The Physiology and Psychology of Commercial Streetscape Preferences

Shu Chun Chang, Ching-Horng, Tsai

Abstract— **In the past, human beings migrated in search for new habitats to survive. Preconditions, such as food, shelter, and water sources were essential to survival, and human beings gradually learned and observed the landscape and environment of these new found habitats. Consequently, through heredity and evolution, the majority of human beings no longer need to learn the content (e.g. plants and water) and shapes of landscapes to generate positive psychological reactions (e.g. preferences). Thus, evolutionary theorists consider that intuitive responses to environmental characteristics are the result of evolution, and preferences are natural responses which are innate and biologically instinctive, particularly from the perspective of shelter and concealment (Kaplan, 1989).**

In Kaplan and Kaplan's (1982) landscape preference matrix, four influential factors of cognition were proposed: Coherence, complexity, legibility, and mystery. The Kaplans further indicated that landscape preference levels would be higher if all four factors were present in a specific environment. Therefore, the questionnaire used in this study includes preference factors (coherence, complexity, legibility, and mystery) in Kaplan and Kaplan's environmental preference matrix. We primarily adopted psychological or theoretical descriptive survey methods in this study, and considered landscape elements and sense of distance regarding image composition during image analysis. In addition, we employed an eye tracking experimentation operation method to analyze the physiological response data of respondents, such as eye movements, visual systems, and visual processes. Through these methods, we determined the landscape elements that best attract and maintain people's visual attention.

Based on the mentioned issues, the study adopted commercial streetscapes as the subject for urban appearance improvement discussions. The primary objective of this study is to determine the influences of landscape spatial contexts on people's psychological preferences.

Index Terms— **Streetscape, Landscape Preference Matrix, Eye Tracking Experimentation, Questionnaire Surveys, Perception, Cognition, Evaluation.**

I. INTRODUCTION

Streetscapes

Manuscript received Jan 06, 2015

Shu Chun Chang, Professor at Graduate Insitution of Bio-industry Management, National Chung Hsing University

Ching-Horng, Tsai, Assistant Professor at Graduate Institute of Civil and Hydraulic Engineering, Feng-Chia University, Taiwan

Streets are the primary space for urban residents and transportation activities. An urban region with excellent quality is reflected through the styles and features of its streetscapes, and the diversity of life can be determined by observing these styles and features. Streets are generally defined as a linear surface adjoining buildings and spaces in an urban context joining the occurrence of all movement between buildings and spaces (translated by Wang, 1999). Selberg (1996) considered that the primary characteristics of street spaces are structured though the linkage of buildings; that is, the confinement of walls. A memorable street generally possesses superior overall qualities which are displayed in the confinement of street walls or surfaces (Li, 1996).

The structure of streetscapes is comprised of tangible and intangible elements. The tangible elements include buildings, sidewalks, paths, plantation, and public street furniture on either side of a street, and the intangible elements are the human activities that occur on a street. Thus, streetscapes can be defined as the overall performance of an environment structured with natural or man-made scenery on the street itself and on either side (Hsu, 1985). It can also be defined as the interaction effect between tangible modeling elements and the intangible spatial context of a street, and influences not only its community, but also resident overall perception regarding the streets and environment. The "objects" which p pedestrians have strong senses towards are primarily physical elements on streets (Table 1), including billboards, street trees, and other public furniture. In addition, street activities are also a significant streetscape element. However, it is primarily temporary and periodic, and frequently decided by mutual participant awareness (Huang, 1998).

Table 1. The Constituting Factors of Streetscapes

Author/Year of Publication	The Physical Constituting Factors of Streetscapes	The Physical Constituting Elements of Streetscapes
Huang (1995)	1. Street space 2. Street facilities 3. Street activities	Street scale, street type, adjacent interface Pavement, furniture, plantation
Lin (1995)	1.Spatial pattern traits 2.Activities content 3.The meaning of time forms	
Li, Tseng, and Lai (1996)	1. Building unit 2. Facility unit 3. Street and open space unit	Buildings and their spatial shaping, the special appendages of buildings

Author/Year of Publication	The Physical Constituting Factors of Streetscapes	The Physical Constituting Elements of Streetscapes
		Transport facilities, pedestrian facilities, street equipment, plantation and their spatial shaping, active scenery, green parks and squares
Lee (1996)		Plantation, buildings, vehicle lanes, vehicles, the sky, billboards, facilities, sidewalks, scenic mountains, viaducts, and utility poles.

Source: Nien-Hsuan Chen (1997)

1. The Functions of Streetscapes

Besides providing frequent public service functionalities, as well as possessing extremely close connections with construction and development, urban streets also enhance regional cultural characteristics and environment quality. Therefore, we considered the studies of two authors who gathered and established streetscape functions in this study. Specifically, Hsu (1985) proposed that streetscape functions should possess three landscape utilities, namely, visual attraction, transportation, and ecology. Wang (1997) collated five urban landscape functions by referencing the studies of Lynch (1960), Rapoport (1977), and Yu (1991), namely, aesthetic, education, economy, and ecology functions. In this study, we combined the theories of the two researchers and established the following six streetscape functions:

1. Visual function: Visual streetscapes refer to the tangible landscape images and intangible psychological images generated by the viewer. These images are induced by the viewer's visual impact and responses to the objects that structure the style, pattern, size, and combination of the street. This function creates street aesthetic effects, expresses the unique essence and historical traditions of a certain region, affects the psychological well-being of street users, and provides visual barriers and visual guidance on the street.

2. Aesthetical function: Urban landscape appearances and forms not only convey social aesthetics, but also reflect socio-cultural values. Therefore, natural and cultural urban landscapes become the aesthetic object for resident appreciation, satisfy the psychological needs of residents, and further create a pleasurable urban living environment. In addition, an overall image or perception of urban landscapes is generated by viewers because people have innate memory recollection characteristics, and the overall style created by urban landscapes becomes the indicator for city affirmation. It is also the source for resident approval and attribution.

3. Transportation function: The transport function must be significantly valued in a streetscape design. These functions include the safety of street use, transport operation fluency, maintenance and management economic efficiency and convenience, and clarity of street signs.

4. Economical function: Attractive cities primarily possess specific and unique landscape features. Urban landscapes with local characteristics provide people with memorable and enjoyable experiences. This undoubtedly attracts tourists and further creates economic value.

5. Educational function: Landscape imagery is the viewer's mental illustration towards external physical environments. These mental images are the production of instinctive senses and past experience memories. Therefore, urban landscape quality depends on past landscape awareness and cognition. People tend to convert objective spatial contexts into locations with complex meaning and, through habit, memory, and association, further combine these places with local residents to achieve educational functions.

6. Ecological function: Street construction promotes urban development, yet impacts the environment and ecology along the construction area. Traffic on these streets produces noise and pollution emissions which seriously affects living environment quality. Therefore, ecology functions include the prevention effect of street noise and air pollution, as well the improvement effect of adjusting the microclimate in local areas.

Regarding feelings of the respondents toward streetscapes, the study disregarded the aspects of occasional occurrence of cultural activities, and found that the design for the physical environment of streets affects direct feelings of a user towards a specific streetscape. A well-developed streetscape design can promote urban place identity and environment quality, subsequently attracting investors and increasing commercial activity. Consequently, this elevates resident sense of honor, improves foreign tourist interests, and ultimately enhances overall urban living quality. Besides possessing transport functionalities and satisfying urban resident demands, urban streets should also include functions such as visual attraction, aesthetic, ecology, education, and economy. In this study, we measured respondent preferences by adopting streetscape preferences and applying eye tracking methods.

II. Landscape Preferences

Definition of Landscape Preferences

Landscape preferences are the results generated from a series of interactions between people and the environment. The process of generating landscape preferences initiates with a person viewing a landscape, developing landscape understanding, and further assesses this information to generate landscape preferences. However, these preferences are only subjective psychological judgments made through viewer evaluations. The purposes of these evaluations are to assist the viewer in understanding landscape characteristics and formulating personal preferences of a landscape, and further use this knowledge as a reference for landscape design planning and management. Rapoport (1977) proposed that the interactive relationship between people and landscape can be divided into three aspects, namely, perception, cognition, and evaluation.

1. Perception

Perception refers to the combination of numerous simple, independent attributes associated with a specific environment to generate an overall sensory response. A further integration of this response into people's practical experiences formulate overall judgmental awareness. This process is known as perception and is the common approach people employ to better understand the objective world (Chang, 1995). In other words, perception is the process in which people choose, organize, and explain the stimuli collected from sight, sound, taste, smell, and touch (these stimuli are all known as data transmission), to subsequently generate a type of meaning (or bestow a type of label). This can further be simplified as the process in which individuals choose, organize, and explain sensory impressions, and further provide a meaning to explain environmental events that are stimulated by these sensory impressions. Zube et al. (1982) proposed that people possess personal qualities (e.g. expectation, experience, motive, and social background) and, when these qualities interact with landscape factors (e.g. physical elements, composition, and regional background), related information, satisfaction, and value results are acquired.

2. Cognition

The use of the term *cognition* was initially adopted in psychology. Receiving visual information, people process this information according to previous learning experiences or current environmental influences. It is divided into similar images, shapes, or objects, and further given names and descriptions accordingly (Shih, 1998). That is, cognition refers to the psychological process of familiarizing and comprehending objects during awareness activities.

Hu (1994) proposed that cognition is the understanding processes of organisms. The framework of these processes is theoretically based on information processing models. These models primarily determine how people's senses receive information and subsequently produce complex psychological activities, such as attention, identification, memory, comprehension, and contemplation. Therefore, cognition is the subjective psychological process in which people obtain knowledge and recognize the world, and is the basis regarding the formation of preferences, values, decisions, and behaviors (Chen, 1986).

People possessing environmental cognitive abilities employ the perception effect to understand the environment, and use a set of experiential learning development tools to understand and judge information received from the environment. This processed environment is neither simple nor objective, but an environment adjusted by the individual's sensory system. Additionally, people's opinion towards the surrounding environment is produced through the cognition effect. This effect relies on people's various senses to induce principles and establish knowledge and guides behavioral development to adapt to the changing environment (Cheung et al., 1995).

3. Evaluation

According to the Merriam-Webster Dictionary, evaluation is the process to determine the significance, quality, importance, degree, or condition by careful observation and judgment. Landscape evaluation is the process of determining the comparative relationship between two or more landscapes based on visual quality assessments; visual quality assessment is the process of recording visual quality; and visual quality refers to the aesthetic emotions produced by a viewer when evaluating the quality and traits of a specific landscape. Therefore, related research is based on visual aesthetics for the purpose of expressing the emotions people have towards the environment. The results of these assessments assist researchers or planners to determine the true meaning of the environment, and further appropriately enhance overall environmental design to create a closer relationships between people and nature (Lin, 1979; Chen, 1999).

Landscape Preference Models

According to previous research and literature review, Kaplan and Kaplan (1989) established the evaluation factors included in landscape cognition. They also considered that research regarding landscape preferences primarily emphasizes the involvement of viewers, and research should be conducted on shared cognitive processes, instead of individual factors. Therefore, landscape preferences, environmental information, species evolution, and cognition and emotion are closely interrelated. In addition, The Kaplans considered that landscape preferences can be predicted using the four landscape cognitive factors: coherence, complexity, legibility, and mystery.

The prediction matrix regarding environmental preference factors proposed by Kaplan and Kaplan (1982) is explained as follows: When people process information produced by the environment, spatial arrangement facilitates the understanding of the environment, and subsequently motivates further exploration of more in-depth environmental arrangements. This preference model is divided into two dimensions, namely, time and environmental information received. In the dimension of time, the environment provides "immediate" or "inferred/predicted" messages. Conversely, the dimension of environmental information received is divided into information that requires "understanding" and "exploration." Table 2 explains the 4 influential factors on environmental preferences.

Table 2. The Environmental Preference Matrix

	Understanding	Exploration
Immediate	Coherence	Complexity
Inferred/Predicted	Legibility	Mystery

Source: Kaplan and Kaplan (1989)

Kaplan and Kaplan's (1982, 1989) four cognitive factors are defined and explained as follows:

1. Coherence: A landscape arrangement that is easy to acknowledge resulting in a consistent and harmonious environment perception. Anything that can arrange the brightness, size, and material into key units enhances coherence.
2. Legibility**:** A landscape that is spatially well-structured with clear, distinguishable elements which are easy to understand and remember, and thus easy to determine the orientation or starting point. For example, "landmark" and "region," proposed in the book, "The Image of the City," by Lynch (1960).
3. Complexity: A landscape that possesses varying amounts and diversity of visual elements. That is, the amount of landscape elements in a specific environment visible to the viewer.

4. Mystery: A landscape or environment that attracts and encourages people to explore, and further provides an opportunity for people to learn about objects that cannot immediately be seen in a vantage environment.

Eye Tracking

Eye tracking is a type of recording technique that determines eye movement. This procedure can track, as well as record, the placement of a person's line of sight and the visual movement and orientation on a surface. Eye tracking technology has been applied in psychological experimentation for the past century in fields including psychiatric research, neurology, medical engineering, flight control, photography, virtual reality, and product identification. The development and application of eye tracking technology can be dated back to the 19th century. Researchers would attach a small glass or metal plate on the pupil of a test subject after the cornea was anesthetized. The plate shifted with movement of the eyeball and transmitted the movement signals to a recording device. This procedure was the earliest form of eye tracking.

Figure 1. Schematic Representation of the EyeLink 1000 Eye Tracking Apparatus

Source: Yang-Li Wang (2008)

In recent years, scholars have based their research regarding landscape evaluation models on visual physiology. For example, De Lucio et al. (1996) proposed eye tracking methods in their exploratory study on visual landscapes. By tracking the line of sight movement of respondents, they explored natural landscapes involving various element characteristic models. Following many years of applied eye tracking development, more methods have been developed that are available for tracking the visual placement and eye movement of respondents, and tracking methods have evolved from infrared tracking technology in the past to optical tracking methods applied today. The advantage of eye tracking is that it tracks movement by utilizing the reflective characteristics of the eyeball to light without causing eyestrain and damage as infrared laser tracking employed in electronic diagram eye tracking technology. Recent optical light methods are safer than infrared laser and can achieve pupil fluctuation and cornea movement results. In this study, we adopted an optical light eye tracking method, that is, the EyeLink 1000. This apparatus is a desktop machine with a chin rest which is comparatively different to other machines that require a fixed headset. The EyeLink 1000 not only provides experimental comfort, but also increases the available experiment test time and data accuracy.

III. Research Methodology

1. Image and Respondent Selection

The study selected commercial streetscapes in Taichung City as the sampling location for this study. The streetscapes comprised of Dalong Road, Donghai Commercial District, Donghai International Commercial District, and Jiguang Street. We used a digital camera to capture the images of these streetscapes. A 35mm lens was attached to the camera and set to auto mode, auto aperture, and infinity focus. The images were captured at 1.5m eye level, mostly backlit. Good weather conditions were selected for the photo shoots to achieve consistent lighting throughout the images. The time of the photo shoots was approximately between 10 a.m. and 12 p.m., as well as 1 p.m. and 3 p.m. The method in which the street photo shoots were conducted is shown in Fig.2. To avoid interferences in streetscape evaluation, such as vehicles and pedestrians, photos were manually filtered and a total of 7 photos were obtained for Dalong Road, 3 for Donghai Commercial District, 9 for Donghai International Commercial District, and 11 for Jiguang Street.

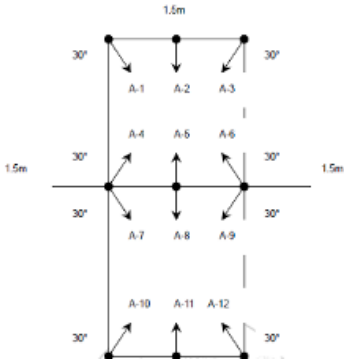


Figure 2. A Schematic Diagram for Streetscape Shooting Positions

Source: Gou (2003)

Respondents varied according to the different requirements of this study. Common respondents included students, local residents, tourists, and social groups. Evan and Wood (1980), as well as Chen and Lin (1999), previously compared the streetscape evaluation differences between students and the general public. The results of their studies showed considerable consistency between the two groups of respondents, yet data is more easily collected from student respondents. Therefore, many studies regarding landscape preferences selected students to represent the general public. Thus, the samples selected for this study were the students of Feng Chia University.

2. Measurement Tools

The primary measurement tools used in this study were eye tracking experimentation and questionnaire surveys. The eye tracking experimentation primarily records the fixation count and gaze time of visual attention. The content of the questionnaires mainly included the four factor dimensions (coherence, complexity, legibility, and mystery) in the landscape preference matrix. The questionnaire and eye tracking experimentation designs are separately explained as follows:

1. Eye Tracking Survey

Eye tracking surveys were conducted in the Feng Chia University eye tracking laboratory (Memorial Hall 406A) for two days from June 4th to June 5th, 2010. The EyeLink 1000, a desktop eye tracking apparatus with a chin rest, was employed

to monitor eye movement (SR Research Ltd. Mississauga, Ontario, Canada), and the stimulus data was presented on screen (View Sonic VG1921wm). The visual physiology involving actual landscape gazes were determined by two procedures, elements tests and questionnaire surveys. As most of the respondents have had no past experience regarding eye tracking procedures, the investigators initially explained the experiment objective and manner of conduct to the respondents prior to experimentation. The investigators provided detailed explanations of the functions and operation precautions of the eye tracking apparatus to eliminate respondent fear and rejection, and further assisted the respondents throughout their experiments. To conduct initial measuring point positioning procedures, the respondents were instructed to fixate their gaze on a measuring point on the screen, and visually follow the measuring point as it moved up, down, left, right, and center. After successful positioning of the measuring point, image testing was formally conducted. The respondents were instructed to fixate their gaze on a black point inside a larger white point on the screen for the images to appear, respondents were told to casually find areas on the image favorable for viewing yet not likely to be seen by others. The respondents quickly browsed through the images with no need for deliberate memorization. The entire experiment presented 30 commercial streetscape images in random order. Each image was presented for 10 seconds, with a short automated interval after 10 images to prevent eyestrain. Additionally, pupil placement single-point calibrations were carried out between each stimulus chart. This process primarily prevents human error caused by accidental head movements. After all the images had been viewed, the respondents sequentially underwent a questionnaire survey. By integrating the questionnaire survey with the results of the eye tracking experiments, we were able to determine respondent preferences toward commercial streetscapes.

2. Questionnaire Design

The questionnaire items designed in this study referenced the 4 psychological factors in Kaplan and Kaplan's landscape preference matrix, namely, coherence, legibility, complexity, and mystery, and adopted the Likert seven-point scale as the measuring tool. According to the perceived cognition of the landscape, the respondents checked each factor group matching their psychological preferences. The significance of the 4 psychological factors is separately explained as follows:

1. Coherence: The arrangement of elements in the landscape presents coherent and repetitive traits. The overall composition presents a sense of depth which induces neatness and order.
2. Legibility: The arrangement of elements in the landscape or landscape types present distinct, easily identifiable traits in significant target objects are present, enabling viewers to quickly determine their location and prevent disorientation.
3. Complexity: Element arrangements in the landscape or landscape types present diversity and arrangement anomaly, generating a sense of intricacy and change.
4. Mystery: Element arrangements in the landscape or landscape types present deep, convoluted imagery, generating curiosity and exploration impulses.

IV. RESULTS ANALYSIS

1. Sample Composition

A total of 15 Feng Chia University students participated in this study, with 15 valid questionnaires obtained. All 15 respondents were of environment-related professional backgrounds (architecture, landscape, and recreation). This section primarily discusses the following: (1) the analysis for preference levels regarding the 30 streetscape images, (2) effects of streetscape elements on psychological preferences, (3) respondent preferences regarding the four factors in the landscape preference matrix (coherence, legibility, complexity, and mystery), and (4) analysis regarding eye tracking image hotspots.

Descriptive Analysis of the 30 Landscape Images

The paper selected 30 images to represent the commercial streetscape elements in Taichung city's commercial districts. The streetscapes comprised of Dalong Road, Donghai Commercial District, Donghai International Commercial District, and Jiguang Street. Subsequently, the study analyzed the psychological factor preferences from the commercial streetscape images, the streetscape hotspots from the eye tracking examinations, and the streetscape preference factors (coherence, legibility, complexity, and mystery) and preferences for analysis. (Tables 3, 4, 5, 6)

Table 3. Psychological Factor and Hotspot Analysis of Donghai International Commercial District Streetscape

Donghai International Commercial District			
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 1			Coherence (4.13/1.69) Legibility (4.33/1.68) Complexity (3.73/1.39) Mystery (2.93/1.16) Preference (4.27/0.88)
Results	Gaze is concentrated. The high legibility and coherence averages exhibit a greater degree of neatness which leads to superior observation and focus. Pupil placement was primarily on the vanishing point, buildings, street trees, and vehicles.		

No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 2			Coherence (4.27/1.53) Legibility (4.73/1.53) Complexity (3.40/1.12) Mystery (3.00/1.41) Preference (4.47/1.06)
Results	Gaze is concentrated. The high legibility and coherence averages exhibit a greater degree of neatness which leads to superior observation and focus. Pupil placement was primarily on billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 3			Coherence (3.87/1.85) Legibility (3.33/1.50) Complexity (4.07/1.49) Mystery (2.80/1.52) Preference (3.53/1.13)
Results	Gaze is concentrated. The high complexity average exhibits a greater degree of disorder. Pupil placement is primarily on billboards and vehicles		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 4			Coherence (5.00/1.56) Legibility (4.47/1.64) Complexity (2.40/1.55) Mystery (2.60/1.64) Preference (3.47/1.06)
Results	Gaze is concentrated. The high legibility and coherence averages exhibit greater degrees of neatness and order which lead to superior observation and focus. Pupil placement was primarily on billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 5			Coherence (6.27/0.70) Legibility (4.47/4.40) Complexity (4.40/1.96) Mystery (2.20/1.21) Preference (3.80/1.08)
Results	The spatial preference of this streetscape was higher than neatness preferences. The high legibility and coherence averages exhibit greater degrees of neatness and order which lead		

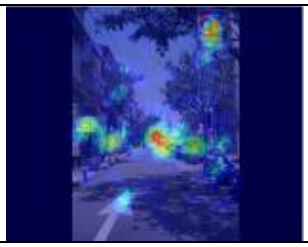
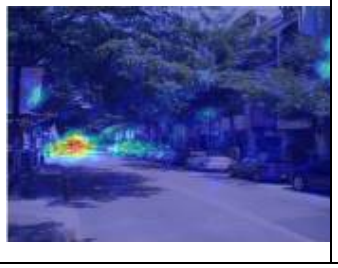
	to superior observation and focus. However, the high complexity average exhibits a greater degree of disorder. Pupil placement was primarily on the vanishing point and billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 6			Coherence (4.20/1.94) Legibility (3.80/1.61) Complexity (2.73/1.34) Mystery (2.87/1.51) Preference (3.07/1.34)
Results	Gaze is concentrated. The high coherence average exhibits a greater degree of neatness and order. Pupil placement was primarily on billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 7			Coherence (4.93/1.62) Legibility (4.40/2.17) Complexity (2.73/1.62) Mystery (4.20/2.01) Preference (4.60/0.86)
Results	The high coherence, legibility, and mystery averages exhibit a greater degree of neatness and leads to better observation and focus. This commercial district streetscape possesses deep, convoluted imagery which induces viewer curiosity. Pupil placement was primarily on the vanishing point and billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 8			Coherence (4.13/1.51) Legibility (4.00/1.56) Complexity (2.73/1.22) Mystery (4.00/1.65) Preference (4.20/0.72)
Results	The high coherence, legibility, and mystery averages show that this streetscape possesses depth, presenting the viewer with a sense of neatness and leads to better observation and focus. Pupil placement was primarily on the vanishing point and billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 9			Coherence (4.07/1.75) Legibility (3.20/1.27) Complexity (3.20/0.78) Mystery (3.27/1.53) Preference (4.33/1.10)
Results	The high coherence average exhibits a greater degree of neatness. Pupil placement was primarily on the vanishing point, billboards, and people.		

Table 4. Psychological Factor and Hotspot Analysis of Donghai Commercial District Streetscape

Donghai Commercial District			
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 1			Coherence (2.93/1.58)
			Legibility (3.13/1.60)
			Complexity (5.60/0.99)
			Mystery (3.33/1.68)
			Preference (2.73/1.16)
Results	The high complexity average exhibits a greater degree of disorder and leads to confusion. Pupil placement was primarily on billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 2			Coherence (3.47/1.85)
			Legibility (3.40/1.64)
			Complexity (5.27/1.44)
			Mystery (2.80/1.61)
			Preference (3.20/0.86)
Results	The high complexity average exhibits a greater degree of disorder and leads to confusion. Pupil placement was primarily on the vanishing point and billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 3			Coherence (3.53/1.40)
			Legibility (3.13/1.40)
			Complexity (4.67/1.59)
			Mystery (3.13/1.73)
			Preference (3.07/1.13)
Results	The high complexity average exhibits a greater degree of disorder and leads to confusion. Pupil placement was primarily on the vanishing point and billboards.		

Table 5. Psychological Factor and Hotspot Analysis of Dalong Road Streetscape

Dalong Road			
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 1			Coherence (6.13/0.74)
			Legibility (4.87/1.73)
			Complexity (2.20/1.21)
			Mystery (4.07/1.94)
			Preference (5.40/0.91)

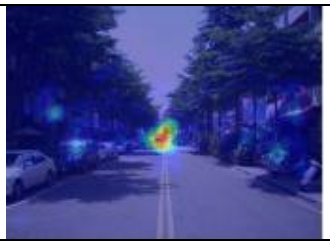
<table>
<tr><td>Results</td><td colspan="3">The high coherence, legibility, and mystery averages exhibit greater degrees of order and neatness which leads to superior observation and focus. This streetscape possesses deep, convoluted imagery which induces exploration impulses.
Pupil placement was primarily on the vanishing point and billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 2</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (5.40/1.45)</td></tr>
<tr><td>Legibility (4.07/1.79)</td></tr>
<tr><td>Complexity (3.00/1.07)</td></tr>
<tr><td>Mystery (3.27/1.28)</td></tr>
<tr><td>Preference (5.13/1.06)</td></tr>
<tr><td>Results</td><td colspan="3">The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to superior observation and focus.
Pupil placement was primarily on the vanishing point and billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 3</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (5.20/1.37)</td></tr>
<tr><td>Legibility (3.33/1.45)</td></tr>
<tr><td>Complexity (2.93/1.03)</td></tr>
<tr><td>Mystery (3.93/1.34)</td></tr>
<tr><td>Preference (5.33/1.11)</td></tr>
<tr><td>Results</td><td colspan="3">The high coherence average exhibit greater degrees of order and neatness.
Pupil placement was primarily on the vanishing point, billboards, and vehicles.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 4</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (6.60/0.63)</td></tr>
<tr><td>Legibility (5.20/1.66)</td></tr>
<tr><td>Complexity (2.67/1.72)</td></tr>
<tr><td>Mystery (4.47/2.00)</td></tr>
<tr><td>Preference (5.73/1.16)</td></tr>
<tr><td>Results</td><td colspan="3">The high coherence, legibility, and mystery averages exhibit greater degrees of order and neatness which lead to superior observation and focus. The arrangement of this streetscape possesses deep, convoluted imagery which induces exploration impulses.
Pupil placement was primarily on the vanishing point, billboards, and vehicles.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
</table>

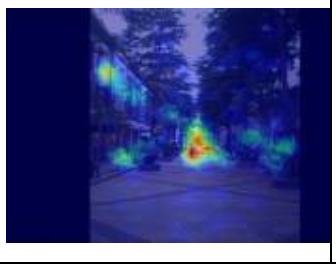
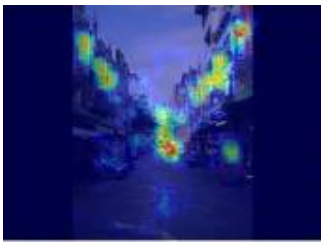
Image 5			Coherence (6.33/0.72) Legibility (5.87/1.25) Complexity (2.87/1.85) Mystery (4.40)/1.50 Preference (5.73/1.03)
Results	The high coherence, legibility, and mystery averages exhibit greater degrees of order and neatness which leads to superior observation and focus. The arrangement of this streetscape possesses deep, convoluted imagery which induces exploration impulses. Pupil placement was primarily on the vanishing point, billboards, street trees, and stores.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 6			Coherence (5.67/1.23) Legibility (5.40/1.24) Complexity(2.73/1.28) Mystery (2.93/1.34) Preference (5.73/0.88)
Results	The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to superior observation and focus. Pupil placement was primarily on the vanishing point and billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 7			Coherence (5.20/1.42) Legibility (4.20/1.42) Complexity (3.87/1.88) Mystery (2.60/1.50) Preference (3.07/1.45)
Results	The high coherence and legibility averages exhibits greater degrees of order and neatness which leads to superior observation and focus. Pupil placement was primarily on the people, vanishing point, billboards, street trees, and stores.		

Table 6. Psychological Factor and Hotspot Analysis of Jiguang Street Streetscape

Jiguang Street			
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 1			Coherence (5.13/1.30) Legibility (4.07/1.22) Complexity (4.07/1.62) Mystery (2.87/1.36) Preference (4.47/0.99)

<table>
<tr><td>Results</td><td colspan="3">This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to superior observation and focus. However, the high complexity average exhibits a greater degree of disorder.
Pupil placement was primarily on the vanishing point and billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 2</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (5.33/1.59)</td></tr>
<tr><td>Legibility (4.00/1.56)</td></tr>
<tr><td>Complexity (4.20/1.74)</td></tr>
<tr><td>Mystery (2.20/1.27)</td></tr>
<tr><td>Preference (4.33/0.82)</td></tr>
<tr><td>Results</td><td colspan="3">This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to better comprehension and focus. However, the high complexity average exhibits a higher degree of disorder.
Pupil placement was primarily on the vanishing point, billboards, and people.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 3</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (3.80/1.944)</td></tr>
<tr><td>Legibility (3.93/1.67)</td></tr>
<tr><td>Complexity (4.40/1.72)</td></tr>
<tr><td>Mystery (2.33/1.29)</td></tr>
<tr><td>Preference (4.13/1.06)</td></tr>
<tr><td>Results</td><td colspan="3">The streetscape elements cause this scene to be disorderly. The high complexity average exhibits a greater level of disorder.
Pupil placement was primarily on billboards and vehicles.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 4</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (4.60/1.64)</td></tr>
<tr><td>Legibility (4.13/1.96)</td></tr>
<tr><td>Complexity(4.20/1.70)</td></tr>
<tr><td>Mystery (2.67/1.84)</td></tr>
<tr><td>Preference (3.47/0.83)</td></tr>
<tr><td>Results</td><td colspan="3">This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibits greater degrees of order and neatness which leads to superior observation and focus. However, the high complexity average exhibits a higher degree of disorder.
Pupil placement was primarily on billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 5</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (3.93/2.05)</td></tr>
<tr><td>Legibility (3.47/1.60)</td></tr>
<tr><td>Complexity (4.40/1.55)</td></tr>
<tr><td>Mystery (3.00/1.65)</td></tr>
<tr><td>Preference (3.47/0.63)</td></tr>
</table>

<table>
<tr><td>Results</td><td colspan="3">The streetscape elements cause this scene to be disorderly. The high complexity average exhibits a greater level of disorder.
Pupil placement was primarily on billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 6</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (3.20/1.42)</td></tr>
<tr><td>Legibility (3.40/1.30)</td></tr>
<tr><td>Complexity (4.27/1.71)</td></tr>
<tr><td>Mystery (3.07/1.34)</td></tr>
<tr><td>Preference (3.40/1.06)</td></tr>
<tr><td>Results</td><td colspan="3">The streetscape elements cause this scene to be disorderly. The high complexity average exhibits a greater level of disorder.
Pupil placement was primarily on the vanishing point and billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 7</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (4.67/1.68)</td></tr>
<tr><td>Legibility (4.40/1.45)</td></tr>
<tr><td>Complexity (4.13/1.46)</td></tr>
<tr><td>Mystery (2.93/1.53)</td></tr>
<tr><td>Preference (3.60/1.10)</td></tr>
<tr><td>Results</td><td colspan="3">This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibits greater degrees of order and neatness which leads to superior observation and focus. However, the high complexity average exhibits a higher degree of disorder.
Pupil placement was primarily on billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results (Mean/Standard Deviation)</td></tr>
<tr><td rowspan="5">Image 8</td><td rowspan="5">  </td><td rowspan="5">  </td><td>Coherence (5.13/1.25)</td></tr>
<tr><td>Legibility (4.00/1.20)</td></tr>
<tr><td>Complexity (4.13/1.81)</td></tr>
<tr><td>Mystery (3.00/1.36)</td></tr>
<tr><td>Preference (4.27/0.83)</td></tr>
<tr><td>Results</td><td colspan="3">This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to superior and focus. However, the high complexity average exhibits a higher degree of disorder.
Pupil placement was primarily on the vanishing point and billboards.</td></tr>
<tr><td>No.</td><td>Image Hotspot</td><td>Original Image</td><td>Questionnaire Results</td></tr>
</table>

			(Mean/Standard Deviation)
Image 9			Coherence (5.20/1.66)
			Legibility (4.27/1.49)
			Complexity (4.00/1.77)
			Mystery (2.47/1.55)
			Preference (4.13/1.10)
Results	This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to superior observation and focus. However, the high complexity average exhibits a higher degree of disorder. Pupil placement was primarily on the vanishing point and billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 10			Coherence (5.20/1.42)
			Legibility (4.20/1.42)
			Complexity (3.87/1.88)
			Mystery (2.60/1.50)
			Preference (3.07/1.45)
Results	This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to superior observation and focus. Pupil placement was primarily on the vanishing point and billboards.		
No.	Image Hotspot	Original Image	Questionnaire Results (Mean/Standard Deviation)
Image 11			Coherence (5.00/1.60)
			Legibility (4.13/1.30)
			Complexity (4.67/1.72)
			Mystery(3.07/1.62)
			Preference (4.21/1.32)
Results	This streetscape possesses distinct orientation and neatness. The high coherence and legibility averages exhibit greater degrees of order and neatness which leads to better comprehension and focus. Pupil placement was primarily on the vanishing point, billboards, and stores.		

According to the analysis results involving eye movement hotspots, the primary streetscape constitution elements viewed by respondents include billboards, people, and the vanishing point. The analysis results regarding the psychological questionnaire for commercial streetscapes were as follows:

1. Coherence: The highest average was in Dalong Road streetscape image 7 (6.53), sequentially followed by Donghai International Commercial District streetscape image 5 (6.27), Jiguang Street streetscape image 2 (5.33), and Donghai Commercial District streetscape image 3 (3.53).
2. Legibility: The highest average was in Dalong Road streetscape image 5 (5.73), sequentially followed by Donghai International Commercial District streetscape image 4 and 5 (4.47), Jiguang Street streetscape image 9 (4.27), and Donghai Commercial District streetscape image 2 (3.40).
3. Complexity: The highest average was in Jiguang Street streetscape image 11 (4.67) and Donghai

Commercial District streetscape image 3 (4.67), sequentially followed by Donghai International Commercial District streetscape image 5 (4.40), and Dalong Road streetscape image 3 (2.93).

4. Mystery: The highest average was in Dalong Road streetscape image 4 (4.47), sequentially followed by Donghai International Commercial District streetscape image 7 (4.20), Donghai Commercial District streetscape image 2 (3.07), and Jiguang Street streetscape images 6 and 11 (3.07).
5. Preference: The highest average was Dalong Road streetscape images 4, 5, and 6 (5.73), sequentially followed by Donghai International Commercial District streetscape image 7 (4.60), Jiguang Street streetscape image 1 (4.47), and Donghai Commercial District streetscape image 2 (3.20).

From the above we can determine that Dalong Road streetscape images 7, 5, and 4 all presented common streetscape elements that attracted visual attention, namely, billboards and street trees. The billboards on Dalong Road were arranged comparatively neatly and orderly. Therefore, the hotspots were primarily concentrated on the vanishing point and billboards of relevant streetscape images. In addition, regarding the psychological questionnaire results of these three images, the coherence, legibility, mystery, and preference averages were also greatest. This proves that physiological and psychological responses correspond to each other.

Streetscape Preference Multiple Regression Analysis on the 4 Psychological Factors of the Environmental Preference Matrix

The study primarily examined the relationship between the psychological factors of streetscape elements (coherence, legibility, complexity, and mystery) and landscape preferences. We considered the 4 psychological factors of the environmental preference matrix as the independent variables and streetscape preferences as the dependent variables. Subsequently, we adopted "enter" as the examination method for the multiple regression model (Table 7).

Table7. Multiple Regression Analysis of the 4 Environmental Preference Matrix Psychological Factors on Streetscape Preferences

Name of Variable	Unstandardized coefficient B value	Standardized coefficient B value	*t* value (Significance level)	Adjusted R^2	F value (Significance level)
Constant	3.713	-	**12.295*** **	0.085	11.395***
Coherence	0.148	**0.197**	3.644***	-	-
Legibility	-0.014	-0.018	-0.332$^{n.s}$	-	-
Complexity	-0.117	-0.152	-3.042***	-	-
Mystery	0.086	0.106	2.303**	-	-

Note 1: *P□0.1, ** P□ 0.05, ***P□0.01, and n.s. indicates p>0.05 (no significance)

According to Table 4, the multiple regression model achieved significance (F (4,445) = 11.395; p < .001), as well as statistical significance. In addition, coherence, complexity, and mystery also achieved significant levels. Results show that the coherence factor exhibited a greater effect on streetscape preferences (B value = 0.197). The positive B value further indicates that the higher the respondent's perception towards the "coherence" psychological factor, the higher the streetscape preferences will be. Thus, coherence is a positive psychological factor. Coherence is followed by complexity (B value = -0.152), and results show that the complexity factor also exhibited considerable influence on streetscape preferences. However, the negative B value indicates that the higher the respondent's perception towards the "complexity" psychological factor, the lower the streetscape preferences will be. Thus, complexity is a negative psychological factor. In summary, legibility and complexity are negative psychological factors, indicating that the higher these factors are, the more the preference value decreases. Conversely, coherence and mystery are positive psychological factors, indicating that the higher these factors are, the more the preference value increases.

The findings show, there is significant association between the four environmental preference matrix psychological factors and streetscape preferences. However, the R squared values indicate that the influential level of psychological factors on streetscape preferences is not significant.

DISCUSSIONS AND SUGGESTIONS

Discussions

The objective of this study is to determine the psychological influences of landscape spatial contexts on preference formulation. The methods used for research are eye tracking experimentation and questionnaire surveys. The eye tracking experimentation records visual responses of visual attention, primarily recording the fixation count and gaze time of visual attention. The content of the questionnaires mainly include the four factor dimensions (coherence, complexity, legibility, and mystery) of the landscape preference matrix. The analysis results are as follows:

The psychological questionnaire survey results indicate that the highest preference values for coherence, legibility, complexity, and mystery were from Dalong Road streetscape images 7, 5, and 4. The billboards on Dalong Road were arranged comparatively neat and orderly with a high legibility. The combination of landscape elements presented distinct orientation and induced the curiosity of respondents. The lowest preference value was of Donghai Commercial District. The landscape elements in this district were overly

complex, resulting in ambiguity. The analysis results for eye tracking hotspots indicated that the visual attention of respondents were mainly on elements including billboards, vanishing points, people, street trees, and stores. Furthermore, the comparative results of eye tracking hotspot analysis and landscape preference investigations indicated that, regarding the eye tracking hotspot analysis, Dalong Road streetscape images 7, 5, and 4 all presented common streetscape elements that attracted visual attention, namely, billboards and street trees. The billboards on Dalong Road were arranged comparatively neat and orderly with high legibility and distinct orientation. Hotspots were primarily concentrated on vanishing points and billboards. In addition, the results of the psychological questionnaires also indicated that Dalong Road streetscape images 7, 5, and 4 exhibited the highest coherence, legibility, and mystery preference values. This proves that physiological and psychological responses correspond to each other.

Suggestions

Issues regarding streetscape spatial context factors can be solved through overall planning to achieve integrated and unified effects. Therefore, it is necessary to determine the psychology of respondents, and further understand and consider landscape constituting factors (e.g. billboards, the appropriateness of street trees to buildings, the width of streets and roads, and overall visual aesthetics). In conclusion, we separately propose suggestions for streetscape planners and future research according to the analysis results obtained from this study.

From theory, analysis, and evaluation perspectives of aesthetics and urban landscapes, an improvement project should be developed which considers the imagery formulated by road users. To organize road and street billboards, we suggest that a consensus should be formulated where store owners agree on sign appearance restrictions, such as fonts and colors. In addition, influential factors for billboard unification, such as regional distribution of font and color, or the amount of applied color, should be further investigated.

During the evaluation processes, five analytical factors can be considered: (1) crowded, disorderly, and uncoordinated, (2) busy and tidy, (3) the effects of advertisement billboards, (4) the street beautification effect of advertisement billboards, and (5) advertisement billboards as streetscape features. These factors can be used as reference for billboard streetscape evaluations.

Urban landscapes are composed of numerous elements. In this study, we selected 4 streets and roads to analyze the effect of various factors on overall landscape preferences, and simultaneously compared the streetscape preferences of each street and road, yet landscape aesthetic quality is related to various factors, such as environmental background, street functionality, street width, and human activity. Therefore, the results proposed in this study cannot be widely applied to urban streets. We suggest that future research can include more street and environmental factors, investigate more types of constituent factors which influence psychological preferences, and ultimately create urban streetscape design principles.

REFERENCES

[1] Chia-Chun Chung (1995). *Architectural and Environmental Psychology*. Garden City Publishing, Taipei.

[2] Chuan-Kang Chen (1986). *Subject, Content, and Significance of Behavioristic Geography*. Anthropogeography Research, P230-242.

[3] Chun-Chieh Huang (1998). *A Study on Pedestrian's Perception of Sidewalk Interface Patterns. Unpublished master's thesis*, Graduate Institute of Horticulture, National Taiwan University.

[4] Chun-Yen Chang, Che-San Cai, and Shih-Yao Weng (1995). An Environmental Cognition Approach to the Analysis of Visitors Vandalism □ A Case Study of Chung-Shan Park in the Taichung City. *Journal of Outdoor Recreation Study*, Ed. 8, P67-89.

[5] De Lucio, J. V., Mohamadian, M., Ruiz, J. P., Banayas, J., & Bernaldez, F. G.(1996). Visual landscape exploration as revealed by eye movement tracking. *Landscape and Urban Planning*, 34□135-142.

[6] Hou-Chiang Lee (2002). *A Study on the Influence of Illuminance and Color Temperature of Artificial Lighting on Visual Perception and Survey of Lighting Models – Using Living Room as an Example*. Unpublished master's thesis, Department of Interior Design, Chung Yuan Christian University.

[7] Hsiung-Chin Hou and Su-Hsin Li (1996). *Basic Elements of Landscape Architectural Design*. Translated from the English Version by Norman K. Booth. Urban Garden Publishing, Taipei (Original published in 1983).

[8] Hui-Mei Chen (1999). *The Effect of Viewing Sequence on Landscape Evaluation: Discuss the Sustainable Management for Visual Resource*. Unpublished master's thesis, Graduate Institute of Horticulture, National Taiwan University, Taipei.

[9] Hui-Mei Chen (1999). *The Effect of Viewing Sequence on Landscape Evaluation: Discuss the Sustainable Management for Visual Resource*. Unpublished master's thesis, Graduate Institute of Horticulture, National Taiwan University, Taipei.

[10] Kaplan, R., & Kaplan, S. (1989). The Experience of Nature: A Psychological Perspective. *Cambridge University Press*, New York.

[11] Kaplan, S., & Kaplan, R. (1982). Cognition and Environment□Function in an Uncertain World. *Praeger*, New York.

[12] Lynch, K. (1960). The Image of The City. *MIT Press*, Cambridge.

[13] Naai-Jung Shih and Chao-Cheng Chang (1998). *Computer Analysis of the Common Attributes in Urban Architectural Landscape Imagery*. 17th CID Annual Design Conference, p339-341.

[14] Nien-Hsuan Chen (1997). *A Study of the Urban Street Identity – a Case Study on Taichung City*. Unpublished master's thesis, Graduate Institute of Landscape Architecture, Tunghai University, Taichung.

[15] Yan-Li Wang (2008). *A Study of Landscape Cognition and Visual Attention of Prospect-refuge Environment*. Unpublished master's thesis, Landscape and Recreation Institute, Feng Chia University, Taichung.

[16] Yen-Chou Lin (1979). *The Evaluation of Landscape Resources in Recreational Planning*. Unpublished master's thesis, Graduate Institute of Urban Planning, National Chang Hsing University, Taichung.

[17] Yen-Chou Lin (1979). *The Evaluation of Landscape Resources in Recreational Planning*. Unpublished master's thesis, Graduate Institute of Urban Planning, National Chang Hsing University, Taichung.

[18] Yu-Yun Kao (2003). *A Study of Streetscape Preference*. Unpublished master's thesis, Graduate Institute of Tourism, Providence University, Taichung.
[19] Shu-Yi Wang (1999). *Streets and Squares. Translated from the English Version by Cliff Moughtin*. Chuang Hsin Publishing, Taipei.
[20] Rapoport, A. (1977). Human Aspects of Urban. *Pergamon Press*, New York.
[21] Selberg, K. (1996). Road and Traffic, *Landscape and Urban planning*, 35(2-3), 153-172.
[22] Yuan-Ching Hsu (1985). A Study on Urban Streetscape Categorization in Taipei City. *Transportation Research*, 14(1):71-100.
[23] Zhong-Fan Hu and Zhao- Ming Zheng (1994). *The History of Memory and Perception*. Unpublished master's thesis, Graduate Institute of Psychology, National Taiwan University, Taipei.