

SYNTACTICAL RELATION BETWEEN SPATIAL CONFIGURATION AND
SENSE OF SAFETY IN NEIGHBOURHOOD COMMERCIAL STREETS

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To my beloved *parents, and siblings*

To my heartiest and dearest *husband* for his love, care, supports and prayers
during my study

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ABSTRACT

Safety has been highlighted as one of the most important factors of urban life quality. The space syntax theory argues that streets with higher accessibility tend to have lower crime rates, which is the objective dimension of safety. The first point of human interaction with an urban environment is known as townscape. Feeling safe, which is a psychological and social phenomenon, is obtained through decoding this environmental understanding. The aim of this study is to identify the relationship between spatial configuration and pedestrian sense of safety in neighbourhood commercial streets. To this end, space syntax analysis was applied to measure the syntactical variables. Taman Universiti, Taman Ungku Tun Aminah, and Taman Mount Austin were chosen based on their integration measures in the global analysis. Forty streets with high local integration value were selected within the three areas and then observation was carried out in order to prorate 400 questionnaires among pedestrians in these streets. The questionnaires were distributed to collect data about townscape variables affecting pedestrian sense of safety. The impact of townscape factors on pedestrian sense of safety was examined by adopting exploratory and confirmatory factor analyses. The Pearson product-moment correlation coefficient was computed to measure the relationship between syntactical variables and townscape factors. The findings show the townscape factors which affected pedestrian sense of safety include: the sense of place; place identity; memorability; form; legibility; and visual pleasure, of which the last two are the most important factors. Furthermore, the legibility and visual pleasure are strongly correlated with two syntactical variables namely local integration and street connectivity. In fact, local integration and connectivity have positive correlation with some items of townscape such as easy navigation and clarity, and visual permeability and vitality which contribute to legibility and visual pleasure respectively. Results of this study clearly reveal that spatial configuration affects townscape factors and consequently pedestrian sense of safety.

ABSTRAK

Keselamatan diketengahkan sebagai salah satu faktor yang paling penting bagi kualiti hidup di bandar. Teori sintaks ruang berpendapat jalan-jalan yang mudah dilalui cenderung mempunyai kadar jenayah yang lebih rendah, yang merupakan dimensi objektif keselamatan. Titik pertama interaksi manusia dengan alam sekitar ini dikenali sebagai townscape. Rasa selamat merupakan fenomena psikologi dan sosial yang diperoleh melalui penyahkodan implikasi alam sekitar. Tujuan kajian ini adalah untuk mengenal pasti hubungan antara konfigurasi ruang dan keselamatan pejalan kaki di jalan-jalan komersil kejiranan. Untuk tujuan ini, analisis sintaks ruang digunakan untuk mengukur pembolehubah sintaktikal. Taman Universiti, Taman Ungku Tun Aminah dan Taman Mount Austin telah dipilih berdasarkan langkah integrasi mereka dalam analisis global. Empat puluh jalan raya dengan nilai integrasi tempatan yang tinggi telah dipilih dalam tiga kajian kes dan kemudian pemerhatian dijalankan untuk menguraikan 400 soal selidik dalam kalangan pejalan kaki di jalan-jalan ini. Soal selidik diedarkan untuk mengumpul data tentang pemboleh ubah lokasi bandar yang mempengaruhi keselamatan pejalan kaki. Kesan faktor bandar pada keselamatan pejalan kaki dikaji dengan menggunakan analisis faktor pengujian dan pengesahan. Kemudian pekali korelasi momen produk Pearson dikira untuk mengukur hubungan antara pembolehubah sintaks dan faktor bandar. Dapatan menunjukkan bahawa faktor bandar yang menjejaskan keselamatan pejalan kaki termasuk: rasa tempat, identiti tempat, mudah diingati, bentuk, keterbacaan dan keseronokan visual, yang mana dua faktor terakhir adalah faktor yang paling penting. Tambahan pula, keterbacaan dan keseronokan visual sangat dikaitkan dengan dua pembolehubah sintaks iaitu integrasi tempatan dan kesinambungan jalan. Malah, integrasi dan kesinambungan jalan tempatan mempunyai korelasi positif dengan beberapa item bandar seperti navigasi mudah, kejelasan, kebolehtelapan visual dan daya hidup yang menyumbang kepada keterbacaan dan keseronokan visual. Dapatan kajian ini dengan jelas menunjukkan bahawa konfigurasi ruang memberi kesan kepada faktor-faktor bandar dan seterusnya keselamatan pejalan kaki.

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LIST OF ABBREVIATIONS

WHO	-	World Health Organization
SPSS	-	Statistical Package for Social Sciences
AMOS	-	Analysis of Moment Structures
EFA	-	Exploratory Factor Analysis
CFA	-	Confirmatory Factor Analysis
SEM	-	Structural Equation Modelling
Ref	-	Reference
VGA	-	Visual Graph Analysis

LIST OF SYMBOLS

n	-	Sample size
Z	-	Level of significant
σ	-	Estimate of standard deviation
e	-	difference between the sample mean \bar{x} and the population mean μ or the acceptable error
\bar{x}	-	Sample mean
μ	-	Population mean
X^2	-	Chi- square
df	-	Degree of freedom
CMIN	-	Chi- square value
GFI	-	Goodness of fit
CFI	-	Comparative fit index
TLI	-	Tuker lewis index
RMSEA	-	Root square error of approximation
N	-	Number
M	-	Mean
SD	-	Standard Deviation
P(p-value)	-	Significance level
ANOVA	-	Analysis of varaiance
%	-	Percentage
R^2	-	Coefficient of determination
AVE	-	Average variance extracted
CR	-	Composit reliability
ASV	-	Average shared variance
MSV	-	Maximum shared variance

R	-	Integration
Rn	-	Global scale integration
R3	-	Local scale integration (radius=3km)
SOS	-	Sense of safety
VP	-	Visual pleasure
VP1	-	Form Diversity
VP2	-	Attractive
VP3	-	Non Polluted
VP4	-	Aesthetics
VP5	-	Visual Permeability
VP6	-	Vitality
F	-	Form
F1	-	Geometry (Form and Size)
F2	-	Furniture
F3	-	Decoration (Material)
F4	-	Natural Elements
F5	-	Color
F6	-	Lighting
SP	-	Sense of place
SP1	-	Interest
SP2	-	Respect to Human Needs
SP3	-	Distinctiveness
SP4	-	Compatible Mix of Uses
PI	-	Place identity
PI1	-	Increasing Self Confident
PI2	-	Differentiation
PI3	-	Culture
PI4	-	Continuity
L	-	Legibility
L1	-	Easy Navigation
L2	-	Clarity
L3	-	Signage
L4	-	Guide

M	-	Memorable
M1	-	Sense of Belonging
M2	-	Being Familiar
M3	-	Having Positive Memory

LIST OF GLOSSARY

- | | | |
|-----------------------|---|---|
| Spatial configuration | - | spatial configuration means a set of relationships among parts (urban streets), all of which interdepend in an overall structure of some kinds. This concept addresses the whole of a complex rather than its parts |
| Axial map analysis | - | Axial map analysis explains the behaviour of people into a pattern of urban spaces. this method illustrate social urban space analysis and treatment of people together by computer simulation |
| Connectivity | - | Connectivity means the number of streets that are connected to a specific street |
| Control | - | Control measures what degree of choice each space represent for its immediate neighbours as a space to move to. Each space has a certain number k of immediate neighbours. Each space therefore gives to each of its immediate neighbours $1/k$, and these are then summed for each receiving space to give the control values of that space. Spaces which have a control value greater than 1 will have strong control, those below 1 will be weak control spaces |
| Integratin | - | Integration shows how many turns have to be made from an origin to reach all other destination in the city, using shortest routes. |
| Inteligiblility | - | Intelligibility is the degree of perception of the environment that is directly related to Iegibility. |
| Legibility | - | The legibility of a route is the ease with which a route can become known or how easily people can understand it |
| Space syntax | - | Space syntax is a method for reading urban spaces which is an association between physical structure and social structure |

- Synergy - synergy, defined as the correlation between radius-3 and radius-n integration. It measures the degree to which the internal structure of an area relates to the larger-scale system in which it is embedded
- Radius - Radius is the set of spaces selected from the whole system to be analysed round a root space. For example, it is used to select all spaces within 3000 m from a root space.
- Natural movement - Natural movement is the proportion of urban pedestrian movement determined by the grid configuration itself
- Gate count - Gate count is used to establish the flows of people at sampled locations within the city over the course of a day
- Axial length - Axial line length measures the metric length of axial lines
- Depthmap - DepthMap is a single software platform to perform a set of spatial network analyses designed to understand social processes within the built environment. It works at a variety of scales from building through small urban to whole cities or states. The objective of the analysis is to derive variables, which may have social or experiential significance
- Gate - Gate is a conceptual line across a street used for counting movement flows in observation studies.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter begins with the introduction of research background. The problem statement and research gap are presented in the following section. It additionally continues with defining the research question, aim and research objectives. Moreover, research methodology, the significance of study, and conceptual framework are explained in the next sections. Section 1.10 describes the thesis organization.

1.1 Background of the Study

Safety is one of the most basic needs of human communities after the basic physiological needs (hunger, thirst) in Maslow's hierarchy of human needs (Maslow, 1987). The relationship between spatial configuration and human behaviour is currently taken into consideration in many research projects to develop urban environments. The issue of safety and crime prevention has been one of the major themes of Space Syntax research. This study includes the relationship between movement pattern and spatial layout, and the impact of spatial design on sense of safety.

In explaining the concept of safety two distinct dimensions should be considered; an objective dimension, is realized as "non crime," i.e. the reduction or absence of crime occurrence (Laflamme *et al.*, 1999), and a subjective dimension,

which can be comprehended as the individual's perception or feelings of being safe (WHO, 1998; Maurice *et al.*, 1997). Both dimensions can influence each other either positively or negatively. Therefore, it is necessary to consider these two dimensions to improve the safety of the population.

In urban studies, safety has always been considered as one of the important indicators of quality of life and in this regard, various theories have been presented. The work of Jane Jacobs (1961) emphasized the importance of the social processes in creating a space that is safe and successful. Newman (1973) follows a similar approach on the importance of social behaviour and the development of a safe environment through creating "defensible" space. Besides these two theories, Hillier (1984) used the space syntax theory with a concentration on the relationship between natural movement and spatial configuration and its impact on safety.

Based on space syntax methodology, a number of research projects highlighted the importance of the presence of people in increasing safety. Hillier found that the determined spatial configurations can contribute to the possibility of the presence of people through movement generation. A study completed by Friedrich *et al.* (2009) attempted to find the relationship between anti-social behaviour and spatial configurations.

Hillier believed that if the urban spatial configuration makes the pedestrians' natural movement more difficult, there will not be a sufficient number of people to create the perception of a well appropriated and used space (Teymur *et al.*, 1988). In addition, some empirical researches support this idea (Jones and Fanek, 1997; Chih-FengShu, 2000; Shu and Huang, 2003). They indicated that places with higher level of accessibility tend to have lower crime rates, while places with low accessibility, i.e. segregated places, have higher crime rates. In other words, the presence of the sufficient number of people on the street reduces the crime occurrence; and where the safety derived from crime reduction is the objective aspect of safety.

1.2 Problem Statement

Crime and sense of unsafe are addressed as a result of population growth and rapid urbanization. They have been highlighted as the most significant social problem which impacts the life quality and hinder the social interaction (Marzbali *et al.*, 2012, Torstensson Levander, 2007 and Zedner, 2009, Savina *et al.*, 2013). Many studies have consistently proven that safety and sense of safety are the main concerns of urban areas (Shaw and Louw, 1998; Vanderschueren, 1998). Architecture and urban designer have attempted to reduce the crime occurrence through the design and arrangement of streets and public spaces while they have paid less attention to the subjective dimension of safety.

Similar to fear of crime, which is dependent on the perception of the environment (Hutchings, 1994), sense of safety is defined as a reaction to the space attributes which has a considerable role in human behaviour. To feel safe and free from concern is realized as a positive condition and a resource in everyday life (WHO, 1986, 1998). Although, the objective dimension of safety is an important issue, but the sense of safety (subjective dimension) is more crucial because sometimes people may fear in the safe environment (Nilsen *et al.*, 2004; Cho and Svanström, 2002).

Previous research findings have shown that fear of being a victim in relation to personal safety can have detrimental effects on well being of human as it can significantly limit their freedom of choice by negatively influencing their walking patterns through space (Nehme *et al.*, 2015; Sallis and Kerr, 2007; Rhodes *et al.*, 2006; Ellaway *et al.*, 2005; Ross and Mirowsky, 1999) which lead to their dissatisfaction with public spaces and neighbourhood places, and ultimately with life in general (Alfonzo, 2005). Therefore investigating the sense of safety in urban environment needs more studies.

1.3 Research Gap

According to the Lang (1994) “Feeling safe depends on the knowledge of the environment which needs the awareness of where you are in the space”. Therefore, spatial knowledge is essential to evaluate feeling of safety. To this end Space Syntax is used for the socio-spatial analysis of urban spaces (Syed Mahdzar, 2008; Dursun and Saglamer, 2003; Hillier and Hanson, 1998; Hillier *et al.*, 1983). It is a mathematically based environmental model that analyses the impact of spatial configuration on human behaviour.

As mentioned in section 1.1, crime reduction or prevention is the objective aspect of safety, which has been addressed in previous space syntax studies (Teymur *et al.*, 1988; Chih-FengShu, 2000; Nubani and Wineman, 2005; Baran, *et al.*, 2006). Therefore, to find the relationship between spatial configuration and safety, the subjective aspect of safety also needs to be examined. In fact, if the relationship between spatial configuration (space syntax variables) and pedestrian sense of safety are found, an improved definition of safety based on spatial configuration will be reached by combining the space syntax theory with new finding.

Feeling safety is a psychological and social phenomenon that is affected by variety of factors and dimensions. Therefore, finding these factors is important to examine the sense of safety in public space. Previous studies used the measures of desirable and satisfactory urban environment for investigating the feeling of people in urban public spaces (Baba and Austin, 1989; Austin, *et al.*, 1994).

Townscape is the first point of human’s contact with the environment. The human’s senses face the townscape and receive required information. Based on this information, people reach to a perception such as sense of safety. In fact, human arranges the received information in his mind and makes them meaningful for himself. According to the meanings formed in his mind, he feels safe or unsafe in various circumstances. In this study townscape variables are regarded as indicators affecting on sense of safety in urban space.

Therefore, to find the relationship between spatial configuration and sense of safety two issues should be studied separately: i) the sense of safety due to facing townscape variables, ii) the impact of spatial configuration on townscape variables which are effective on sense of safety.

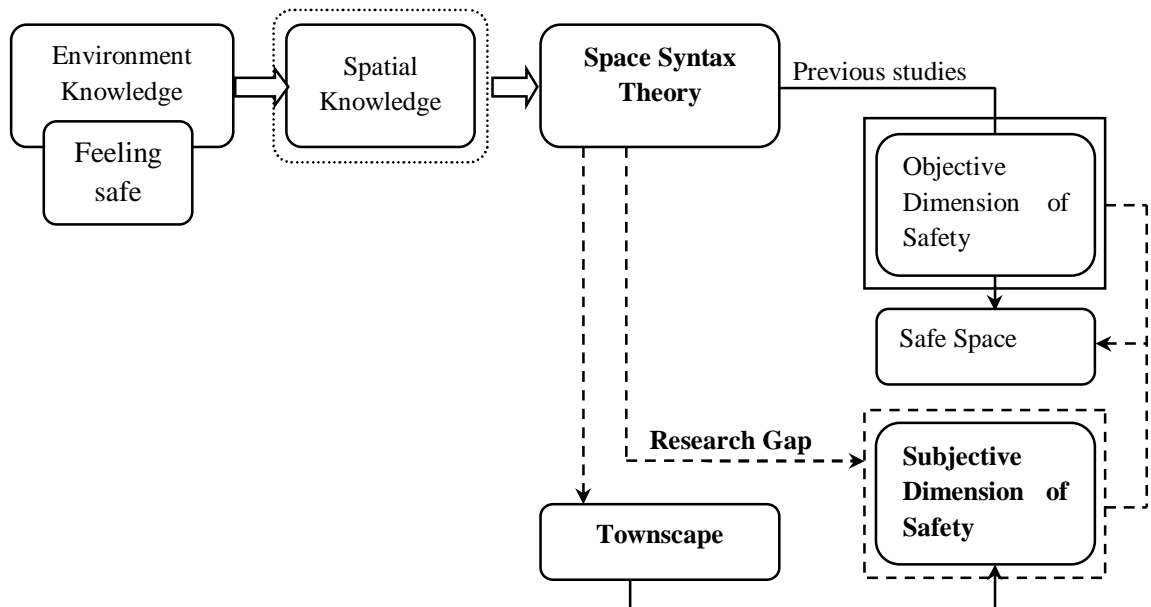


Figure 1.1 Research Gap

1.4 Research Questions

It is expected that at the end of the study, responses to the following research questions will be provided.

1. What are the latent factors of townscape which affect sense of safety?
2. To what extent is the each townscape factor impacting on sense of safety?
3. What is the relationship between spatial configuration and townscape factors that affect pedestrian sense of safety?

1.5 Research Aim and Objective

Sense of safety has been pointed out as one of the significant factors in improving the quality of life in urban environment in previous researches. They consider street as one of the key elements of urban environment that should be safe for pedestrian. The goal of this study is to identify the relationship between spatial configuration and pedestrian sense of safety in neighbourhood commercial streets. This aim will be achieved via the following objectives:

1. To examine the latent factors of townscape which affect on pedestrian sense of safety
2. To determine the impact of each townscape factor on pedestrian sense of safety
3. To measure the relationship between space syntax variables (integration value, level of connectivity, control, and line length) and townscape factors that affect the pedestrian sense of safety

1.6 Research Methodology

This study uses a quantitative method, which combines four research approaches:

1.6.1 Literature Review

Literature was carried out in order to understand the debate on the sense of safety and how the environment affects it as well as the factors of townscape which make pedestrians in the urban streets feel safe. It includes contributions from architects; social scientist, urban designers, planners, geographers, sociologists, and psychologist in order to better understand the complex dynamic of people's sense of

safety and environment. The literature review explores in detail many of the issues outlined above.

1.6.2 “Space syntax analysis”

The theory of natural movement from ‘space syntax’ method states the pedestrian movement pattern in urban space is essentially generated by its spatial configuration, as pedestrians tend to follow the most direct and shortest route to move from place to place (Hillier *et al.*, 1993, Hillier 1996, 1989). Space syntax axial line analysis is computed by software (Depthmap) simulation. It analyses the distribution and flow of movement (which includes people, cycles, traffic, etc) in the street. This constituted one of the important design issue related to the street safety due to accessibility of street in urban area (Hillier and Hanson 1984).

Space syntax methodology is used in order to analyse the structure of the urban streets. Through preparing the axial model of Johor Bahru city district, this study examines space syntax measures such as integration value, street connectivity, control, and line length. After finding the results from the axial model, these integrated and segregated parts of the neighbourhood are explored in depth with observation.

1.6.3 Observation Analysis

The third aspect of methodology includes observations of people activity in the street using “snapshot” method (space syntax manual 1999). This method has been adopted in the assessment and planning process of urban analysis (Francis 1984, Moudon 1992). The “snapshot” method maps out pedestrian activities within urban streets (Syed Mahdzar, 2008).

Another type of observation is gate observation for counting people movement. Pedestrian counts suggest an opportunity to obtain a sense of the unique movement patterns at each street. Scholars believe Pedestrian counts are a simple inexpensive and common way of measuring overall volumes at selected street (Major, 1997-98; Grajewski and Vaughan, 2001). The aim of this observation is to understand the effect of syntactical variables on pedestrian volume within studied area.

1.6.4 Questionnaire

Questionnaires are conducted after the observation. The purpose of this questionnaire is to collect data about variables affecting on pedestrian sense of safety in selected neighbourhood commercial streets. Specifically, this study will allow us to investigate reasons why pedestrian in these neighbourhood commercial streets have or do not have sense of safety according to townscape items. The summary of process is presented in a flowchart diagram in Figure 1.2.

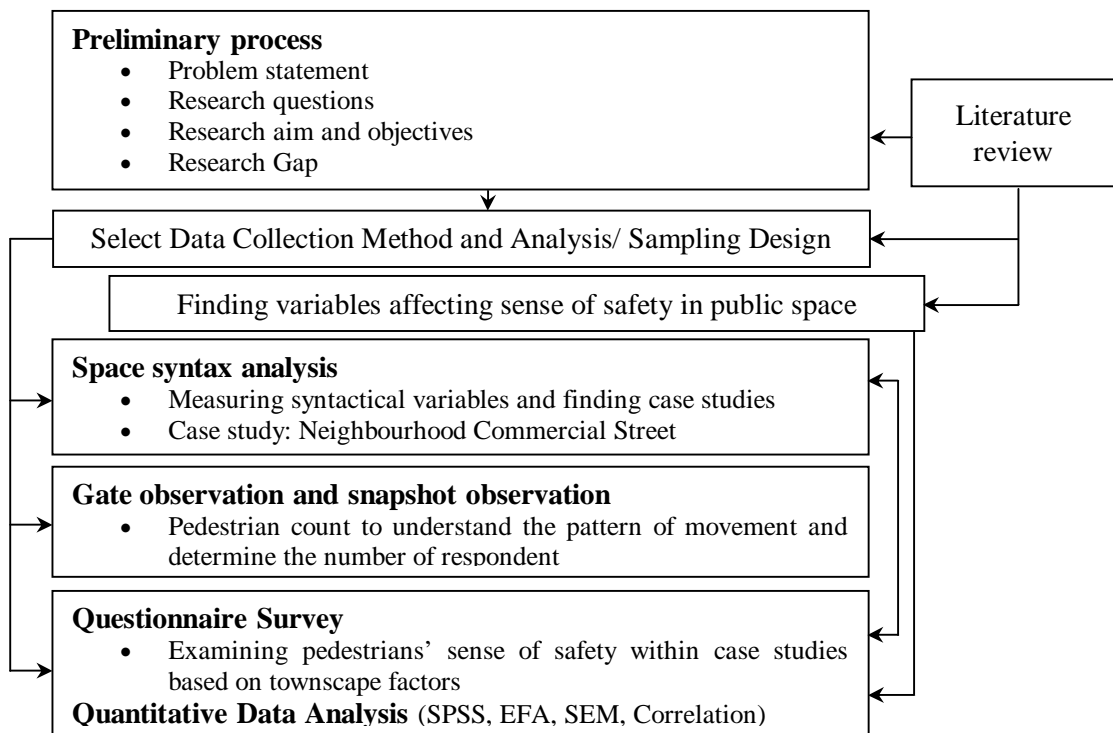


Figure 1.2 Research Methodology Process

1.7 Research Scope

As mentioned in problem statement environment affect on sense of safety. In fact, feeling safety in space is obtained through comfort and desirability of environment. Therefore due to having objective – subjective properties, townscape allows designers and planners to investigate pedestrian sense of safety.

This study is an empirical examination on feeling safety of pedestrian as respondent in the neighbourhood commercial street in Johor Bahru city district. The main competitive preference of neighbourhood commercial streets is their ability to support social interaction. In this study, the differences of feeling safety between genders were not investigated.

Three mixed land use neighbourhood are selected in this research. Urban design studies in the last few decades has shown that mixed-use neighbourhoods causes a more vital, and vibrant urban lifestyle predominantly in core areas – the neighbourhood commercial streets.

The studied streets are selected among the neighbourhood commercial streets with high integration values which presence of people could be observed. Therefore these streets are assumed to be safe objectively based on “space syntax” theories.

1.8 Conceptual Framework

This study explores the relation between urban configuration and pedestrian sense of safety through the impact of syntactical variables on townscape factors in neighbourhood commercial streets. Spatial configuration means a set of relationships among urban streets; Configuration analysis begins with the characterization of the urban layout’s spatial properties. This study uses axial lines for analyzing the urban configuration; each line has own specifications which the

most important one is integration value. According to Space syntax theory high integrated streets are safe due to the presence of the sufficient number of people on the street. This theory emphasizes on people movement because the most urban use is movement.

A comprehensive review of literature provided ideas for the construct of the “conceptual framework”. The construct as demonstrate in Figure 1.3 concentrated on urban configuration and syntactical variables such as local integration value, street connectivity, control value, and line length, which have been used in previous studies for examining the urban safety through crime reduction. Furthermore townscape variables were considered as the factors that can make sense of safety in urban spaces.

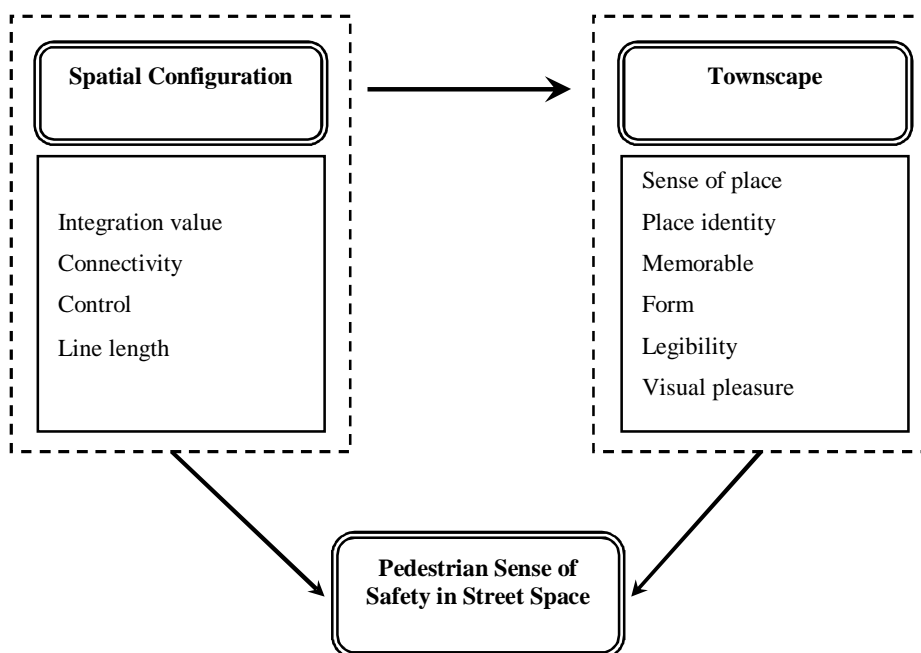


Figure 1.3 The conceptual framework of the research

1.9 Significance of the Study

The concept of urban space is extended to the unrestricted access spaces such as street, where most human interaction occurs. An appropriate urban space supports safety well. And conversely, improper urban space destroys safety and underlines the social harm (Crowe, 2000; Cozens *et al.* 2005; Cozens and Love, 2015). Accordingly, necessity of attention to the relationship between people's sense of safety in urban spaces become evident more than ever (Brunsdon *et al.* 1995; Chowdhury, 2014).

While promoting the sense of safety in neighbourhoods is essential for social life quality, it has yet to be defined how spatial configuration can affect such a sense of safety. Therefore, this study is significant because:

1. It will provide some empirical evidence to represent the relation between urban street network and the sense of safety;
2. The findings of this research may be used to help develop environmental design guidelines aimed at improving the quality of life in mixed-use neighbourhoods;
3. The findings of this study may lead to an improvement in safety definition based on space syntax theory for pedestrian.

1.10 Organization of Thesis

The thesis is structured into seven chapters and outlined as follows:

Chapter 1 presents the research and provides introductory background information that is relevant to the study. The chapter contains problem statement, research gap, determining research questions and formulating research aim and

objectives. Additionally, it includes the research scope and significance of the study and concludes with the conceptual and research framework.

Chapter 2 presents the literature review that focused on safety issue and its dimensions. The concepts and theories of urban safety with more emphasize on space syntax theory and safety is addressed in this chapter.

Chapter3 presents the literature review about safety on urban streets. It describes the relationship between sense of safety and satisfaction. The townscape variables which affect sense of safety are addressed in this chapter. In addition the factors of desirable urban environment are explained.

Chapter 4 introduces the research methodology; it indicates the research design process applied for this study. It contains the research approach, sampling procedure and design, case study, data collection and analysis methods. The chapter also explains space syntax as analytical techniques. In addition, the chapter discusses the instrument and content validity through “exploratory factor analysis” (EFA) and the construct validity through “confirmatory factor analysis” (CFA).

Chapter 5 is the syntactical variables measurement of case studies. This chapter presents the quantitative result of space syntax analysis extracted by simulation in Depthmap software and the result of observation study.

Chapter 6 presents the results derived from data analysis, explains and discusses the findings. The results focus on the exploratory and confirmatory factor analysis of townscape factors. It includes the EFA and CFA of townscape variables and their impact on pedestrian sense of safety. At the end of this chapter relationship between syntactical variables and townscape factors is measured.

Chapter 7 presents the concluding discussion of the research findings by providing answers to the research questions raised at the beginning of the study. The chapter concluded by stating the contribution of the study while suggesting

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