. Together, traditional visual preference methods and eye tracking methods can provide a better understanding of people's perceptions of a landscape and its elements. While traditional visual preference studies can give us a general understanding of which images people prefer, these studies cannot tell us which areas of the images people liked most or how people examine landscapes differently. Nor can such information be learned through surveys alone.

The small sample size and limited study area could be limitations of the study. An eye tracking study, however, can suggest specific landscape elements or image areas that have direct implications for design and planning practices. Further studies should consider a greater variety of eye movement and human perception parameters and vary sample sizes and study areas. Furthermore, these parameters should be studied in daytime landscapes and compared with results for nighttime landscapes.

These study results provide a more detailed picture of people's preferences for nightscape images by identifying particular elements of the image they looked at, for how long, and in what order through the use of eye tracking equipment. This study demonstrates the potential contributions of eye tracking methods in visual preference studies.

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