ENCLOSURE AS A FUNCTION OF HEIGHT-TO-WIDTH RATIO AND SCALE: ITS INFLUENCE ON USER'S SENSE OF COMFORT AND SAFETY IN URBAN STREET SPACE

By

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To my father and my mother
To my wife and my children

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Urban street spaces in today's cities are merely byproducts of planning and design decisions including buildings' heights, density, and transportation regulations. The resulting spaces have 2nd-order functions that impact their users' sense of comfort and safety; among the 2nd-order functions is the sensorial value of enclosure. Literature suggests strong relationships between enclosure of urban spaces and user's senses. My research examined how height-to-width ratio and scale influence perceived enclosure, and how enclosure influences comfort and safety in urban street spaces.

Because of methodological difficulties to achieve this goal in real-life urban streets, my research used computer-simulated urban street spaces. Different software packages were used to build the simulated 3D models. A total of 42 different degrees of simulated enclosure were produced and integrated as still images in an on-screen survey. The survey involved 83 participants who responded to questions about the degrees of comfort, safety, and perceived enclosure relative to each image. Data were collected and tested using non-parametric statistical tests of variance, association and regression.

My research showed that enclosure has a linear association with height-to-width ratio and scale of urban street space, and that it has a curvilinear association with both senses of comfort

and safety. My research found a certain degree of enclosure that satisfies ideal comfort and safety perceptions. This degree of enclosure corresponds to the ratio value of (3/4) and scale value of (1,600 sq. ft). Thresholds of urban street ratio and width values were established in my research; below which urban street spaces are not perceived to be comfortable or safe. While my research confirms the relationship between simulated enclosure and perceived enclosure suggested in previous empirical work; it does not confirm the suggested linear relationship between perceived enclosure and safety. My research proposes a non-linear relationship instead; where moderate degrees of enclosure correspond to higher levels of comfort and safety, while both high and low degrees of enclosure correspond to lower levels of comfort and safety.

CHAPTER 1
INTRODUCTION

Research Purpose

Urban design literature suggests that enclosure in urban street spaces impacts users' perceptions of comfort and safety. This literature also suggested that the value of enclosure is a function of height-to-width ratio, and it proposed ideal ratios for urban street spaces. However, such suggestions are without empirical basis. The purpose of my research is to conduct an empirical investigation on the influence of enclosure of urban street space (as a function of height-to-width ratio and scale) on users' sense of comfort and safety. The main question of my research is how does enclosure influence users' sense of comfort and safety in urban street space? By answering this question, my research contributes to space-morphology inquiry, toward integrating users' impressions, opinions, and needs, relative to enclosure as a function of both ratio and scale, into the theory and practice of urban planning and design.

Strategies for establishing good physical public spaces, including urban streets, stress the concept of "positive urban space" promoted in recent urban design literature. The positive urban space is an explicitly eligible and defined space; it is in balance with its defining masses. One major aspect of such balance is what scholars often refer to as enclosure. Enclosure is a perceived sensorial value evoked by spatial compositional characters of urban space. It is the degree to which containment is felt as a result of the surrounding defining surfaces (Garćıa et al., 2006; Stamps, 2005a; Zacharias, 1999).

Knowledge about people's perception of enclosure in urban street space can be transformed into practical planning and design strategies and guidelines. Professionals, informed about the influence of enclosure of urban street space on users, will be able to advance policies that are conducive to a balanced degree of enclosure, including connecting values of street widths, building heights, and buildings setbacks together, to create a perceptually comfortable and safe urban environment for the users.

Research Significance

The significance of studying enclosure is threefold. First, enclosure relates to sense of comfort, which has an impact on people's decisions in their urban experience. This notion is expressed in numerous theoretical bodies of inquiry such as urban design, environmental psychology and visual aesthetics (Carmona et al., 2003; Im, 1984; Isaacs, 2000; Jacobs, 1993; Kaplan and Kaplan, 1989; Lynch & Hack, 1975; Moughtin, 1992; Nelessen, 1993; Salingaros, 1999; Stamps& Smith, 2002). Second, enclosure relates to safety and survival as expressed in the theory of prospect and refuge (Appleton, 1975; Gibson's, 1979; Stamps, 2005a; Stamps, 2005b). Third, a finding in neurophysiological research indicated a strong relationship between certain regions of the brain and the value of space enclosure, such that the "response [of the human brain] is reduced if the surfaces in the scene are rearranged so that they no longer define a coherent space" (Epstein & Kanwisher, 1998, p. 598). The later was also reported by scholars who investigated enclosure in urban streets (Stamps, 2005a).

Research Problem

In today's cities, streets' compositional variables of ratio and scale that produce the sense of enclosure are only byproducts of other design and planning considerations. Enclosure may be a byproduct of the morphological characteristics of the original layout of the city, building-heights standards, or transportation planning and engineering strategies. Basically, enclosure can be a byproduct of any planning and design decision that has to do with the width of the street and the height of the buildings, however, it is seldom the product of an intentional urban design strategy that involves the three-dimensional perspective of the urban street, and that relates width and height together. The street in today's city is designed as two-dimensional entity instead of a three-dimensional space.

There are few empirical works that studied the role of enclosure in urban spaces in general, and in urban street spaces in particular. When faced with decisions concerning heights of buildings, and widths of streets, urban planners and designers need concrete, clear, and practical information about enclosure as an important component in urban space quality. To make the informed decisions in reference to the concepts expressed above, they need to know how the compositional values of the urban spaces impact users' senses of comfort and safety. To mention one phenomenon of such assertion; Gehl (1987, p. 93), describing new streets, noted that "it is as if the planners and architects have a strong tendency, whenever in doubt, to throw in some extra spaces, just in case, reflecting the general uncertainty concerning the proper handling of small dimensions and small spaces."

The research problem consists of three aspects; first, streets have not received sufficient space-morphology analysis proportionate to their significance in cities. Second, scholars in urban planning and design literature have suggested different and, in some cases, conflicting values concerning the recommended ratios for an ideal urban space enclosure. This means that the decisions in urban design concerning enclosure in urban spaces are mostly based on an intuitive approach. Third, the scale of urban space has not received any empirical investigation as an element that might influence enclosure. Below is an explanation of each aspect of the research problem.

Urban Streets

Within the boundaries of today's cities, most of the public realm belongs to streets. Streets have the immediate scale above the private domain, and in contrast to plazas, they exist everywhere in the urban milieu. Streets are significant because, morphologically, they are the foundation of the urban pattern. They, socially, bring people together and provide the physical setting for socioeconomic activities (Jacobs, 1993), they invite more recreation for people than parks (Appleyard, 1981), and they are preferred places for children to play (Whyte, 1980). Streets, culturally, embrace the physical and historical identities of an urban area (Ouf, 2001) and provide the first impression a visitor has of a community (Nelessen, 1993). Streets, visually, impact the image of the city and contribute predominantly to its spatial structure (Carmona et al, 2003). Although streets have these important roles in the public realm, there is not enough research concerning their three-dimensional characteristics.

Enclosure and Ratio

Literature suggests that users' preference of urban space enclosure is an inverted U-shape relationship (Carmona et al., 2003; Jacobs, 1993, Nelessen, 1993). Extreme high values of enclosure evoke claustrophobia and confinement, while extreme low values of enclosure evoke discomfort because of lack of psychological shelter. There are preferred values of enclosure in the middle. There is a lack of empirical work that explain the relationship between the value of enclosure in urban street space (as a function of ratio of the height of the defining buildings to the width of the street) and the related user's sense of comfort, safety, and judgment of enclosure itself.

Scholars have suggested different, and sometimes conflicting, positions on preferred enclosure values in urban space. Most of these suggestions stemmed from theoretical constructs (Lynch & Hack, 1975; Bacon, 1967; Jacobs, 1993; Moughtin, 1992; Nelessen, 1993, Carmona et al., 2003). These theoretical constructs reported a relationship between enclosure and the compositional qualities in urban spaces. The most emphasized compositional quality was the ratio of the height of the defining buildings in urban space and the width of that space (R = H/W).

For urban street spaces, these scholars suggested ideal height-to-width ratios of (1:3 to 1:2) (Lynch & Hack, 1975), (1:1) (Alexander et al., 1977), (1:2) (Moughtin, 1992), (1:2 to 1:1) (Nelessen, 1993), and (2:1 to 2.5:1) (Carmona et al., 2003). They also suggested minimum ratios of (1:1) (Carmona et al., 2003), (1:5) (Nelessen, 1993), (1:6) (Duany & Plater-Zyberk, 1992) and maximum ratios of 4:1 (Nelessen, 1993).

There is a reasonable body of empirical work that has researched the concept of enclosure in different settings; especially as it relates to interior spaces. However, few empirical inquiries were devoted to enclosure in urban settings including the works of Stamps (2005a), Stamps & Smith (2002) and Im (1983, 1984). An examination of these works called for further investigation. To start with the earliest, although was concerned only with squares, Im (1993) has reported preferred values of height-to-width ratio of (1: 6.7) or (15%) in urban spaces that virtually contradict all urban design literature. Im's study itself states that "the desirable range [of height-to-width ratio] needs to be investigated further in future research" (Im, 1983, p. 95). Methodological limitations in Im's study; such as the range of ratio tested from (1:12.5) to (1:1.2), and the possible confounding variables in the existing sites that were examined, might explain the unexpected result.

Stamps & Smith (2002) investigated enclosure in urban settings by means of presenting stimuli of scenes selected from photographs of Parisian streets taken in the 1860s. Their work is an important contribution to the question of enclosure in urban spaces; nevertheless, there are some methodological caveats. First, to predict enclosure, their protocol used the variables of proportions of walls and ground as calculated from perspective views. Such variables of "proportion of walls" and proportion of ground" do not translate directly into concrete information and do not amount easily to the knowledge of urban designers.

Second, because Stamps & Smith (2002) used existing stimuli, some confounding variables like lighting conditions and architectural styles were not controlled. Third, there were possible biases in the viewpoints of the used scenes, as they were not created for the purpose of the experiment. This last caveat was reported in a recently-published work by one of the authors (Stamps, 2005a).

Stamps (2005a) investigated the impression of enclosure and safety in urbanscapes. The study used three virtually reconstructed historical Greek sites. The experiment was highly sophisticated in terms of control over the variables, processing of stimuli, and other methodological strategies. No biases in viewing angles and no natural confounding variables existed attributable to the reconstruction of the scenes using CAD. Nevertheless, all buildings were assigned the same height of 6m (20 ft), which resulted in limited variations in the independent variable “proportion of walls”.

Enclosure and Scale

Enclosure, as suggested in literature, is a function of ratio and scale as well. Spaces with the same ratios and different scales do not have the same sense of enclosure. The ratios suggested above are sometimes associated with certain heights and widths, and sometimes are just stated alone. These ratios that are associated with specific recommended heights and widths have another unrevealed value; the value of scale. Obviously, reporting the ratio out of its context means that the scale value; indicated by height or width, is either thought of as insignificant, or it is just not calculated. The baseline of this argument is that if a height-to-width ratio of 1:2 is recommended to design good urban street space, then a height of 10 feet to a width of 20 feet is expected to yield the same sense of enclosure as, for example, a height of 100 feet to a width of 200 feet, as both of them have the same ratio, which is most likely incorrect.

The scale of the urban street space is an important value that could influence the sense of enclosure. Huge streets are rarely perceived as a whole entity in the selective phase of human perception, nor are they sensitive to human and intimate scales. Streets with small scale have many advocates; especially those streets that belong to historical cities (Carmona et al., 2003; Jacobs, 1993). Researchers suggested some embedded social and functional values in scale; "small space makes people deal with each other" (Jacobs, 1993, p. 15) and "facilitate shopping" (Moughtin, 1992, p.142), they make it easy for shoppers to move from one side of the street to the other for window shopping. Safety is another embedded psychological value attributed to enclosure; "narrowness and enclosure and intimacy bring a feeling of safety" (Jacobs, 1993, p. 15). So far, this relationship of enclosure and scale is not investigated, and no works have yet related scale and ratio together as predictors of the sense of enclosure, nor explored the way they both affect each other in the urban space.

Research Hypothesis

The hypothesis of my research is that different simulated geometric dimensions of urban street spaces will evoke different estimations of enclosure values, and consequently different feelings of comfort and safety. A cause-effect relationship is hypothesized; wherein change in the values of simulated enclosure will change perceived enclosure, which in turn will change sense of comfort and safety.

Chapter 2, first, reviews the theoretical constructs pertaining to urban design, the meaning of the environment, environmental perception, urban scale, urban space, social and physical meaning of urban space, urban street space, and enclosure in urban street space. Second, it reviews previous methodological strategies pertaining to the investigation of urban environments using environmental simulation.

CHAPTER 2
LITERATURE REVIEW

This review of literature is composed of two parts; a review of theoretical constructs, organized in nine categories, and a review of methodological strategies; organized in four categories. In the first part, the epistemological constructs of urban design will be reviewed, followed by a review of meaning of the urban environment to its users, and the way they communicate with it. Since such communication is limited to users' subjective faculties, perception will be discussed next. For the reason that the real perception experience happens only at local levels, urban scale is reviewed after perception. Smaller scales are public spaces just outside our private domains; therefore, urban space will be reviewed next. The dilemma of social vs. physical meanings of urban space and the probabilistic approach will then be reviewed. The role of urban streets and plazas in cities will then be discussed, while enclosure in urban street space will be reviewed in the final section.

In the second part, the four categories pertaining to methodological strategies that establish grounds for the method of the current research will be reviewed. These categories are environmental simulation, computer simulation, computer simulation validity, and cognitive and psychophysical approaches.

Theoretical Constructs

Urban Design

Urban design is defined as "the interface between architecture and planning" (Moughtin, 1992, p.1). It could be conceived as the design beyond the borders of single land properties. It is involved in the relationship of space and mass entities that exist in the public realm and most importantly, buildings, streets and plazas (Carmona et al., 2003). While urban design started from a primarily aesthetic concern about the arrangement of buildings in space in a deterministic manner, it evolved into a multidisciplinary subject concerned with the quality of the public realm (Carmona et al., 2003). The term "urban design" is an "action-oriented" term (Moudon, 1992, p. 334), and because of the term "design", it necessarily implies what *should be* done. While some scholars like Kallus (2001) and Whyte (1980) criticize this notion , Carmona et al. (2003, p. 3) stated that "the idea that urban design is about making better places is unashamedly and unapologetically a normative contention about what it *should be*, rather than what *it is* at any point of time."

The arguments against the normative approach stemmed from the fact that it is based in a moral context. Designers, basing on their intuitive capacities, produce designs as functions of their moral stand and subjective visions about the world, and consequently, the resulting urban environment may not respond to socio-economic, functional and psychological needs of the users. This happens when designers provide solution without an explanatory component. However, if designers conducted informed decisions based in socio-economic, environmental, and cultural contexts, no harm is seen in envisioning what *should be* done as opposed to what *is*.

Moudon (1992, p. 334) describes the dilemma of the normative approach as "a gap between knowledge and action." She asserted that urban designers need to pay more attention to substantive research rather than making quick prescriptive inference from it. Moudon (1992) listed 9 substantive research concentrations pertaining to urban design:

- Urban history studies; design process and resulting forms
- Picturesque studies; visual attributes of the environment
- Image studies; people's perception of the environment
- Environment-behavioral studies; interaction between people and their surroundings
- Place or social studies; environment meaning and symbolism
- Material culture studies; objects values to society
- Typology-morphology studies; the impact of two-dimensional geometry of space
- Space-morphology studies; the impact of three-dimensional space geometry
- Nature-ecology studies; the relationship between cities and natural environment

These 9 approaches represent different epistemological constructs concerning urban design knowledge. Each of these approaches is either taking a different philosophical stand, or working at a different urban scale. This classification does not imply strict borders between these research approaches because they overlap. My research on enclosure can best be understood in the context of two of the nine overlapping approaches, namely the “space- morphological approach” and the “environmental-behavioral approach”.

Meaning of the Environment

The decisive prerequisite for building substantive knowledge in urban design is to understand the meaning of the environment for its users. This understanding provides designers and planner with the needed explanatory component. To do that, urban planning and design research needs to examine the relationship of the physical environment and its users; which elements influence emotions, attitudes, preferences, and behavior (Rapoport, 1982). From an urban design point of view, the physical environment is a range of “designed objects” that have multiple meanings. Krampen (1979) noted that the design object has a “hyletic” dimension; its material aspect, a semantic dimension; its “morphic” nature and a functional dimension; its “synthetic” aspect. The physical environment communicates, in addition to the primary functions of design objects, the secondary acquired function of meaning. My research is concerned with the “morphic” nature or the physical form of the environment that is conveying the secondary meaning.

Rapoport (1982, p. 19) explained the communication with the environment and noted that physical environment encodes information and users decode them. He stated “while people filter this information and interpret it, the actual physical elements guide and channel these responses.” Thus, the meaning of the environment is partially a function of the physical environment. On the other hand, some scholars; like Carmona et al. (2003 p. 96), noted that the meaning of the environment is rooted in the physical environment, however, it is not a property of it, it is a function of "our subjective institution of it". But it is also asserted by other scholars that there is a certain degree of similarity between the physical world and the perception of it (Zimring & Dalton, 2003).

The dilemma whether physical environment is an isolated entity that exists outside our perception or it is only a part of our perception could be resolved by emphasizing that the communication itself is cognitive, and consequently, a perception dimension actually exists. To understand the relationships of a space enclosure and the senses of people who use that space, their perception is unavoidable within environment-behavioral studies.

Perception

Perception is a mechanism by which man makes sense of the environment. It is the first step in communication that involves sensing the environment. Next is cognition; which is encoding it; followed by evaluation, and finally taking action (Rapoport, 1997). Similarly, Carmona et al. (2003) classified this process into cognitive; acquiring information and storing them, affective; adding our feeling to them, interpretative; associating meaning to them, and evaluative; judging them.

Krampen (1979) suggested a different classification of the process of perception. Perception starts, first, by the selective phase that is determined by scale, where recipients decide a scale level - usually a manageable scale within the cone of vision. Second, there is the synthetic phase - where structural or compositional relations are perceived. Third, there is the analytical phase; where structural or compositional relations are analyzed to their components. The selected scale is an important factor that governs how we perceive our surroundings. Humans maximize their acquisition of the information to control their navigation globally. They selectively focus their attention to a local scale, by maximizing their local acquisition, and start the process of perception, cognition, evaluation and taking action.

Urban Scale

Researchers classified urban scale into regional and local, and suggested that the quality of the urban environment at the local scale is dominated by buildings and streets, while the regional scale is concerned with the whole city and beyond (Nichol & Wong, 2004). Researchers also suggested that human scale is a crucial concept toward understanding how people relate to the environment (Moughtin, 1992; Nelessen, 1993; Nichol & Wong, 2004; Salingaros, 2000; Sternberg, 2000). Gehl (1987) noted that the quality of the urban environment depends on the design of individual spaces and their details, even down to the smallest component. Salingaros (2000) asserted that urban environments need strongly connected smaller scales, and loosely connected larger scales. Sternberg (2000, p. 275) combined scale in an integrative concept, he stated “as I walk, I react to the scale of a building in relation to the scale of others and to that of my own body, in all their proportionate interrelationships, lightening my awareness of self in space."

The meaning of the environment is communicated primarily at the local scale where the experience materializes. While users are navigating space, it is what relates to human scale that matters the most for them. Some scholars went far to suggest that the smallest elements in the environment accessible to users at arm length are those elements that ultimately determine the order in the built environments (Salingaros, 2000). Since the concern of urban designers is the shaping of the environment at scales larger than individual buildings or one plot of land, then it is the smallest scale of urban space directly above the scale of buildings and private ownerships that matters the most. It is the line where private and public realms meet.

Urban Space

Urban space is the realm where urban life takes place; it is “the three-dimensional extension of the world around us, the intervals, distances, and relationships between people and people, people and things, things and things” (Rapoport, 1982, p. 179). Urban spaces such as streets, squares, piazzas and parks are central to our awareness in cityscape; they are the urban designers’ raw material (Taylor, 1999). Madanipour (1996), drawing on previous work, noted that urban space could be defined in two ways – social space, and built space. Social space is the spatial form and the output of social institutions. Built space is “the physical space, its morphology, the way it affects our perceptions, the way it is used, and the meaning it can elicit” (Madanipour, 1996, p. 10). Hillier & Hanson (1984) emphasized the need for a theory on the relationship between societies and space. Space, along this line of thought, is seen as a function of the social structure, and society is seen as a function of the spatial structure.

Urban space is the habitat where meaning of the environment is communicated. It is the physical and social extension of our private physical and social domains. When we step outside our private domains, we know that we are exercising our desire to communicate as social beings, and we expect other to communicate with us. It is in the urban space that such fundamental human experience takes place. This experience is a social phenomenon manifested in a physical setting. To what extent social activities and physical setting influence each other is an ongoing debate among scholars.

Social, Physical, Behavioral and Probabilistic Approaches

Social approach

Urban space needs the presence of people for other people to join; people attract people (Whyte 1980). Some scholars criticized what they call the abstracted morphological reading of urban spaces, and suggest a more subjective and social reading (Kallus 2001). Kallus proposed taking urban design from merely viewing the city as a spatial structure to viewing it as it holds the relationship between space and social process, wherein a city as a space of habitation is not ignored. She asserted that the failure of the postmodern discourse is caused by the inability to understand urban space as a primary form of habitat.

For these scholars, the physical aspect of urban space including its volumetric relationships and visual details is of little relative importance (Zacharias, 2001). The basic assumption for advocates of the social meaning of space is that aesthetic, geometric and visual quality of urban space is not significant in comparison to other aspects of urban space; like socioeconomic and functional ones. The antithesis of this position is the picturesque tradition – a line of thought that goes back through Camillo Sitte's famous work to ancient cities.

Physical approach and the picturesque tradition

Cities through history have always incorporated aesthetic, geometric relationships, and visual dimension in their designs. As early as the plan of Ur in Mesopotamia, the Hippodamian grid-plan in ancient Greek cities, the principle of the Cardo and Decumanus in Roman cities, through Pope Sixtus V's plan for Rome in the 16th century, aesthetic principles of city organization had existed. The tradition was pursued after the medieval era by works like L'Enfant's plan for the city of Washington in the late 18th century, Haussmann's scheme for Paris and Nash's plan for London in the 19th century (Bacon, 1967; Mumford, 1961). Cities were planned according to the aesthetic qualities of vistas, majestic spatial compositions, ceremonial axes, and monumental buildings.

Sitte (1889) emphasized aesthetics principles; however, he moved another step toward defining long vistas and creating stationary spaces to serve for street intersection as virtually closed nodes (Mumford, 1961). Although Sitte's approach is often criticized for emphasizing aesthetics values only, some scholars believe that he is the founder of urban design (Moughtin, 1992). The notion of "serial vision" promoted by Cullen (1961) considering the urban setting as a series of unfolding views is the basis for the new urbanism notion of positive spaces where spaces are defined using buildings; that is, to design space between buildings. Cullen asserted that a city is not a pattern of streets but a sequence of spaces defined by buildings (Salingaros, 2000). However, there is no evidence that this is true in today's streets.

Aesthetic and behavioral approach

Researchers still maintain that aesthetic quality is a factor of success of urban spaces. However, it is through a behavioral channel that such notion is made. It is not the aesthetic principles of creative design that cities need, nor is it the artistic and architectural composition of mass and void under light. It is rather how those principles are tied to people's needs. Isaacs (2000) suggested that the urban form is capable of evoking an engaging aesthetic experience. It occurs when people enjoy the space and linger in it, maintaining the concept that aesthetic experience is a social phenomenon.

Along the same line, Nasar (1990) noted that the visual quality of the urban environment can evoke emotions of fear, pleasure and excitement, and influence our social status. He also stated that the visual quality "may influence behavior, in attracting people to pleasant places and repelling them from unpleasant places" (Nasar, 1990, p. 41). Carmona et al. (2003) synthesized the earlier literature, and concluded that urban space is an aesthetic entity and a behavioral setting.

Since urban space is the extension of our private physical and social domains, both domains should fit to make a successful space. Fit or misfit between people and urban space can range from safety, to health, to economy, to social connectedness, to aesthetic discomfort because of unattractive urban areas (Marans & Stokols, 1993). The question of how important is the physical-aesthetic dimension relative to socio-economic, functional and other utilitarian aspects of urban space is a question of the importance of the visual-behavioral dimension in urban space. Considering the behavioral dimension, there is a line of reasoning pertaining to the importance of the physical environment that could be found in a probabilistic approach promoted by Gehl (1987) in his book *Life between Buildings*.

Probabilistic approach

The probabilistic approach pulls together the physical approach and the social approach. The physical approach holds that aesthetic and visual dimensions of the environment influence the social environment in a deterministic manner, while the social approach holds that there is an insignificant effect of the physical environment on the social life. Gehl (1987) proposed a solution for this dilemma. He classified outdoor activities into three types: necessary; like shopping and going to work, optional; like stopping for a cup of coffee and reading the paper, and social; which is a mixture of necessary and optional activities. He argues that when the outside environment is of "poor quality", only necessary activities take place, however, when the environment is of "high quality", necessary activities will happen with the same frequency as in poor environments, but they tend to linger more because of good physical conditions. Moreover, good physical conditions invite more optional activities. The social activities are, for him, the "resultant activities" that will also intensify as optional activities intensify.

Other scholars have promoted this line of thought, and have maintained that necessary activities will occur regardless of the physical quality, while optional activities will occur only when the environmental quality is good (Isaacs, 2000; Appleyard, 1981). Moirongo (2002) emphasized that optional activities of human beings happen only in favorable exterior conditions and that these activities are especially dependent on exterior physical conditions. This indicates that if urban space quality is poor, only strictly necessary activities will take place. Isaacs (2000, p. 145) noted that "physical design is only one of the factors" and that social and economic issues, urban infrastructure and life-style have much to do with drawing people to a certain urban space, yet, “once [people are] in that location, physical design will probably have influence on how they spend their time there, and on their attitude toward the place.”

The essence of this approach is that physical design can influence the social constitution of space in a probabilistic way. The least influenced activities by the physical setting are necessary activities as they only tend to linger. However, the optional activities are the most sensitive, and depending on the physical setting, they either occur or do not occur, while the social activities are resultant of both, and consequently are influenced to the extent that they encompass optional activities.

The physical setting that is argued to influence other aspects of urban life in a probabilistic way is the outside extension of our private realm, the immediate urban scale that communicates to us at our human-scale, and the visually perceived field of information of our choice. It is therefore the three-dimensional urban space, in shapes of plazas and streets.

Plazas and Streets

It is argued that streets and plazas are the basic elements for organizing cities through the entire history of human settlement (Gehl, 1987). Carmona et al. (2003 p. 147) stated that “although positive urban space come in different forms and shapes, there are two main types ‘streets’ … and ‘squares’.” Evidently, this argument is supported by the many ceremonial axes and squares in the history of human settlements; including the Greek Agora, the Roman Forum, the Roman Cardo and Decumanus, and the medieval and renaissance European plazas and avenues. Scholars in the post modern era, facing the products of the modern discourse including new technologies, new materials and new sources of energy in cities, have many problems to deal with. These include sprawl and decentralization of land use (Nelessen, 1993), the vanishing social function of public space (Carmona et al., 2003), the implementation of the “traffic control schemes” rather than the “townscape scheme” (Appleyard, 1981, p. 277), the large and impersonal nature of outdoor spaces, the disappearance of streets and squares, and the general ambiguity concerning the appropriate handling of small dimensions and small spaces (Gehl, 1987).

Although plazas have played a major role in creating a social arena for urban dwellers through history, in today’s cities, it is the street that shapes their experience and communicates to them more often. Unfortunately, Cullen’s (1961) concept of serial vision is inapplicable, and today’s streets are linear elements with no termination, and segmentation of the street into more stationary places is rare. It is evident that most of our city spaces belong to streets, and many scholars have pointed out the significant role of the street in today’s urban setting (Appleyard, 1981; Carmona et al., 2003; Jacobs, 1993; Moughtin, 1992; Nelessen, 1993).

Urban Street

It is important to distinguish the difference between the term “road” and the term “street”. While “road” indicates movement and destination and implies a journey, “street” maintains this definition too, but it exhibits an additional attribute of running in urban areas between two rows of buildings and has an enclosed three-dimensional space (Moughtin, 1992). (Carmona et al., 2003 p. 147) define the street as “a linear three-dimensional spaces enclosed on opposite sides by buildings.”

Enclosure in Urban Street Space

When streets, as a type of urban spaces, and by the definitions mentioned above, have to be enclosed by two rows of buildings, it becomes reasonable to conclude that their attribute of enclosure is of a great importance in contributing to the quality of city space. Previous research suggested that the ratio of the height of the defining surfaces to the width of the street is an important predictor for the degree of enclosure (Alexander et al., 1977; Carmona et al., 2003; Im, 1983; Lynch & Hack, 1975; Moughtin, 1992; Nelessen, 1993).

Enclosure implies the impression of safety. The correlation between perceived safety and enclosure is strong; "*r* = .82" (Stamps, 2005a, p. 121). (Jacobs, 1993, p. 15) suggested the same relationship and stated that "narrowness and enclosure and intimacy bring a feeling of safety". Safety implication of enclosure is derived from the "prospect and refuge" theory. Previous research suggested that vision is related to survival instincts in humans; such that one needs to see the enemies and not to been seen by them; "an unimpeded opportunity to see is called a prospect whereas an opportunity to hide is called a refuge" (Stamps, 2005a, p. 105). The baseline of this theoretical conception is that humans, even when not endangered, have a cognitive capacity that is synchronized to recognize spatial regions as safe or not safe.

Drawing on previous literature, Carmona et al. (2003 p. 141) noted that "the ideal street must be a completely enclosed unit! The more one's impressions are confined within it, the more perfect will be its tableau: one feels at ease in a space where the gaze cannot be lost in infinity." This notion was suggested in literature, especially in the aesthetic discourse; it asserts that streets needs to be enlivened with nodes, and certain breaks should take place to create sequential units of cognition; however this is not the case in current street systems. The pattern of today's streets yields to the functional and utilitarian concepts of connectivity, as suggested by the New Urbanism movement. Unlike plazas that have an additional aspect of enclosure called "openness", which is the relationship of length to width, streets do not. Most street spaces today have only two geometric dimensions that contribute to the sense of enclosure, namely height and width.

Methodological Strategies

Since actual urban environments have numerous variables that could predict their qualities, it is virtually impossible to conduct a test of cause-effect relationship without risking the presence and influence of confounding or hidden variables. Because empirical inquiries need more controlled testing conditions, the use of computer-simulated environments has proved to be helpful, where the independent variables can be manipulated to measure user's responses.

Environmental Simulation

Our world is a perceived world; we know it through our perceptual capacities. Even when we experience our "real" surroundings, and learn about our environments, we do that with certain simulation capacities. Kaplan (1993 p. 62) noted that "humans can and do act on the basis of very incomplete information." The less complete the information around us, the more room for our capacity to reconstruct reality into something we know and understand. Kaplan (1993, p. 61) also noted that "much of what we know is learned from something other than actual place and therefore involved some form of simulation." Our imaginative capacities allow us to picture, for example, a city we never visited, and a house we never entered. Simulating real worlds, then, is a tool to support an already existing human ability to visualize the environment even if it is not really here. Simpson (2001, p. 361) supports this theoretical approach and stated "realistic simulated images cut across traditional cognitive boundaries and reach those who may not be as adept at processing more abstract two-dimensional imagery."

Environmental simulation is defined as "the creation of a desired set of physical and operational conditions in a controlled process or setting through a combination of graphic and mental images, technical assumptions, and direct experience" (Clipson,1993, p. 24). It involves the production of an image as close as possible to a real setting, the introduction of these representations to prospective users, and the collection of their judgment (Bosselmann, 1993, 1998).

Environmental simulation in urban design could be categorized from a methodological point of view into applied and experimental. Applied simulation is used to support planning and design processes including assessing future development, user participation, and training. Experimental environmental simulation, on the other hand, is for urban planning and design research; which involves inquiring, testing hypotheses, and building theories (Ozel, 1993). These hypotheses are about environmental influence on users responses, which will be used to assess relationships expected to happen in real settings (Marans & Stokols, 1993).

Computer Simulation

There are different ways that are used to simulate urban environments including sketches, scale models, photographs, videos and computer simulations (Marans & Stokols, 1993). The use of computer simulations allows for the production of as many variables as needed, and as many levels of manipulation as needed, with less time and money. Because of the speed of data processing and high storing capabilities, computer simulation is one of the most feasible means that could be used to learn about certain phenomenon in the urban environment (Ozel, 1993; Simpson 2001; Zacharias, 2001).

Computer Simulation and Method Validity

Some scholars have expressed doubts about validity of computer simulation in representing real-life situations, especially social ones that may not yield to simulation, rendering the whole process ineffective. This calls for an external validity or "social validity" where simulation should be able to represent social environments. However, it is also suggested that this validity is only necessary in "community decision-making contexts than … for validating the scientific rigor of investigations" (Marans & Stokols, 1993, p. 16); especially if the scientific rigor needs to isolate the social variables from the physical variables, such as the case of my research.

Some scholars suggested that it is even better to use simulation than the real context. Kaplan (1993, p. 77), basing this claim on previous research, noted that “the understanding or working knowledge of a building provided by the simulation techniques was actually more useful than that provided by the visit to the building itself.” The internal validity of environmental simulation in research and hypothesis-testing purposes has been discussed by scholars as the reason why simulation is used in the first place. For possible confounding variables, scholars noted that using simulation in experimental procedures decreases the likelihood of respondents being biased by extraneous variables (Marans & Stokols, 1993). Kaplan (1993) using the same argument, talks about the internal validity of simulation of Berkley Simulation Project, and pointed out that familiarity had a strong impact in real-life settings than in simulation.

Realism is an important factor in creating valid simulation. Because urban environments are sophisticated phenomena, realism in creating simulation for these environments is proportionately difficult. It is only by determining the purposes of the simulation are we able to approach certain levels of realism. Previous research suggested that realism is the “technical accuracy” where the simulated environment is rendered with high quality and close resemblance to reality, (Karjalainen & Tyrainen, 2002, p.15). Bosselmann (1993, p. 284, 285) noted that realism was established in the Berkeley Simulation Laboratory where “simulated environments yielded the same responses as the real ones.” While applied simulations need the highest possible degree of realism, experimental simulations have a degree of realism corresponding to the main purpose of the experiment; which is not necessarily the highest.

Cognitive and Psychophysical Approaches

Since environmental simulation should be based on the purpose of the research, it is convenient to explain two models of simulation that relate to my research - the cognitive model and the psychophysical model. The cognitive model involves asking respondents about their impression of a certain subjective value of the environment. Respondents have more interpretive power over the stimuli. The inquiry concerning how simulated enclosure relates to perceived enclosure, for example, needs to use of this model. The psychophysical model, on the other hand, assumes respondents as passive recipients. When there is a need to know how enclosure influences comfort, for example, it is necessary to use the psychophysical model (Karjalainen & Tyrainen 2002).

This chapter reviewed urban design literature covering 9 theoretical and 4 methodological concepts pertaining to urban streets. The theoretical part presented epistemological constructs of urban design, meaning of the urban environment to its users, perception, urban scale, urban space, the dilemma of social vs. physical meanings of urban space, the probabilistic approach, urban streets vs. plazas and enclosure. The methodological part presented environmental simulation, computer simulation, computer simulation validity, and cognitive and psychophysical approaches.

Chapter 3 explains the method of my research. It states the research independent and dependent variables and their measurement scales. It presents the research procedure; including exiting context and control measures taken to eliminate potential confounding variables, creating the three-dimensional models, extracting images from the three-dimensional models, on-screen survey, participant sampling and survey implementation, and collecting the data upon participants’ responses.

CHAPTER 3
RESEARCH METHOD

My research is mainly concerned with measuring the influence of simulated enclosure, as a function of the independent variables of height-to-width ratio and scale on users' sense of comfort, sense of safety and perceived enclosure. It explores, as well, the potential influences of demographic differences (gender, age, design background, type of living area, height of buildings in living area, and width of streets in living area) on user's sense of comfort, sense of safety and perceived enclosure in urban streets. To achieve control over the different potential confounding variables that exist in the real-life urban streets, three-dimensional computer models were created to simulate urban street spaces and to allow for manipulating the independent variables of the street space.

An exiting area in Downtown Gainesville, Florida was selected to serve as a real-life reference for the simulation. A segment of the main street with a length of 2500 ft, 20 urban blocks was digitized, and extruded into 3D geometric models. Texture were collected and applied to the 3D models. A total of 42 stimuli were extracted as images from the models and integrated into an on-screen survey to collect responses of perceived enclosure, comfort and safety.

This chapter explains the research method; first it presents independent and dependent variables. Second, it presents the research procedures; including controlling the existing urban context, three-dimensional models, extracting images and integrating them into an on-screen survey, and finally collecting and coding response data.

Research Variables

Independent Variables

There are two sets of independent variables in my research. The first set is independent variables that were simulated by computer models relative to the geometric characteristic of the urban street space. These independent variables are "space variables" or "within-subjects" variables. The "within-subjects" independent variables are those variables that held data across stimuli like ratio of height to width. The second set contained the demographic or "between-subjects" independent variables. The "between-subjects" independent variables are those variables that hold data across participants like gender.

Within-subject independent variables

The research used two within-subjects independent variables; height-to-width ratio and scale. These two variables are functions of the height and width of the simulated space. The height, denoted by (H) is the average height of the defining buildings of the street space, measured from ground to the highest point in the vertical defining wall. Width, denoted by (W), is the width of the street measured from the face of the buildings on one side of the street to the face of the buildings on the other side. Height and width together produce different values of height-to-width ratio and scale.

Width measurement scale. Nelessen (1993) recommended widths for urban streets as 20 ft for the alley, 64 ft for the main streets, and 86 ft for the boulevard. A review of major cities of the world using Google Earth© revealed that widths of major urban streets can go up to 110 ft in New York, 100 ft in Chicago, 100 ft in Austin, 90 ft in LA, 74 ft in London, 74 ft in Amsterdam, 85 ft in Rome, 120 ft in Berlin, 120 ft in Tokyo, 90 ft in Baghdad, and 110 ft in Cairo. The average street driving lane is 10 ft (Godley et al., 2004; Chandra & Kumar, 2003), and the minimum sidewalk width is 5 ft (FHWA, 2005).

Based on these figures, a width of 20 ft - one lane and two sidewalks - for the minimum value of the width scale, and a width of 130 ft - 12 lanes and two sidewalks - for the maximum value of the width scale were used. Initially, an interval of 10 ft was decided to increment the width scale; however an interval of 10 ft is intangible at the upper levels of the width scale. Consequently, instead of using scale levels of 20 ft, 30 ft, 40 ft and so on, it was found more convenient to use the 6 width levels of 20 ft, 30 ft, 40 ft, 60 ft, 90 ft, and 130 ft. This eliminated unnecessary levels of width and reduced the number of levels to more manageable ones, (Table 3-1).

Height measurement scale. It was assumed that the minimum value of the height scale is 15-20 ft, which is the height of a typical ground floor. The maximum value of the height scale was decided based on the maximum value of ratio that the research needed to include. A maximum ratio was decided to go beyond what literature has reported. Therefore, it was found suitable to use a maximum ratio of 6:1. Since my research used a maximum street width of 130 ft; thus the maximum height was 6 x 130 = 780 ft, or 78 floors. However, each street width had a maximum height corresponding to the maximum ratio, which meant a maximum height of 120 ft for the width of 20 ft, 180 ft for the width of 30 ft, 240 ft for the width of 40 ft and so on.

Gehl (1987) suggested that above the fifth floor, things and events are out of touch with the ground level. Since the difference of narrow intervals in the upper levels of the height scale is insignificant; that is, the difference between floor number 70 and 71, for example, is assumed to be minimal as perceived by respondents, it was decided to use height categories of 20 ft, 30 ft, 40 ft, 60 ft, and divide the remaining distance above the sixth floor into three equal intervals at heights H5, H6, and H7. A matrix of 42 spaces has resulted form the 7 variations of height and the 6 variation of width, (Table 3-1).

Groups of spaces. The matrix of (6 x 7 = 42 spaces) was clustered into (3 x 3 = 9) groups of spaces. While the matrix of 42 spaces is convenient for analysis of association, the 9 groups were convenient for analysis of variance, (Table 3-2).

Ratio measurement scale. Inheriting from the aforementioned variation of width and height, the height-to-width ratio, henceforth called ratio, (R) = H/W, varied in the range of a minimum value of 20/130 or (0.15) to a maximum value of 780/130 or (6.00), producing a total of 42 different ratio levels, (Table 3-3). The resulting 42 different ratios were clustered into 14 categories; pertaining to the ranges of 1/6, 1/5, 1/4, 1/3, 1/2, 2/3, 3/4, 1, 3/2, 2, 3, 4, 5, and 6, (Table 3-4).

Scale measurement range (scale). The range of the scale variable, (Sc) = H * W was varied in the range of a minimum value of (20 ft * 20 ft) or 400 sq. ft, to a maximum value of (780 ft * 130 ft) or 101,400 sq. ft, (Table 3-5). It was necessary to select three groups of small scale (low, narrow), medium scale (medium (H), medium (W), and large scale (high, wide) for variance analysis. This selection reduced the effect of ratio and provided a clear scale variation, (Table 3-6).

Between-subjects independent variables

The research used six between-subject independent variables; gender, age, design background, type of living area (urban, suburban and rural), height of buildings in living area, and width of streets in living area. These variables were included to test for the influence of demographic and experience differences on perception of dependent variables of comfort, safety and perceived enclosure in urban street space.

Participants were students and employees from the University of Florida based on a convenience sample. The sample size was 83 participants (mean age = 29.8 and standard deviation = 8.8); 64% were men (53 men, mean age = 29.6 and standard deviation = 8.5) and

36% were women (30 women, mean age = 30, standard deviation = 9.3). For design background variable, 52 (63%) of the participants had no design background, while 30 (37%) had design background.

For the type of living area, (45.1%) of the participants live in urban areas, (46.3%) live in suburban areas, and (8.5%) live in rural areas. The distribution of the participants as for the average height of buildings in their living area was (41%) for “1 to 2 floors”, (22.9%) for “2 to 4 floors”, (15.7%) for “5 to 6 floors”, (10.8%) for “6 to 7 floors”, and (9.6%) for “over 10 floors”. The distribution of the participants as for the average width of streets in their living area was (43.4%) for “1 to 2 lanes”, (48.2%) for “2 to 4 lanes, (7.2%) for “5 to 6 lanes”, and (1.2%) for “7 to 10 lanes”.

Dependent Variables

My research used five dependent variables; sense of comfort (C), sense of safety (S), perceived enclosure (E_P), perceived height (H_P) and perceived width (W_P).

Sense of comfort

Literature suggested a strong relationship between enclosure and feeling comfortable in urban spaces. Alan Jacobs envisioned successful urban spaces as livable, safe and comfortable (Jacobs, 1993). Alexander et al. (1977) tied comfort to enclosure for streets, they reported “…it should be noted that pedestrian streets which seem most comfortable are the ones where the width of the street does not exceed the height of the surrounding buildings” (Alexander et al., 1977, p. 178). The Essex design guide suggested that a ratio of 1:1 is the minimum for comfortable space, and a ratio of 1:2.5 is the maximum that can be tolerated (Moughtin, 1992).

Drawing on the prospect and refuge theory, sense of comfort was found to be an excellent measure of the theory’s notion concerning enclosure. The theory ties enclosure to aesthetic appreciation and feeling of comfort at the higher levels for human needs. A preference variable is reasonable too, nevertheless, to ask “how comfortable is this space?” would help respondents envision being in the space, but to ask “how do you prefer this space?”, could be understood as “how do you like it as an image?”; risking respondents’ separation from the scene. The variable “sense of comfort” is considered from the psychophysical model. Therefore, enclosure was predicted without directing respondents’ attention to it.

Sense of comfort measurement scale. A six-point Likert scale was used to collect responses for sense of comfort. The scale consisted of six levels on an ordinal scale. Respondents rated comfort level from (1) through (6); where (1) is the lower level of comfort or the least comfortable and (6) is the higher level of comfort or the most comfortable.

Sense of safety

In contrast to sense of comfort, sense of safety is related to the basic level of human need. The prospect and refuge theory suggests a strong relationship between enclosure and sense of safety. It was useful to examine sense of safety and enclosure and compare the results to sense of comfort and enclosure to understand this connection between them. It was also important to test the suggested relationship that empirical literature reported so far (Stamps, 2005a). Similar to sense of comfort, the variable “sense of safety” is considered from the psychophysical model.

Sense of safety measurement scale. A six-point Likert scale was used to collect responses for sense of safety. The scale consisted of six levels on an ordinal scale. Respondents rated safety level from (1) through (6); where (1) is the lower level of safety or the most unsafe and (6) is the higher level of safety or the safest.

Perceived enclosure, perceived height and perceived width

The three dependent variables “perceived enclosure”, “perceived height”, and “perceived width” are from the cognitive model. The purpose of including perceived enclosure is to test the validity of the simulated enclosure, and to be able to relate to previous empirical literature that used perceived enclosure only. Scholars have used cognitive variables as both dependent and independent for visual communication experience (Heft & Nasar 2000; Stamps, 2005a). Perceived enclosure was used as both dependent and independent variable in my research. Ratio and scale were used to predict perceived enclosure, while perceived enclosure was used to predict comfort and safety. The purpose of including perceived heights and widths is to test to what extent are the simulated height and the simulated width of the streets perceived by respondents as assumed by the research, which is a reliability test.

Measurement scales of perceived enclosure, perceived height, and perceived width. A six-point Likert scale was used to collect responses for perceived enclosure. The scale consisted of six levels on an ordinal scale. Respondents rated perceived enclosure level from (1) through (6); where (1) is the lower level of enclosure or the most open, and (6) is the higher level of enclosure or the most closed. Interval scales were used to collect responses for perceived height and perceived width. Respondents estimated height and widths in feet. Both independent and dependent variables are summarized in (Table 3-7).

Research Procedure

The procedure for my research had of five phases. First, selecting an existing environment to serve as a context for the computer simulation and conducting control measures over potential external confounding variables, second, creating three-dimensional (3D) models of 42 different height and width combinations, third, extracting 42 still images pertaining to the desired viewing point, and integrating them into an on-screen survey, fourth, sampling participants and conducting the survey, and fifth, collecting and coding data and conducting statistical analysis .

Existing Context and Control Measures over Potential Confounding Variables

A street section with 10 segments, a length of 2500 ft, and a width of 60 ft, was selected from Main Street in Downtown Gainesville, Florida. This section was used as a real-life context to serve as a reference when constructing all contextual elements that are not varied. The street section is intersected by 9 perpendicular streets, creating 20 blocks on both sides of the street. Blocks areas vary from 45, 500 to 113, 000 sq. ft, with an average of 75, 000 sq. ft. The widths of the perpendicular streets vary with values of 25 ft, 50 ft, and 60 ft, (Figure 3-1). Sizes of urban block and shapes were maintained, and real textures were extracted from the existing buildings and used in the 3D models.

Some of the street elements that were simulated for the context of my research had potential effects on the independent variables. These elements influence the perception of enclosure and some measures were taken to modify them accordingly. These elements are street length, vacant land plots, viewing point, skyline, and street furniture. The way these elements were modified is explained below.

Street length

This element is about what street length would better serve the purpose of the simulation. Scholars analyzed segments of streets, reported streets of certain lengths, and sometimes suggested the ideal segment length. The acceptable walking distance for most people could be considered a determining factor, as it was noted that it should be about 400 to 500 meters (1,300 to 1,600 ft) (Gehl, 1987; Nelessen, 1993). Moughtin (1992) noted that an elegant and well-proportioned street is 300 m long by 30 m wide (984 ft × 98 ft) and three-storey high (Moughtin, 1992).

Based on the above suggestions; an optimum street length of 1000 to 1,600 ft with 4-6 segments was initially decided to be used in my research, (Figure 3-2A). However, such a length did not satisfy all different conditions of the manipulation of the independent variables– wider streets needed more length to be portrayed properly using the same viewing point. It was found that a street length of 2500 ft with 10 segments was more appropriate to maintain enough information and allow for wider streets to be displayed in the same manner as narrower ones, (Figure 3-2B).

Vacant land plots

Vacant land plots, mainly surface car parking, were expected to influence the sense of enclosure in urban street spaces because they break the continuity of the building wall that defines the street, (Figure 3-3A). My research maintained a continuous wall on both sides of the street. Vacant plots in the real-life street were filled with buildings, and a zero setback was maintained along both sides of the street. Additional buildings were given modified textures from existing ones. Widths of building footprints facing the street were maintained above 100 ft, which allowed for varying the heights of the building realistically, (Figure 3-3B).

Set backs

Although at heights approximately twice the width of the street, a set back should take place as suggested by the legacy of American skyscraper tradition (Willis, 1986), this study did not integrate setbacks. If setbacks were included, they have to vary with the width of the street which could have resulted in a confounding variable. It is logical to expect that less sense of enclosure could be predicted by including setbacks, however, such comparisons are beyond the scope of my research.

Viewing point

My research was limited to the pedestrians' viewing point. The viewing point was at human-eye level, taken from one sidewalk of the street. This viewing point was selected to capture one view of the space that reveals the nature of its enclosure, and it was maintained constant at all levels of independent variables, (Figure 3-4). Other viewing points; like views from vehicles, bicycles and other operated modes of movements were beyond the scope of my research. This viewing point was captured in the form of still images to be used as stimuli.

Previous studies have shown the reliability of using still images (Stamps, 1999 & Heft & Nasar, 2000). Concerning validity of using image stimuli, previous research reported that on-site vs. photographs stimuli and color slides vs. computer-generated stimuli have correlated strongly at "$r \geq .83$" (Stamps, 1999, p. 736). Concerning static vs. dynamic representations, it was found that static displays, contrary to expectations, were significant in stimulating response of preference than dynamic displays (Heft & Nasar, 2000).

Skyline

Stamps (1999) reported that buildings skyline predicts user's preference for buildings. It was necessary to maintain this component constant within a range of optimum levels across all buildings on both sides of the street. Roof lines were kept straight, and, for each stimulus, a random variation between adjacent buildings was used. The range of variation was 1 to 4 ft and was applied in the parapet walls. It is important to emphasize that, although the skyline varied across adjacent buildings in the same stimulus, it was not varied across stimuli.

Street furniture

As my research depends enormously on perception of scale, clues of scale should exist to the extent that they do not have the potential to bias responses. These clues of scale were introduced by representation of people and the use of a real textures and material from the site. In contrast, although trees are important elements in urban streetscape, they play a major role in defining spaces and manipulating enclosure, so they were not included in the models.

Because the dependent variables comfort and safety were to be investigated as predicted from enclosure values only, the presence of realistically modeled sidewalks, lanes, and cars have a profound confounding influence. It was decided to reduce that influence by providing simple clues about the width of the street with gray neutral material, (Figure 3-5).

Creating 3D Models

All 20 blocks, the street segment, and the closest segments of the intersecting perpendicular streets were digitized in ESRI© ArcMap™ software based on an aerial image of the city. The two-dimensional shape file was exported to AutoDesk VIZ® software using DXF format. In AutoDesk VIZ®, four initial 3D models were created; a ground model, a ground-floor model, a typical floor model, and a parapet wall model. Ground floors were extruded to a height of 16 ft, typical floors to 10 ft, and parapet walls extrusion ranged from 1 to 4 ft. All empty plots were filled, and a straight continuous street wall was maintained.

In the context of simulating urban environments, real site photos were used to produce a realistic simulation. Texture mapping (the application of real photos on modeled geometries) is an inexpensive technique that proved to be successful in conveying the desired level of details (Shoide, 2000). Texture mapping is preferred in urban environments because high degree of realism can be achieved with smaller file sizes compared to geometric detailing.

An average of 3 pictures was taken for each segment facing the main street. Weather conditions were observed to insure sufficient sun light, a digital camera was used with a storage capacity of 60 megabytes, and a map was prepared to keep track of photos and the corresponding façades. A reasonable high image resolution was used to allow for more flexibility in the photo-editing process, even though this resolution would have to be reduced later before application to the geometries; a minimum of 640 × 480 pixels was used as an initial image resolution. The time needed to collect the textures for all segments was 4 hours taken from 10:00 AM to 2:00 PM.

Adobe® Photoshop® software was used to prepare the images for texture mapping. The photo-editing session had three steps; correction of perspective effect, removing obstacles, and optimizing image sizes. Correction of perspective effect was done by editing the image so that its orthographic depiction was restored and real dimensions and proportions of the façades were reconstructed. Removing obstacles involved removing trees, shrubs, cars and any other street elements that hide portions of the façade in the original photo. Optimizing image sizes involved reducing the sizes of the images to an optimum value that preserves good image resolution, while maintaining manageable file size. A value of 100 pixels for each floor was found to be convenient for such purpose, (Figure 3-6). Each corrected image was divided into three parts corresponding to the façade levels of ground floor, typical floor and parapet wall. Textures were then applied to 3D models in AutoDesk VIZ®, (Figure 3-7).

Since the viewing point is at human-eye level; it was found that more details should be added because, at the level of the ground floor and closer to the camera, texture mapping was not enough. Therefore, the initial 3D model was exported using 3DS format to SketchUp @ Last® software, which, in contrast to AutoDesk VIZ®, allows for direct editing on the surfaces of façades after texture application. Façade fenestrations, awnings, window hoods, and cornices were articulated, (Figure 3-8). Next, a total of 42 3D models were created relevant to a matrix of (7 x 6); a height variation of 7 levels, and a width variation of 6 levels.

Extracting Images and on-Screen Survey.

Each of the resulting 3D models was then exported to a convenient software package with a powerful rendering capacity, namely Bryce 5.5 in DAZ® software. The camera setting for the desired view was at human-eye level with an FOV of 46.72, and shadows were automatically generated after setting a virtual sun from south-east direction; which simulated 10:00 AM. A total of 42 different images were extracted from the models to be integrated in an on-screen survey, (Figure 3-9).

The on-screen survey was designed to collect information about the aforementioned independent and dependent variable that are functions of either participant perceptions or demographic differences. Microsoft Visual Basic 6.0© was used to design 6 pages to be displayed for participants. The first page was an introductory page, where participant are introduced to the research concept and informed about what they are expected to do. In this page, as well, participants were asked to enter the number that was assigned to each one of them, (Figure A-1). The second page displayed the 4 most extreme cases of the 42 space images; lowest and narrowest, lowest and widest, highest and narrowest, and highest and widest. The purpose of this page was to help participant calibrate their judgment by comprehending the maximum values of the height and width scales, (Figure A-2).

For participant perceptions of comfort and safety, two methods were used to collect participant responses. First, the choices' responses; where participants were asked, in the third page of the survey, to select the most comfortable three spaces, and the most uncomfortable single space. Similarly, and in the same page, they were asked to select the safest three spaces, in addition the most unsafe single space. Participants were asked to do that by browsing all 42 different cases by clicking on a button relative to each case. Upon clicking on one button, the relative image was displayed in an area designated for the images in the interface. When participants arrived at a decision, they simply dragged and drop the selected image into an empty box designated for that exact response, (Figure A-3). These responses were called "choices responses" to able to distinguish them from the second set of responses which were called "ratings responses".

Second, in the fourth page of the survey, two questions were asked for each individual image relative to level of comfort and level of safety. While choices responses were collected for frequencies of choices of each case, rating responses were collected for case-by-case rating of images that were arranged in a random order. In addition, this page included three more questions for each individual image. These three questions were about perceived enclosure, perceived height and perceived width. A total of five questions were included in this page. A radio-button ordinal scale was provided for the first three questions of comfort, safety and enclosure, and two text boxes were provided for the last two questions of perceived height and perceived width. In the estimation part, participants were given the choice to either enter their estimations using feet or meters, (Figure A-4).

In the fifth page, participants responded to questions about their own perspective of why some spaces are more comfortable than others, and some are safer than others, (Figure A-5). The last page was about demographic information of gender, age, design background, type of living area; urban, suburban, or rural, heights of buildings and widths of streets in the living area, (Figure A-6).

Participants' Sampling

A total of 100 packages were prepared to be handed to potential participants. Each package contained one CD of the digital survey material, namely, an execution file and a folder that contained all 42 images. In addition, the package contained an incentive of $6.00, participant number note, and two copies of the form of consent. Using convenience sampling, each participant was approached individually and briefed shortly about the nature of the survey. A total of 84 participants from students and employees of the University of Florida have agreed to participate in the survey. Upon their initial approval, participants were given the survey package, where they signed one copy of the consent form. Because each participant response was to be collected in a text file that will write itself on his or her c:\ drive, they were asked, upon the completion of the survey, to email the file to the researcher.

The 84 students and employees who accepted to participate responded during a period of two months. Only one response was found to be unusable because the survey was not completed. The total number of participants (*n*) whose answers were ultimately coded was 83 participants.

Coding Data and Statistical Analysis

Each of the 83 participants entered 42 responses for each dependent variable. The total observations for each response were 83 x 42 = 3,486. All observations were organized into two different working files; a participants' file, and a spaces' file. The data in the participants' file were coded so that $n = 83$, and was used for analysis of repeated measures and between-subject variance. The spaces' file, on the other hand, was created by aggregating the within-subject variables and using the mean ranks where ($n = 42$), and was used for analysis of association and regression for within-subject variables.

Analysis of variance, association and regression were carried out using the following groups and categories of spaces clustered to serve the purpose of different types of tests:

- For analysis of spaces variance, 42 spaces were used; each was identified by its height, width and ratio by the format "space (H, W, R)". For example, a space with a height of 20 ft, a width of 20 ft, and a ratio of 1, was identified as "space (20, 20, 1)".
- For analysis of space groups variance, 9 space groups were used; each groups of spaces was identified by the format "group (Height, Width)". For example, "group (Medium (H), Medium (W))" is the central group of the 9 space groups.
- For analysis of ratio association, 14 ratio categories were used; each ratio category was identified by the ratio value that the category clustered around, in the format of "ratio (R)". For example, the category of ratios (0.88 to 1.25) was identified as "ratio (1)".
- For analysis of ratio variance, 3 ratio groups were used; (1/6 to 1/3), (1/2 to 2), and (3 to 6).
- For scale analysis of association, 19 spaces; which satisfy the condition (0.5 <= R<=2).
- For scale analysis of variance, 3 scale groups were used; each scale group was identified in the format of "scale group (scale)". For example the smallest group was identified as "scale group (small)".

My research used 5 types of statistical tests; non parametric Freidman tests were used to examine differences of repeated measures, non parametric Mann-Whitney U tests and Kruskal-Wallis tests were used to examine differences or variance, Spearman correlation coefficient (rho) for ordinal association tests were used to examine correlations, and logistic regression tests were used to predict dependent variables using independent variables.

This chapter presented the research method. It presented first independent and dependent variables, then it presented the research procedure pertaining to existing urban context, the three-dimensional models, extracting images and integrating them into an on-screen survey, and collecting and coding response data. Chapter 4 presents the results of statistical analysis concerning the influence of independent variables on perceived enclosure.

Table 3-1. Height and width levels.

		Width (ft)					
		W1: 20	W2 : 30	W3 : 40	W4 : 60	W5 : 90	W6 : 130
Height (ft)	H1: 20	20 : 20	20 : 30	20 : 40	20 : 60	20 : 90	20 : 130
	H2: 30	30 : 20	30 : 30	30 : 40	30 : 60	30 : 90	30 : 130
	H3: 40	40 : 20	40 : 30	40 : 40	40 : 60	40 : 90	40 : 130
	H4: 60	60 : 20	60 : 30	60 : 40	60 : 60	60 : 90	60 : 130
	H5: varied	80 : 20	100 : 30	120 : 40	160 : 60	220 : 90	300 : 130
	H6: varied	100 : 20	140 : 30	180 : 40	260 : 60	380 : 90	540 : 130
	H7: varied	120 : 20	180 : 30	240 : 40	360 : 60	540 : 90	780 : 130

Table 3-2. Spaces clustered in 9 groups

		Width (ft)					
		W1 : 20	W2 : 30	W3 : 40	W4 : 60	W5 : 90	W6 :130
Height (ft)	H1: 20 H2: 30	Low, Narrow		Low, Medium(W)		Low , Wide	
	H3: 40 H4: 60	Medium(H), Narrow		Medium(H), Medium(W)		Medium(H), Wide	
	H5: varied H6: varied H7: varied	High, Narrow		High, Medium(W)		High, Wide	

Table 3-3. Ratio levels.

		Width (ft)					
		W1 : 20	W2 : 30	W3 : 40	W4 : 60	W5 : 90	W6 :130
Height (ft)	H1: 20	1.00	0.67	0.50	0.33	0.22	0.15
	H2: 30	1.50	1.00	0.75	0.50	0.33	0.23
	H3: 40	2.00	1.33	1.00	0.67	0.44	0.31
	H4: 60	3.00	2.00	1.50	1.00	0.67	0.46
	H5: varied	4.00	3.33	3.00	2.67	2.44	2.31
	H6: varied	5.00	4.67	4.50	4.33	4.22	4.15
	H7: varied	6.00	6.00	6.00	6.00	6.00	6.00

Table 3-4. Ratio categories

		Width (ft)					
		W1 : 20	W2 : 30	W3 : 40	W4 : 60	W5 : 90	W6 :130
Height (ft)	H1: 20	1	2/3	1/2	1/3	1/5	1/6
	H2: 30	3/2	1	3/4	1/2	1/3	1/4
	H3: 40	2	3/2	1	2/3	1/2	1/3
	H4: 60	3	2	3/2	1	2/3	1/2
	H5: varied	4	3	3	3	2	2
	H6: varied	5	5	4	4	4	4
	H7: varied	6	6	6	6	6	6

Table 3-5. Scale levels

		Width (ft)					
		W1 : 20	W2 : 30	W3 : 40	W4 : 60	W5 : 90	W6 :130
Height (ft)	H1: 20	400	600	800	1200	1800	2600
	H2: 30	600	900	1200	1800	2700	3900
	H3: 40	800	1200	1600	2400	3600	5200
	H4: 60	1200	1800	2400	3600	5400	7800
	H5: varied	1600	3000	4800	9600	19800	39000
	H6: varied	2000	4200	7200	15600	34200	70200
	H7: varied	2400	5400	9600	21600	48600	101400

Table 3-6. Scale groups

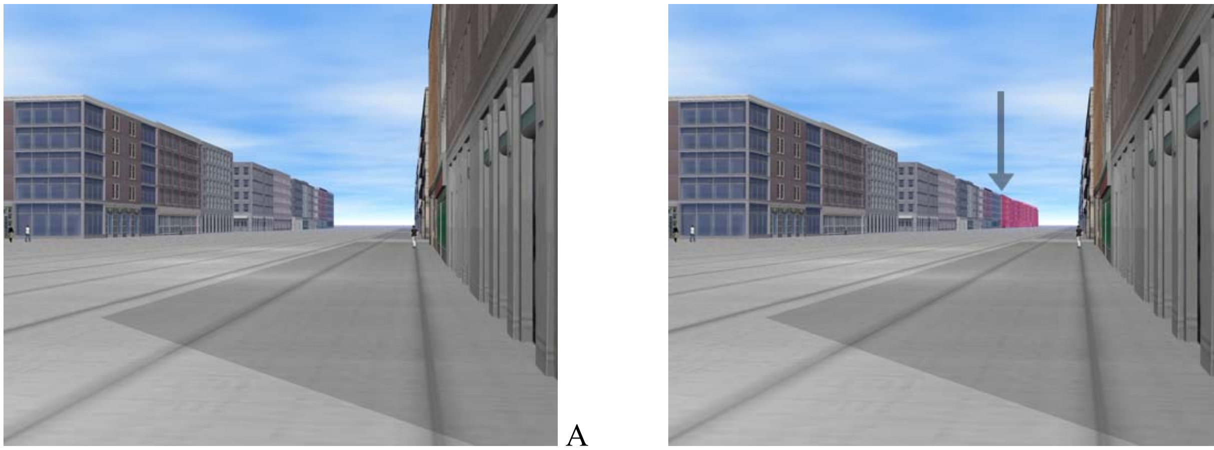
		Width (ft)					
		W1 : 20	W2 : 30	W3 : 40	W4 : 60	W5 : 90	W6:130
Height (ft)	H1: 20 H2: 30	Small					
	H3: 40 H4: 60			Medium			
	H5: varied H6: varied H7: varied					Large	

Table 3-7. Summary of independent and dependant variables.

Independent variables		Type	Dependent variables		Type
Within-subject (space)			Psychophysical		
Height to width ratio Scale	R S_C	Ordinal Ordinal	Comfort Safety	C S	Ordinal Ordinal
Between-subjects (demographic)			Cognitive		
Gender Age Design Background Type of OAL Height of buildings in AOL Width of streets in AOL		Nominal Interval Nominal Nominal Interval Interval	Perceived enclosure Perceived Height Perceived Width	E_P H_P W_P	Ordinal Interval Interval

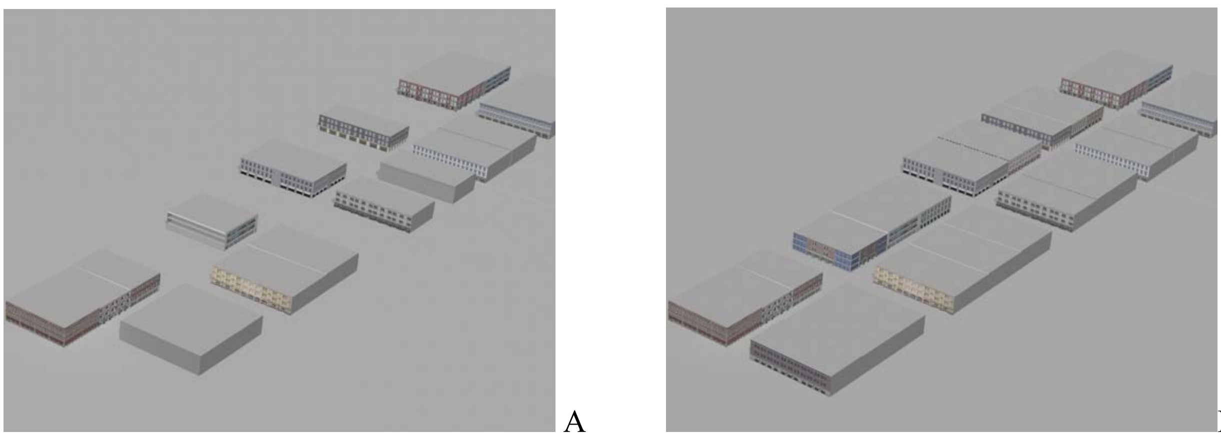
A B

Figure 3-1. Existing context: Main Street, Downtown Gainesville, Florida. A) Site aerial image. B) Example of context architecture.



A B

Figure 3-2. Street length. A) Length of 1320 ft. B) Length of 2500 ft. With wider streets, there was a need to double the length of the simulated street.



A B

Figure 3-3. Vacant land plots. A) Existing empty land plots. B) Empty plots filled.

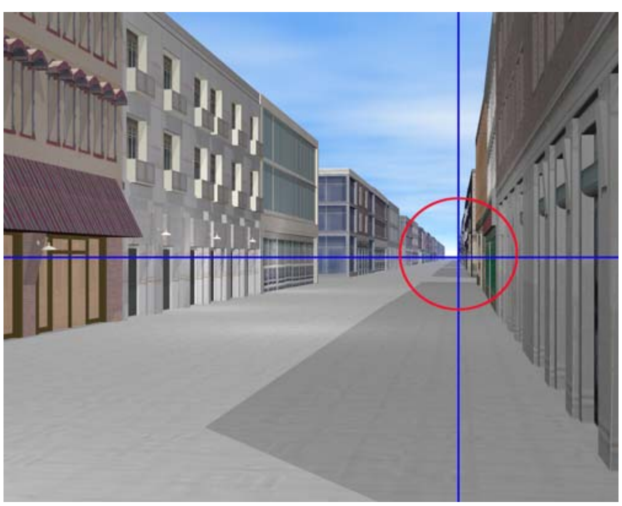


Figure 3-4. Viewing point. Human-eye level from one side of the street.

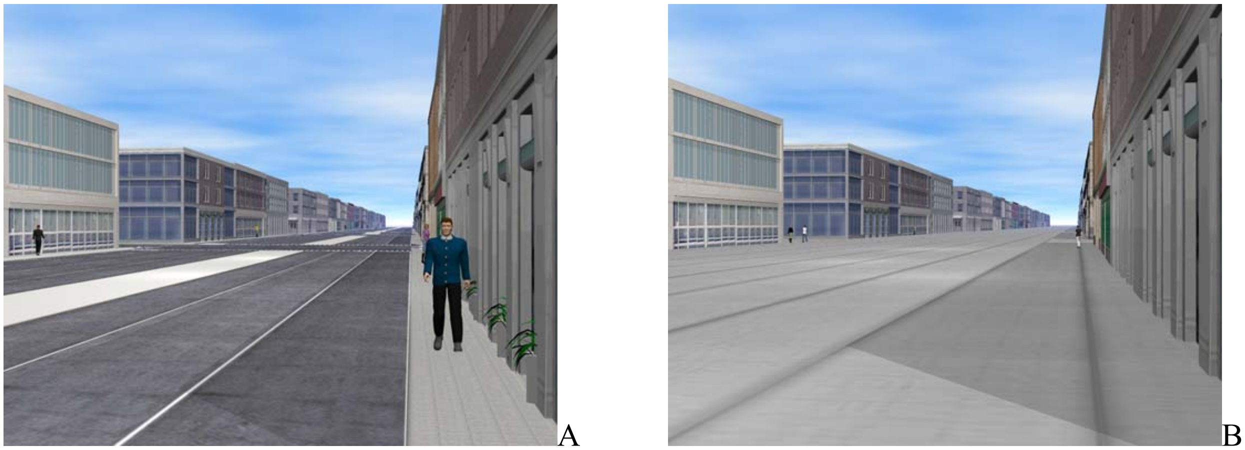
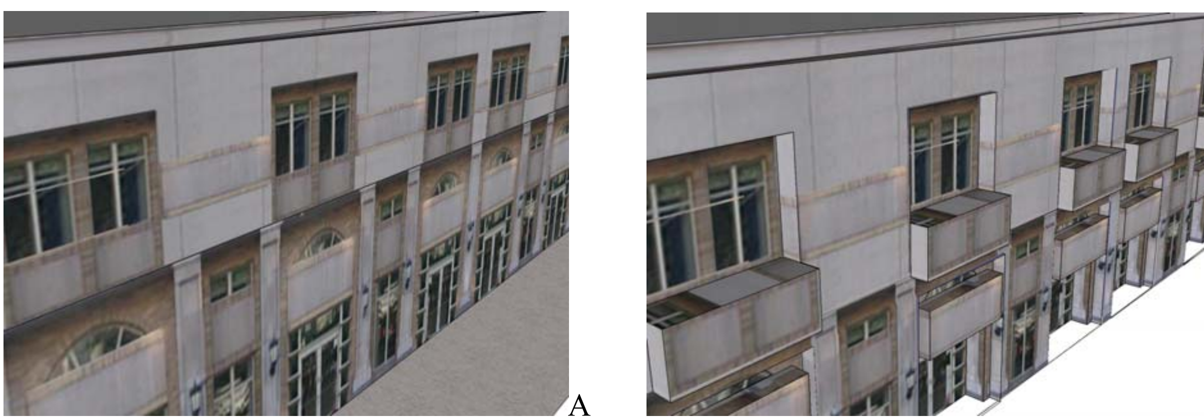


Figure 3-5. Street furniture. A) Lanes, sidewalks and median are realistically represented. B) Reduced realism; neutral material.

Figure 3-6. Texture correction. A) Original image. B) Corrected image.

Figure 3-7. Texture mapping



A B

Figure 3-8. Facade articulation. A) Before façade articulation. B) After façade articulation.

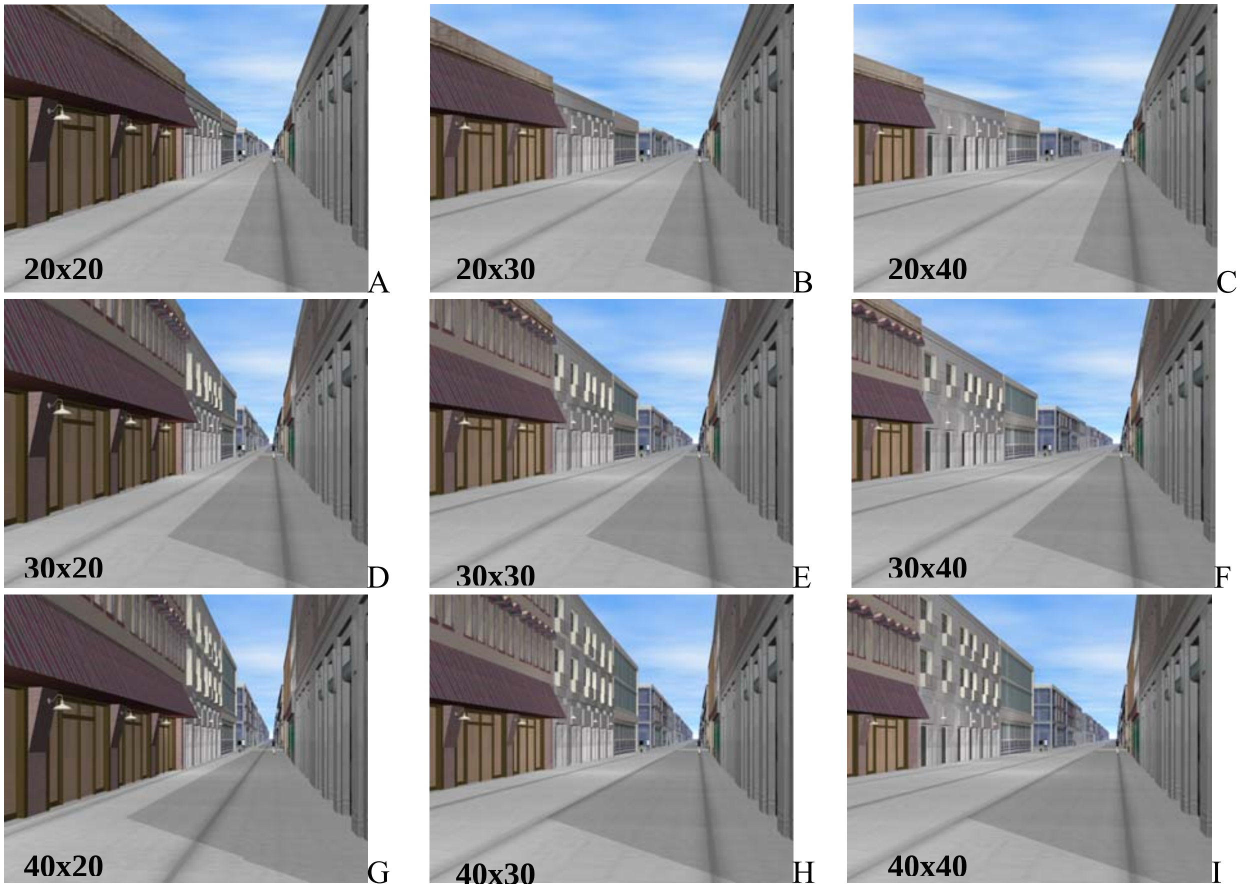


Figure 3-9. Examples of 9 images from the matrix. A) 20ft x 20ft. B) 20ft x 30ft. C) 20ft x 40ft. D) 30ft x 20ft. E) 30ft x 30ft. F) 30ft x 40ft. G) 40ft x 20ft. H) 40ft x 30ft. I) 40ft x 40ft.

CHAPTER 4
RESULTS: PERCEIVED ENCLOSURE

My research used 42 images of simulated urban street spaces that were extracted from three-dimensional computer models, designed to investigate the influence of enclosure, as a function of ratio and scale of urban street spaces, on user's sense of comfort, sense of safety and perceived enclosure. Each of the 83 participants responded to all 42 images, resulting in a total of 3,486 observations for each dependent variable. Consequently, for analysis of variance of between-subject variables, *n* was 83, and for analysis of association and regression of within-subject variables, *n* was 42.

This chapter reports results from variance, association and regression statistical analysis of the dependent variable perceived enclosure. Analysis of variance answers the question; whether or not there was a difference in perceived enclosure responses for the different groups and categories of the independent variables. Analysis of associations answers the question; how does the magnitude of perceived enclosure change, and in what direction, when the magnitudes of independent variables change. Regression analysis answers the question; which independent variables are best predictors of perceived enclosure.

Before presenting result of perceived enclosure, results from tests of normal distribution and reliability will be reported first. The normal distribution test was used to decide the appropriate type of statistical analysis to be used in my research. The reliability test was conducted to examine whether simulated dimensions are actually perceived as designed, which examines the validity of the simulation method.

Normal Distribution and Reliability Tests

Normal Distribution Test

It was necessary to first decide whether to use parametric or nonparametric statistical analysis in my research. To use parametric statistics; including T-test, ANOVA, Pearson correlation coefficient (r), etc., dependent variables should be normally distributed. If this condition is violated, equivalent nonparametric analysis should be used including; Mann-Whitney U test, Friedman test, Kruskal-Wallis test, Spearman correlation coefficient (rho), etc. Dependent variables of perceived enclosure, comfort, and safety were not normally distributed based on the rule that skewness and kurtosis, divided by their standard errors, should not exceed 5.5 for dependent variables to be considered normally distributed (Morgan & Griegro, 1998; Pallant, 2001), (Table 4-1). Normal distribution conditions were violated; therefore only nonparametric tests were used in my research.

Test of Reliability: Simulated vs. Perceived Heights and Widths

Reliability tests were conducted for the computer simulation method used in my research. Using this test, it can be established that heights and widths of the simulated spaces of urban street spaces are actually perceived by participants as assumed by the simulation. For simulated heights with perceived heights, a strong positive correlation was found at rho = +0.904, $\alpha = 0.01$, $n = 3{,}486$. The alternative hypothesis, H^1: simulated heights are strongly associated with estimated heights, was supported.

For simulated widths with estimated widths, a strong positive correlation was found at rho = +0.771, $\alpha = 0.01$, $n = 3{,}486$. The alternative hypothesis, H^1: simulated widths are strongly associated with estimated widths, was supported. These findings indicated that, for purposes of conveying the differences in the magnitudes of urban space dimensions to participants, the computer simulation method that was used in my research is reliable, (Table 4-2), (Figure 4-1).

Perceived Enclosure

The influence of both sets of independent variables on the dependent variable "perceived enclosure" will be discussed. The influences of within-subjects independent variables of height, width, ratio and scale, on perceived enclosure are discussed first, followed by influences of between-subjects independent variables of gender, age, design background, type of living area, height of buildings in living area, and width of streets in living area.

Perceived Enclosure and Within-Subject Variables: Height, Width, Ratio and Scale

Repeated measures: test of variance

Friedman test for repeated measures on an ordinal scale was conducted four times for analysis of perceived enclosure for the 42 spaces, the 9 groups of spaces, the 14 ratio categories, and the three scale groups.

For the 42 spaces, the test was conducted to answer the question whether or not there was a difference in perceived enclosure scores across the 42 spaces. The test result was significant, P = 0.000, n = 83, df = 41. The alternative hypothesis, H^1: there is a difference in perceived enclosure responses across the 42 spaces, was supported. The highest perceived enclosure mean rank (37.59) was received by space (120, 20, 6), the 2nd highest perceived enclosure mean rank (34.14) was for space (180, 30, 6), and the 3rd highest perceived enclosure mean rank (33.82) was for space (140, 30, 4.67). The lowest perceived enclosure mean rank (4.97) was for space (20, 130, 0.15), (Table 4-3).

To account for randomness caused by the large sample of 3,486 observations, the 9 groups of spaces were tested. Friedman test was used to answer whether or not there was a difference in sense of perceived enclosure scores across these 9 groups. The test result was significant, P = 0.000, n = 83, df = 8. The alternative hypothesis, H^1: there is a difference in perceived enclosure responses across the 9 spaces groups, was supported. The highest perceived enclosure mean rank of (8.41) was received by group (High, Narrow), the lowest perceived enclosure mean rank (1.31) was for group (Low, Wide), (Table 4-4).

For categories of ratio, the test result was significant (P = 0.000, *n* = 83, *df* = 13), the alternative hypothesis, H^1: there is a difference in perceived enclosure responses across the 14 ratio categories, was supported. High ratios of 5 and 6 received the highest perceived enclosure mean rank, while low ratios of 1/6 and 1/5 received the lowest perceived enclosure mean ranks, (Table 4-5).

For scale groups, the test result was significant, P = 0.000, *n* = 83, *df* = 2, the alternative hypothesis, H^1: there is a difference in perceived enclosure responses across the 3 scale groups, was supported. The scale group (Large), received the highest rank (2.22); followed by group scale (Small), with a mean rank of (2.16). The least mean rank (1.62) was received by the group scale (Medium), (Table 4-6). It should be noted here that with the 3 scale groups, the ratio variable is in effect; this is explained more in the coming tests of association. In other words, without controlling for ratio, scale does not have a significant influence on perceived enclosure.

Ratio association

There was a high significant positive correlation between perceived enclosure and ratio at rho = 0.84; the relationship was linear. When the correlation was conducted after controlling for scale, a higher positive correlation resulted at rho = + 0.936, (Table 4-7), (Figure 4-2). There was strong statistical evidence to conclude that as ratio increases, perceived enclosure increases. This result means that the dependent variable perceived enclosure can be used as independent variable, as suggested in chapter 3, where dependent variables like comfort and safety can be examined in relation to it.

Scale association

Perceived enclosure and scale were correlated without controlling for ratio, no significant correlation was found; rho =.049. After statistically controlling for ratio, a negative over all significant correlation was found at rho = - 0.683. When selecting only cases which satisfy the condition (0.5 <= R<=2), no significant correlation was found. When the cases with ratio range of (1 to 2) were selected, perceived enclosure correlated negatively with scale at rho = -0.620, (P = 0.03, *n* = (12*83)). Selecting cases with only ratio value of (6) revealed a higher negative correlation between perceived enclosure and scale at rho = -0.943, (P = 0.005, *n* = (6*83)), (Table 4-8), (Figure 4-3). There was enough statistical evidence to conclude that, by controlling for ratio, perceived enclosure decreases as scale increases. There was evidence that the scale variable can predict perceived enclosure only when ratio variable is controlled, which rendered the scale variable as a function attached to ratio and can not operate alone.

Height association

There was a statistically significant positive correlation between perceived enclosure and height; rho = +0.508, (P = 0.001, *n* = 42*83). However, when a partial correlation was conducted between perceived enclosure and height controlling for width, the correlation was higher; rho =.774, and when the correlation was conducted for spaces at width levels of (20 to 30 ft), the correlation was at rho =.75, (P = 0.001, *n* = 15*83), at width levels of (40 to 60 ft) the correlation was at rho =.921, (P = 0.000, *n* = 14*83), and at width levels of (90 to 130 ft) the correlation was at rho =.898, (P = 0.000, *n* = 13*83), (Table 4-9), (Figure 4-4). It can be concluded that perceived enclosure increases as height increases, and that height is a better predictor of perceived enclosure after controlling for width, and that height has the highest influence on perceived enclosure at width range of (40 to 60 ft).

Width association

There was a statistically significant negative correlation between perceived enclosure and width in general; rho = - 0.677, (P = 0.000, *n* = 42*83). However, when a partial correlation was conducted between perceived enclosure and width controlling for height, the correlation was stronger; rho = -.858, and when the correlation was conducted for spaces at height levels of (20 to 30ft), the correlation was at rho = - 0.965, (P = 0.001, *n* = 10*83), at height levels of (40 to 60 ft) the correlation was at rho = - 0.989, (P = 0.000, *n* = 11*83), and at width levels of (> 60 ft) the correlation was at rho = -.881, (P = 0.000, *n* = 18*83), (Table 4-10), (Figure 4-5). There is enough evidence to conclude that perceived enclosure decreases as width increases, and that width is a better predictor of perceived enclosure after controlling for height, and that width has the highest influence on perceived enclosure at height range of (40 to 60ft).

Regression analysis

Logistic regression predicts the presence of a dependent variable based on independent variables (Morgan & Griegro, 1998; Pallant, 2001); it allows for the prediction of a discrete outcome of success (e.g., comfortable) or failure (e.g., uncomfortable). Logistic regression was used to predict the presence of closedness based on within-subjects independent variables. The dependent variable perceived enclosure was recoded into two binary values of 0 and 1, where 0 represents the absence of closedness, and 1 represents the existence of closedness. Perceived enclosure scores of 1 and 2 were recoded into 0; perceived enclosure scores of 5 and 6 were recoded into 1, while perceived enclosure scores of 3 and 4 were not included. The total number of selected cases was 1949.

Ratio, scale, height, and width variables were all fitted in the model, and they were able to estimate 87.63% of responses correctly. Since these variables are all functions of height and width, it was logical to reduce the number of variables to the minimum that could predict the same percentage that the complete model predicted. Since ratio had the highest estimation capacity among the 4 variables, 3 tests were conducted combining ratio with each of the other 3 variables. The tests results revealed that ratio and scale estimated 86.4% of the responses, ratio and height estimated 86.4% as well, while ratio and width estimated the same percentage that the full model estimated, 87.63%. Based on that, it was decided to include only ratio and width in the final model. It is important to note that the notion of scale is still included, but represented by width combined with ratio; i.e., for each ratio and width values there is only one scale value. What supported this decision is that it is more practical to report the relationship as a function of ratio and width as indicator of scale, instead of ratio and scale.

The model is significant (P = .000, *n* = 1949, Cox & Snell's Pseudo $R^2 = .522$), (Table 4-11). The probability that a space of ratio (R) and width (W) will be perceived as closed or not can be calculated using the constant and the *B* values reported in the regression model, (Eq. 4-1). For example, if a space has a ratio of 1, and a width of 20 feet, then $P_{(Ep)} = 0.717$, and if a space has a ratio of 6 and a width of 40 feet, then $P_{(PE)} = 0.986$. A calculator was created where ratio and width values can be input and probability of closedness can be obtained.

$$P_{(Ep)} = \frac{1}{1 + e^{-(-3.5799 + 0.5716 R - 0.0309 W)}} \tag{4-1}$$

Perceived Enclosure and between-Subject Variables: Gender, Age, Design Background, Type of living area, Height of buildings in living area, and Width of streets in living area.

For this analysis, the 3 ratio categories and the 3 scale groups were used to examine differences of perceived enclosure of different demographic groups. In addition, perceived enclosure scores of different demographic groups for the 42 spaces were extracted and were correlated.

Gender

A non parametric test; namely Mann-Whitney U test was used to examine whether men and women differ in terms of their perceived enclosure. For the 3 ratio categories, although women have higher perceived enclosure mean ranks for higher ratios than men, the test result was not statistically significant. The null hypothesis, H°: women and men have the same perceived enclosure across the 3 ratio categories, could not be rejected, (Table B-1), (Figure B-1).

For the 3 scale groups, there was no statistically significant difference, the null hypothesis, H°: men and women have the same perceived enclosure across the 3 scale groups, couldn't be rejected, (Table B-2), (Figure B-2). The correlation between perceived enclosure scores of men and women, for the 42 spaces, was at rho = .97, ($P = .000$, $n = 42$), which indicates a high level of consensus

Age

Age was recoded into three categories; (< 24), (25 to 31), and (< 31) for the purposes of variance analysis. Kruskal-Wallis test, which is a non-parametric test of variance for variables that have more than two levels, was conducted to test the difference in perceived enclosure responses of the 3 age groups. For ratio categories, although the older two groups tended to have higher perceived enclosure than the youngest group for higher ratios, the test result was statistically insignificant. The null hypothesis, H°: the 3 age groups have the same perceived enclosure scores across the 3 ratio categories) couldn't be rejected, (Table B-3), (Figure B-3).

For scale groups, the test result was statistically insignificant, the null hypothesis, H°: the 3 age groups have the same perceived enclosure scores across the 3 scale groups, couldn't be rejected, (Table B-4), (Figure B-4). The range of correlations between perceived enclosure scores of the 3 age groups, for the 42 spaces, was at rho = .97 to .98, (P = .000, n = 42), which indicates a high level of consensus.

Design background

A Mann-Whitney U test was conducted to examine the variance in perceived enclosure responses of designers and non designers. The test result was statistically insignificant. The null hypothesis, H°: designers and non designers have the same sense of perceived enclosure scores across the 3 ratio categories, couldn't be rejected, (Table B-5), (Figure B-5).

For scale groups, the test result was statistically insignificant. The null hypothesis, H°: designers and non designers have the same sense of perceived enclosure scores across the 3 scale groups, couldn't be rejected, (Table B-6), (Figure B-6). The correlation between perceived enclosure scores of designers and non designers, for the 42 spaces, was at rho = .97, (P = .000, n = 42), which indicates a high level of consensus.

Type of living area

Kruskal Wallis test was conducted to examine the difference in perceived enclosure responses between inhabitants of the three types of living area; urban, suburban and rural. The test result was statistically insignificant. The null hypothesis, H°: inhabitants of the three types of living area have similar perceived enclosure across the 3 ratio categories, couldn't be rejected, (Table B-7), (Figure B-7).

For scale groups, the test result was statistically insignificant. The null hypothesis, H°: inhabitants of the three types of living area have similar perceived enclosure across the 3 scale groups, couldn't be rejected, (Table B-8), (Figure B-8). The range of correlations between perceived enclosure scores of inhabitants of the 3 types of living area, for the 42 spaces, was at rho = .94 to .96, (P = .000, n = 42), which indicates a high level of consensus.

Height of buildings in living area

The dependent variable “height of buildings in the living area” was recoded into 4 categories “1 to 2 floors”, “3 to 4 floors”, “5 to 6 floors”, and “>6 floors”. This variable was analyzed using the scale groups and the simulated heights. Kruskal Wallis test was conducted to examine the difference in perceived enclosure responses between the four groups. The test result was statistically insignificant. The null hypothesis, H°: inhabitants of areas with different heights of buildings have the same perceived enclosure across the 3 scale groups, couldn’t be rejected, (Table B-9), (Figure B-9).

For simulated heights, the simulated height range of (30 to 60 ft) received significantly lower perceived enclosure mean ranks by those who live in buildings higher than (6 floors) than those who live in buildings with lower heights. The alternative hypothesis, H^1: height of buildings, that people are accustomed to, influences perceived enclosure at simulated heights of (30 to 60 ft), was supported, (Table B-10), (Figure B-10). Nevertheless, the range of correlations between perceived enclosure scores of inhabitants of areas that have the 4 heights of buildings, for the 42 spaces, was at rho = .92 to.97, (P = .000, n = 42), which indicates a high level of consensus.

Width of streets in living area

The variable width of streets in the living area was recoded into 3 categories “1 to 2 lanes”, “3 to 4 lanes, and “>4 lanes”. There was no significant difference between perceived enclosure scores relative to the three levels of the independent variable “width of streets in the living area”. The null hypothesis, H°: width of streets, that people are accustomed to, does not influence perceived enclosure at all scale groups, was not rejected, (Table B-11), (Figure B-11).

For the simulated widths, the test revealed no significant differences between perceived enclosure scores, relative to the 3 levels of width of streets in the living area, at all simulated width levels. The null hypothesis, H°: width of streets, that people are accustomed to, does not influence perceived enclosure at all simulated width levels, was not rejected, (Table B-12), (Figure B-12). The range of correlations between perceived enclosure scores of inhabitants of areas that have the 3 widths of streets, for the 42 spaces, was at rho = .95 to.98, (P = .000, *n* = 42), which indicates a high level of consensus.

Summary

The simulated heights of urban street spaces used in the method of my research correlated with participants perceived heights at (rho = 0.904), and simulated widths correlated with perceived widths at (rho = 0.771). Simulated heights and widths are actually perceived by people as designed. These findings strengthen the premise that such computer simulation method is reliable for purposes of conveying geometric and spatial information of urban streets spaces for participants in an experimental setting.

There is a difference in perceived enclosure responses across different urban street spaces. Space (120, 20, 6) was rated as the most enclosed spaces, while space (20, 130, 0.15) was rated as the most open one. Ratio influences perceived enclosure; high ratios of (5 and 6) received the highest perceived enclosure mean ranks, while low ratios of (1/6 and 1/5) received the lowest perceived enclosure mean ranks. Perceived enclosure has a high positive correlation with ratio (rho = 0.84); as ratio value increases, perceived enclosure increases. There is a difference in perceived enclosure responses across different scales of urban street spaces. Controlling for ratio, there is a negative correlation between perceived enclosure and scale (rho = - 0.683); as scale value increases, perceived enclosure decreases.

There is a difference in perceived enclosure responses across different heights of urban street spaces. Controlling for width, there is a high positive correlation between perceived enclosure and height (rho =.774); as height increases, perceived enclosure increases. There is also a difference in perceived enclosure responses across different widths of urban street spaces. Controlling for height, there is a high negative correlation between perceived enclosure and width (rho = -.858); as width increases, perceived enclosure decreases. The probability that a space ratio (R) and width (W) will be perceived as comfortable or not, can be calculated using the constant and the *B* values reported in the regression model using the equation (4-1).

Except for height of buildings in living area, which influences perceived enclosure at simulated heights of (30 to 60 ft), all demographic variables of gender, age, design background, living area, and width of streets in living area do not influence perceived enclosure of urban street spaces. Perceived enclosure has correlated, within all demographic groups, in the range of (.92 to .98), which indicates a clear consensus between different demographic groups on perceived enclosure.

Chapter 5 will present results of the statistical analysis for the two dependent variables sense of comfort and sense of safety. The high correlation between these two variables suggests minimal differences between them. It would be useful to report results of comfort and safety together. Findings from statistical analysis of repeated measures, variance, association and regression, will be reported similar to perceived enclosure analysis in this chapter.

Table 4-1. Test of skewness and kurtosis for normal distribution.

		Perceived enclosure	Comfort level	Safety level
N	Valid Missing	3486.00 0.00	3486.00 0.00	3486.00 0.00
Skewness Std. error of skewness Kurtosis Std. error of kurtosis		−0.033 0.041 −0.961 0.083	−0.317 0.041 −0.643 0.083	−0.326 0.041 −0.580 0.083

Table 4-2. Correlations of simulated heights and widths with perceived heights and widths

			Height	Width
Spearman's rho	Perceived height	rho	0.904**	
	Perceived width	rho		0.771**
		Sig. (2-tailed)	0.000	0.000
		N	3486	3486

**Correlation is significant at the .01 level (2-tailed).

Table 4-3. Friedman test of repeated measures of perceived enclosure scores across 42 spaces, sorted by perceived enclosure mean rank.

Space	Mean rank	Space	Mean rank
Space(120,20,6)	37.59	Space(60,40,1.5)	23.24
Space(180,30,6)	34.14	Space(220,90,2.44)	23.00
Space(140,30,4.67)	33.82	Space(780,130,6)	22.58
Space(100,20,5)	33.70	Space(540,130,4.15)	19.46
Space(240,40,6)	33.07	Space(300,130,2.31)	18.74
Space(40,20,2)	32.19	Space(40,40,1)	17.14
Space(60,20,3)	31.65	Space(60,60,1)	16.53
Space(30,20,1.5)	31.34	Space(40,60,0.67)	16.49
Space(100,30,3.33)	29.82	Space(20,30,0.67)	16.21
Space(80,20,4)	29.24	Space(30,30,1)	15.77
Space(540,90,6)	28.97	Space(60,90,0.67)	15.64
Space(20,20,1)	28.73	Space(30,40,0.75)	14.14
Space(180,40,4.5)	27.78	Space(20,40,0.5)	13.75
Space(360,60,6)	27.37	Space(30,60,0.5)	13.61
Space(20,20,1)	26.24	Space(40,90,0.44)	9.73
Space(120,40,3)	25.16	Space(30,90,0.33)	8.38
Space(60,30,2)	24.20	Space(20,60,0.33)	8.07
Space(260,60,4.33)	23.66	Space(40,130,0.31)	5.90
Space(380,90,4.22)	23.65	Space(30,130,0.23)	5.36
Space(160,60,2.67)	23.58	Space(20,90,0.22)	4.98
Space(40,30,1.33)	23.39	Space(20,130,0.15)	4.97
Friedman test	N Chi-Square df Asymp.Sig.	83 567.839 41 0.000	

Table 4-4. Friedman test of repeated measures for perceived enclosure scores across 9 groups of spaces, sorted by perceived enclosure mean rank.

Group	Mean Rank	Friedman test	
Group(High, Narrow)	8.41	N	83
Group(Medium(H), Narrow)	6.98	Chi-Square	509.928
Group(High, Medium(W))	6.66	df	8
Group(Low, Narrow)	6.06	Asymp.Sig.	0.000
Group(High, Wide)	5.51		
Group(Medium(H), Medium(W))	4.46		
Group(Low, Medium(W))	3.07		
Group(Medium(H), Wide)	2.55		
Group(Low, Wide)	1.31		

Table 4-5. Friedman test of repeated measures for perceived enclosure scores across 14 ratio categories, sorted by perceived enclosure mean rank.

Ratio	Mean Rank	Friedman test	
5	13.15	N	83
6	12.21	Chi-Square	858.301
2	10.69	df	13
1 1/2	10.61	Asymp.Sig.	0.000
3	10.27		
4	9.57		
1	8.36		
2/3	6.86		
3/4	6.07		
1/2	5.45		
1/3	3.78		
1/4	2.79		
1/5	2.66		
1/6	2.54		

Table 4-6. Friedman test of repeated measures for perceived enclosure scores across 3 scale groups, sorted by perceived enclosure mean rank.

Scale group	Mean rank	Friedman test	
Large scale	2.22	N	83
Small scale	2.16	Chi-Square	18.735
Medium scale	1.62	Df	2
		Asymp.Sig.	0.000

Table 4-7. Ratio correlation.

Spearman's rho		Ratio	
		All values	Ctrl. for scale
Perceived enclosure	rho	0.840**	0.937**
	Sig. (2-tailed)	0.000	0.000
	N	42	42

**Correlation is significant at the .01 level (2-tailed).

Table 4-8. Scale correlation.

Spearman's rho		Scale			
		All ratios	Ctrl. for ratio	For 0.5 <= R<=2	For R = 6
Perceived enclosure	rho	0.049	0.937**	−0.620*	−0.943**
	Sig.(2-tailed)	0.757	0.000	0.032	0.000
	N	42	12	12	6

*Correlation is significant at the .05 level (2-tailed).
**Correlation is significant at the .01 level (2-tailed).

Table 4-9. Height correlation.

Spearman's rho		Height				
		All widths	Ctrl. for width	For W = 20 to 30	For W = 40 to 60	For W = 90 to 130
Perceived enclosure	rho	0.508**	0.774**	0.748**	0.921**	0.898**
	Sig. (2-tailed)	0.001	0.001	0.001	0.000	0.000
	N	42		15	14	13

**Correlation is significant at the .01 level (2-tailed).

Table 4-10. Width correlation.

Spearman's rho		Width				
		All heights	Ctrl. for heights	For H = 20 to 30	For H = 40 to 60	For H > 60
Perceived enclosure	rho	−0.677**	−0.858**	−0.965**	−0.989**	−0.881**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	42		13	11	18

**Correlation is significant at the .01 level (2-tailed).

Table 4-11. Logistic regression model for perceived enclosure.

Logistic regression model			
-2 Log Likelihood Goodness of Fit	1258.637 5766.163	Cox & Snell - R^2 Nagelkerke - R^2	0.522 0.522
	Chi-Square	df	Significance
Model Block Step	1440.048 1440.048 1440.048	2 2 2	0.000 0.000 0.000

Classification for perceived enclosure, the cut value is .50				
		Predicted		
		0	1	
Observed		0	1	Percent correct
0	0	846	168	83.43%
1	1	73	862	92.19%
			Overall	87.63%

Variables in the equation							
Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
Ratio	0.5716	0.0280	417.7694	1	0.000	0.3925	1.7711
Width	−0.0309	0.0022	201.6351	1	0.000	−0.2720	0.9696
Constant	−3.5799	0.2636	184.3899	1	0.000		

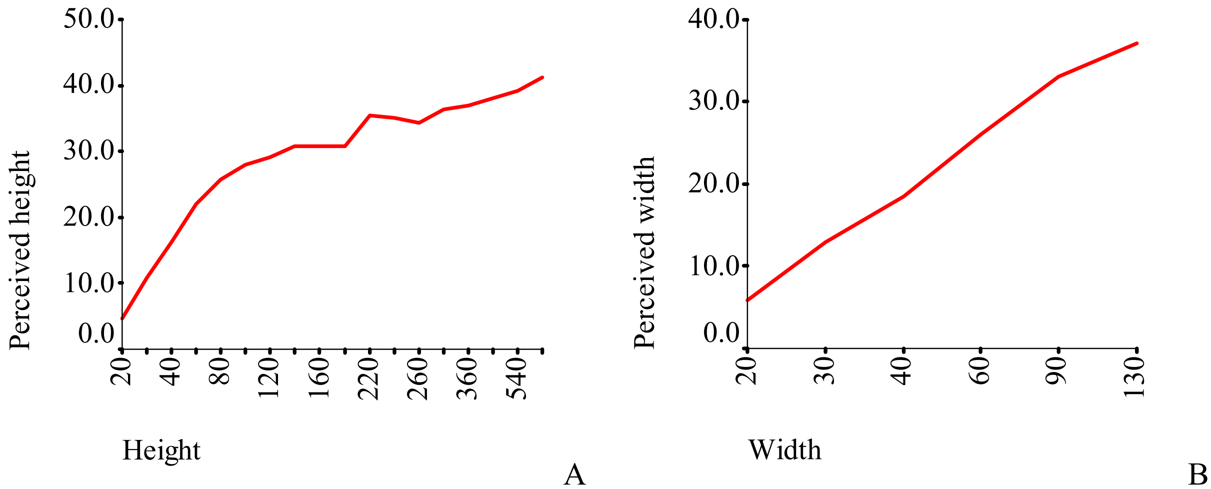


Figure 4-1. Correlations of perceived measures with simulated measures. A) Simulated heights correlated with perceived heights (rho = +0.993). B) Simulated widths correlated with perceived widths (rho = +0.986).

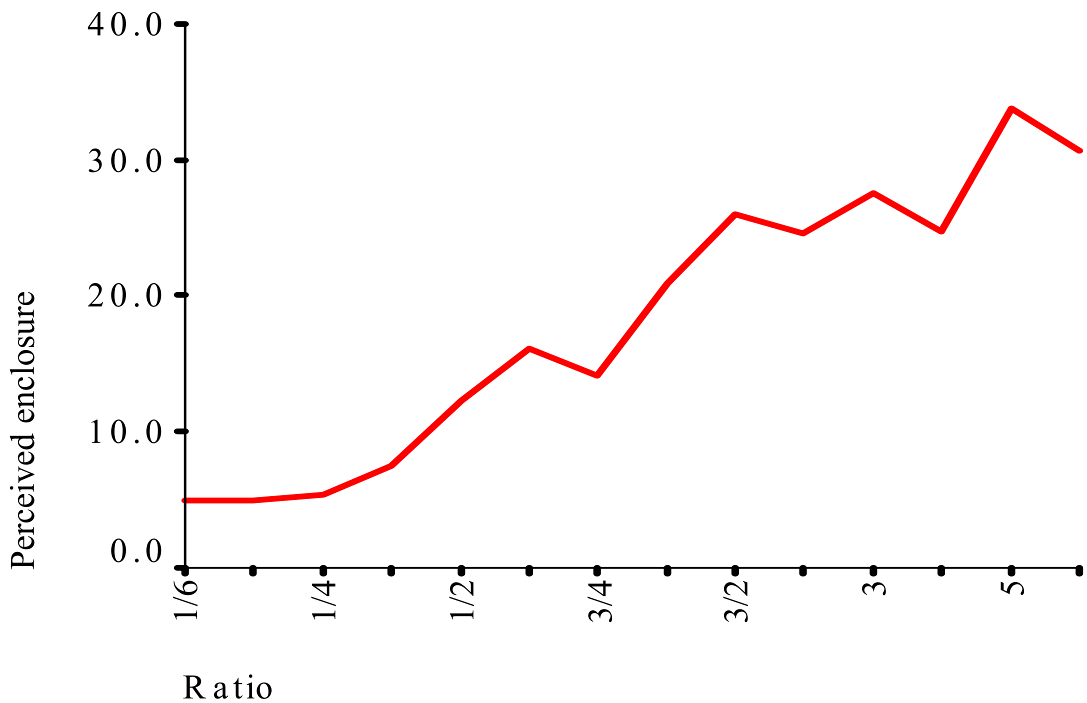


Figure 4-2. Relationship of perceived enclosure and ratio.

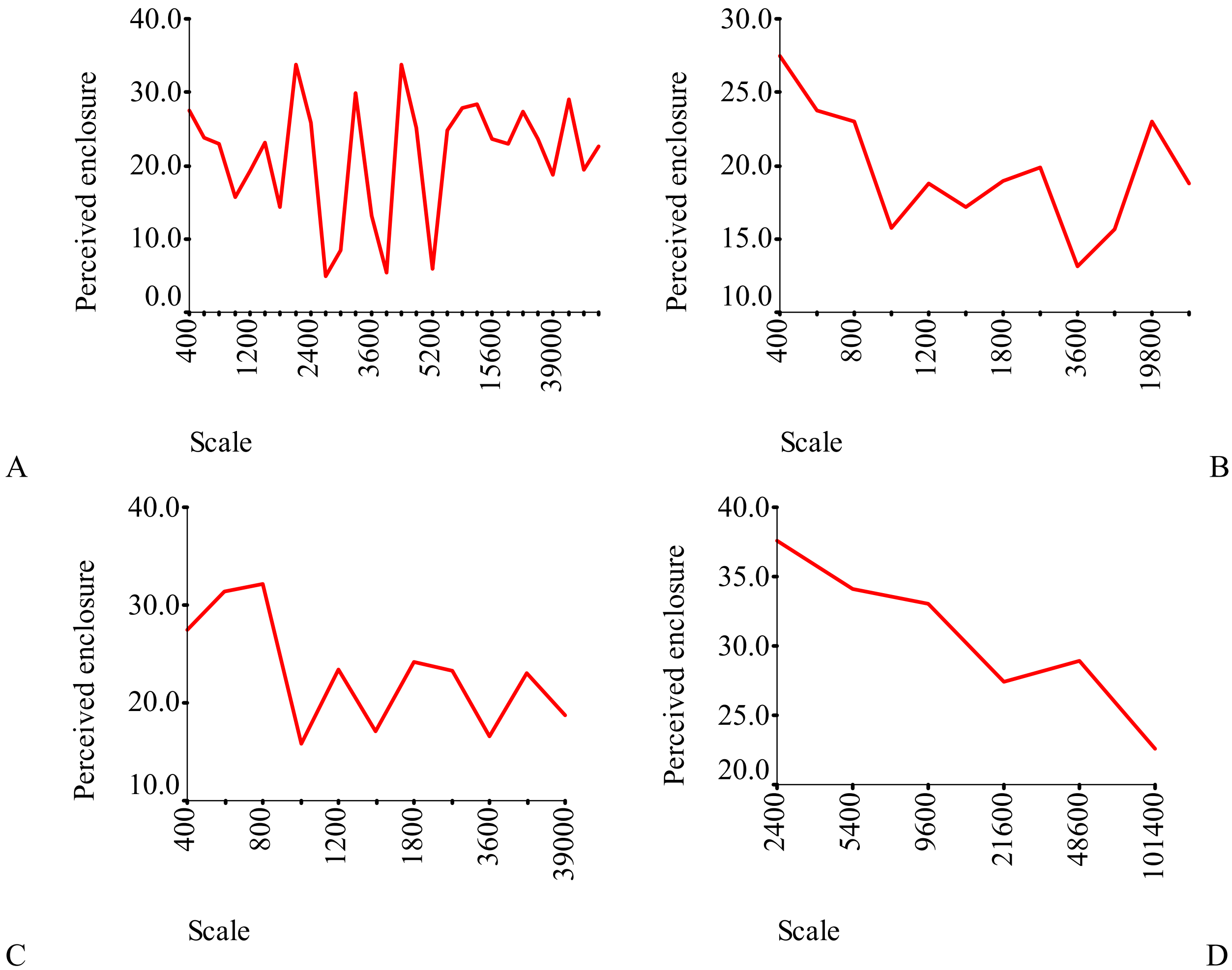


Figure 4-3. Relationship of perceived enclosure and scale. A) Perceived enclosure and scale for all ratio values. B) Perceived enclosure and scale; selecting cases with ratio values of (0.5 to 2). C) Perceived enclosure and scale; selecting cases with ratio values of (1 to 2). D) Perceived enclosure and scale; selecting cases with ratio values of (6).

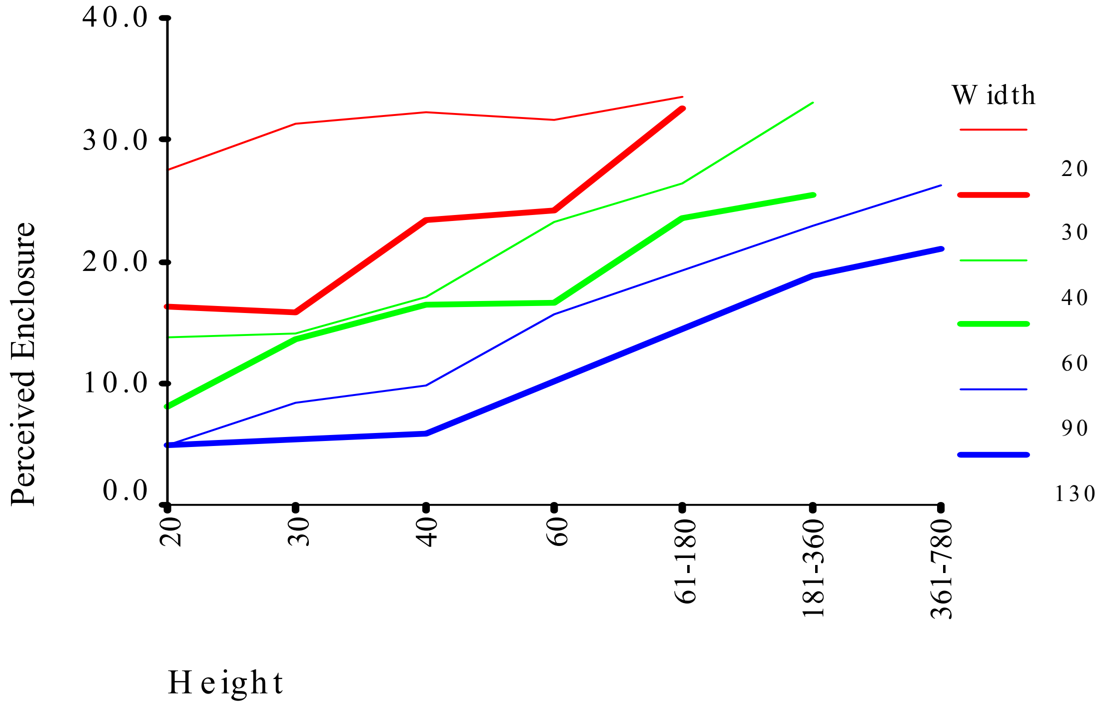


Figure 4-4. Relationship of perceived enclosure and height, clustered by width.

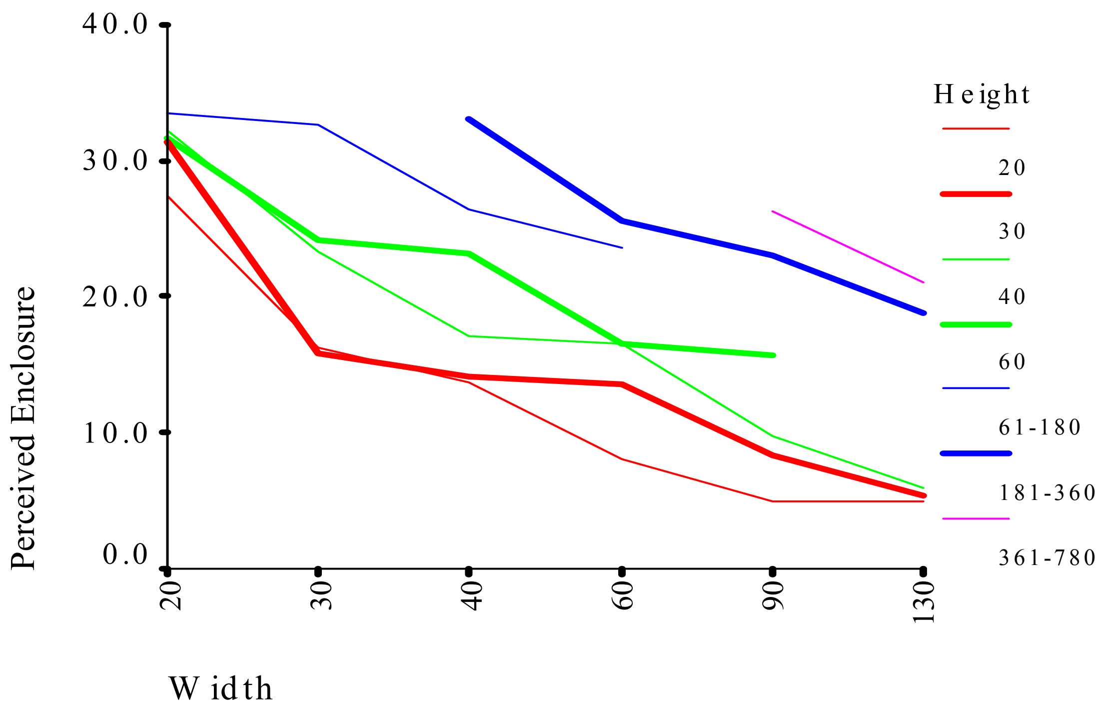


Figure 4-5. Relationship of perceived enclosure and width, clustered by height.

CHAPTER 5
RESULTS: SENSE OF COMFORT AND SENSE OF SAFETY

This chapter reports results from variance, association and regression statistical analysis for both dependent variables sense of comfort and sense of safety. Results of statistical analysis for the influence of both sets of independent variables on both dependent variables are presented. Influences of within-subjects independent variables of height, width, ratio and scale, are presented first, followed by influences of between-subjects independent variables of gender, age, design background, type of living area, height of buildings in living area, and width of streets in living area.

Relationship of Comfort and Safety

The relationship between sense of comfort and sense of safety will be reported first. Then, the influence of all independent variables on both dependent variables, sense of comfort and sense of safety, will follow. The latter will be presented in two folds; first, a descriptive overview pertaining to choices' responses, second, a thorough statistical analysis pertaining to rating's responses of each individual space.

The two dependent variables of comfort and safety were correlated using Spearman's rank correlation coefficient (rho). The test result revealed high positive correlation of the mean ranks of the two variables at (rho = 0.96, P = .000, n = 42), (Table 5-1), (Figure 5-1). Based on this finding, results for both dependent variables of comfort and safety will be reported together.

Choices Responses for Comfort and Safety

In choices' responses, participants were asked to select from a pool of 42 spaces the most comfortable 3 spaces, the least comfortable space, the safest 3 spaces, and the least safe space. It is important to note that this set of responses is only for frequency analysis and visual assessment, with no statistical tests. Responses for the 3 most comfortable spaces and 3 safest spaces were weighted, and a total aggregated response was obtained satisfying the formula [Choice 1 * 42) + (choice 2 * 41) + (choice 3 * 40)]. The respondents agreed that the most comfortable space was space (20, 40, 0.5), and space (30,30,1) was the safest space, the second most comfortable space was space (30,40,0.75) , and the second safest space was space (40,40,1). The third most comfortable space was space (40, 30, 1.33), and the third safest spaces was space (30, 20,1.5).

All three most comfortable and all three safest spaces belong to ratio range of (0.5 to 1.5), height range of (20 to 40), width range of (20 to 40), and small scale range of (400 to 1,600), (Table C-1). Space (120, 20, 6) was the least comfortable and the least safe space, followed by space (20, 130, 0.15), followed by space (780,130, 6). The first two most uncomfortable and unsafe spaces have the extreme ratio values of (6, 0.15), and the third most uncomfortable and unsafe space has the extreme scale value of (101,400 sq. ft), (Table C-2)

The relationships between ratio categories and the weighted frequencies of comfort and safety choices were visually investigated. The relationships were not linear; spaces with low or high ratios were the least frequently selected spaces as most comfortable and safest, while spaces with medium ratios were the most frequently selected spaces as most comfortable and safest. Ratios value of (3/4) received the highest frequencies as the most comfortable ratio, followed by ratio (1), on the other hand, spaces with ratio value of (1) received the highest frequencies as the safest ratio, followed by ratio (3/4) and (3/2), (Figure C-1).

The relationships between scale groups and weighted frequencies of comfort and safety choices were visually investigated. The relationships were not linear; spaces with scale range of (400 to 1,600) were the most frequently selected as most comfortable and safest. Spaces, larger than (1,600), were less frequently selected; the larger the space the less comfortable and the less safe it was, (Figure C-2).

Rating Responses for Comfort and Safety

A detailed analysis, including statistical tests, of the influence of within-subjects independent variables of height, width, ratio and scale, on comfort and safety responses will be presented first, followed by the influence of between-subjects independent variables of gender, age, design background, type of living area, height of buildings in living area, and width of streets in living area.

Comfort and Safety and within-Subject Variables: Height, Width, Ratio and Scale

Repeated measures: tests of variance

Friedman test was conducted four times to examine variance of both comfort and safety responses; for the 42 spaces, for the 9 spaces groups, for the 14 ratio categories, and for the 3 scale groups.

For the 42 spaces, Friedman tests were conducted to answer the question whether or not there was a difference in the sense of both comfort and safety scores across the 42 spaces. The tests results were significant ($P = 0.000$, $n = 83$, $df = 41$). The alternative hypothesis, H^1: there is a difference in both comfort and safety responses across the 42 spaces, was supported. Both highest comfort and safety mean ranks (32.77 and 30.88 respectively) were for space (40, 40, 1). The lowest comfort and safety mean ranks (10.3 and 11.79 respectively) were for space (120, 20, 6), (Table 5-2).

For the 9 groups of spaces; Friedman tests were used to know whether or not there was a difference in both comfort and safety scores across the 9 spaces groups. The tests results were significant ($P = 0.000$, $n = 83$, $df = 8$). The alternative hypothesis, H^1: there is a difference in both comfort and safety responses across the 9 space groups, was supported. The space group that received the highest comfort and safety mean ranks (6.92 and 6.6 respectively) was space group (Medium (H), Medium (W)). The lowest comfort and safety mean ranks (3.10 and 3.6 respectively) were for space group (High, Narrow), (Table 5-3).

For ratio categories, the tests results were significant (P = 0.000, n = 83, df = 13). The alternative hypothesis, H^1: there is a difference in both comfort and safety responses across the 14 ratio categories, was supported. High ratios of (5 and 6) and low ratios of (1/6 and 1/5) received the lowest mean ranks, while ratios of (3/4 and 1), in the middle received the highest comfort and safety mean ranks, (Table 5-4).

For scale groups, the test result was significant (P = 0.000, n = 83, df = 2). The alternative hypothesis, H^1: there is a difference in both comfort and safety responses across the 3 scale groups, was supported. Group scale (Medium) received the highest comfort and safety mean ranks (2.36 and 2.34 respectively). The lowest comfort and safety mean ranks (1.43 and 1.48 respectively) were received by the group scale (Large), (Table 5-5).

Ratio association

Both comfort and safety mean ranks were correlated with ratio under the assumption of linear relationships, the result was a significant low negative correlation at rho = -0.31 for comfort, and an insignificant negative correlation at rho = -0.49 for safety. However, the relationships of ratio with both comfort and safety were found to be not linear. The ratio (3/4) was found to be the cut point about which both relationships behaved differently, (Figure 5-2). Spearman's correlation tests were conducted selecting only values of ratio (≤ 3/4), there was statistically significant high positive correlation between ratio and both comfort and safety at rho = +0.92 (n = (12*83)).On the higher side of the ratio range (R≥3/4), high statistically significant negative correlations were found at (rho = -0.84) for comfort, and at rho = -0.85 for safety (n = (30*83)), (Table 5-6).

Scale association

Scale relationship with both comfort and safety was found to better be analyzed if values of ratio were controlled. Scale across all variations of ratio was not efficient, because ratio superseded scale relative to comfort and safety. A group of 19 spaces were selected that satisfy the condition (0.5 <= R<=2), to isolate the ratio effect as much as possible. With such selected spaces, scale was found to have a non-linear relationship with comfort and safety, (Figure 5-3). It is important to note that, even with this selection of the 19 spaces, there was still an influence of ratio.

Both comfort and safety mean ranks were correlated with scale for the 19 spaces, still the results were statistically insignificant negative correlation at rho = -.244 for comfort and at rho = - 0.240 for safety (*n* = 19*83). However, when the test was conducted after selecting only values of scale (≤1,600), which is the value of scale that received the highest mean ranks of comfort (32.8) and safety (30.9), there were statistically significant positive correlations at rho = 0.77 for comfort, and at rho = 0.66 for safety (*n* = (10*83)). On the higher side of the scale range (≥1,600), statistically significant negative correlations were found at rho = -0.75 for comfort, and t rho = -0.78 for safety (*n* = (10*83)), (Table 5-7).

Height association

There were statistically significant low negative correlations at rho = -0.334 (P= 0.03, *n* = (42*83)) between height and comfort, and at rho = -0.46 (P = 0.002, *n* = 42) between height and safety. When the correlation was conducted for spaces with widths (≤ 40 ft), the results were higher negative correlations at rho = -0.66 (P= 0.001, *n* = (22*83)) with comfort and at rho = - 0.68 (P = 0.000, *n* = 22*83) with safety. Comfort and safety correlations with height for spaces with width values (> 40 ft) were statistically insignificant, (Table 5-8), (Figure 5-4).

Width association

There were no statistically significant correlations between both comfort and safety with width in general. When the correlations were conducted for spaces with heights (<60 ft), a negative correlation at rho = -0.585 ($P = 0.03$, $n = (19*83)$) resulted with comfort, however, there was still no significant correlation with safety. The correlation of both comfort and safety with width for spaces with height values (≥ 60 ft) were not statistically significant, (Table 5-9), (Figure 5-5).

Regression analysis

Both dependent variables comfort and safety were recoded into binary values of 0 and 1; where 0 represents the absence of comfort or safety, and 1 represent the existence of comfort or safety. Comfort and safety scores of 1 and 2 were recoded into 0, scores of 5 and 6 were recoded into 1, while scores of 3 and 4 were not included. The probability of a space being comfortable or not, and safe or not, falls between 0 and 1, for all possible values of the independent variables (Agresti & Finlay, 1997).The total number of selected cases was 1803 for comfort and 1795 for safety. It is important to note that this reduction in cases had no impact on the distribution of scores across all levels of independent variables.

Ratio, scale, height, and width variables were all fitted in a logistic regression model to predict sense of comfort and safety Ratio and width alone were able to estimate 63.3% of responses, which is only 1% lower than the complete model, so it was decided to use them alone in the final model. It is important to state here that height and scale are still present in this analysis, because for each combination of ratio and one width, there is only one height and one scale values, e.g., for a ratio value of 1, combined with a width of 20 ft, the only possible values of height is 20 ft, and the only possible value of scale is 400 sq. ft.

Unlike the relationship with perceived enclosure, ratio and width relationships with comfort and safety are not linear; which means that transformations for values of ratio and width should take place before fitting them together in the final model, (Eq. 5-1), (Eq. 5-2), (Eq. 5-3), and (Eq. 5-4).

$$Y_{(Comfort)} = -0.2218 + 0.3265R - 0.0281R^2 + .0005R^3 \tag{5-1}$$

$$Y_{(Comfort)} = 0.4633 + 0.0995W - 0.0085W^2 \tag{5-2}$$

$$Y_{(Safety)} = 0.0407 + 0.2799R - 0.0273^2 + .0007R^3 \tag{5-3}$$

$$Y_{(Safety)} = 0.4347 + 0.1157W - 0.0088W^2 \tag{5-4}$$

Transformed ratio value, R_t, and transformed width value, W_t, were fitted in the regression models. The models were significant, and were able to estimate 74.88% of participants' comfort responses, and 71.36% of participants' safety responses correctly, (Table 5-10) and (Table 5-11).

The probability that a space of ratio (R) and width (W) will be perceived as comfortable or not, can be calculated using the constant and the *B* values reported in the regression model, (Eq.5-5). The probability that a space of ratio (R) and width (W) will be perceived as safe or not, can be calculated using the constant and the *B* values reported in the regression model for safety, (Eq. 5-6). If, for example, a space has a ratio of 1, and a width of 20 feet, then $P_{(Comfort)} = .8337$, and $P_{(Safety)} = .8197$. A calculator was created where ratio and width values can be entered and probabilities of comfort and safety can be obtained, (Object 5-1).

$$P_{(comfort)} = \frac{1}{1 + e^{-(-3.5334 + 4.0027 * Rt + 2.7887 * Wt)}} \tag{5-5}$$

$$P_{(Safety)} = \frac{1}{1 + e^{-(-4.7196 + 4.9733 * Rt + 2.8563 * Wt)}} \tag{5-6}$$

The thresholds for comfort and safety probabilities were calculated at fixed width value of 40 ft. The ratio values (<1/4) and (>4) have probabilities (<0.50) of being comfortable, and the ratio values range of (<1/4) and (>7) have probabilities (<0.50) of being safe. It is important to note that spaces have wider span of being safe than being comfortable. In other words, at fixed width of 40 ft, ratio values in the range of (5 to 7) are felt safe but not comfortable based on the approximate curve estimations and regression model.

Comfort and Safety with between-Subject Variables: Gender, Age, Design Background, Type of living area, Height of buildings in living area, and Width of streets in living area.

The 3 ratio categories and the 3 scale groups were used to examine differences among comfort and safety scores of the between-subjects variables.

Gender

Mann-Whitney U test was conducted to examine the difference in both comfort and safety responses of men and women. For the 3 ratio categories, although the mean ranks suggested that women felt less comfortable and less safe with both high and low ratios, and more comfortable and safer with medium ratios than men, the tests results revealed no statistical significant difference. The null hypothesis, H°: women and men have the same sense of both comfort and safety across the 3 ratio categories, could not be rejected, (Table D-1), (Figure D-1).

For the 3 scale category, there was a statistically significant difference between both comfort and safety scores of men and women for the scale group (Large) at ($\alpha = 0.01$, $n = 83$); with higher men's comfort mean rank of (47.2) and safety mean rank of (47.01) than women's comfort mean rank of (32.8), and safety mean rank of (33.15). Moreover, there was a statistically significant difference between safety scores of men and women for group (Small) at ($\alpha = 0.01$, $n = 83$). Men's safety mean rank for group (Small) (37.6) was lower than women's safety mean rank (49.77). The alternative hypothesis, H^1: women and men have different sense of comfort and different sense of safety across the 3 scale groups, was supported, (Table D-2), (Figure D-2).

However, the correlation between comfort scores of men and women, for the 42 spaces, was at rho = .84, (P = .000, n = 42), while the correlation between safety scores of men and women, for the 42 spaces, was at rho = .74, (P = .000, n = 42). This indicated a reasonably high degree of consensus between men and women comfort and safety responses in general.

Age

Kruskal-Wallis test was conducted to examine the differences in both comfort and safety responses of the three age groups. For the 3 ratio categories, there was a statistically significant difference between comfort scores of the 3 age groups for the ratio category (1/2 to 2) at (α = 0.01, n = 83); with lower comfort mean ranks of the younger group than the older two groups. The alternative hypothesis, H^1: the 3 age groups have different sense of comfort across the 3 ratio categories, was supported. For safety responses, the test result was statistically insignificant. The null hypothesis, H°: the three age groups have the same sense of safety across all ratio categories, was not rejected, (Table D-3), (Figure D-3).

For scale groups, there was statistically significant differences between both comfort and safety scores of 3 age groups for the scale group (Small) at (α = 0.05, n = 83); with lower comfort and safety mean ranks for the younger group than the two older groups. The alternative hypothesis, H^1: the 3 age groups have different sense of comfort and different sense of safety across the 3 scale groups, was supported, (Table D-4), (Figure D-4).

The range of correlations between comfort scores of the 3 age groups, for the 42 spaces, was at rho = .71 to .93, (P = .000, n = 42). The range of correlations between safety scores of the 3 age groups, for the 42 spaces, was at rho = .75 to .86, (P = .000, n = 42). The lower correlation was for youngest with oldest. This indicated a reasonably high degree of consensus between age groups' comfort and safety responses.

Design background

A Mann-Whitney U test was conducted to examine the variance in both comfort and safety responses of designers and non designers. For the 3 ratio categories, there was a statistically significant difference between both comfort and safety scores of designers and non designers for the ratio category (3 to 6) at ($\alpha = 0.01$, $n = 83$). The comfort and safety mean ranks of non designers were lower than those of designers. For ratio category (1/6 to 1/3) there was a statistically significant difference, ($\alpha = 0.05$, $n = 83$), between designers and non designers scores of comfort only. The comfort mean rank for non designers was higher than the comfort mean rank of designers. The alternative hypothesis, H^1: designers and non designers have different sense of comfort and different sense of safety across the 3 ratio categories), was supported, (Table D-5), (Figure D-5).

For scale groups, there was no statistical evidence of any significant difference in both comfort and safety scores of designers and non designers for the three scale groups. The null hypothesis, H°: design background does not influence sense of comfort nor does it influence sense of safety for 3 scale groups, was not rejected, (Table D-6), (Figure D-6). The correlation between comfort scores of designers and non designers, for the 42 spaces, was at rho = .79, ($P = .000$, $n = 42$). The correlation between safety scores of designers and non designers, for the 42 spaces, was at rho = .69, ($P = .000$, $n = 42$), this indicated a reasonably high degree of consensus between design background groups' comfort and safety response.

Type of living area

Kruskal-Wallis test was conducted to examine the difference in both comfort and safety responses relative to the inhabitants of the three types of living area; urban, suburban and rural.

For the 3 ratio categories, there was a statistically significant difference between comfort scores of three types of living area for the two smaller ratio categories (1/6 to 1/3) and (1/2 to 2) at (α = 0.05, n = 81). For the ratio category (1/6 to 1/3), the comfort mean rank was higher for “rural” than “suburban” and “urban”, the difference between “urban” and “suburban” was not significant. For the ratio category (1/2 to 2), the opposite was true, the comfort mean rank for “rural” was lower than “suburban”, which is in turn lower than “urban”. The alternative hypothesis, H^1: inhabitants of the three types of area have different sense of comfort across ratio categories, was supported. For safety, although safety mean ranks suggested that inhabitants of rural areas feel safer with smaller ratios than those of urban and suburban areas, the difference was not strong enough and the test result was insignificant,(Table D-7), (Figure D-7).

For the 3 scale category, there were statistically significant differences between both comfort and safety scores of inhabitants of the three types of areas of living for the scale group (Small) at (α = 0.05, n = 81); with higher comfort and safety mean ranks for “urban”, than “suburban”, and higher comfort and safety mean ranks for “suburban” than “rural”. The alternative hypothesis, H^1: inhabitants of the three types of living area have different sense of comfort and different sense of safety across the 3 scale groups, was supported, (Table D-8), (Figure D-8).

The range of correlations between comfort scores of inhabitants of the 3 types of living area, for the 42 spaces, was at rho = .53 to .92 (P = .000, n = 42). The range of correlations between safety scores of them, for the 42 spaces, was at rho = .47 to .93), (P = .000, n = 42). Low correlations for both comfort and safety scores were for “rural” with both “urban” and “suburban”, while high correlations were for “urban” and “suburban”. This indicated a low degree of consensus between comfort and safety responses of groups of area of living.

Height of buildings in living area

The dependent variable “height of buildings in the living area” was recoded into 4 categories “1 to 2 floors”, “3 to 4 floors”, “ 5 to 6 floors”, and “>6 floors”. This variable was analyzed using the scale groups and the simulated heights. For scale groups, there was no significant difference between comfort and safety scores of inhabitants of areas of all four levels of “height of building in the living area”. The null hypothesis, H°: inhabitants of areas with different heights of buildings have similar sense of comfort and similar sense of safety across the 3 scale groups, was not rejected, (Table D-9), (Figure D-9).

For the simulated heights, and relative to the 4 levels of height of buildings in the living area, a statistically significant difference in comfort scores was found only at heights (≥ 60). At the simulated height (≥60), the comfort mean rank of participant who lived in areas with buildings (>6 floors) was higher than those with buildings heights (< 6 floors). The alternative hypothesis (H^1: Height of buildings, that people are accustomed to, influences sense of comfort at different simulated heights. The null hypothesis, H°: height of buildings, that people are accustomed to, does not influence sense of safety at all simulated height levels, was not rejected, (Table D-10), (Figure D-10).

The correlation between comfort scores of inhabitants of areas that have different heights of buildings, for the 42 spaces, was at rho = .80to .91 (P = .000, *n* = 42). The correlation between safety scores of inhabitants of areas that have different heights of buildings, for the 42 spaces, was at rho = .71 to .91) (P = .000, *n* = 42). This indicated a reasonably high degree of consensus in comfort and safety responses regardless of the height of buildings in living area.

Width of streets in living area

The variable “width of streets in the living area” was recoded into 3 categories “1 to 2 lanes”, “3 to 4 lanes, and “>4 lanes. This variable was analyzed using the scale groups and the simulated widths. For scale groups, there was no significant difference between both comfort and safety scores relative to the three levels of the independent variable “width of streets in the living area”. The null hypothesis, H°: width of streets, that people are accustomed to, does not influence sense of comfort and does not influence sense of safety across the 3 scale levels, was not rejected, (Table D-11), (Figure D-11).

Kruskal-Wallis test revealed no significant differences between both comfort and safety scores, relative to the 3 levels of width of streets in the living area, at all simulated width levels. The null hypothesis, H°: width of streets, that people are accustomed to, does not influence sense of comfort and does not influence sense of safety at all simulated width levels, was not rejected, (Table D-12), (Figure D-12).

The range of correlations between comfort scores of inhabitants of areas that have the 3 widths of streets, for the 42 spaces, was at rho = .79 to .97 (P = .000, n = 42). The range of correlations between safety scores of inhabitants of areas that have the 3 widths of streets, for the 42 spaces, was at rho = .75 to .91) (P = .000, n = 42). This indicated a reasonably high degree of consensus in comfort and safety responses regardless of the width of streets in living area.

Comfort and Safety with Perceived Enclosure

Perceived enclosure was used in chapter 4 as a dependent variable, in this section it will be treated as a predictor for comfort and safety. The purpose of this swapping is, first, to examine the notion, stated in literature, that it is possible to replace the variable perceived enclosure, which is from the cognitive model, by the variables ratio and width, which are from the psychophysical model, which means less interpretative power is given to participants. Second, to create a connection with some empirical work that is already done in this field that had only used “perceived enclosure”; this point will be explained more in chapter 6.

Since perceive enclosure had a high positive correlation with ratio (rho = 0.840), and relatively high negative correlation with width (rho = - 0.677), it was expected to have the same predicting capacity of sense of comfort and safety that ratio and width had. The relationship between perceived enclosure and both sense of comfort and sense of safety is not linear, (Figure 5-6). Perceived enclosure was correlated with both sense of comfort and sense of safety. No significant correlation with comfort, and negative weak correlation with safety was found (rho = -0.394). Correlations were then conducted about the ratio value of (3/4). There was statistically significant high positive correlation between perceived enclosure with comfort (rho = 0.896), and with safety (rho = 0.890) for ratio values (≤3/4), and statistically significant negative correlation with comfort (rho = -0.620), and with safety (rho = -0.625) for ratio values (>3/4), (Table 5-12). Below the ratio value of (3/4) both sense of comfort and sense of safety increase as perceived enclosure increase, and above ratio value of (3/4), both sense of comfort and sense of safety decrease as perceived enclosures increase. Curve estimations were conducted to approximate the relationships of both comfort and safety with perceived enclosure, (Eq. 5-7), (Eq. 5-8).

$$Y_{(Comfort)} = 7.2863 + 1.9435 * \mathrm{E_P} - .0507\,\mathrm{E_P}^2 \tag{5-7}$$

$$Y_{(Safety)} = 13.2918 + 1.3261 * \mathrm{E_P} - .0373\,\mathrm{E_P}^2 \tag{5-8}$$

Summary

Sense of comfort for different enclosure degrees is very similar to sense of safety; they correlated at rho = 0.96. Ratio influences senses of comfort and safety in urban streets spaces. Urban street spaces with ratios of (3/4 and 1) evoke the highest sense of comfort and safety, while streets with high ratios of (5 and 6) and low ratios of (1/6 and 1/5) evoke the least sense of comfort and the least sense of safety. Urban streets with ratio value of (3/4) have the highest sense of comfort and safety. Sense of comfort and safety increases as ratio increases, until ratio value of (3/4), above that, sense of comfort and safety decreases as ratio increases.

Scale influences senses of comfort and safety in urban street spaces. Providing that urban street spaces have ratios within the range of (1/2 to 2), sense of comfort and safety increases as scale increases until scale value of (1,600) square feet, above that, sense of comfort and safety decreases. Outside the ratio range of (1/2 to 2); the ratio effect starts to strongly influence sense of comfort and safety and to supercede scale. The probability that a space of certain values of ratio and width will be perceived as comfortable or not and safe or not, can be calculated using comfort and safety probabilities, (Eq. 5-5) and (Eq. 5-6)

Women and men have a consensus at rho = .84 for sense of comfort and at rho = .74 for sense of safety for urban street spaces. The difference between them is that women feel more comfortable and safer in small spaces than men, and the opposite is true. Age groups have a consensus at rho = .71 to .93 for comfort, and at rho = .75 to .86 for safety. The difference between them is that across different ratios and scale of urban street spaces, older people (>24) feel more comfortable with ratios in the range of (1/2 to 2) and scales (≤1,600) than younger people (<24).

Designers and non designers have a consensus at rho = .79 for comfort and at rho = .69 for safety. The difference between them is that designers feel more comfortable and safer with higher ratios in the range of 3 to 6 than non designers. Non designers feel more comfortable with lower ratios in the range of 1/6 to 1/3 than designers.

Inhabitants of the 3 types of living area, urban, suburban and rural, have a consensus at rho = .53 to .92 for comfort and at rho = .47 to .93 for safety. The difference between them is that inhabitants of urban areas feel more comfortable with higher ratios than those of suburban and rural areas, while inhabitants of rural areas feel more comfortable with lower ratios than inhabitants of urban and suburban areas. Inhabitants of urban and suburban areas feel more comfortable and safer with smaller spaces than those of rural areas, and the opposite is true. Sense of safety, on the other hand, is not influenced by the type of living area. Inhabitants of urban, suburban and rural areas have the same sense of safety across all ratios of urban street spaces.

Inhabitants of areas with different heights have a consensus at rho = .80 to .91 for comfort and at rho = .71 to .91 for safety. The difference between them is that people who are accustomed to higher buildings, (<6 floors), feel more comfortable with higher buildings, in general, than those who are not. Inhabitants of areas with different streets widths have a consensus of at rho = .79 to .97 for comfort and at rho = .75 to .91 for safety.

Perceived enclosure predicts sense of comfort and safety in the same manner that ratio does. Perceived enclosure correlates positively with both sense of comfort at rho = 0.896 and sense of safety at rho = 0.890 for ratio values (<3/4), and negatively with sense of comfort at rho = -0.620 and sense of safety at rho = -0.625 for ratio values (>3/4).

To further summarize, ratio and scale of urban street spaces influence sense of comfort and safety; sense of comfort and safety is the highest in spaces with ratios closer to the value of (3/4), and with scales closer to the value of 1,600 sq. ft. Most demographic differences have smaller influences on sense of comfort and safety relative to stimuli differences. Gender, age, design background, height of buildings, and width of streets have a relatively high consensus among them; generally at rho >0.7, type of living area exhibited lower consensus levels, e.g., at rho = 0.47, (Table 5-13).

Table 5-1. Correlation of sense of comfort and sense of safety.

			Safety
Spearman's rho	Comfort	rho	0.960**
		Sig. (2-tailed)	0.000
		N	42

**Correlation is significant at the .01 level (2-tailed).

Table 5-2. Friedman test of repeated measures of comfort and safety scores across 42 spaces.

Spaces sorted by comfort MR	Comfort MR	Spaces sorted by safety MR	Safety MR	Friedman tests	
Space(40,40,1)	32.77	Space(40,40,1)	30.88	Comfort	
Space(30,40,0.75)	31.36	Space(30,30,1)	30.33	Test statistics	
Space(30,30,1)	31.21	Space(30,40,0.75)	29.85	N	83
Space(60,40,1.5)	29.96	Space(20,40,0.5)	29.05	Chi-Square	902.591
Space(40,30,1.33)	29.31	Space(20,30,0.67)	28.20	df	41
Space(20,30,0.67)	29.05	Space(40,30,1.33)	27.80	Asymp.Sig.	0.000
Space(20,40,0.5)	27.99	Space(60,40,1.5)	27.48		
Space(60,60,1)	26.72	Space(40,60,0.67)	26.80	Safety	
Space(60,30,2)	26.58	Space(60,60,1)	26.69	Test statistics[a]	
Space(40,60,0.67)	25.50	Space(30,60,0.5)	25.42	N	83
Space(30,60,0.5)	25.37	Space(60,30,2)	24.87	Chi-Square	567.839
Space(20,20,1)	24.40	Space(20,20,1)	23.60	df	41
Space(30,20,1.5)	24.18	Space(60,90,0.67)	23.33	Asymp.Sig.	0.000
Space(180,40,4.5)	23.99	Space(260,60,4.33)	22.61	[a]Friedman test	
Space(120,40,3)	23.86	Space(40,90,0.44)	22.55		
Space(60,90,0.67)	23.81	Space(120,40,3)	22.52		
Space(260,60,4.33)	23.45	Space(20,20,1)	22.44		
Space(20,20,1)	23.32	Space(180,40,4.5)	22.37		
Space(160,60,2.67)	22.81	Space(160,60,2.67)	22.32		
Space(220,90,2.44)	21.80	Space(20,60,0.33)	21.81		
Space(40,20,2)	21.36	Space(30,90,0.33)	21.60		
Space(40,90,0.44)	20.84	Space(30,20,1.5)	20.78		
Space(360,60,6)	20.83	Space(40,20,2)	20.49		
Space(380,90,4.22)	20.81	Space(220,90,2.44)	20.33		
Space(20,60,0.33)	20.28	Space(100,30,3.33)	19.76		
Space(30,90,0.33)	20.11	Space(360,60,6)	19.70		
Space(60,20,3)	20.02	Space(300,130,2.31)	19.30		
Space(300,130,2.31)	19.37	Space(60,20,3)	19.07		
Space(100,30,3.33)	18.83	Space(380,90,4.22)	19.04		
Space(780,130,6)	17.98	Space(40,130,0.31)	18.95		
Space(80,20,4)	17.11	Space(30,130,0.23)	18.14		
Space(540,130,4.15)	16.55	Space(20,90,0.22)	17.61		
Space(140,30,4.67)	16.51	Space(540,130,4.15)	17.55		
Space(30,130,0.23)	15.99	Space(140,30,4.67)	17.25		
Space(40,130,0.31)	15.80	Space(780,130,6)	17.02		
Space(180,30,6)	15.25	Space(80,20,4)	16.80		
Space(540,90,6)	15.19	Space(20,130,0.15)	16.20		
Space(240,40,6)	14.32	Space(540,90,6)	15.89		
Space(20,130,0.15)	13.53	Space(180,30,6)	15.62		
Space(20,90,0.22)	13.23	Space(240,40,6)	14.90		
Space(100,20,5)	11.36	Space(100,20,5)	14.30		
Space(120,20,6)	10.29	Space(120,20,6)	11.79		

Table 5-3. Friedman test of repeated measures for comfort and safety scores across 9 groups of spaces.

Group	Comfort	Group	Safety
Group(Medium(H), Medium(W))	6.92	Group(Medium(H), Medium(W))	6.60
Group(Low, Medium(W))	6.29	Group(Low, Medium(W)	6.28
Group(Low, Narrow)	6.28	Group(Low, Narrow)	5.87
Group(Medium(H), Narrow)	5.79	Group(Medium(H), Narrow)	5.27
Group(High, Medium(W))	4.95	Group(Medium(H), Wide)	4.87
Group(Medium(H), Wide)	4.51	Group(High, Medium(W))	4.58
Group(High, Wide)	3.98	Group(High, Wide)	4.01
Group(Low, Wide)	3.19	Group(Low, Wide)	3.92
Group(High, Narrow)	3.10	Group(High, Narrow)	3.60

	Comfort Test statistics[a]		Safety Test statistics[a]	
	N	83	N	83
	Chi-Square	187.201	Chi-Square	114.317
	df	8	df	8
	Asymp. Sig.	0.000	Asymp. Sig.	0.000

[a]Friedman test.

Table 5-4. Friedman test of repeated measures for comfort and safety scores across 14 ratio categories.

Ratio	Comfort	Ratio	Safety
3/4	11.67	3/4	10.86
1	10.25	2/3	9.57
3/2	9.76	1	9.57
2/3	9.61	1/2	9.17
1/2	9.20	3/2	8.95
2	8.37	2	7.67
4	7.37	1/3	7.30
3	7.31	3	6.87
1/3	6.64	4	6.64
1/4	5.67	1/4	6.45
6	5.01	1/5	6.28
1/6	4.83	1/6	5.53
1/5	4.75	5	5.22
5	4.55	6	4.91

	Comfort Test statistics[a]		Safety Test statistics[a]	
	N	83	N	83
	Chi-Square	347.826	Chi-Square	215.525
	df	13	df	13
	Asymp. Sig.	0.000	Asymp. Sig.	0.000

[a]Friedman test.

Table 5-5. Friedman test of repeated measures for comfort and safety scores across 3 scale groups

Scale group	Comfort		Safety	
Meduim	2.36		2.34	
Small	2.21		2.18	
Large	1.43		1.48	
	Comfort Test statistics[a]		Safety Test statistics[a]	
	N	83	N	83
	Chi-Square	42.226	Chi-Square	35.837
	df	2	df	2
	Asymp. Sig.	0.000	Asymp. Sig.	0.000

[a]Friedman test.

Table 5-6. Ratio correlations.

Spearman's rho		Ratio				
		All values	R<3/4	R≤3/4	R>3/4	R≥3/4
Comfort	rho	−0.308*	0.893**	0.916**	−0.826**	−0.842**
	Sig. (2-tailed)	0.470	0.000	0.000	0.000	0.000
	N	42	12	13	29	30
Safety	rho	−0.485**	0.893**	0.916**	−0.835**	−0.849**
	Sig. (2-tailed)	0.001	0.000	0.000	0.000	0.000
	N	42	12	13	29	30

*Correlation is significant at the .05 level (2-tailed).
** Correlation is significant at the .01 level (2-tailed).

Table 5-7. Scale correlations.

Spearman's rho		Scale at ratio values = 1/2 to 2		
		All values	Sc≤1600	Sc≥1600
Comfort	rho	−0.244	0.773**	−0.746*
	Sig. (2-tailed)	0.315	0.009	0.013
	N	19	10	10
Safety	rho	−0.240	0.656**	0.777**
	Sig. (2-tailed)	0.322	0.039	0.008
	N	19	10	10

*Correlation is significant at the .05 level (2-tailed).
**Correlation is significant at the .01 level (2-tailed).

Table 5-8. Height correlations.

Spearman's rho		Height		
		All values	Width ≤ 40	Width > 40
Comfort	rho	−0.334*	−0.660**	−0.140*
	Sig. (2-tailed)	0.03	0.001	0.482
	N	42	22	27
Safety	rho	−0.460**	−0.680**	−0.231
	Sig. (2-tailed)	0.002	0.000	0.328
	N	42	22	27

*Correlation is significant at the .05 level (2-tailed).
** Correlation is significant at the .01 level (2-tailed).

Table 5-9. Width correlations.

Spearman's rho		Width		
		All values	Height<60	Height ≥ 60
Comfort	rho	−0.224	−0.585*	0.221
	Sig. (2-tailed)	0.154	0.030	0.523
	N	42	19	23
Safety	rho	−0.130	−0.440	0.240
	Sig. (2-tailed)	0.412	0.059	0.269
	N	42	19	23

*Correlation is significant at the .05 level (2-tailed).

Table 5-10. Logistic regression model for comfort

Logistic regression model			
-2 Log Likelihood Goodness of Fit	1922.306 1801.291	Cox & Snell - R^2 Nagelkerke - R^2	0.214 0.214
	Chi-Square	df	Significance
Model Block Step	433.828 433.828 433.828	2 2 2	0.000 0.000 0.000

Classification for comfort; the cut value is 0.50				
		Predicted		
		0	1	
Observed		0	1	Percent Correct
0	0	365	284	56.24%
1	1	169	985	85.36%
			Overall	74.88%

Variables in the equation							
Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
Ratio_t	4.0027	0.2465	263.7764	1	0.000	0.333	54.7470
Width_t	2.7887	0.4134	45.5070	1	0.000	0.136	16.2601
Constant	−3.5334	0.2891	149.4154	1	0.000		

Table 5-11. Logistic regression model for safety

Logistic regression model			
-2 Log Likelihood Goodness of Fit	1941.099 1761.822	Cox & Snell - R^2 Nagelkerke - R^2	0.152 0.152
	Chi-Square	df	Significance
Model Block Step	294.964 294.964 294.964	2 2 2	0.000 0.000 0.000

Classification for safety; the cut value is 0.50				
		Predicted		
		0	1	
Observed		0	1	Percent Correct
0	0	195	370	34.51%
1	1	144	1086	88.29%
			Overall	71.36%

Variables in the equation							
Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
Ratio_t	4.9733	0.384	167.5800	1	0.000	0.2721	144.4980
Width_t	2.8563	0.468	37.3095	1	0.000	0.1257	17.3966
Constant	−4.7196	0.386	149.5934	1	0.000		

Table 5-12. Correlations of perceived enclosure with sense of comfort and safety.

Spearman's rho		Perceived enclosure All values	R ≤ 3/4	R > 3/4
Comfort	rho	−0.226	0.896**	−0.620**
	Sig. (2-tailed)	0.151	0.000	0.000
	N	42	13	29
Safety	rho	−0.394**	0.890**	−0.625**
	Sig. (2-tailed)	0.010	0.000	0.000
	N	42	13	29

**Correlation is significant at the .01 level (2-tailed).

Table 5-13. Influences of independent variables on dependent variables

	Comfort		Safety	
Height	W = all W ≤ 40 ft W > 40 ft	rho = −0.33 rho = −0.66 No influence	W = all W≤ 40 ft W> 40 ft	rho = −0.46 rho = −0.68 No influence
Width	H = all H < 60 ft H > 60 ft	no influence rho = −0.585 No influence	H = all H < 60 ft No influence	No influence No influence No influence
Ratio	R = all R ≤ ¾ R ≥ ¾	rho = −0.31 rho = 0.92 rho = −0.84	R = all R ≤ ¾ R ≥ ¾	rho = −0.49 rho = 0.92 rho = −0.85
Scale at (0.5 ≤ R ≤ 2)	Sc = all Sc≤ 1600 Sc> 1600	No influence rho = 0.77 rho = −0.75	Sc = all Sc≤ 1600 Sc> 1600	No influence rho = 0.66 rho = −0.78
	Comfort		Safety	
	Ratio	Scale	Ratio	Scale
Gender	No influence	Women felt less comfortable with large spaces than men.	No influence	Men felt safer in large spaces than women, and women felt safer in small spaces than men
	rho = 0.84		rho = 0.74	
Age	Older people felt more comfortable with medium ratios than younger people	Older people felt more comfortable with smaller spaces than younger people	No influence	Older people felt safer in small spaces than younger people
	rho = 0.71 to 0.93		rho =0 .75 to 0.86	

Table 5-13. Continued.

	Comfort		Safety	
Design background	Designers felt more comfortable with higher ratios than non designers, non designers felt more comfortable with lower ratios than designers	No influence	Designers felt safer with higher ratios than non designers	No influence
	rho = 0.79		rho = 0.69	
Living area	Inhabitants of rural areas felt more comfortable with lower ratios, inhabitants of urban areas felt more comfortable with higher ratios than suburban and rural	Inhabitants of urban areas felt more comfortable with smaller spaces than inhabitants of suburban areas, while inhabitants of rural areas felt the least comfortable	No influence	Inhabitants of urban areas felt safer with smaller spaces than inhabitants of suburban areas, and inhabitants of rural areas felt the least safe
	rho = 0.53 to 0.92		rho = 0.47 to 0.93	
	Comfort		Safety	
	Simulated height	Scale	Simulated height	Scale
Height of buildings in living area	Inhabitants of buildings >6 floors felt more comfortable with simulated heights ≥ 60 ft than others	No influence	No influence	No influence
	rho = 0.8 to 0.91		rho = 0.7 to 0.91	
	Simulated width	Scale	Simulated width	Scale
Width of streets in living area	No influence	No influence	No influence	No influence
	rho = 0.79 to 0.97		rho = 0.75 to 0.91	

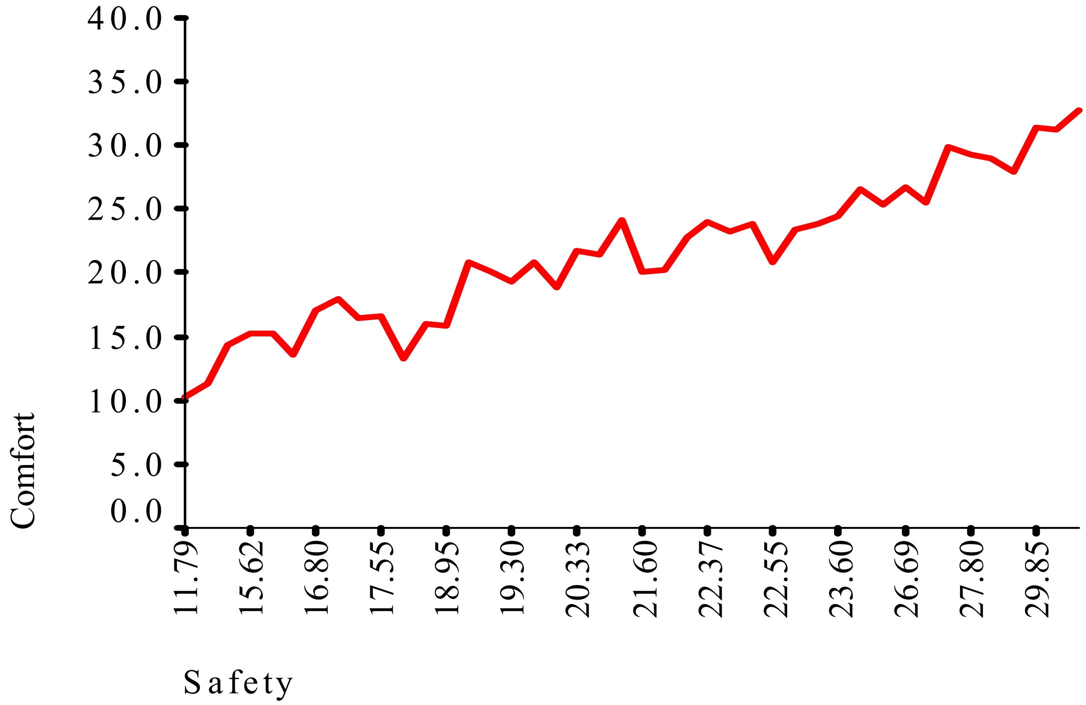


Figure 5-1. Relationship of sense of comfort and safety.

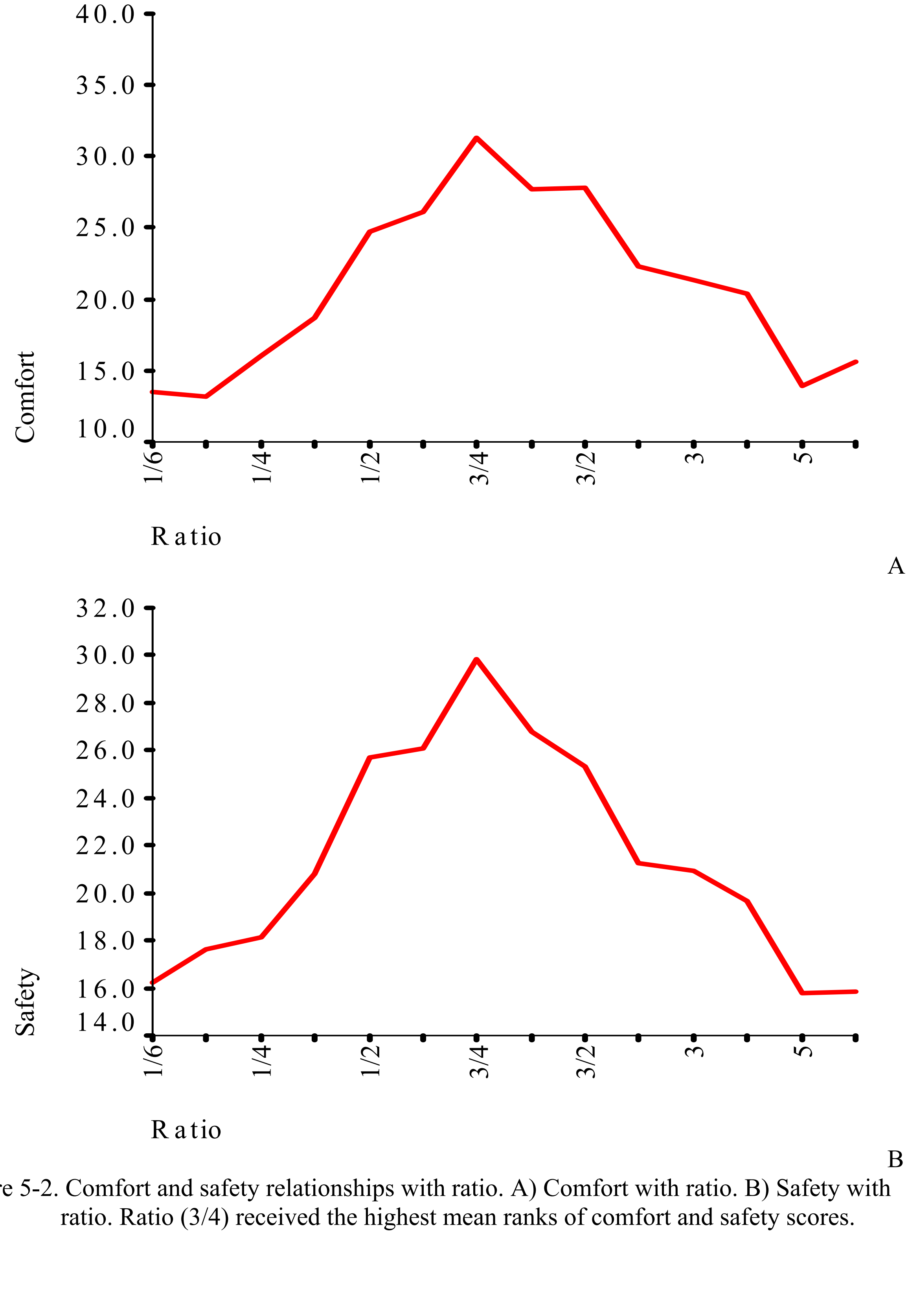
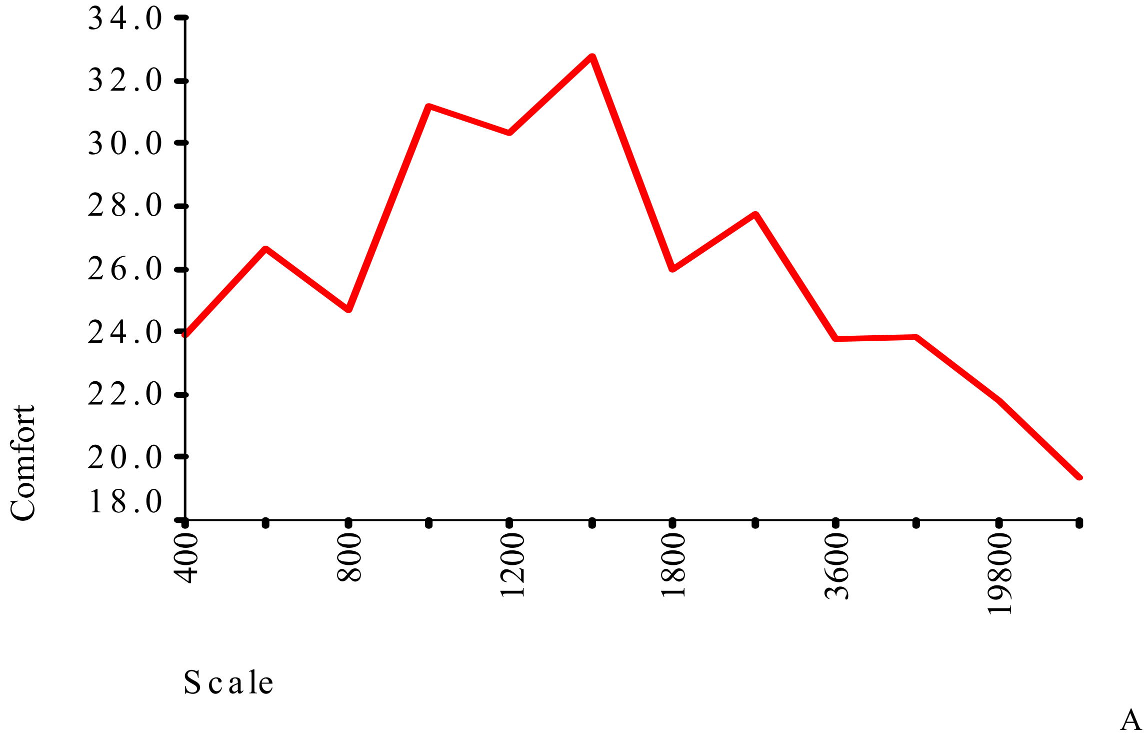


Figure 5-2. Comfort and safety relationships with ratio. A) Comfort with ratio. B) Safety with ratio. Ratio (3/4) received the highest mean ranks of comfort and safety scores.



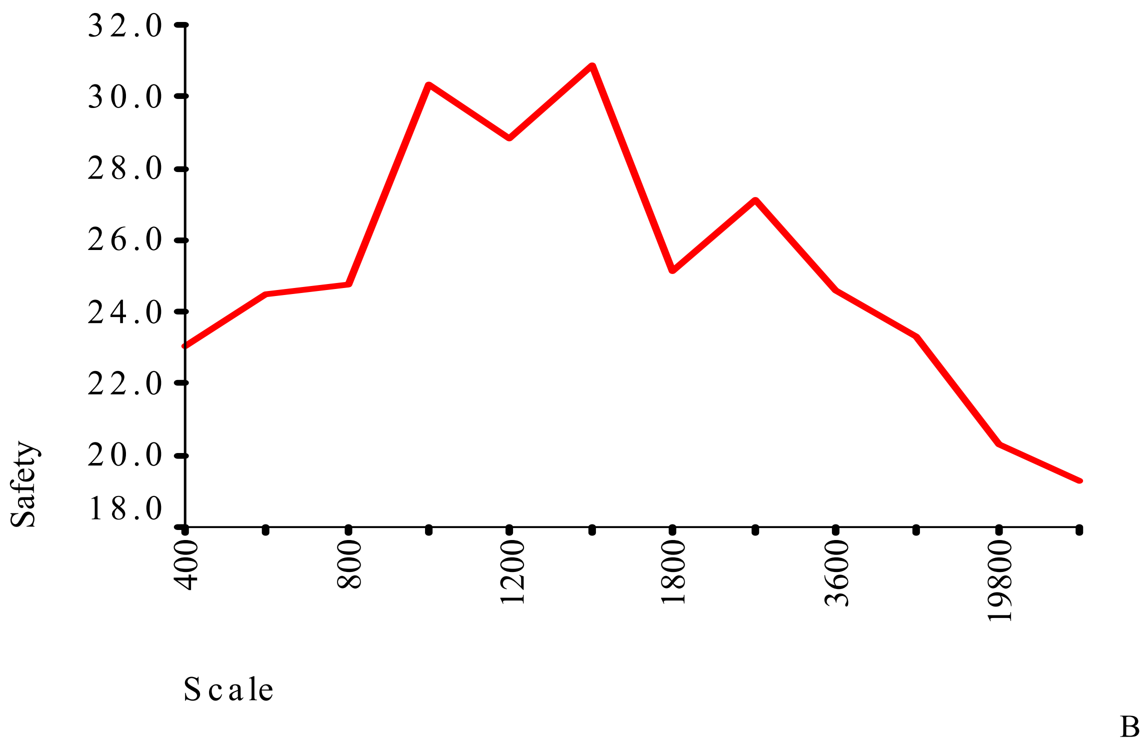


Figure 5-3. Comfort and safety relationship with scale, for ratio values in the range of (0.5 to 2). A) Comfort with scale. B) Safety with scale.

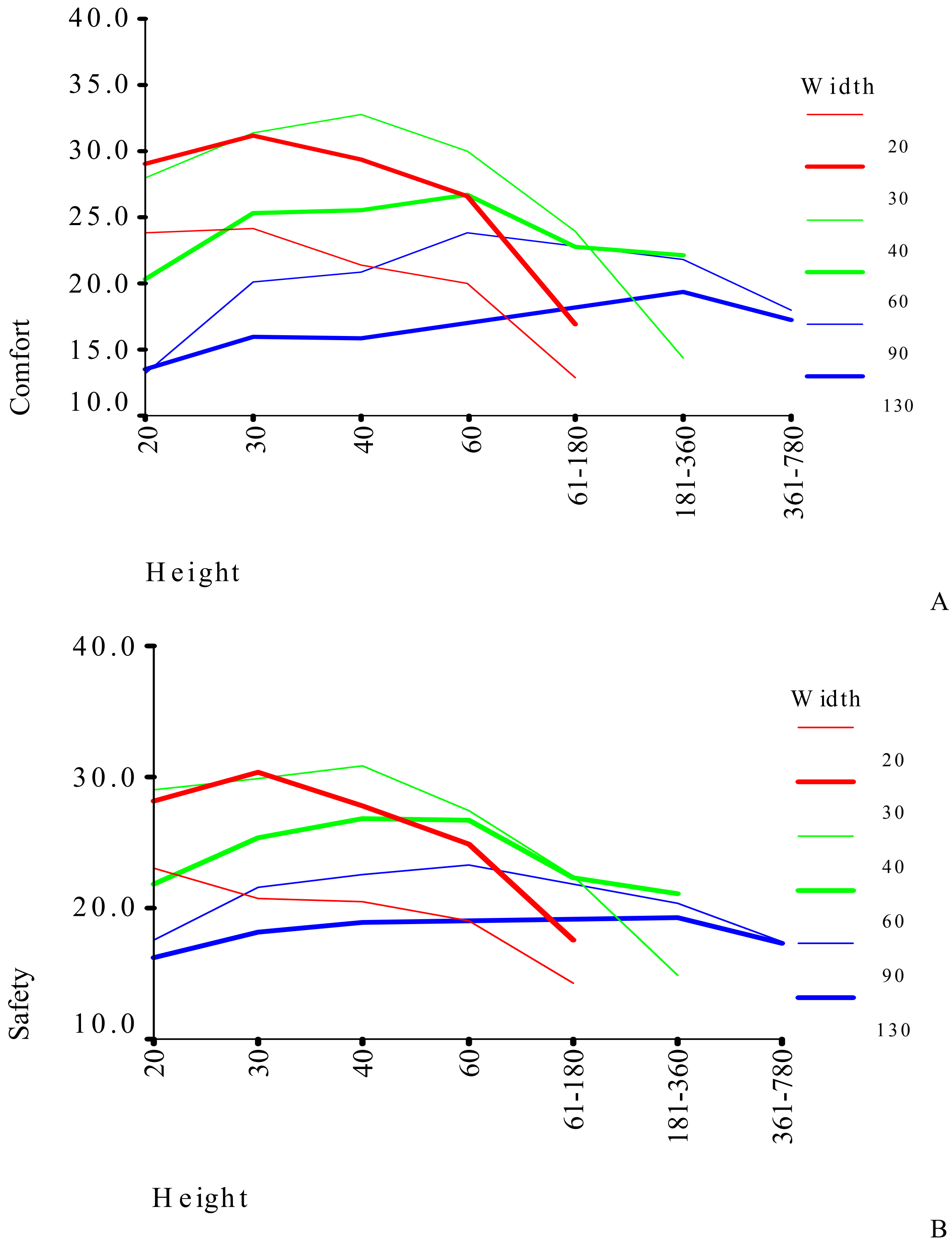
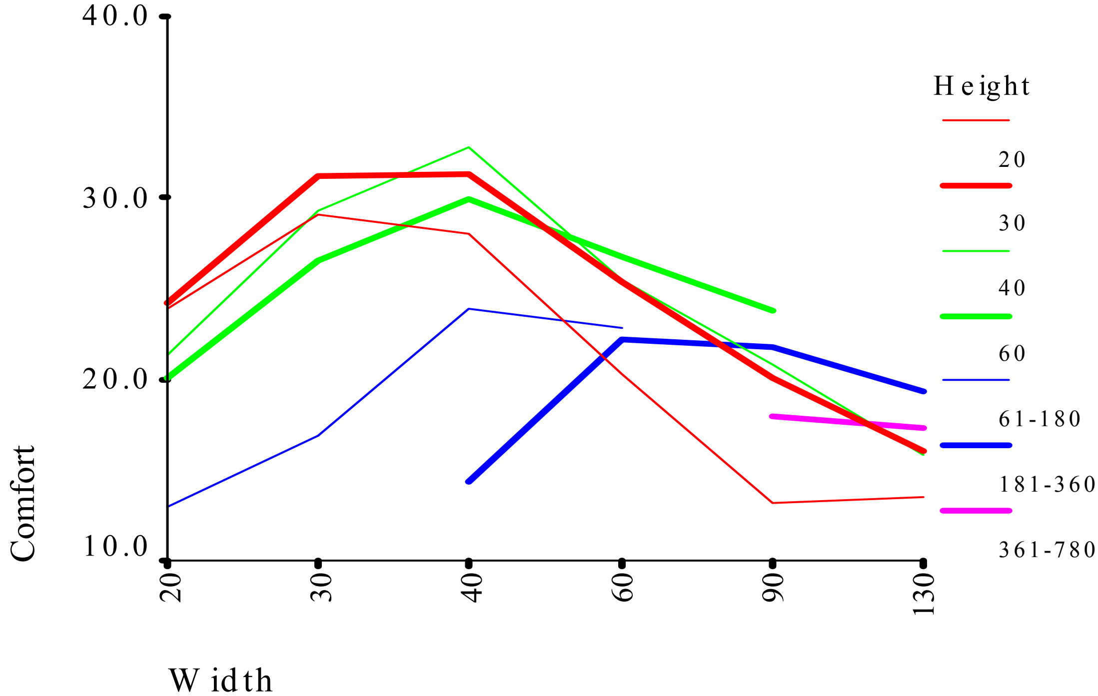
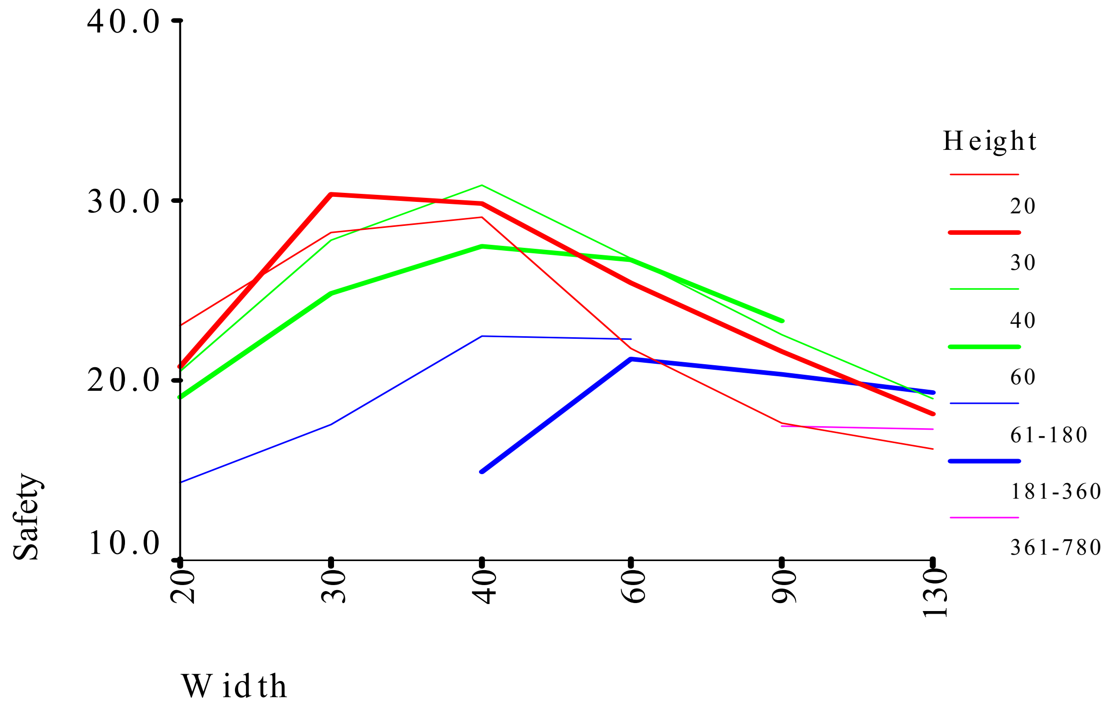


Figure 5-4. Comfort and safety relationship with height, clustered by width. A) Comfort with height. B) Safety with height.



A



B

Figure 5-5. Comfort and safety relationships with width, clustered by height. A) Comfort and width. B) Safety and width.

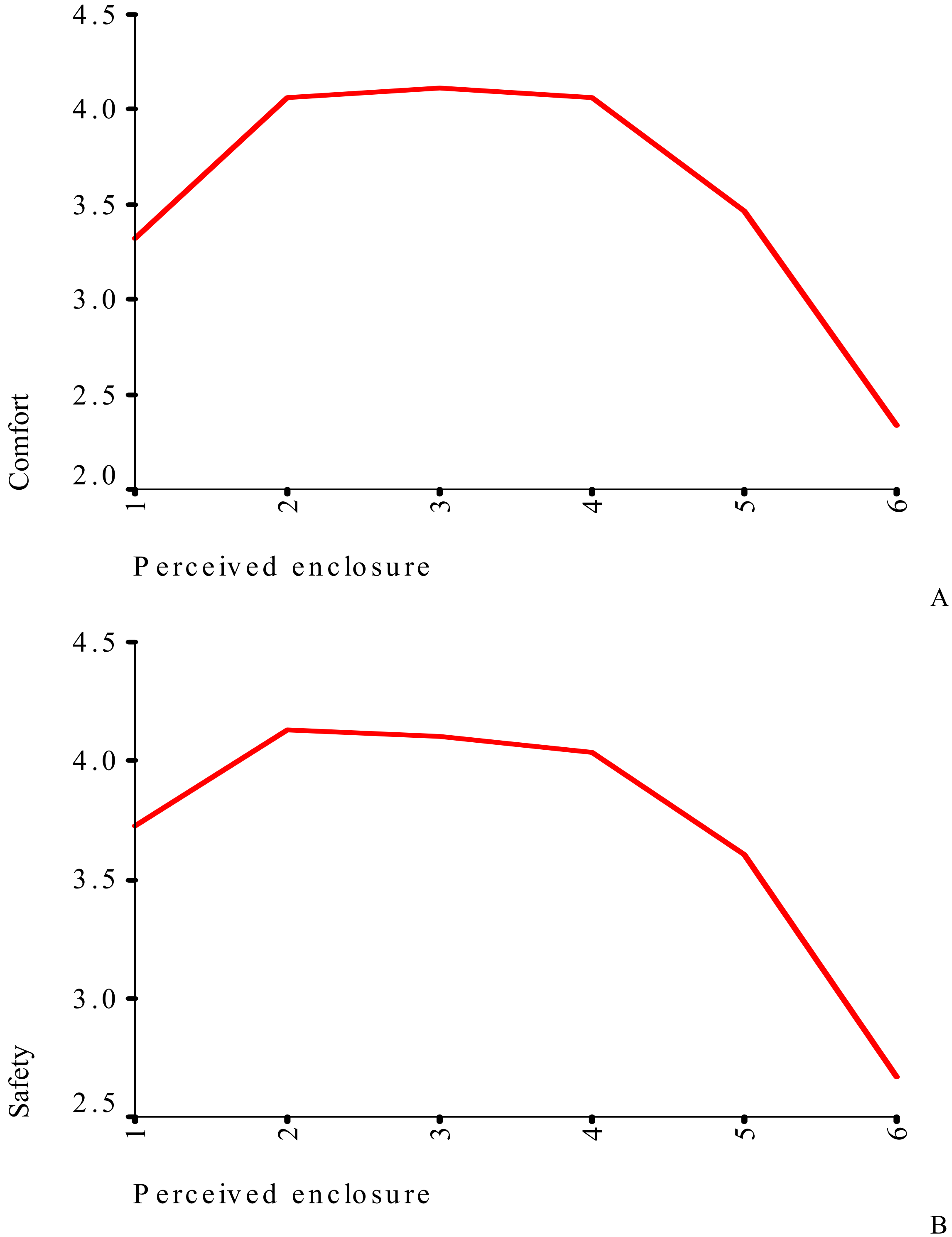


Figure 5-6. Relationship of perceived enclosure with both comfort and safety. A) Perceived enclosure with comfort. B) Perceived enclosure with safety.

Object 5-1. Probabilities calculator

CHAPTER 6
DISCUSSION

In this chapter, a discussion of the findings presented in chapter 4 and 5 will be conducted with reference to urban planning and design literature. The findings will be analyzed in light of both theoretical and empirical works of literature. First, the chapter discusses the reasoning behind using experimental computer-simulation method and its reliability. Second, it discusses the dependent variable perceived enclosure; including its relationship with the simulated variables. Third, comfort and safety dependent variables are discussed; including their relationships with simulated variables and perceived enclosure. Fourth, a discussion of the implications of my research for urban planning and design professions is presented. Fifth, the chapter discusses limitations of the research method.

Experimental Computer Simulation

Empirical inquiries need rigorous testing conditions and necessitate the isolation of external variables. There are numerous factors in the urban environments that can influence perception of enclosure and senses comfort and safety including; functional, social, physical, and psychological ones. My research is mainly concerned with the sensorial value of enclosure in urban street spaces, and its influence on comfort and safety, therefore there was a need to control these external variables. Since such control is difficult, if not impossible, in real-life environments, my research used computer-simulated urban street spaces as stimuli, and manipulated their values of ratio and scale to measure user’s comfort, safety and enclosure responses.

Such simulation is categorized in urban design literature as experimental, wherein the simulation is directed toward a certain research question. In experimental simulation research, the simulation does not need to replicate the environment fully; it needs a rather flexible replication of it that allows for the needed manipulation of the independent variables, for the purposes of testing hypotheses and building theories (Ozel, 1993). The flexibility in realism usually entails limitations that have to be accepted within the framework of each specific scientific protocol.

The most important qualification in computer simulation, that is designed to stimulate human senses, is to insure that the stimuli are evoking, as close as possible, the same feelings evoked by the real environment. My research relied on the premise that different simulated geometric dimensions of urban street spaces will evoke different estimations of enclosure values, and consequently different feelings of comfort and safety. To test the reliability of this method, my research incorporated two additional dependent variables; “estimated height” and “estimated width” to examine how well they correlate with the simulated heights and widths embedded in the computer 3D models, and whether the simulated dimensions are actually perceived as designed.

Literature reported some findings that support the use of simulated environments as an alternative to real-life environments. Im (1984) reported a value of ($r = 0.923$) for on-site and slide evaluation. Ewing (2005) reported similarities between on-site and photographs. Stamps (2005a) reported a high level of correlation value at $r = .83$ for preferences from static color simulations and on-site preferences.

The results of my research confirm these previous research findings for simulation methods. The estimated heights and widths had a high positive correlation with the respective simulated heights and widths ($\rho = .90$ for height, and $\rho = .77$ for width). My research’s findings verified that the stimuli were able to convey the desired information about the differences of heights and widths, and ultimately, ratio and scale, as specifically needed for my research. The relatively lower width correlation is caused by the optimization of texture realism that was applied to the street furniture to isolate the effect of implications of street vehicular lanes on safety responses.

Perceived Enclosure

Simulated and Perceived Enclosure

Urban design literature is promoting the concept of positive urban space, which is an explicitly eligible and defined space that is in balance with its defining masses. Enclosure is a major component of such balance. Enclosure is the perceived sensorial value evoked by spatial compositional characters of urban space. My research simulated these spatial compositional values and hypothesized that ratio and scale of urban street space, as simulated, are functions of enclosure.

The independent simulated variables of ratio and scale proved to be good estimator of perceived enclosure; ratio had a stronger relationship with perceived enclosure at (rho = 0.936). Scale correlated negatively with perceived enclosure at (rho = -.683). Height correlated positively with perceived enclosure (rho = 0.774). Width was found to be the second best predictor of perceived enclosure after ratio (rho = -.858).

Across the different simulated variations, ratio superceded scale such that, there was always a need to suppress the ratio value in order for scale to appear, and the opposite is not true. While the simulated ratio variable alone has certainly evoked strong perceived enclosure, simulated scale was less capable to do that alone. It was concluded that if scale, as a product of height and width, can not work except under ratio, then width or height are more practical to use instead of scale, because the other dimension is already present in the ratio value. Because a combination of ratio and width alone, when entered in the regression model together, can estimate 87% of the participants’ responses correctly, which is higher than any other possible combinations, width was used to substitute for scale. In other words, all that is needed to represent enclosure is ratio and width, where width is a scale indicator attached to ratio.

Enclosure increases as ratio increases and as width decreases, and the probability that a given space will be perceived as enclosed or not can be calculated using closedness probability in equation (4-1). Building on that, the variable “perceived enclosure” can be replaced in future research with the simulated values of ratio and width. This means that it is possible to not include variables from the cognitive model, with more interpretative power given to respondents, like perceived enclosure, and rely solely on simulated variables from psychophysical model like ratio and width, where respondents have limited interpretative power. What supports this notion is that nearly all between-subject (demographic) variables had no influence on the perception of enclosure, which rendered the within-subject (space) variables of ratio, scale, height and width, alone responsible for predicting perceived enclosure, and among those; ratio and width alone are the best predictors.

Perceived Enclosure with Reference to Literature

This section will connect the results of my research to both available empirical works about perceived enclosure. The scientific protocol that investigated enclosure in previous empirical literature can be traced back through the work of Stamps (2005a). This most replicated scientific protocol, that is available until now, used two variables to predict enclosure; “proportion of the stimulus (or image) that is covered with walls” and “proportion of the stimulus that is covered with ground”. To relate to this protocol, some calculations were performed to extract these variables from the stimuli of my research.

Stamps (2005a) reported three empirical works about perceived enclosure. In the first work by Hayward and Franklin (1974), perceived enclosure correlated with “proportion of scene covered by walls” at $r = .93$, with “proportion of scene covered by ground” at $r = –.18$. The second work, which is a replication of Hayward and Franklin’s (1974) work, revealed a correlation of perceived enclosure with “proportion of scene covered by walls at $r = .68$”, and with “proportion of scene covered by ground” at $r = -.31$. The third work, by Stamps and Smith (2002), revealed a correlation of perceived enclosure with “proportion of scene covered by walls” at $r = .73$, and with “proportion of scene covered by ground” at $r = -.53$.

In my research, the generated variables of proportions of walls and ground were correlated with perceived enclosure. Perceived enclosure correlated at rho = .95 with “proportion of scene covered by walls”, and at rho = -.55 with “proportion of scene covered by ground”. My research confirms the findings that were reported along this line of empirical work, however it maintains that the variables ratio and width have higher predictability than “proportions of the scenes” and easier transformability into urban planning and design policies.

Comfort and Safety

Simulated Variables and Sense of Comfort and Safety

Both sets of responses in my research; choices responses and ratings responses revealed virtually the same results concerning the dependent variables of comfort and safety. In the choices response, sense of comfort and safety is the highest for ratio range 0.5 to 1.5, height range 20 to 40 ft, width range 20 to 30 ft, and scale values <1,600 sq. ft. Visual investigation of weighted responses revealed that there are non-linear relationships between sense of comfort and safety and both ratio and scale.

Variance tests for rated responses revealed that there were significant differences in comfort and safety responses across all levels of simulated independent variables. Correlation tests for ratings responses revealed that below the ratio value of 3/4, sense of comfort and safety increases when ratio increases, while above it, sense of comfort and safety decreases as ratio increases, consequently ratio value 3/4 is felt as the most comfortable and the safest. Correlation tests revealed also that below the scale value of 1,600 sq ft, sense of comfort and safety increases as scale increases, while above it, sense of comfort and safety decreases as scale increases, which makes the scale value1,600 sq ft the most comfortable and the safest.

Across the different simulated variations, the influence of ratio on comfort and safety was higher than that of scale; the ratio variable had to be controlled, in order for scale to appear, and the opposite is not true. In other words, while simulated ratio alone has evoked high levels of sense of comfort and safety, simulated scale was able to do that only after controlling for ratio. Similar to perceived enclosure, it was decided that, width is more practical to use instead of scale. The combination of ratio and width alone, when entered in the regression model together to estimate comfort and safety, were only 1% lower than the complete model. After transformation, they were able to correctly estimate 74.88% and 71.36% of the participants' comfort and safety responses respectively, which are higher than any other possible combinations. Based on that, width was used to indicate scale.

Both senses of comfort and safety have non-linear relationships with ratio and width. The probability that a space of ratio of (R) and width (W) will be perceived as comfortable or not, safe or not, can be calculated using comfort and safety probabilities in equations (5-5) and (5-6). At fixed width value of 40 ft, the range ratio values <1/4 and >4 have a range of probabilities <0.50 of being comfortable, and the ratio values range <1/4 and >7 have a range of probabilities <0.50 of being safe. To satisfy both comfort and safety, the recommended ideal ratio is 3/4, the recommended minimum ratio value is 1/4, and the recommended maximum ratio value is 4.

Comparison of Comfort and Safety

Except for the difference that sense of safety had a wider span and more relaxed inverted U-shape than comfort, senses of comfort and safety are very similar. First, sense of comfort correlated positively with sense of safety (rho = 0.96, P = .000, *n* = 42*83). Second, in choices responses, all three of the most comfortable and all three of the safest spaces belong to the smallest group of spaces with ranges of heights <40, of widths <40, of ratio 0.5<R<1.5, and scale <1,600. Third, in choices responses as well, the least comfortable and the least safe spaces were exactly the same; all choices had either extreme ratio values of 1/6 or 6, or the extreme scale value of 101,400. Fourth, both comfort and safety correlated positively with ratio on the right side of the ratio value 3/4, and negatively on the left side of it.

Fifth, both comfort and safety correlated positively with scale for scale value <1,600, and negatively for scale values >1,600. Sixth, both comfort and safety have negative correlation with height. Seventh, both comfort and safety have negative correlations with width after controlling for height. Eighth, in 75% of the cases, both comfort and safety are influenced in the same manner by between-subject (demographic) independent variables. These similarities strengthen the notion that both advanced sense of comfort and survival instincts of safety are connected, where safety can be considered as a function of comfort. Differences between sense of comfort and safety are a question that needs more future research to investigate. For example, why does the ratio range of 5 to 7 received safe but not comfortable responses? There is a connection between this phenomenon and the prospect and refuge theory.

Sense of Comfort and Safety with Reference to Literature

This section will connect the results of my research to both available theoretical and empirical literature about sense of comfort and safety. It will first discuss sense of comfort and safety in the light of theoretical constructs, and then it will discuss the results relative to the empirical literature.

Theoretical constructs and sense of comfort and safety

Literature suggests that users' preference of space enclosure is an inverted U-shape relationship. Both extreme high and low values of enclosure are not favored; there are preferred values of enclosure in the middle. If we assume that comfort and safety are themselves indicators of preference, my research confirms the inverted U-shape relationship. Both comfort and safety has an inverted U-shape relationship with perceived enclosure. They also have an inverted U-shape relationship with ratio and scale; whether scale indicated by width or not.

Similar to perceived enclosure, an optimum width of 40 ft was included. The corresponding comfort and safety probability values ideal ratios reported in literature were calculated. Lynch & Hack's (1975) ideal ratio range of 1/3 to 1/2 has a comfort and safety probability of .76 to .83, Alexander and colleagues' (1977) ideal ratio of 1 has a comfort and safety probability of .87, Moughtin's (1992) ideal ratio of 1/2 has a comfort and safety probability of .83, Nelessen's (1993) ideal ratio range 1/2 to 1 has a comfort and safety probability of.83 to .87, and Carmona and colleagues' (2003) ideal ratio range 2 to 2.5 has a comfort and safety probability of .81 to .74. Carmona and colleagues' (2003) minimum ratio of 1 has a comfort and safety probability of .87, Nelessen's (1993) minimum ratio of 1/5 has a comfort and safety probability of .45, and Duany & Plater-Zyberk's (1992) minimum ratio of 1/6 has a comfort and safety probability of .23. Nelessen's maximum ratio of 4 has a comfort and safety probability of .63.

The inconsistency in these proposals is evident. Nelessen's (1993) suggestions are the most compatible with my research's findings. The ideal ratio for comfort and safety suggested by my research is 3/4, which is exactly the middle point of Nelessen's suggested range 1/2 to 1. Furthermore, Nelessen's suggested minimum ratio value of 1/5 has a probability of .45 of being both comfortable and safe, which is slightly lower than the thresholsd of .5, rendering the results of my research most compatible with Nelessen's proposals. In addition, Nelessen's suggested maximum ratio 4 has a probability of .63, which is reasonably close to the threshold of .5.

Empirical literature and sense of comfort and safety

The available empirical work that involved enclosure is a line of empirical work that has been culminated in the work of Stamps (2005a) about the relationship of safety and enclosure. Because comfort and safety correlated highly in my research, it was found convenient to discuss the results of my research about the relationship of both comfort and safety with enclosure in the light of stamps' work on enclosure and safety.

Stamps (2005a), in consistence with this empirical line of work, used proportions of the scenes covered by walls and ground, to predict perceived enclosure, and then used perceived enclosure to predict safety. Stamps reported that the correlation between perceived enclosure and safety was (r = .82, n = 21 stimuli). While my research has already confirmed Stamps' findings in the relationship of perceived enclosure and predictors of proportions of the scenes that are covered with walls and ground, it does not confirm Stamps' conclusion on the relationship between enclosure and safety

My research found that this relationship is not linear, and that high and low values of enclosure correspond to lower values of comfort and safety, and that medium values of perceived enclosure correspond to high values of comfort and safety. The finding of my research does not confirm Stamps' result which assumes linearity of the relationship between safety and perceived enclosure; alternatively a curvilinear relationship is proposed. This curvilinear relationship has regression coefficient value of (R^2 = .545) compared to (R^2 = .129) of the linear relationship, (Figure 6-1). One explanation for stamps' result is that all models in his experiment were given a fixed height of 6 meters, which probably rendered the stimuli sample with insufficient ratio values > 3/4.

What supports this finding, as well, is that both sets of predictors; Stamps' predictors of proportions of the scenes and my research's predictors of ratio and scale, were tested to predict safety, and both resulted in non-linear relationships, (Figure 6-2). My research proposes a non-linear relationship between safety and perceived enclosure, (Eq. 5-8). Although it is not important to replicate this equation exactly, my research asserts that when enough variations in ratio are included, the relationship between safety and perceived enclosure is better predicted using, at least, a 2nd degree polynomial function.

Demographic Differences and Sense of Comfort and Safety with Reference to Literature

The line of empirical literature that investigated the influence of demographic difference on people's judgment of the environment used correlation instead of variance tests. This line of literature suggested that there is no significant differences in people's preferences of the environment founded on demographic differences; and it reported that the consensus between demographic groups is ($.8 < r < .89$), (Stamps, 1999a). Stamps (2005a) also talked about gender relationship with safety, and concluded that a 10% difference in correlation between men and women is small.

The rule of thumb in these studies is to consider that the difference is small if the correlation was > 0.8. My research used correlations between different demographic groups to be able to connect to these studies. In my research, correlations had values as low as 0.47, which means that some differences are significant relative to this line of empirical inquiry.

All correlations within demographic variables of gender, age, design background, type of living area, height of buildings in living area, and width of street in living area have exhibited at least one correlation that is <.8. Consequently, it can be concluded that comfort and safety senses are generally influenced by these demographic differences. Moreover, it is crucial to report that, correlations within the variable "type of living area" were clearly lower than all other variables. Whether people live in rural areas or not is a decisive factor in the way they feel comfortable and safe in urban street spaces. The correlation between rural and both urban and suburban were < .53 for comfort and safety.

While empirical literature suggested high consensus levels among demographic groups concerning aesthetic appreciation of architectural styles and building facades, my research can not refute or confirm these result. However, it suggests that judgments concerning sensorial values of enclosure depart from this notion. It suggests that judgments of three-dimensional spatial values of urban spaces are more influenced by demographic difference than judgment of, for example, an architectural façade portrayed two-dimensionally.

Judgments of 2D compositions is usually governed by the relationships between the internal elements of the composition, which probably have higher consensus among demographic groups as it relates to the over-arching appreciation of beauty embedded in all humans and shared by them. However, judgments of compositional qualities of 3D spaces is governed by the sensorial value of enclosure, which belong to a lower level of human senses; sense of comfort and safety. In other words, sense of comfort and safety are more influenced by demographic differences than aesthetic appreciation.

Comfort and Safety and Participants' Qualitative Input

Qualitative responses revealed interesting interpretation of people's reasoning in relation to the stimuli. The overwhelming factor that determined why a space is felt comfortable or safe is attributed to the relationship between height of buildings and width of the streets, which confirms the findings about the reliability of the method. This relationship was expressed in different ways. Some responses have directly stated "ratio" or "proportion", some responses explained this relation using the "not too" expression, like "not too wide" and "not too high", while other responses just stated "the relationship between height and width" was the major factor that influenced their judgment. Safety and comfort qualitative responses were similar; however, some expressions were specifically used for safety, (Table 6-1).

Some response for safety included other reasons that are not ratio or scale in the direct sense, like shadows and light, which was mentioned by three different participants as factors for their choices. It is important to note here that shadow and light were embedded in the different stimuli, and that more shadow is expected with higher buildings and narrower streets. Although no cars were included in the simulation, and no lanes were present to implicate cars, yet other responses included “traffic” and explained that wider streets mean more traffic, which is not safe. Some connected high buildings with bigger cities where crime rate is high.

Some intermediate factors were also detected that are implied by either height of buildings or width of the street. Interpretation of density of people based on the height of buildings and width of street had been expressed; some expressed that “high buildings mean more people, which means more safety”, some expressed the opposite; “more people is less comfortable”. Some expressed a relationship between high buildings and earthquakes or fire, and consequently safety. Some associated comfort with narrower streets for functional reasons like moving easier from one side of the street to the other, others thought it is safer in narrow streets because it is easier for some one on the other side of the street to come to help in case of emergency.

Although some extraneous factors have appeared as subjective interpretations by participants, the overwhelming reason that was cited is the relationship of height to width. Safety has exhibited more extraneous factors than comfort, mostly connected to traffic. It is imperative to seek more ways to isolate this factor in future research. The wider span, and the more relaxed inverted-U shape relationship that safety responses has with ratio, compared to comfort, is probably a result of a lower consensus on safety concerning the width variable. Some people feel safer in wider streets, while others feel safer in narrower streets.

This phenomenon can be analyzed in light of the prospect and refuge theory, which had evident implications in the qualitative responses. Prospect entails a viewing point that has control over the space, while refuge entails the ability to escape the scene in case of danger. Some people want prospect; more room or distance, to have control over the space, where they can protect themselves when they sense danger. This group of people might be younger and stronger people; they consequently want wider spaces to take action. Other people want refuge; those might be older or softer people, and this is available only if spaces are smaller, which means more opportunity to get help from others.

It is not just the width of street that has an influence on people's perception of safety corresponding to prospect and refuge notions. More buildings' height implies more people; this is interpreted differently by different people. Some people want the personal space, or the distance, or ultimately the prospect situation; more people, for them, means less personal space, less reaction distance, and higher opportunity of being attacked. Other people want more people to be present to help them in case of emergency. This difference should be accounted for when trying to relate safety to the geometry of urban street spaces in future research.

Urban Planning and Design Implications

It is the responsibility of urban planning and design professions to shape the urban environment for the convenience of its users. It is also their responsibility to create opportunities for a fit of the social and physical urban layers. Urban planners and designers should observe the physical, socio-economic, political, functional, and behavioral factors that resist a healthy social and physical fit. Some of these factors are directly in the center of planers and designer's realms; they are solely responsible for them, like decisions concerning physical and functional aspects of the urban environment. Other factors are shared by numerous parties of the society, and belong mainly to the socio-economic and political realms.

The fit of social and physical domains is reasonably attainable at least from the physical side of the equation. Providing the functional requirements for vitalizing an urban space is a prerequisite for any further tuning. Because the functional dimension is within the realm of urban planning and design professions, it is most important to first create the functional grounds for other more advanced dimensions to operate. Mixed uses, higher mass-to-void densities, higher population density, less-hierarchal street network, multimodal-oriented transportation schemes, and decentralization of shopping and retailing structures are among the numerous functional aspects that lay the grounds for other higher dimensions like the behavioral dimension.

An urban street supported with retailing functions at the lower floors, offices and residential functions at the upper floors, and working infrastructures, invites functional activities, while an urban street with all that in addition to convenient width and height of buildings will evoke a psychological attachment. An ideal ratio value of 3/4, a scale value of 1,600, a minimum ratio value of 1/4, and a maximum ratio value of 4 are proposed by my research to be observed by professionals of urban planning and design.

Heights of buildings are usually governed by the maximum height requirements, which are guided by land use and density policies. Widths of streets are mostly a product of transportation policies including number of driving lanes, bicycle lanes, sidewalks and right of way. However, my research proposes the use of some policies that support a balanced degree of enclosure which does not contradict these functional requirements of urban street spaces. These policies can be divided into two sets of policies; overarching policies for new developments, city expansion and new cities, and policies to modify existing conditions.

For future development and urban expansion, the first policy is planning for low-rise and high-density morphology. Low-rise buildings less than five floors generally result in acceptable scales and ratios. High mass-to-void density ensures enough mass to form positive urban spaces, regulates less setback distances on the ground floor; which maintains a street wall, and guarantees less empty lots and surface car parking. The second policy is the adaptation of smaller blocks and street widths. Smaller street widths with smaller urban blocks produce more visual and physical connectivity and smaller spaces closer to the human scale.

Policies of higher densities and smaller street widths can only operate under other policies at a higher level. The implementation of higher mass-to-void densities involves policies for decentralization and mixing of urban uses, policies for controlling urban limits, and overarching governmental policies to guide private developments. The implementation of smaller streets policies involves policies for providing smoother connection in cities using more number of streets rather than more lanes of streets, policies of small urban blocks with convenient buildings heights, and policies for less arterial streets that create damaging urban edges.

The third policy is considering a minimum and maximum height corresponding to each street width. When higher floors are inevitable, height recesses and set backs should be introduced to break the sheerness of the height. The fourth policy is integrating arcades, awnings, and canopies on the street sides. In addition to their weather-related and functional purposes of shelter, these elements help in creating the desired degree of enclosure. The fifth policy is attaching buildings heights to the length of street segments. Frequent breaks of the length of the street, lower the impression of enclosure as more sky appears.

For modifying existing conditions, the first policy is concentrating efforts on streets that have pedestrian-friendly scale. The second policy is eliminating urban street elements that impose an undesired higher degree of enclosure, usually those that increase ratio in narrow streets. This occurs sometimes in streets with high ratios, yet street elements like trees and light poles exacerbate the condition by creating an illusion of even higher degree of enclosure. The third policy is to articulate material and color to increase the degree of enclosure or decrease it. Transparent materials and lighter colors probably reduce the impact of enclosure, while solid materials and darker colors convey more enclosure. The fourth policy is encouraging regulatory grounds to motivate adding more floors in spaces with lower ratio values. The fifth policy is breaking larger spaces into smaller subspaces by means of trees and street furniture. Some existing streets with large scales can be broken down into smaller spaces by using trees, shrubs, and other street furniture, in the median and on both sides of the street. Rather than one space, a large street space can be divided into four or more subspaces to create enclosed pedestrian spaces on both sides of the street and two enclosed driving lanes.

Supported by numerous arguments in urban planning and design today, these policies produce human-scale environments and smaller blocks and streets with the appropriate building heights, which ensure a feeling of belonging and control over the environment. These policies promote the notion of smaller scales which provides for easier extensions of private realms into public realms, gives sense of community, and emphasizes the role of streets as a social arena for people to live safely. These policies are based in the urban design notion of reviving positive urban space; which involves the reestablishment of their social and visual integrity within frameworks like Neo-traditional neighborhoods, transit-oriented development, and revival of traditional “main street” which constitute some important notion of new urbanism.

Planning and designing urban street spaces taking enclosure- as understood by users- into consideration implies introducing the space-morphology dimension of urban design into the equation, more control over the meaning of urban street to its users, taking the perceptual dimension into consideration, relating more to human scale, and democratizing urban planning and design policies.

Methodological Limitations

There are some limitations pertaining to the research method that suggests alternative reasoning of some of the findings. The first limitation is about the finding that ratio overwhelmed scale. My research method revealed that scale does not appear except if ratio was fixed. However, one alternative line of reasoning is that because of the limitation of the simulation method itself, and unlike ratio which is more conveyable by simulation, scale is less conveyable by simulation. The point here is that people need to sense the magnitude of the scale as related to their own scale, and unless they are actually inside a real-life space or more immersive simulated environments, they may not sense the expansiveness of the space.

It is important to state that this alternative concept does not imply that my research's simulation method does not convey scale values always; rather it asserts that scale can not be conveyed in the presence of manipulated ratio values, but it can be conveyed after fixing ratio values. So the unresolved question would be whether if this is also the case in real-life and more immersive simulated environments or not.

The second limitation relates to the degree of realism. My research maintains that in experimental research design, and when more realism produces potential confounding variables, an optimum degree of realism should be produced instead of the maximum possible one. Examples of avoiding the maximum realism degree in my research is the exclusion of trees from the stimuli, the continuous uninterrupted walls on both side of the street, the neutral texture for the ground, and the exclusion of cars. Each of these decisions has a methodological rationale; however, they have negative impact on the degree of realism of the simulated environment. Such impacts were detected in some of the qualitative response like: “it looks like a ghost town”; referring to the absence of life-indicating elements like cars, trees, and people. Decisions to reduce realism in favor of more rigorous scientific protocols should be carefully considered, and an optimum realism degree should be reached.

The third limitation is related to the immersion degree of the simulated environment. My research method required 42 street spaces as stimuli, which were represented as still images on computer screens. On aspect of perception in urban areas is that people minimize and maximize their acquisition of information by alternating between the local and the global scales. Real-time visualization techniques are perhaps the most conducive to simulate such mechanism. Had my research not been limited in time and money, more immersive stimuli with the 4^{th} dimension of time and virtual larger screens with real-time visualization could have been used, which should have enhanced the participants’ immersion in the scenes and probably enhanced the opportunity for such alternation of the information field to take place.

The fourth limitation is related to the incapacity of linear regression models to analyze ordinal data, and to the fact that the ordinal regression model, that is available now, assumes parallel behavior at deferent levels of the response variable, which was not the case in my research’s response variables. This entails the use of logistic regression model which is less powerful than the linear and the ordinal models in explaining the response variables. Alternatively, some researchers consider ordinal data as “approximately continuous” if collected using a wider scale, say 1 to 30. In this case, and providing that the response variable is normally distributed, linear regression models can be used. If not normally distributed, then some transformation can be used to make the data normally distributed, however this is not accepted by other scholars. My research was limited by the choice to use logistic regression model which resulted in limited predictability.

The fifth limitation pertains to the convenience sample of 83 participants who were students and employees from the University of Florida. Because literature suggested that demographic differences have no significant impact on users' preference of urban environment, my research used a convenience sample. The convenience sample does not necessarily maintain proportionate representations of demographic groups; e.g. people with lower levels of education. Since there was evidence in my research that the initial assumption is not true, and that comfort and safety are influenced by demographic differences, it is maintained that further research is needed using stratified sampling.

Chapter 7 presents the conclusions and recommendations that were derived form my research. It places my research within the body of urban design literature, summarizes findings pertaining to perceived enclosure and sense of comfort and safety, presents notes on the research method, and concludes by recommendations for future research.

Table 6-1. Qualitative responses.

	Comfort	Safety
Ratio	Ratio Proportion Not too wide and not too high The relationship between height and width Coziness Not claustrophobic Proportion of the sky Enough shelter, but not being overly constrictive Narrow and high means suffocating Narrow is comfortable unless it looks like back alleys Not too wide, not too tall are comfortable Balanced proportion more comfortable Balance between solid and void Enough sky but also walls to protect Low and narrow means coziness, familiarity, intimacy without being claustrophobic	Moderately narrow streets give sense of security, wide streets and short building give a feeling of insecurity Too close means confinement, too open means insecure Narrow means no where to escape, no time to react Narrow means safer, but not canyon Closed reduce reaction time The more I see the safer I feel Low and narrow means safer; it cradles you Enclosed spaces mean more density of pedestrian which means more witnesses Smaller streets mean high density and more people to help
Scale	Coziness Height and width in relation to the human scale Smaller scales relate more to humans	Open spaces are easy to escape in smaller spaces you find people easier when you need them
Height		High buildings mean more people; which is safer
Width	Wide is not comfortable, narrow means coziness	If too wide it is socially alienating

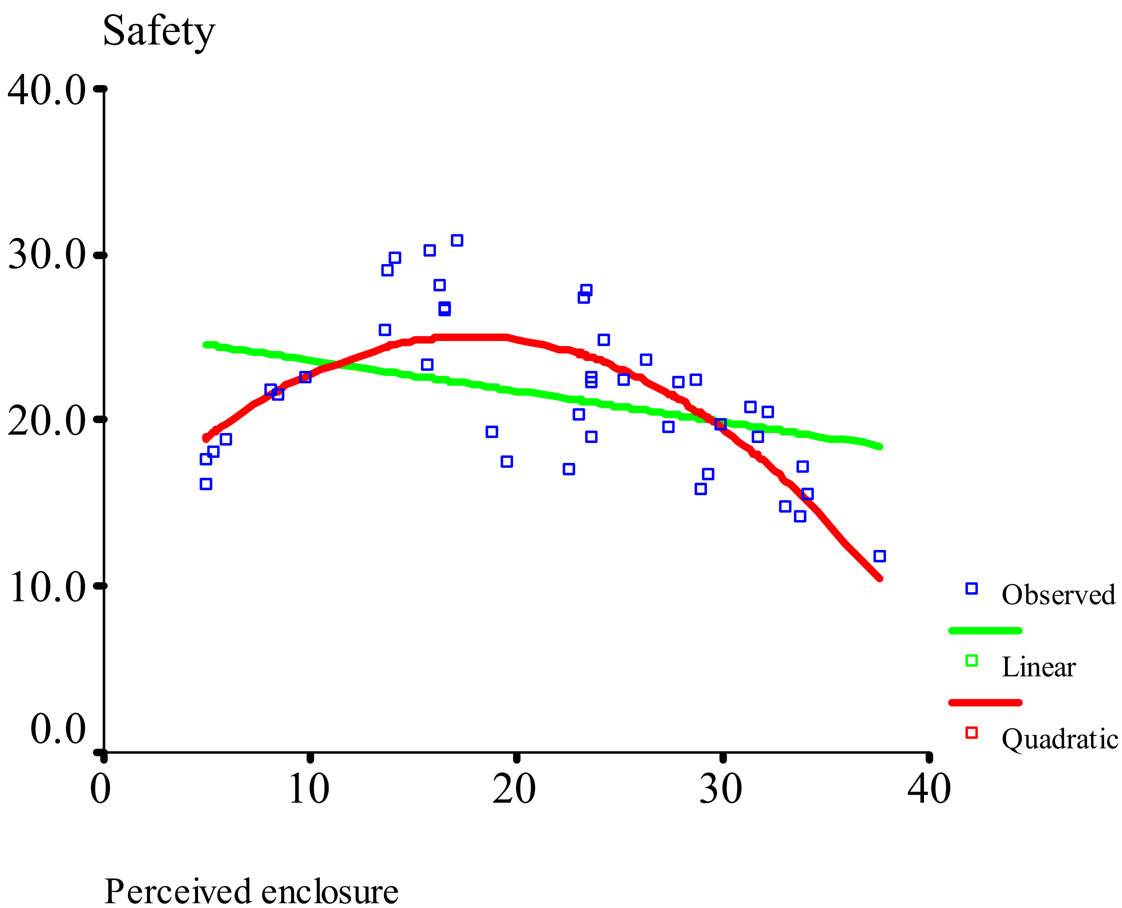


Figure 6-1. Curve estimation to predict safety using perceived enclosure.

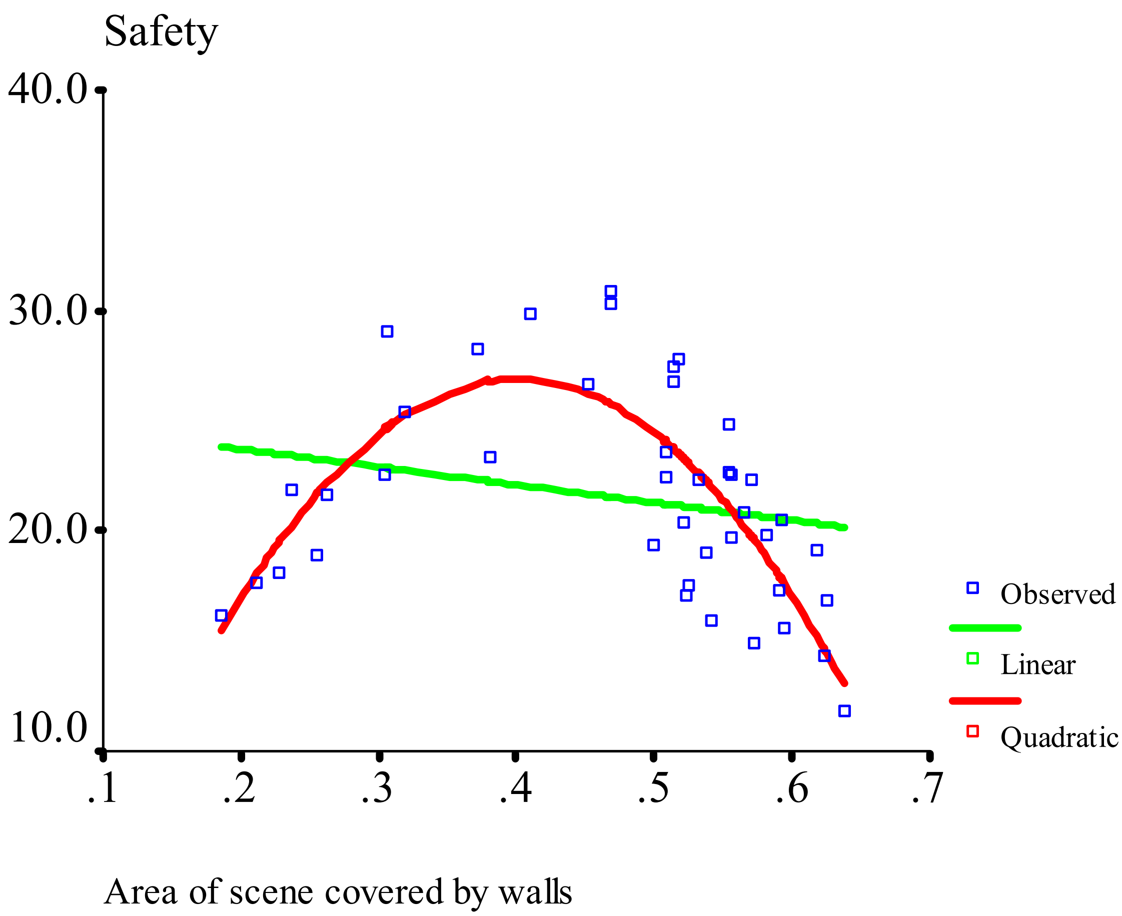


Figure 6-2. Curve estimation to predict safety using proportions of scene covered by walls.

CHAPTER 7
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Urban street spaces in today's cities are merely byproducts of planning and design decisions including buildings' heights, density, and transportation regulations. The resulting spaces have second-order functions that impact sense of comfort and safety. One major second-order function is the degree of enclosure, which can be measured using the ratio of height to width and scale of these spaces. My research examined how the sensorial value of enclosure influences comfort and safety, and established a certain degree of enclosure that satisfies ideal comfort and safety perceptions, and concluded thresholds for comfort and safety, below which, urban street spaces are not comfortable and safe.

This section, first, fits my research into the body of space-morphology inquiry; and eventually within urban planning and design theory. Second, it summarizes conclusions on the influence of ratio and scale on perceived enclosure. Third, it presents conclusions pertaining to the influence of enclosure; simulated and perceived, on senses of comfort and safety. Finally, the section presents the methodological limitations encountered in my research, and the alternative possibilities.

Connection to Urban Design Theory

Urban design operates over the line that separates public and privates realms. It is responsible for the interaction between the public and the private realms, and it seeks a fit of the social and the physical urban layers. The physical dimension of urban design is concerned with urban masses and voids, while the social dimension is concerned with the extension of our private life into the public realm, or our public life. Space-morphology approach in urban design is concerned with the impact of three-dimensional spaces and masses on other urban systems;

including social and behavioral aspects. Such approach connects to the social approach in a probabilistic manner. This means that design influences social systems such that it allows necessary activities to linger and it has a direct cause-effect relationship with optional activities.

Urban streets constitute the major part of urban spaces in today's cities. The space-morphological quality of our cities is a product of the streets' two-dimensional layout at larger scale, and their three-dimensional geometric nature at smaller scales. While, at larger scale, we identify with our cities using lines and point elements like landmarks, paths, and edges, at smaller scales, we perceive our localities using volumes and masses that fall within our cone of vision. The volumetric qualities of urban streets is communicated to us through our perceptual capacities, subsequently we make a decision to interact one way or another. Our collective social decisions, derived from perception, determine the fit or misfit between the physical and social layers of urban design.

There are numerous factors that encourage people to retreat into private domains, leaving behind them dead urban spaces. These factors include socio-economic factors like social lifestyles, technology, privatization and fear. On the other hand, they include planning and design factors like functional zoning, decentralization of land uses, vehicles-oriented planning and loss of social spaces, market-oriented development, and the distribution of activities in time and space resulting in an amorphous urban milieu.

In addition to its functional meaning, the physical urban environment has a second-order meaning; the perceptual meaning. The perceptual meaning of the physical urban environment is primarily a function of complexity and architectural articulation in addition to geometric quality and enclosure; and both are conveyed to humans through cognition. Both functions evoke in humans, senses of fear or safety, ease or anxiety, curiosity or apathy, amusement or boredom, and freedom or restriction. While a degree of complexity means a degree of detailing that engages humans in an interesting urban experience, a degree of enclosure is needed to offer a psychological shelter but not restriction and claustrophobia. There is a point of balance between the human needs of security and freedom where enclosure allows for both.

My research relied on the premise that different simulated geometric dimensions of urban street spaces evoke different estimations of enclosure values, and consequently different feelings of comfort and safety. It concludes that this hypothesis is true, and that each different simulated scene evoke different perceived enclosure and consequently different sense of comfort and safety. It also concludes that there are strong associations as well. For example, perceived enclosure changes in a systematic linear manner, when ratio and scale of the urban street space change, while senses of comfort and safety change in a systematic curvilinear manner, when enclosure changes.

Perceived Enclosure

The degree of enclosure that is needed is a balance of the height of the defining buildings with the width of the street. My research confirms both theoretical and empirical literature in urban design that suggests this balance. My research concludes that the sensorial value of enclosure in urban street space is a function of its height-to-width ratio and scale, and that perceived enclosure increases as ratio increases and as scale decreases. Perceived enclosure correlated with ratio at rho = .94, with scale at rho = -.68, with height at rho =.77, and with width at rho = -.86.

When ratio and scale are operating together, ratio influences enclosure and consequently sense of comfort and safety regardless of the scale values, while the opposite is not true; ratio values should be controlled before scale starts to have an influence. Scale, based on that, can be indicated by width, because the height variable is already embedded in the ratio variable. My research concludes that it is more practical to use ratio with width as functions of enclosure for simulation experiments. Both ratio and width were able to estimate 87.63%.of the perceived enclosure correctly. The research proposed equation (4-1) to predict perceived enclosure from ratio and width. My research concludes as well that while within-subjects (space) independent variables influence perceived enclosure, the between-subject (demographic) variables have no significant influence on it.

Sense of Comfort and Safety

Senses of comfort and safety are influenced by height-to-width ratio and scale of urban street space; ratio value of 3/4 and scale value of 1,600 sq ft are the balance points where the highest comfort and safety levels were detected. The relationships of ratio and both comfort and safety are not linear. Both comfort and safety have positive correlations with ratio at rho = 0.92, for ratio values ≤3/4, and negative correlations at rho = -0.84, -0.85, respectively, for ratio values ≥3/4. Both comfort and safety have positive correlations with scale at rho = 0.77, 0.66, respectively, for scale values ≤1,600, and negative correlations with scale at rho = -0.75, -0.78, respectively, for scale values >1,600. Ratio and width are able to predict 74.88% of comfort responses and 71.36% of safety responses correctly. The research proposes equations (5-5) and (5-6) to predict comfort and safety, respectively, from ratio and width.

Demographic differences have relatively smaller, yet statistically significant, influence on senses of comfort and safety compared to space variables. Gender groups agreed at rho = .84 for comfort, at rho = .74 for safety. Age groups agreed at rho = .71 to .93 for comfort, and at rho = .75 to .86 for safety. Design background groups agreed at rho = .79 for comfort, and at rho = .69 for safety. Inhabitants of urban, suburban and rural areas agreed at rho = .53 to .92 for comfort, and at rho = .47 to.93 for safety. Inhabitants of areas with different building heights agreed at rho = .80 to .91 for comfort, and at rho = .71to .91 for safety. Inhabitants of areas with different street widths agreed at rho = .79 to .97 for comfort, and at rho = .75 to .91 for safety. There are statistically significant differences in all demographic variables, however, the type of living area has the heaviest influence on people's senses of comfort and safety in urban street spaces; inhabitants of rural areas feel more comfortable and safer in urban spaces with lower ratios and larger scales compared to inhabitants of urban and suburban areas.

My research hypothesized that sense of comfort and sense of safety are influenced differently by enclosure. Small differences were detected especially in the span of the relationships; safety has a more relaxed inverted U-shape relationship and a wider span than comfort. While the ratio of 3/4 received the highest responses on comfort and safety scales, safety span was wider to include more values of higher ratios than comfort, comfortable ratios span was R = 1/4 to 4, while safe ratios span was R = 1/4 to 7. This can be attributed to the fact that sense of safety was more influenced by the reaction distance and personal space, explained by the prospect and refuge theory, than sense of comfort. Within the design framework of my research, the overall conclusion is that both comfort and safety are influenced similarly by enclosure as they accord at (rho = 0.96), and the differences between them are minimal. A research design that is specifically oriented toward investigating these differences might produce more solid results.

The empirical literature that investigated enclosure has used proportions of walls and ground of the stimuli scenes as indicators of enclosure. While my research confirms the findings of this line of empirical work concerning perceived enclosure, it does not confirm the reported linear relationship between enclosure and safety. My research asserts that to predict comfort or safety from enclosure, at least a 2^{nd} polynomial function should be considered to describe the relationship.

My research presents its finding as a component of knowledge within space-morphology studies. While the main purpose of the research is describing relationships of enclosure with comfort and safety in an empirical framework, it reaches out to suggest considering ten urban planning and design policies that support the implementation of these findings. These policies are two types; policies for future urban expansions and new cities, and policies for modifying existing urban conditions.

For future development and urban expansion, the first policy suggests low-rise and high-density morphology, which enhances the opportunity for positive urban spaces to appear, insures minimum setbacks, maintains less empty lots, and allow for continuous street walls. The second policy is planning smaller blocks and narrower streets, which facilitates the creation of smaller urban street spaces and higher physical and visual connectivity. The third policy is considering a minimum and maximum height corresponding to each street width in addition to height recesses and setbacks when higher buildings are inevitable. The fourth policy is integrating arcades, awnings, and canopies on the street sides to help establish the desired degree of enclosure when wider streets are inevitable. The fifth policy is attaching buildings' heights to the length of street segments, and to use this relationship to manipulate enclosure; because longer street segments introduce more enclosure.

For existing conditions, the first policy is concentrating efforts on streets that have the potential in their scale, closer to 1,600 sq. ft, to be modified into pedestrian-friendly ones. The second policy is eliminating urban street elements that impose an undesired degree of enclosure; usually those that increase ratio in narrow streets like commercial signage and light poles. The third policy is to articulate material and color to increase the degree of enclosure or decrease it. The fourth policy is enacting regulatory grounds to motivate adding more floors in spaces with lower ratio values. The fifth policy is breaking larger spaces into smaller subspaces by means of trees and street furniture.

Methodological Notes

For the purposes of investigating geometric qualities of the urban environment and the effect of its physical dimension on behavioral dimension of human beings, computer simulation was found to be a practical and reliable method. Simulated height has a high positive correlation, at rho = .90, with perceived height, and simulated width has a high positive correlation at rho = .77 with perceived width. Providing the use of the appropriate realistic textures and articulations as much as the scientific protocol permits, it is possible to convey geometric information of urban street spaces to people through computer simulation.

For the purposes of specifically conveying the sensorial value of enclosure in urban street spaces, computer simulation has as well proved to be a practical and reliable method. The ratio variable is a strong estimator of enclosure (rho = 0.936), while scale is a relatively weaker estimator of enclosure (rho = - 0.683). Based on that, scale can be indicated by width (rho = -.86), where both ratio and width are capable of estimating 87% of enclosure correctly.

One possible interpretation of the scale performance relative to ratio is that scale of urban street space cannot be completely conveyed by computer simulation, and people need to be physically in real-life environment to actually sense the expansiveness of urban spaces. This possibility doesn't imply that scale cannot be conveyed through simulation, it just states that scale can not be conveyed at the same time as ratio. This leaves the unresolved question as follows; while scale in simulated environments is overwhelmed by ratio, is this also true in real-life and in more immersive simulated environments?

Recommendations

This section presents recommendations for potential future research. Future research can follow the protocol of my research for purposes of investigating the influence of urban environment on people's perceptions. Some potential relationships that can be investigated include the relationship of simulated enclosure with variables of architectural articulation and texture complexity, building functions, trees, shadows, cars and street furniture, or different cultural spacescapes. Other recommendations are concerned with the relationships of comfort and safety with variables of mass-to-void density, street and block structure and scale, or stationary urban spaces, and the differences of comfort and safety senses.

Among the environmental factors that may have an influence on people's perceptions are architectural articulation and texture. Different architectural treatments and texture complexities need to be measured and related to perception of enclosure in urban street spaces. Previous studies that can help as starting points for such research are Kaplan and Kaplan (1989), Garc´ıa et al. (2006), Heath et al. (2000), Krampen (1979), and Stamps, (1999).

Another environmental factor that may have an influence on people's perception of urban spaces is the scale of street pattern. What size of urban blocks produces livable and comfortable environments for its users? The independent variables can be areas of urban blocks, building heights, and streets widths. The stimuli can involve an animation of a tour or real-time visualization. If animation and real-time visualization are used, it is recommended to keep the number of variables to the minimum for better management of the scientific protocol.

Following the same line of my research, enclosure in urban spaces of more stationary natures; i.e., squares or plazas, can be investigated. Methodological modifications include introducing the third dimension which is the depth of the space. This potential research may have four independent variables width-to-depth ratio, height-to-width ratio, height-to-depth ratio, and volume.

Another intriguing line of research is measuring enclosure as influenced by different urban functions. Some urban functions have inviting façades while some do not. The visual permeability at the ground floor level may evoke different degrees of perceived enclosure. Some functions interfaced with permeable material extend the urban spaces inside private domains. While other functions interfaced with opaque materials strictly define the urban space.

Trees may have a strong impact on sense of enclosure. One line of research could be measuring enclosure with and without trees, and calculating what volumes or numbers of trees produce what difference in perceived enclosure. This is rather a difficult task, where quantifying trees is a challenging objective.

One other line of research could be calculating the mass-to-void densities in different area of the cities using GIS, and relating that to inhabitants comfort levels. The use of two measurement groups can isolate the non physical factors; measurement of responses for inhabitants in real-life contexts, and measurement of responses for computer simulated densities. This line of research is expected to have numerous methodological challenges.

Another possible future research involves replications of my research using different simulation methods. While replicating my research in real-life context is virtually impossible, more immersive simulated environment, for example, may be able to convey scale variances more efficiently than the method of my research. Literature suggests that there are minimum differences between different methods of simulation; such possible research can verify this notion.

A possible area of inquiry is to investigate the differences between comfort and safety themselves, and to explain why they have different acceptable ranges relative to ratio categories. Such possible research can include the reaction time, and can tie that to distances, in the light of the prospect and refuge theory. For example, what widths and depths are associated with what higher and lower sense of safety? Moreover, what demographic differences can explain the contradicting sense of safety concerning width?

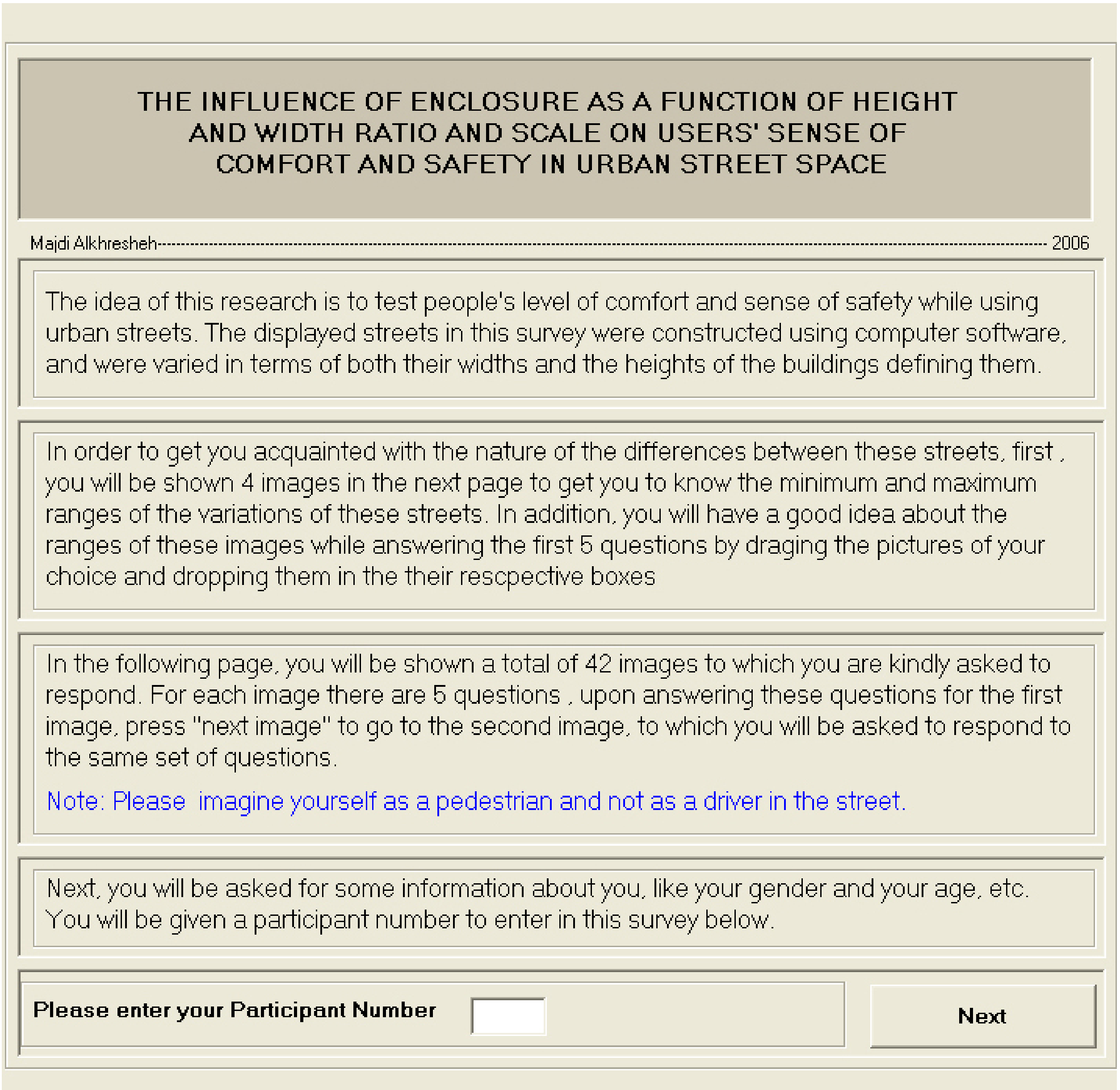
Shadow was embedded in my research method and was attached to the degree of enclosure. What if shadow was not included, and to what extent does it contribute to explaining the outcomes from comfort and safety responses? Cars were not included in my research method. If cars were included, how much would they shift the relationship of comfort and safety with perceived enclosure and simulated values of ratio and scale, and to what extent would they influence safety responses differently from comfort?

Replicating my research in a different region of the world may produce results that confirm or contradict it. There are indications that people from regions with high population densities depart significantly in their perception from the mean perceptions of people from regions with lower population densities. There are also indications that people who are accustomed to cities that have historical roots have a different perspective about enclosure from those who are not. Moreover, the culture of the urbanscape may have different perceptual implications. Stone construction, for example, may have a different visual impact and safety implications than wood construction.

Theoretically, the dilemma of physical versus social environments or the relationship of the social structure and the spatial structure of the city and how they are made to fit together is perhaps the most important line of research that need to be advanced now. The problem that faces empirical research in this context is quantification of the social side of the equation. Population densities, yearly income, and ethnic groups are among the easiest variables of the social structure that can be quantified. However, the social structure is deeply rooted in culture and history, and it is perhaps the ultimate challenge to quantify such intangible values. One possible ground for a start is to measure the shifts of the line that separates public and private realms, and the physical overlapping circles of shared territorial sense as an indicator of different social lifestyles and cultural contexts. The shared territorial sense is a bounded physical area within which an individual, a group of individuals, or certain social units have senses of belonging and social attachment.

If communities are fragmented, it is possible to find this line matching the private ownership of the individual or the family, while it is possible to find more than one circle of belonging pertaining to each level of social bonds in more socially-connected contexts. The first step could be an attempt to promote a tool to measure the associations of societal connectedness with perceived territorial sense quantified by the physical area of sense of territoriality. Upon establishing an indicator, further research may use this indicator to establish how territoriality impact urban experience. When quantifying both social and physical realms is possible, an empirical work can actually reveal important relationships. Theoretical constructs that should help as a starting point to pursue this line of research are Newman (1972), (Akbar 1988), and Kostof (1992).

APPENDIX A
ON-SCREEN SURVEY


THE INFLUENCE OF ENCLOSURE AS A FUNCTION OF HEIGHT AND WIDTH RATIO AND SCALE ON USERS' SENSE OF COMFORT AND SAFETY IN URBAN STREET SPACE

Majdi Alkhresheh-- 2006

The idea of this research is to test people's level of comfort and sense of safety while using urban streets. The displayed streets in this survey were constructed using computer software, and were varied in terms of both their widths and the heights of the buildings defining them.

In order to get you acquainted with the nature of the differences between these streets, first , you will be shown 4 images in the next page to get you to know the minimum and maximum ranges of the variations of these streets. In addition, you will have a good idea about the ranges of these images while answering the first 5 questions by draging the pictures of your choice and dropping them in the their rescpective boxes

In the following page, you will be shown a total of 42 images to which you are kindly asked to respond. For each image there are 5 questions , upon answering these questions for the first image, press "next image" to go to the second image, to which you will be asked to respond to the same set of questions.

Note: Please imagine yourself as a pedestrian and not as a driver in the street.

Next, you will be asked for some information about you, like your gender and your age, etc. You will be given a participant number to enter in this survey below.

Please enter your Participant Number

Next

Figure A-1. Survey introductory page.

Figure A-2. Survey page 2; extreme cases.

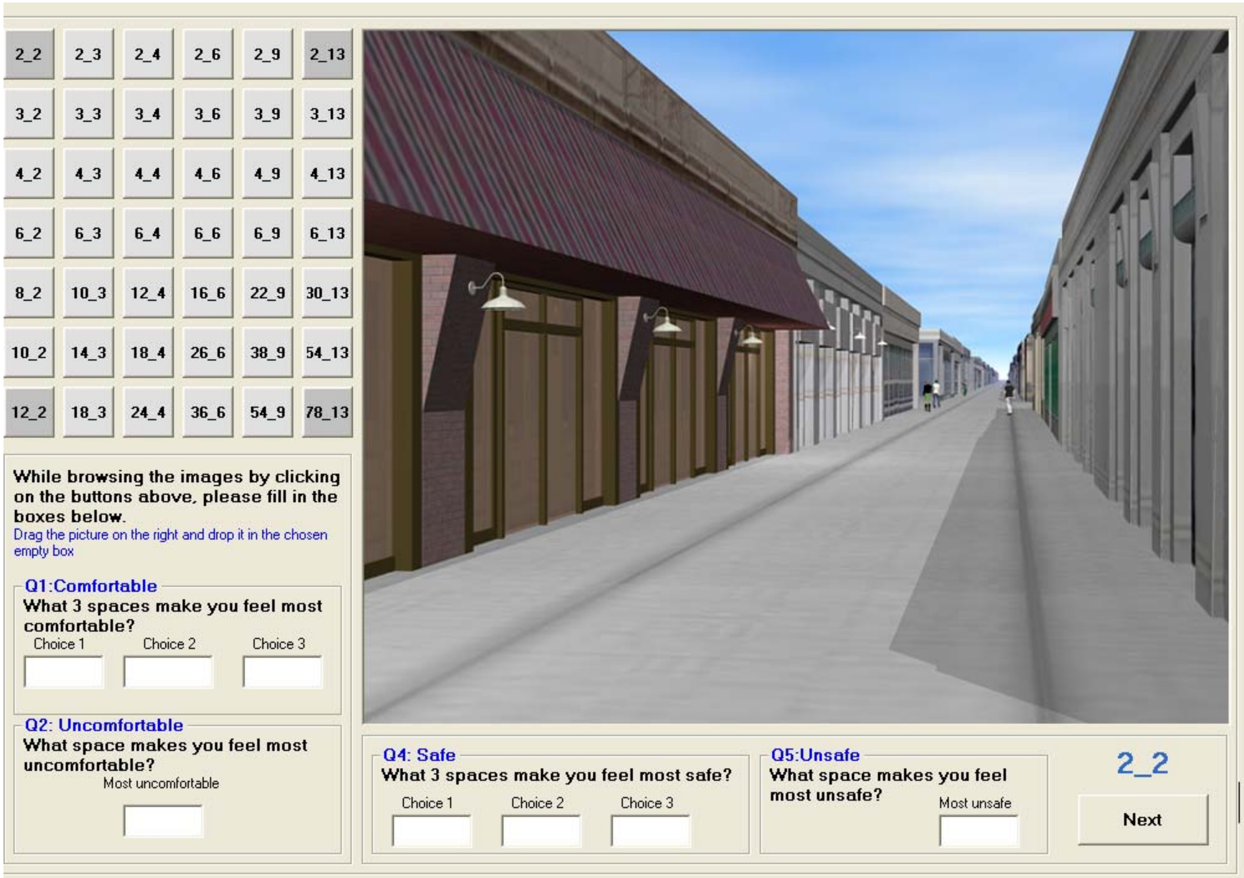


Figure A-3. Survey page 3. Choices of most comfortable three spaces, most uncomfortable space, most safe three spaces, and most unsafe safe.

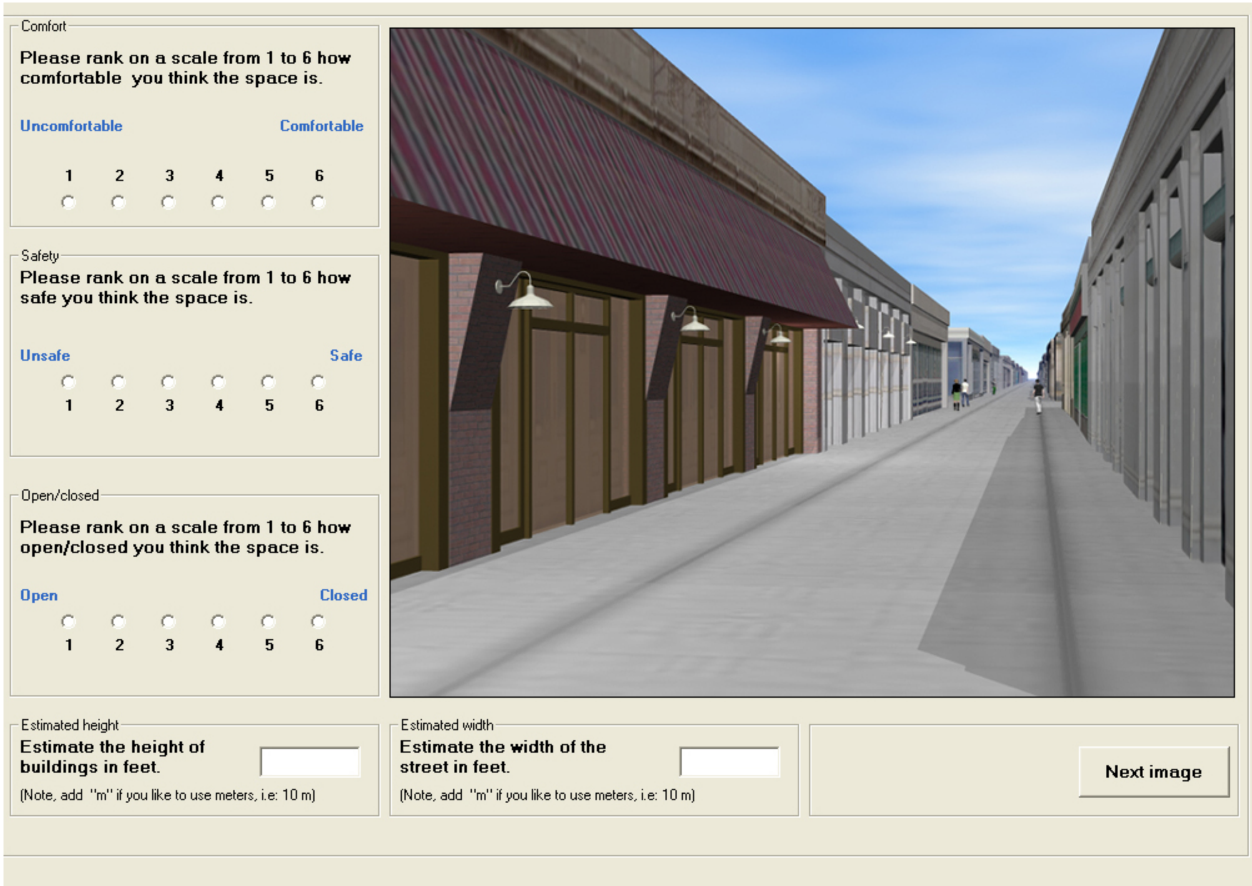
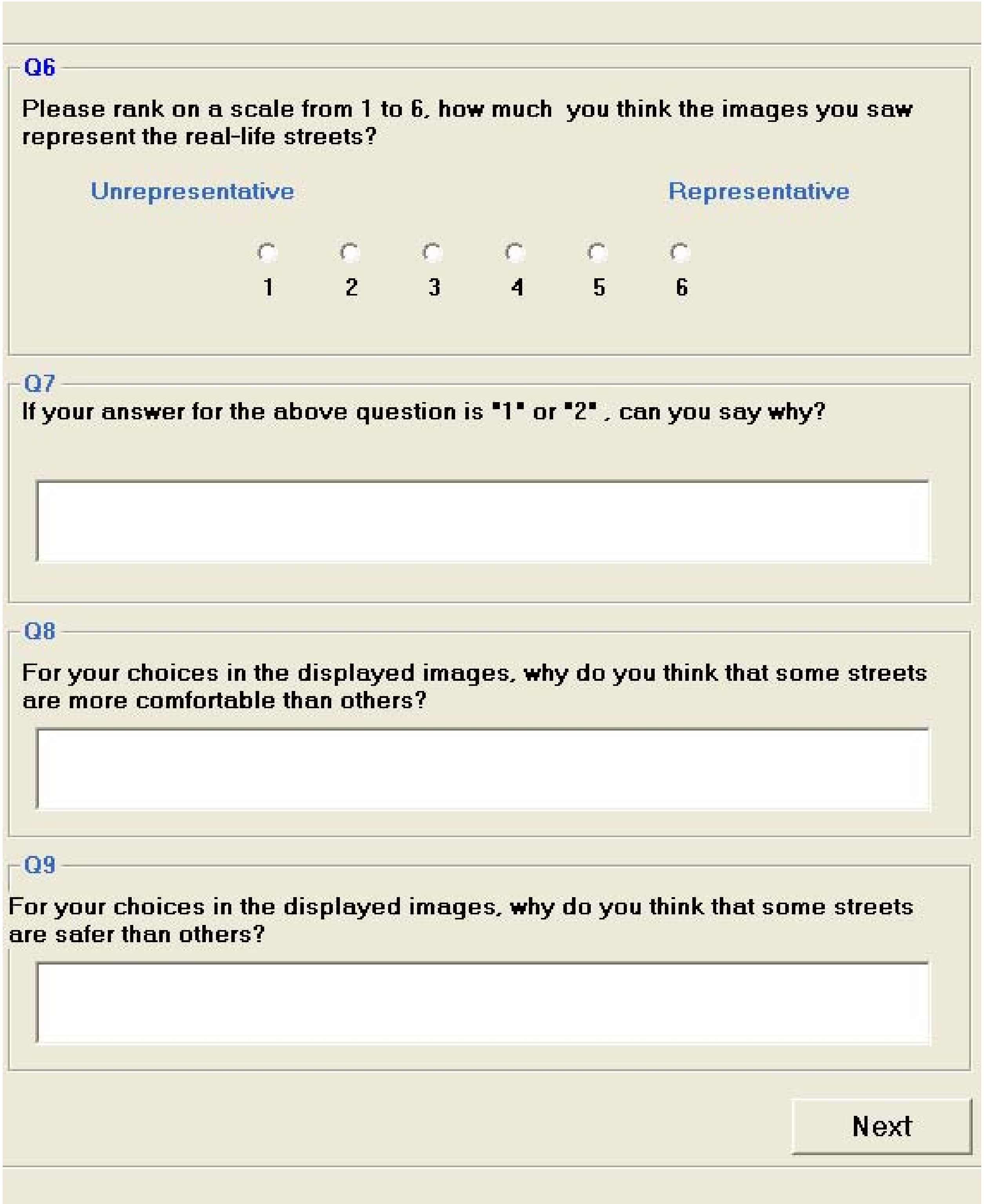


Figure A-4. Survey page 4. Rating comfort, safety and enclosure levels and perceived height and width. This page was repeated 42 times for each case.



Q6

Please rank on a scale from 1 to 6, how much you think the images you saw represent the real-life streets?

Unrepresentative — Representative

1 2 3 4 5 6

Q7

If your answer for the above question is "1" or "2" , can you say why?

Q8

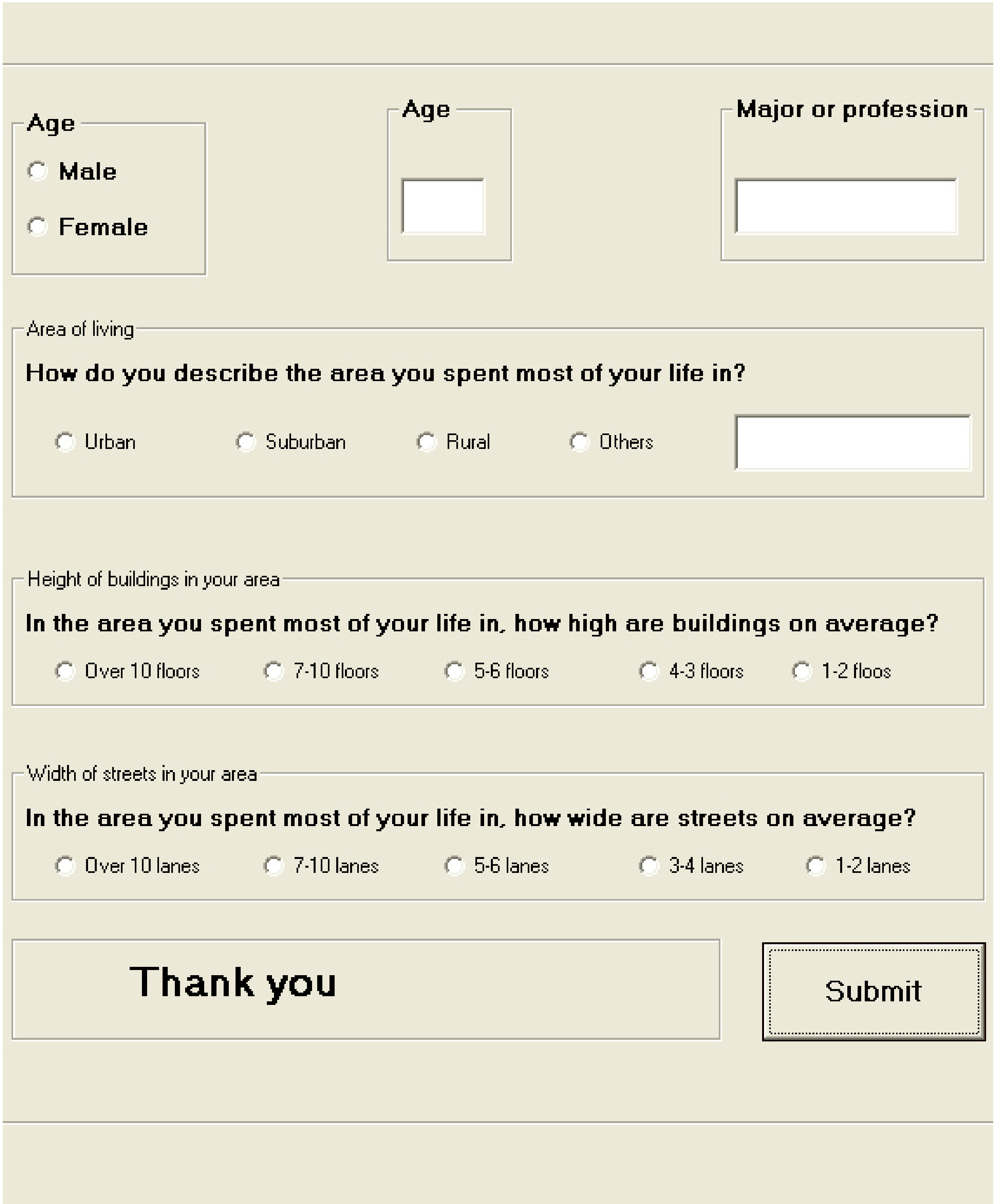
For your choices in the displayed images, why do you think that some streets are more comfortable than others?

Q9

For your choices in the displayed images, why do you think that some streets are safer than others?

Next

Figure A-5. Survey page 5. Participants' reasoning of their responses.



Age

Male

Female

Age

Major or profession

Area of living

How do you describe the area you spent most of your life in?

Urban Suburban Rural Others

Height of buildings in your area

In the area you spent most of your life in, how high are buildings on average?

Over 10 floors 7-10 floors 5-6 floors 4-3 floors 1-2 floos

Width of streets in your area

In the area you spent most of your life in, how wide are streets on average?

Over 10 lanes 7-10 lanes 5-6 lanes 3-4 lanes 1-2 lanes

Thank you

Submit

Figure A-6. Survey page 6. Demographic differences of gender, age, profession, and nature of living area.

APPENDIX B
PERCIEVED ENCLOSURE ACROSS DEMOGRAPHIC DIFFERENCES

Table B-1. Mann-Whitney test for differences in perceived enclosure scores of men and women across 3 ratio categories.

Ratio	N			Perceived enclosure MR		Test statistics[a]		
	Gender			Gender		Mann-Whitney U	Z	Asymp Sig.
	Male	Female	Total	Male	Female			
1/6-1/3	53	30	83	42.13	41.77	788.000	−0.067	0.947
1/2-2	53	30	83	41.68	42.57	778.000	−0.161	0.872
3-6	53	30	83	40.67	44.35	724.500	−0.668	0.504

[a]Grouping variable: gender.

Table B-2. Mann-Whitney test for differences in perceived enclosure scores of men and women across 3 scale groups.

	N			Perceived enclosure MR		Test statistics[a]		
	Gender			Gender		Mann-Whitney U	Z	Asymp. Sig.
	Male	Female	Total	Male	Female			
Small	53	30	83	44.18	38.15	679.500	−1.101	0.271
Medium	53	30	83	42.09	41.83	790.000	−0.048	0.962
Large	53	30	83	39.38	46.63	656.000	−1.321	0.187

[a]Grouping variable: gender.

Table B-3. Kruskal Wallis test for differences in perceived enclosure scores of the 3 age groups across 3 ratio categories.

Ratio	N				Perceived enclosure MR			Test statistics[a,b]		
	Age				Age			Chi-Square	df	Asymp Sig.
	< 24	25-32	>32	Total	< 24	25-32	>32			
1/6-1/3	31	25	27	83	39.83	41.72	44.69	0.581	2	0.748
1/2-2	31	25	27	83	42.48	38.06	45.09	1.125	2	0.570
3-6	31	25	27	83	40.35	36.40	49.07	3.820	2	0.148

[a]Kruskal Wallis test.
[b]Grouping variable: age.

Table B-4. Kruskal Wallis test for differences in perceived enclosure scores of the 3 age groups across 3 scale groups.

Scale	N				Perceived enclosure MR			Test statistics[a,b]		
	Age				Age			Chi-Square	df	Asymp Sig.
	< 24	25-32	>32	Total	< 24	25-32	>32			
Small	31	25	27	83	42.39	40.20	43.22	0.219	2	0.896
Medium	31	25	27	83	40.10	40.68	44.48	0.493	2	0.782
Large	31	25	27	83	37.45	38.68	50.30	4.799	2	0.091

[a]Kruskal Wallis test.

[b]Grouping variable: age.

Table B-5. Mann-Whitney Test for differences in perceived enclosure scores of designer and non designer groups across 3 ratio categories.

Ratio	N			Perceived enclosure MR		Test statistics[a]		
	Design background			Design background		Mann-Whitney U	Z	Asymp Sig.
	Yes	No	Total	Yes.	No			
1/6-1/3	30	52	82	41.50	41.50	780.000	0.000	1.000
1/2-2	30	52	82	40.80	41.90	759.000	−0.202	0.840
3-6	30	52	82	44.18	39.95	699.500	−0.775	0.438

[a]Grouping variable: design background.

Table B-6. Mann-Whitney Test for differences of perceived enclosure scores of designer and non designer across 3 scale groups.

Scale	N			Perceived enclosure MR		Test statistics[a]		
	Design background			Design background		Mann-Whitney U	Z	Asymp Sig.
	Yes	No	Total	Yes.	No			
Small	30	52	82	39.18	42.84	710.500	−0.637	0.501
Medium	30	52	82	45.38	39.26	663.500	−1.132	0.258
Large	30	52	82	43.92	40.11	707.500	−0.700	0.484

[a]Grouping variable: design background.

Table B-7. Kruskal Wallis test for differences in perceived enclosure scores relative to the types of living area across 3 ratio categories.

Ratio	N				Perceived enclosure MR			Test statistics[a,b]		
	Living area				Living area			Chi-Square	df	Asymp Sig.
	Urban	Suburban	Rural	Total	Urban	Suburban	Rural			
1/6-1/3	36	38	7	81	37.17	43.71	46.00	1.784	2	0.410
1/2-2	36	38	7	81	34.35	47.05	42.36	5.419	2	0.067
3-6	36	38	7	81	41.21	40.82	40.93	0.005	2	0.997

[a]Kruskal Wallis test.

[b]Grouping variable: type of living area.

Table B-8. Kruskal Wallis test for differences in perceived enclosure scores relative to the type of living area across 3 scale groups.

Scale	N				Perceived enclosure MR			Test statistics[a,b]		
	Living area				Living area			Chi-Square	df	Asymp Sig.
	Urban	Suburban	Rural	Total	Urban	Suburban	Rural			
Small	36	38	7	81	34.57	45.83	47.86	4.944	2	0.084
Medium	36	38	7	81	39.64	44.28	30.21	2.373	2	0.305
Large	36	38	7	81	45.44	36.45	42.86	2.764	2	0.251

[a]Kruskal Wallis test.

[b]Grouping variable: type of living area.

Table B-9. Kruskal Wallis test for differences in perceived enclosure scores relative to the height of buildings in the living area across 3 scale groups.

Scale	N					Perceived enclosure MR				Test statistics[a,b]		
	Height of buildings in area of living (floors)					Height of buildings in living area (floors)				Chi-Square	df	Asymp Sig.
	1-2	3-4	5-6	>6	Total	1-2	3-4	5-6	>6			
Small	34	19	13	17	83	46.82	39.89	48.85	29.47	7.235	3	0.065
Medium	34	19	13	17	83	37.90	43.95	54.54	38.44	5.092	3	0.165
Large	34	19	13	17	83	37.85	43.05	47.08	45.24	1.935	3	0.586

[a]Kruskal Wallis test.

[b]Grouping variable: height of buildings in living area.

Table B-10. Kruskal Wallis test for differences in perceived enclosure scores relative to the height of buildings in the living area, across simulated heights.

Simulated height	N					Perceived enclosure MR				Test statistics[a,b]		
	Height of buildings in area of living (floors)					Height of buildings in living area (floors)				Chi-Square	df	Asymp Sig.
	1-2	3-4	5-6	>6	Total	1-2	3-4	5-6	>6			
20 ft	34	19	13	17	83	46.68	35.79	43.65	38.32	3.032	3	0.387
30 ft	34	19	13	17	83	43.60	40.21	55.65	30.35	8.482	3	0.037
40 ft	34	19	13	17	83	44.31	39.13	54.69	30.88	7.908	3	0.048
60 ft	34	19	13	17	83	36.63	48.95	55.58	34.59	9.158	3	0.027
>60 ft	34	19	13	17	83	37.94	44.24	47.77	43.21	1.917	3	0.590

[a]Kruskal Wallis test.

[b]Grouping variable: height of buildings in living area.

Table B-11. Kruskal Wallis test for differences in perceived enclosure scores relative to widths of streets in the living area across 3 scale groups.

Scale	N: Width of streets in area of living (lanes) 1-2	3-4	>4	Total	Perceived enclosure MR: Width of streets in area of living (lanes) 1-2	3-4	>4	Test statistics[a,b] Chi-Square	df	Asymp Sig.
Small	37	39	7	83	45.57	40.91	29.21	2.894	2	0.235
Medium	37	39	7	83	41.88	41.45	45.71	0.191	2	0.909
Large	37	39	7	83	41.11	41.74	48.14	0.512	2	0.774

[a]Kruskal Wallis test.

[b]Grouping variable: width of streets in living area.

Table B-12. Kruskal Wallis test for differences in perceived enclosure scores relative to widths of streets in the living area across simulated widths.

Simulated width	N: Width of streets in area of living (lanes) 1-2	3-4	>4	Total	Perceived enclosure MR: Width of streets in area of living (lanes) 1-2	3-4	>4	Test statistics[a,b] Chi-Square	df	Asymp Sig.
20 ft	37	39	7	83	47.61	39.23	27.79	4.986	2	0.083
30 ft	37	39	7	83	45.68	40.21	32.57	2.166	2	0.339
40 ft	37	39	7	83	40.27	42.36	49.14	0.821	2	0.663
60 ft	37	39	7	83	44.14	39.81	42.93	0.630	2	0.730
90 ft	37	39	7	83	43.58	40.05	44.50	0.494	2	0.781
130 ft	37	39	7	83	40.58	42.64	45.93	0.345	2	0.842

[a]Kruskal Wallis test.

[b]Grouping variable: width of streets in living area.

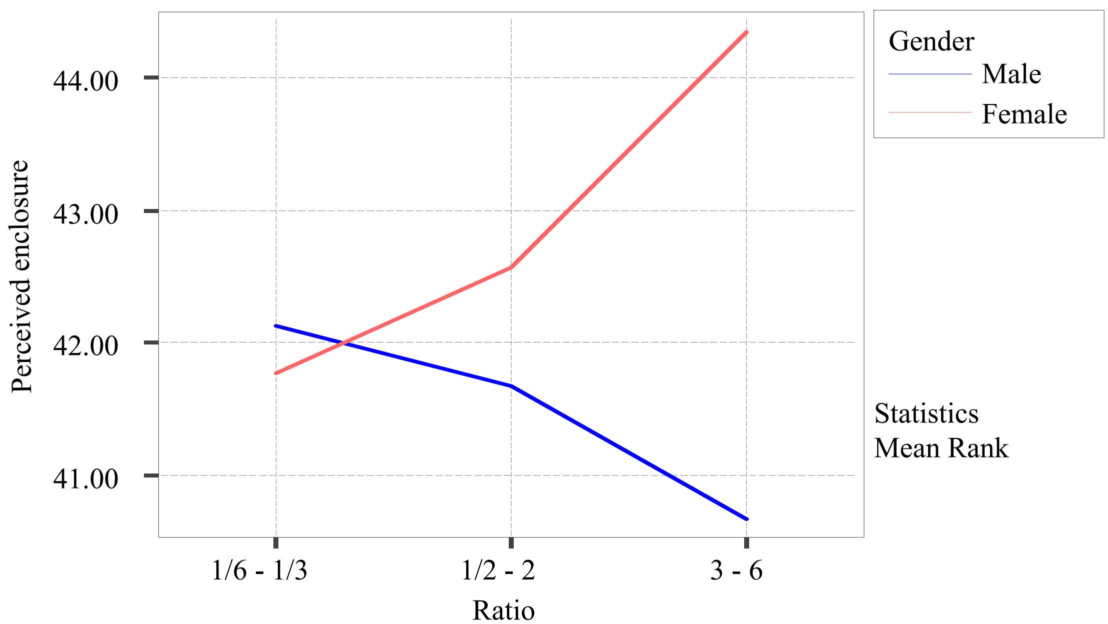


Figure B-1. Differences in perceived enclosure scores of men and women across 14 ratio categories.

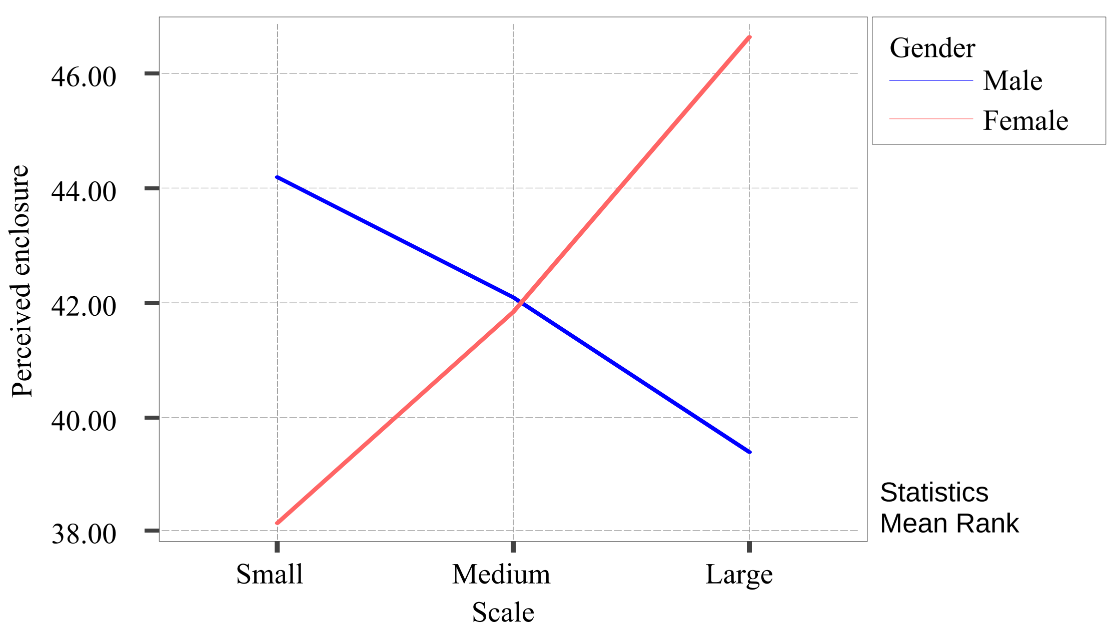


Figure B-2. Differences in perceived enclosure scores of men and women across 3 scale groups.

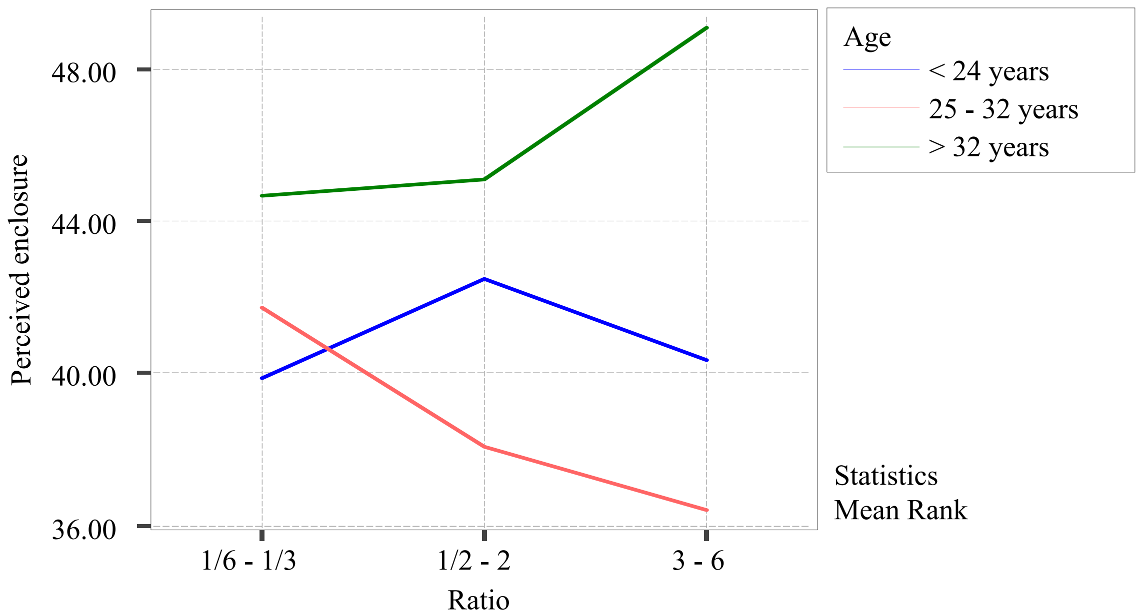


Figure B-3. Differences in perceived enclosure scores of the 3 age groups across 3 ratio categories.

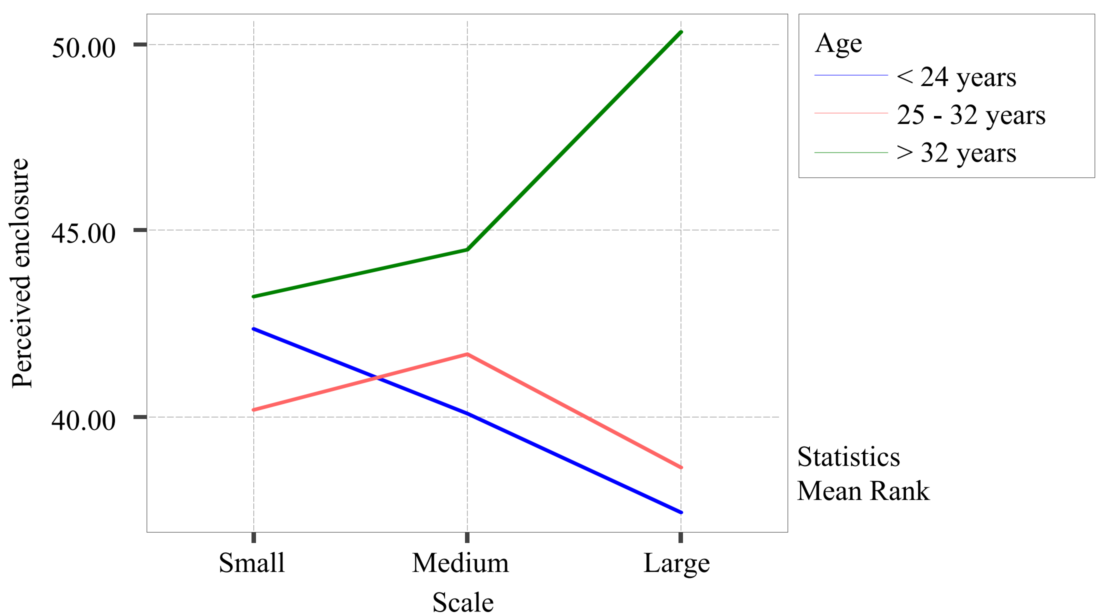


Figure B-4. Differences in perceived enclosure scores of the 3 age groups across 3 scale groups.

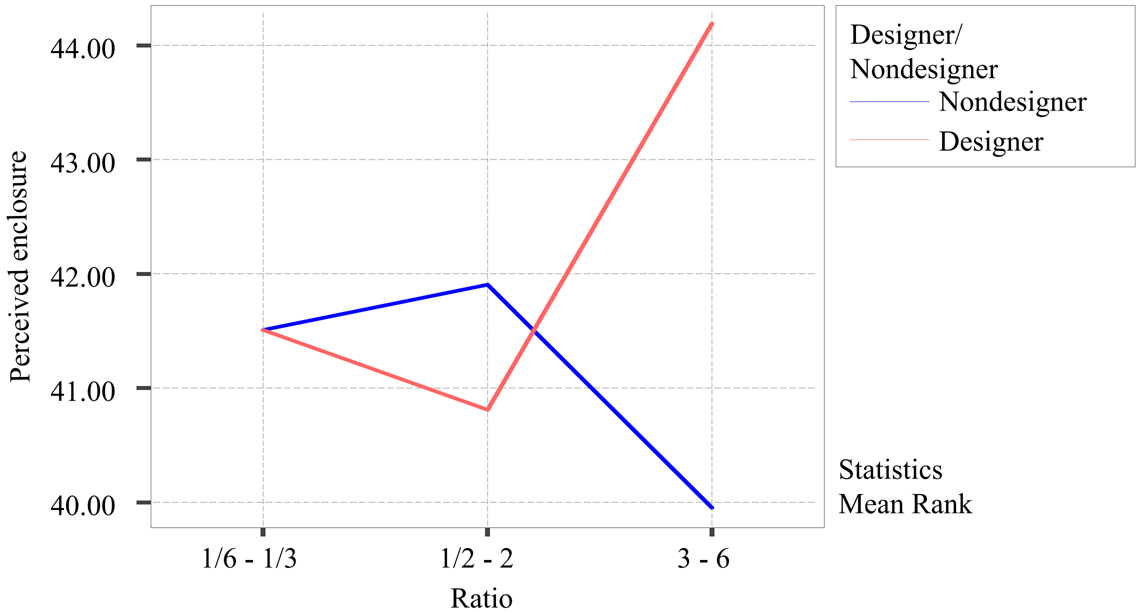


Figure B-5. Differences in perceived enclosure scores of designers and non designers across 3 ratio categories.

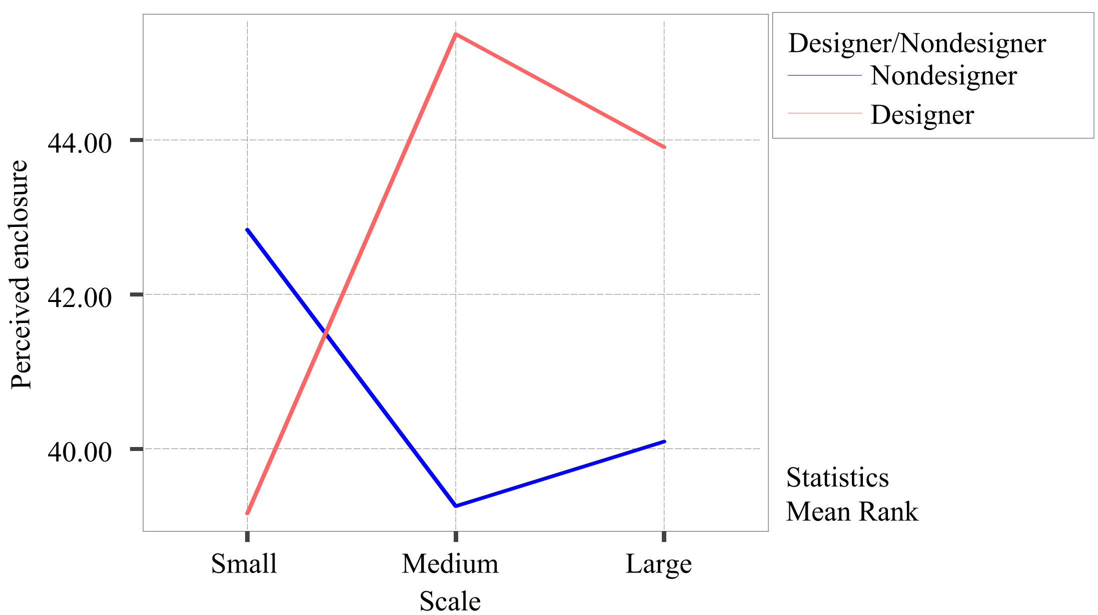


Figure B-6. Differences in perceived enclosure scores of designers and non designers across 3 scale groups.

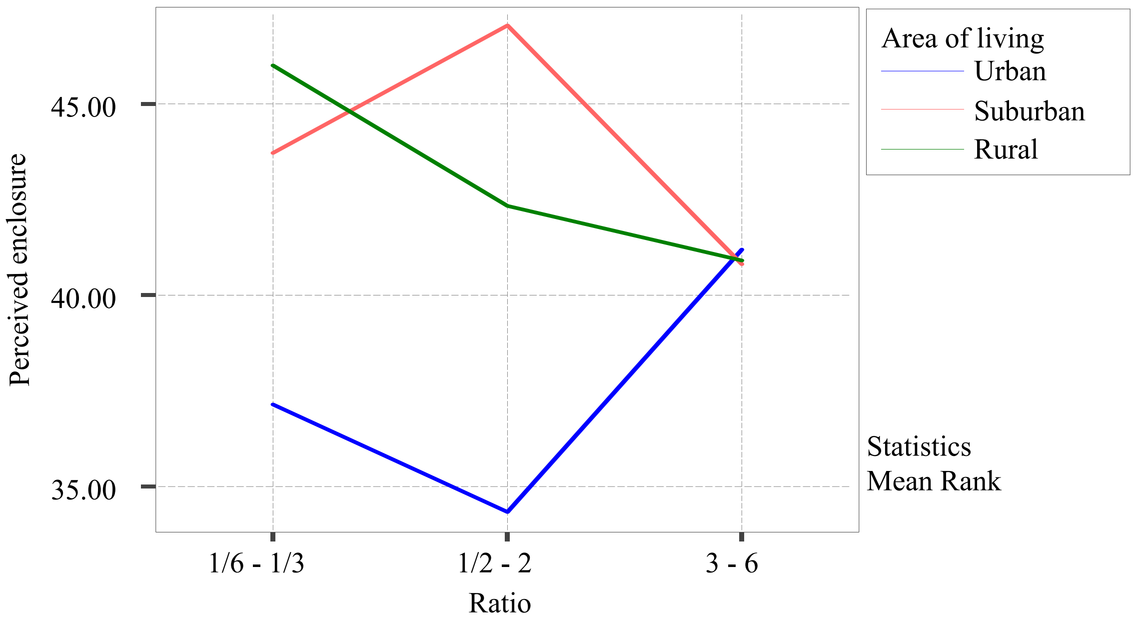


Figure B-7. Differences in perceived enclosure scores relative to the types of living area across 3 ratio categories.

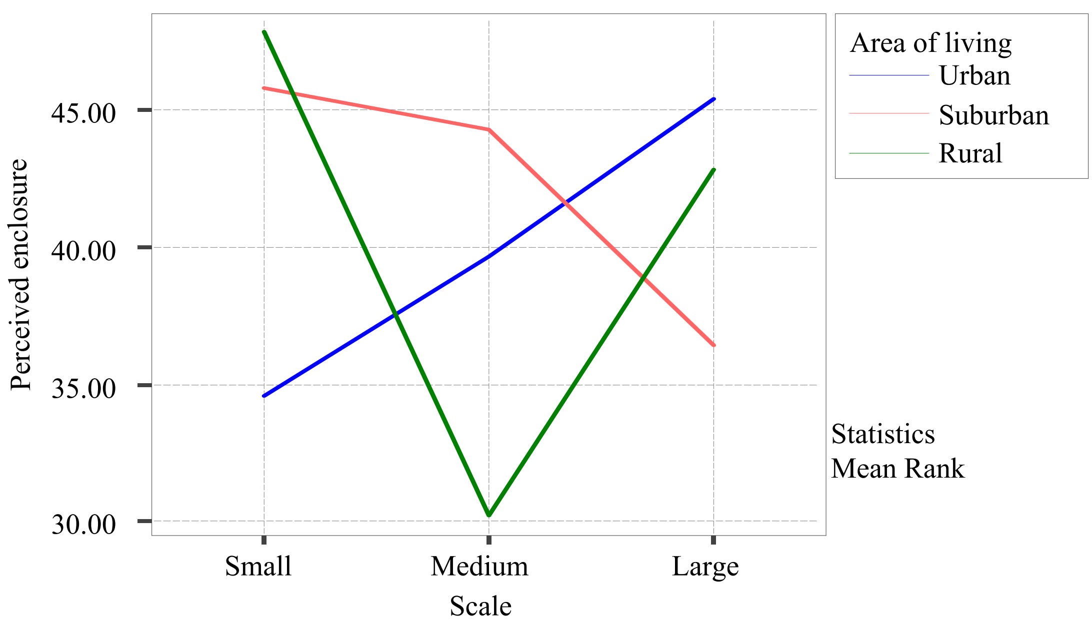


Figure B-8. Differences in perceived enclosure scores relative to the type of living area across 3 scale groups.

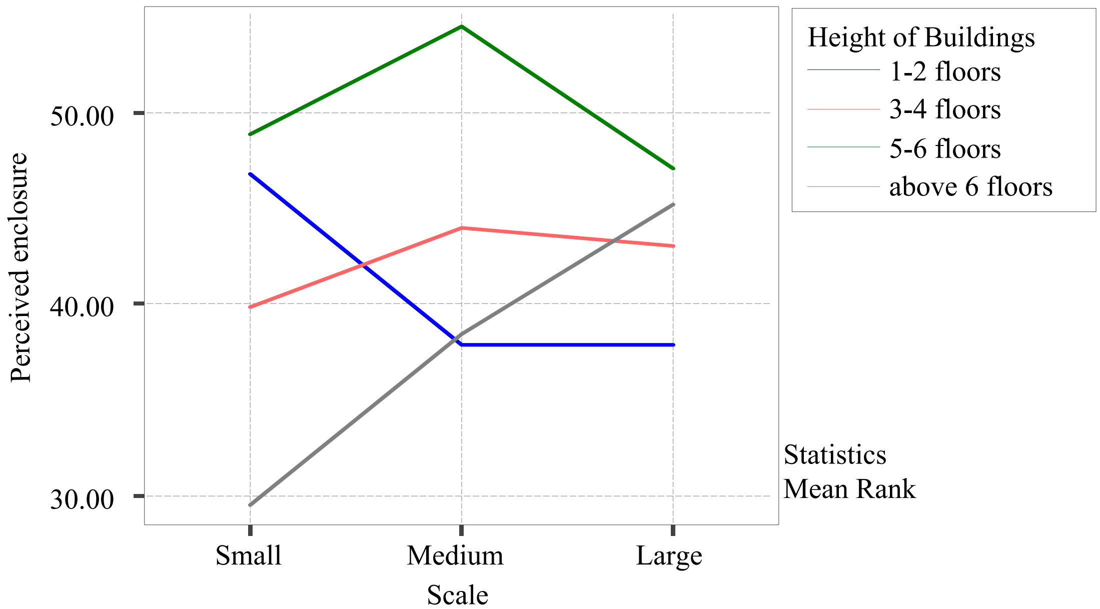


Figure B-9. Differences in perceived enclosure scores relative to the height of buildings in living area, across 3 scale groups.

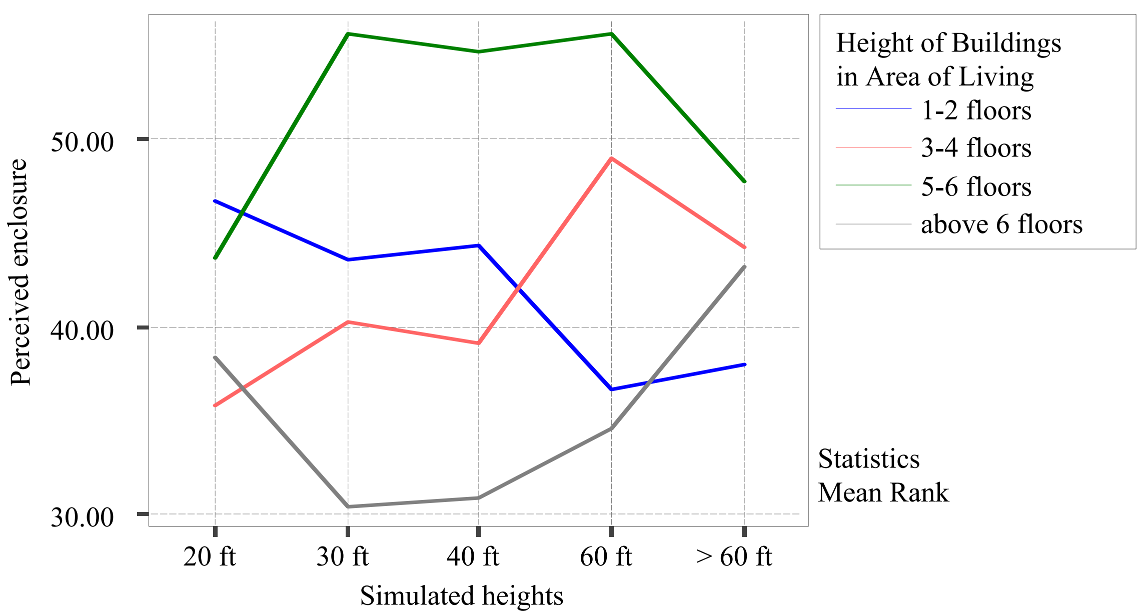


Figure B-10. Differences in perceived enclosure scores relative to the height of buildings in living area, across simulated heights.

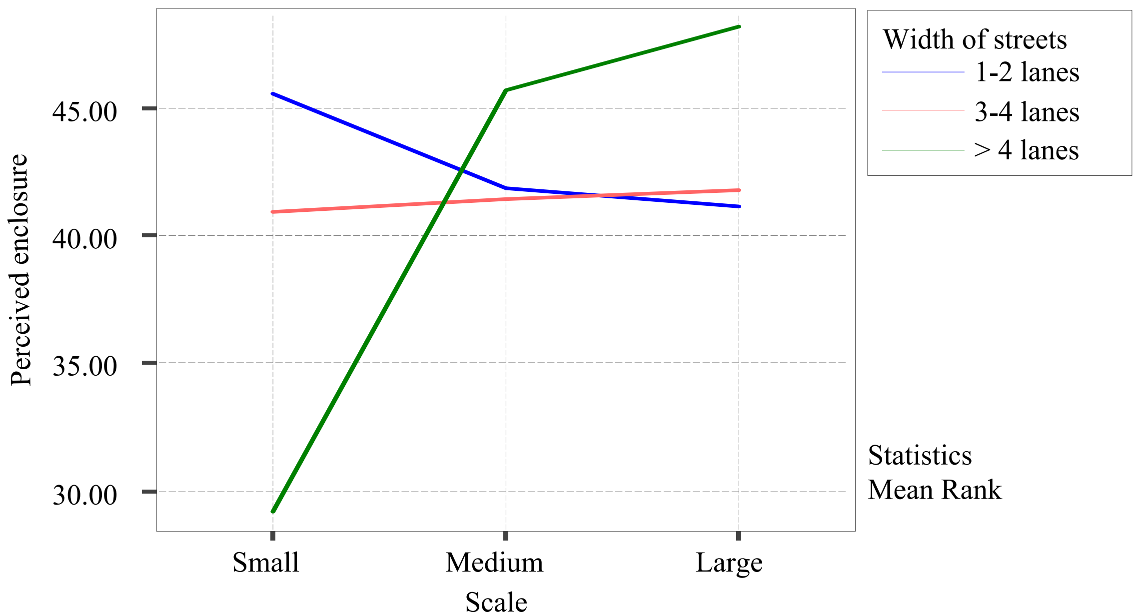


Figure B-11. Differences in perceived enclosure scores relative to the width of streets in living area , across 3 scale groups.

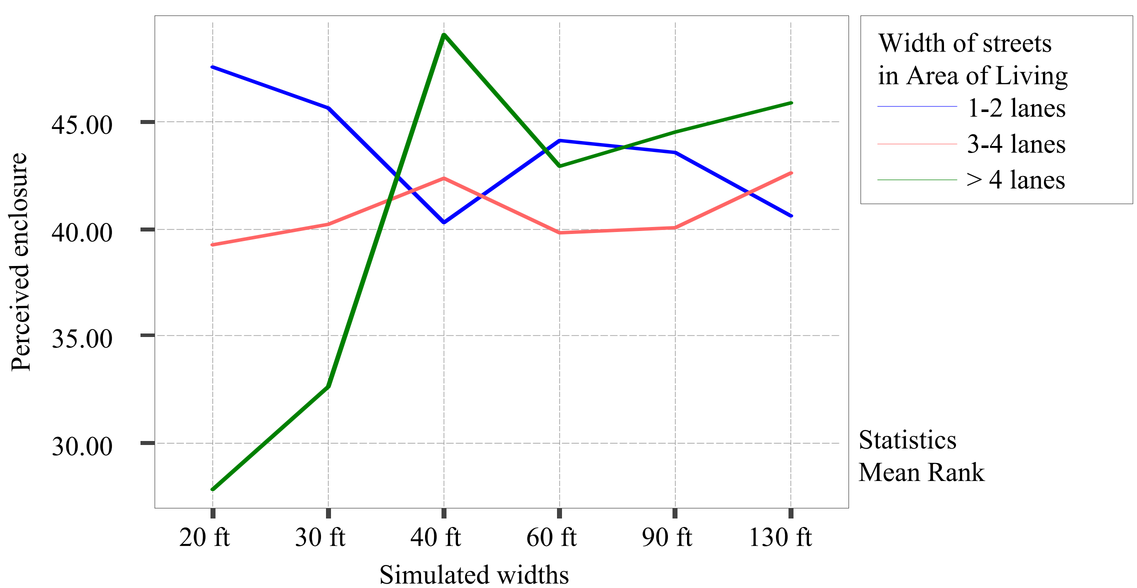


Figure B-12. Differences in perceived enclosure scores relative to the width of streets in living area , across simulated widths.

APPENDIX C
WEIGHTED FREQUENCIES OF COMFORT AND SAFETY RESPONSES

Table C-1. Frequencies of choices for most comfortable and safest spaces, ranked by weighted frequencies.

Space	Weighted frequencies of 3 most Comfortable spaces	Space	Weighted frequencies of 3 safest spaces
Space(20,40,0.5)	659	Space(30,30,1)	693
Space(30,40,0.75)	657	Space(40,40,1)	659
Space(40,30,1.33)	653	Space(30,20,1.5)	654
Space(40,40,1)	618	Space(20,20,1)	583
Space(20,20,1)	617	Space(30,40,0.75)	454
Space(30,30,1)	576	Space(40,30,1.33)	449
Space(60,40,1.5)	490	Space(20,30,0.67)	413
Space(30,20,1.5)	460	Space(30,60,0.5)	409
Space(60,60,1)	408	Space(20,130,0.15)	376
Space(780,130,6)	407	Space(60,40,1.5)	370
Space(20,30,0.67)	375	Space(60,30,2)	370
Space(40,60,0.67)	369	Space(20,60,0.33)	330
Space(60,30,2)	327	Space(20,40,0.5)	329
Space(20,60,0.33)	325	Space(40,20,2)	325
Space(220,90,2.44)	287	Space(40,60,0.67)	285
Space(120,40,3)	284	Space(780,130,6)	246
Space(160,60,2.67)	283	Space(100,30,3.33)	246
Space(30,60,0.5)	249	Space(120,40,3)	246
Space(300,130,2.31)	246	Space(20,90,0.22)	245
Space(60,90,0.67)	244	Space(120,20,6)	206
Space(40,20,2)	244	Space(160,60,2.67)	206
Space(60,20,3)	206	Space(40,90,0.44)	204
Space(100,30,3.33)	162	Space(60,60,1)	203
Space(360,60,6)	124	Space(540,90,6)	201
Space(540,90,6)	123	Space(60,90,0.67)	165
Space(540,130,4.15)	122	Space(30,130,0.23)	164
Space(260,60,4.33)	121	Space(300,130,2.31)	123
Space(120,20,6)	83	Space(60,20,3)	122
Space(180,40,4.5)	82	Space(380,90,4.22)	121
Space(240,40,6)	82	Space(30,90,0.33)	120
Space(20,90,0.22)	81	Space(80,20,4)	83
Space(380,90,4.22)	80	Space(540,130,4.15)	82
Space(20,130,0.15)	42	Space(240,40,6)	82
Space(30,130,0.23)	42	Space(360,60,6)	81
Space(180,30,6)	41	Space(140,30,4.67)	81
Space(40,90,0.44)	40	Space(220,90,2.44)	80
Space(100,20,5)	0	Space(20,20,1)	42

Table C-1. Continued.

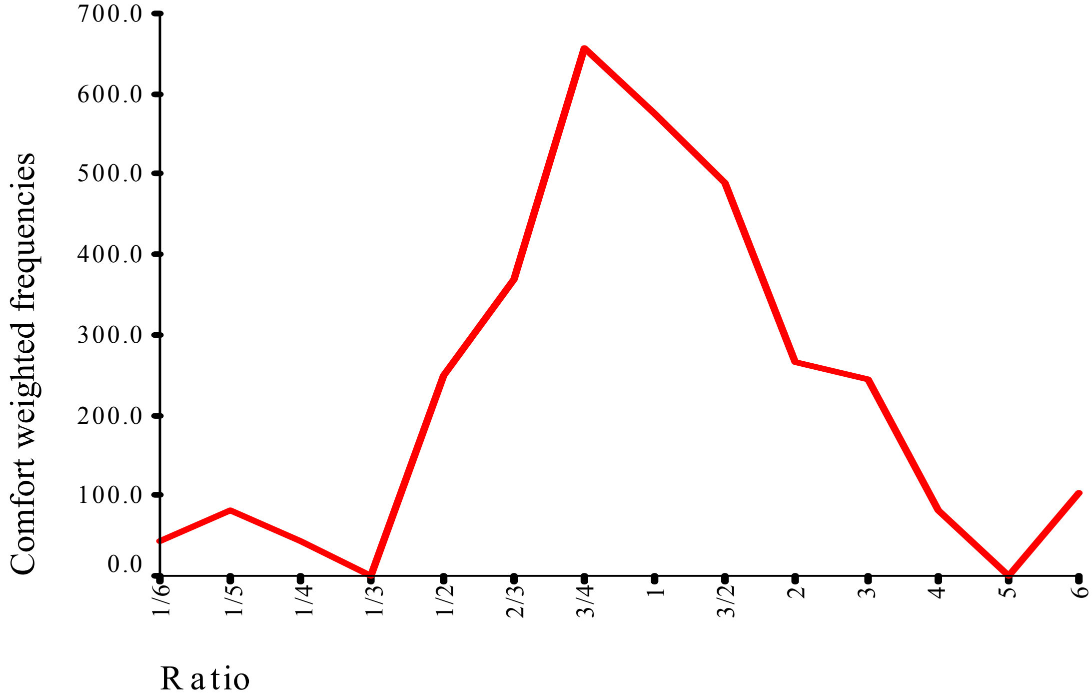
Space	Weighted frequencies of 3 most Comfortable spaces	Space	Weighted frequencies of 3 safest spaces
Space(80,20,4)	0	Space(100,20,5)	41
Space(20,20,1)	0	Space(180,40,4.5)	40
Space(140,30,4.67)	0	Space(180,30,6)	40
Space(40,130,0.31)	0	Space(40,130,0.31)	40
Space(30,90,0.33)	0	Space(260,60,4.33)	0

Table C-2. Frequencies of choices for least comfortable and least safe spaces.

Space Name	Frequencies of choices for least comfortable space	Space Name	Frequencies of choices for least safe space
Space(120,20,6)	37	Space(120,20,6)	25
Space(20,130,0.15)	26	Space(20,130,0.15)	21
Space(780,130,6)	13	Space(780,130,6)	21
Space(20,20,1)	3	Space(20,20,1)	3
Space(100,20,5)	1	Space(100,20,5)	2
Space(20,60,0.33)	1	Space(540,90,6)	2
Space(360,60,6)	1	Space(20,90,0.22)	2
Space(30,130,0.23)	1	Space(60,20,3)	2
Space(60,40,1.5)	0	Space(60,90,0.67)	1
Space(80,20,4)	0	Space(40,20,2)	1
Space(40,90,0.44)	0	Space(360,60,6)	1
Space(300,130,2.31)	0	Space(180,30,6)	1
Space(20,40,0.5)	0	Space(30,130,0.23)	1
Space(220,90,2.44)	0	Space(60,40,1.5)	0
Space(20,30,0.67)	0	Space(80,20,4)	0
Space(30,60,0.5)	0	Space(40,90,0.44)	0
Space(60,90,0.67)	0	Space(300,130,2.31)	0
Space(40,60,0.67)	0	Space(20,40,0.5)	0
Space(540,90,6)	0	Space(220,90,2.44)	0
Space(40,20,2)	0	Space(20,30,0.67)	0
Space(40,30,1.33)	0	Space(20,60,0.33)	0
Space(60,60,1)	0	Space(30,60,0.5)	0
Space(20,90,0.22)	0	Space(40,60,0.67)	0
Space(20,20,1)	0	Space(40,30,1.33)	0
Space(60,20,3)	0	Space(60,60,1)	0
Space(180,40,4.5)	0	Space(20,20,1)	0
Space(540,130,4.15)	0	Space(180,40,4.5)	0
Space(180,30,6)	0	Space(540,130,4.15)	0
Space(260,60,4.33)	0	Space(260,60,4.33)	0
Space(380,90,4.22)	0	Space(380,90,4.22)	0
Space(40,40,1)	0	Space(40,40,1)	0
Space(160,60,2.67)	0	Space(160,60,2.67)	0

Table C-2. Continued.

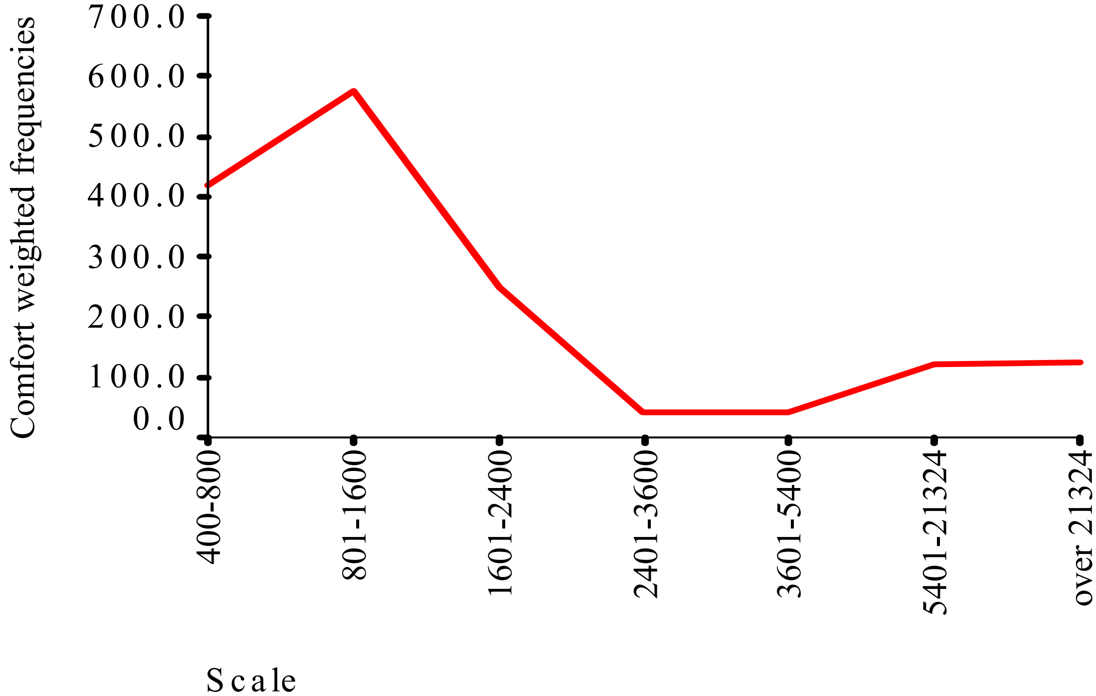
Space	Weighted frequencies of 3 most Comfortable spaces spaces	Space	Weighted frequencies of 3 safest spaces
Space(30,40,0.75)	0	Space(30,40,0.75)	0
Space(240,40,6)	0	Space(240,40,6)	0
Space(100,30,3.33)	0	Space(100,30,3.33)	0
Space(120,40,3)	0	Space(120,40,3)	0
Space(140,30,4.67)	0	Space(140,30,4.67)	0
Space(60,30,2)	0	Space(60,30,2)	0
Space(30,30,1)	0	Space(30,30,1)	0
Space(40,130,0.31)	0	Space(40,130,0.31)	0
Space(30,20,1.5)	0	Space(30,20,1.5)	0
Space(30,90,0.33)	0	Space(30,90,0.33)	0



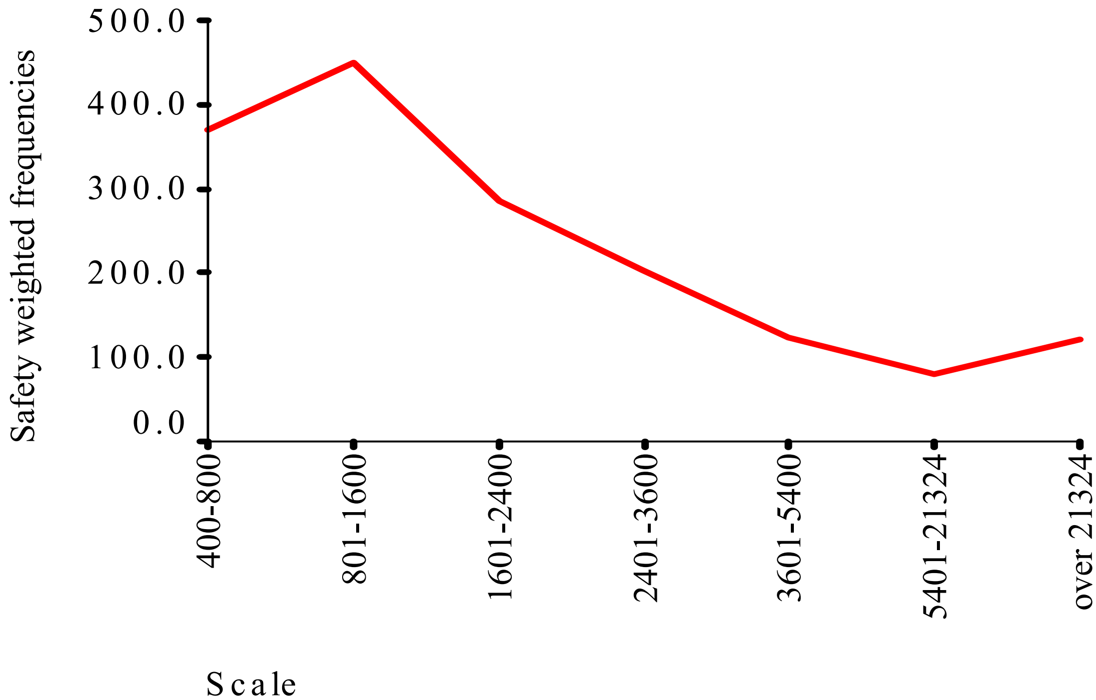
A

B

Figure C-1. Ratio and weighted frequencies of choices. A) For most comfortable three spaces, B) For safest three spaces.



A



B

Figure C-2. Scale and weighted frequencies of choices. A) For most comfortable three spaces. B) For safest three spaces.

APPENDIX D
SENSE OF COMFORT AND SAFETY ACROSS DEMOGRAPHIC DIFFERENCES

Table D-1. Mann-Whitney test for differences in comfort and safety scores of men and women across 3 ratio categories.

Ratio	N			Mean rank		Test statistics[a]		
	Gender			Gender		Mann-Whitney U	Z	Asymp Sig.
	Male	Female	Total	Male	Female			
	Comfort							
1/6-1/3	53	30	83	43.02	40.20	741.000	−0.512	0.609
1/2-2	53	30	83	40.92	43.92	737.500	−0.545	0.586
3-6	53	30	83	44.80	37.05	656.500	−1.408	0.159
	Safety							
1/6-1/3	53	30	83	44.84	36.98	644.500	−1.427	0.154
1/2-2	53	30	83	40.18	45.22	698.500	−0.915	0.360
3-6	53	30	83	43.86	38.72	696.500	−1.934	0.350

[a]Grouping variable: gender.

Table D-2. Mann-Whitney test for differences in comfort and safety scores of men and women across 3 scale groups.

Scale	N			Mean rank		Test statistics[a]		
	Gender			Gender		Mann-Whitney U	Z	Asymp Sig.
	Male	Female	Total	Male	Female			
	Comfort							
Small	53	30	83	38.39	48.38	603.500	−1.822	0.069
Medium	53	30	83	43.13	40.00	735.000	−0.577	0.564
Large	53	30	83	47.79	31.77	488.000	−2.916	0.004
	Safety							
Small	53	30	83	37.60	49.77	562.000	−2.220	0.026
Medium	53	30	83	41.08	43.62	746.500	−0.464	0.642
Large	53	30	83	47.01	33.15	529.500	−2.523	0.012

[a]Grouping variable: gender.

Table D-3. Kruskal-Wallis test for differences in comfort and safety scores of age groups for 3 ratio categories.

Ratio	N				Mean rank			Test statistics[a,b]		
	Age				Age			Chi-Square	df	Asymp Sig.
	< 24	25-32	>32	Total	< 24	25-32	>32			
	Comfort									
1/6-1/3	31	25	27	83	39.18	41.98	45.26	0.920	2	0.631
1/2-2	31	25	27	83	31.34	51.02	45.89	10.271	2	0.006
3-6	31	25	27	83	43.92	41.34	40.41	0.333	2	0.847
	Safety									
1/6-1/3	31	25	27	83	41.87	43.20	41.04	0.106	2	0.948
1/2-2	31	25	27	83	36.63	47.02	43.52	2.731	2	0.255
3-6	31	25	27	83	44.40	39.26	41.78	0.634	2	0.729

[a]Kruskal Wallis test.

[b]Grouping variable: age.

Table D-4. Kruskal-Wallis test for differences in comfort scores of 3 age groups across 3 scale groups.

Scale	N				Mean rank			Test statistics[a,b]		
	Age				Age			Chi-Square	df	Asymp Sig.
	< 24	25-32	>32	Total	< 24	25-32	>32			
	Comfort									
Small	31	25	27	83	32.60	49.04	46.28	7.756	2	0.210
Medium	31	25	27	83	36.50	48.16	42.61	3.360	2	0.186
Large	31	25	27	83	48.47	41.12	35.07	4.707	2	0.095
	Safety									
Small	31	25	27	83	33.11	47.16	47.43	6.798	2	0.033
Medium	31	25	27	83	39.60	45.16	41.83	0.754	2	0.686
Large	31	25	27	83	46.76	38.86	39.44	1.945	2	0.378

[a]Kruskal Wallis test.

[b]Grouping variable: age.

Table D-5. Mann-Whitney test for differences in comfort and safety scores of designer and non designer groups across 3 ratio categories.

Ratio	N			Mean rank		Test statistics[a]		
	Design background			Design background		Mann-Whitney U	Z	Asymp Sig.
	Yes	No	Total	Yes.	No			
	Comfort							
1/6-1/3	30	52	82	34.08	45.78	557.500	−2.143	0.032
1/2-2	30	52	82	41.55	41.47	778.500	−0.014	0.988
3-6	30	52	82	51.63	53.65	476.000	−2.927	0.003
	Safety							
1/6-1/3	30	52	82	36.37	44.64	626.000	−1.483	0.138
1/2-2	30	52	82	44.97	39.50	676.000	−1.001	0.317
3-6	30	52	82	52.93	34.90	437.000	−3.302	0.001

[a]Grouping variable: design background.

Table D-6. Mann-Whitney Test for differences in comfort scores of designer and non designer groups across 3 scale groups.

scale	N			Mean rank		Test statistics[a]		
	Design background			Design background		Mann-Whitney U	Z	Asymp Sig.
	Yes	No	Total	Yes.	No			
	Comfort							
Small	30	52	82	39.70	42.54	726.000	−0.522	0.602
Medium	30	52	82	45.27	39.33	667.000	−1.103	0.270
Large	30	52	82	42.62	40.86	746.500	−0.323	0.747
	Safety							
Small	30	52	82	40.47	42.10	749.000	−0.300	0.764
Medium	30	52	82	47.45	38.07	601.500	−1.735	0.083
Large	30	52	82	44.00	40.06	705.00	−0.724	0.469

[a]Grouping variable: design background.

Table D-7. Kruskal-Wallis test for differences in comfort and safety scores relative to the types of living area across 3 ratio categories.

Ratio	N				Mean rank			Test statistics[a,b]		
	Living area				Living area			Chi-Square	df	Asymp Sig.
	Urban	Suburban	Rural	Total	Urban	Suburban	Rural			
	Comfort									
1/6-1/3	36	38	7	81	43.40	35.08	60.79	7.740	2	0.021
1/2-2	36	38	7	81	48.38	35.66	32.71	6.507	2	0.039
3-6	36	38	7	81	45.99	37.07	36.71	2.912	2	0.233
	Safety									
1/6-1/3	36	38	7	81	40.29	38.66	57.37	3.796	2	0.150
1/2-2	36	38	7	81	45.44	37.38	37.79	2.315	2	0.314
3-6	36	38	7	81	44.65	39.07	32.71	1.993	2	0.369

[a]Kruskal Wallis test.

[b]Grouping variable: type of living area.

Table D-8. Kruskal-Wallis test for differences in comfort and safety scores relative to the type of living area across 3 scale groups.

Scale	N				Mean rank			Test statistics[a,b]		
	Living area				Living area			Chi-Square	df	Asymp Sig.
	Urban	Suburban	Rural	Total	Urban	Suburban	Rural			
	Comfort									
Small	36	38	7	81	48.29	36.24	29.36	6.779	2	0.034
Medium	36	38	7	81	45.39	38.12	34.07	2.499	2	0.287
Large	36	38	7	81	40.58	40.04	48.36	0.762	2	0.683
	Safety									
Small	36	38	7	81	48.56	36.12	28.46	7.351	2	0.025
Medium	36	38	7	81	44.43	38.46	37.14	1.424	2	0.491
Large	36	38	7	81	41.22	39.50	48.00	0.781	2	0.677

[a]Kruskal Wallis test.

[b]Grouping variable: type of living area.

Table D-9. Kruskal-Wallis test for differences in comfort and safety scores relative to the height of buildings in the living area across 3 scale groups.

Scale	N: Height of buildings in area of living (floors)					Mean rank: Height of buildings in living area (floors)				Test statistics[a,b]		
	1-2	3-4	5-6	>6	Total	1-2	3-4	5-6	>6	Chi-Square	df	Asymp Sig.
	Comfort											
Small	34	19	13	17	83	40.26	38.24	37.50	53.12	4.743	3	0.192
Medium	34	19	13	17	83	40.40	41.21	32.88	53.06	5.773	3	0.123
Large	34	19	13	17	83	37.78	42.42	39.42	51.94	4.105	3	0.250
	Safety											
Small	34	19	13	17	83	41.40	37.95	33.38	54.32	6.733	3	0.081
Medium	34	19	13	17	83	39.74	46.45	32.65	84.71	4.305	3	0.230
Large	34	19	13	17	83	38.90	36.66	44.96	51.91	4.589	3	0.204

[a]Kruskal Wallis test.

[b]Grouping variable: height of buildings in living area.

Table D-10. Kruskal-Wallis test for differences in comfort and safety scores relative to the height of buildings in the living area across simulated heights.

Simulated height	N: Height of buildings in area of living (floors)					Mean rank: Height of buildings in living area (floors)				Test statistics[a,b]		
	1-2	3-4	5-6	>6	Total	1-2	3-4	5-6	>6	Chi-Square	df	Asymp Sig.
	Comfort											
20 ft	34	19	13	17	83	42.47	43.32	36.54	43.76	0.832	3	0.842
30 ft	34	19	13	17	83	40.37	43.47	34.69	49.21	2.060	3	0.396
40 ft	34	19	13	17	83	38.82	41.32	40.00	50.65	2.916	3	0.405
60 ft	34	19	13	17	83	35.46	40.92	38.65	58.85	11.298	3	0.010
>60 ft	34	19	13	17	83	35.49	46.61	36.27	54.26	8.327	3	0.040
	Safety											
20 ft	34	19	13	17	83	40.62	40.53	42.08	46.35	0.740	3	0.864
30 ft	34	19	13	17	83	41.94	39.39	42.04	45.00	0.490	3	0.921
40 ft	34	19	13	17	83	39.46	44.13	41.50	45.09	0.823	3	0.844
60 ft	34	19	13	17	83	39.90	40.24	34.50	53.91	5.856	3	0.119
>60 ft	34	19	13	17	83	37.04	42.11	40.23	53.15	5.153	3	0.161

[a]Kruskal Wallis test.

[b]Grouping variable: height of buildings in living area.

Table D-11. Kruskal-Wallis test for differences in comfort and safety scores relative to widths of streets in the living area across 3 scale groups.

Scale	N: Width of streets in area of living (lanes) 1-2	3-4	>4	Total	Mean rank: Width of streets in area of living (lanes) 1-2	3-4	>4	Test statistics[a,b] Chi-Square	df	Asymp Sig.
	Comfort									
Small	37	39	7	83	39.76	43.49	45.57	0.627	2	0.731
Medium	37	39	7	83	41.35	41.29	49.36	0.733	2	0.693
Large	37	39	7	83	38.07	42.41	60.50	5.140	2	0.077
	Safety									
Small	37	39	7	83	40.42	42.78	46.00	0.397	2	0.820
Medium	37	39	7	83	41.08	41.88	47.50	0.428	2	0.807
Large	37	39	7	83	37.01	43.85	58.07	4.947	2	0.084

[a]Kruskal Wallis test.

[b]Grouping variable: width of streets in living area.

Table D-12. Kruskal-Wallis test for differences in comfort and safety scores relative to widths of streets in the living area across simulated widths.

Simulated width	N: Width of streets in area of living (lanes) 1-2	3-4	>4	Total	Mean rank: Width of streets in area of living (lanes) 1-2	3-4	>4	Test statistics[a,b] Chi-Square	df	Asymp Sig.
	Comfort									
20 ft	37	39	7	83	36.70	46.62	44.29	3.286	2	0.139
30 ft	37	39	7	83	37.78	44.95	47.86	2.145	2	0.342
40 ft	37	39	7	83	41.41	41.22	49.50	0.754	2	0.686
60 ft	37	39	7	83	39.61	42.12	54.00	2.117	2	0.347
90 ft	37	39	7	83	38.38	43.01	55.43	3.089	2	0.213
130 ft	37	39	7	83	40.12	42.64	48.36	0.742	2	0.690
	Safety									
20 ft	37	39	7	83	35.27	47.82	45.14	5.288	2	0.071
30 ft	37	39	7	83	37.32	44.92	50.43	2.840	2	0.242
40 ft	37	39	7	83	40.43	42.83	45.64	0.368	2	0.832
60 ft	37	39	7	83	39.01	41.58	60.14	4.574	2	0.102
90 ft	37	39	7	83	38.35	42.95	56.00	3.282	2	0.194
130 ft	37	39	7	83	39.70	42.95	48.86	0.966	2	0.617

[a]Kruskal Wallis test.

[b]Grouping variable: width of streets in living area.

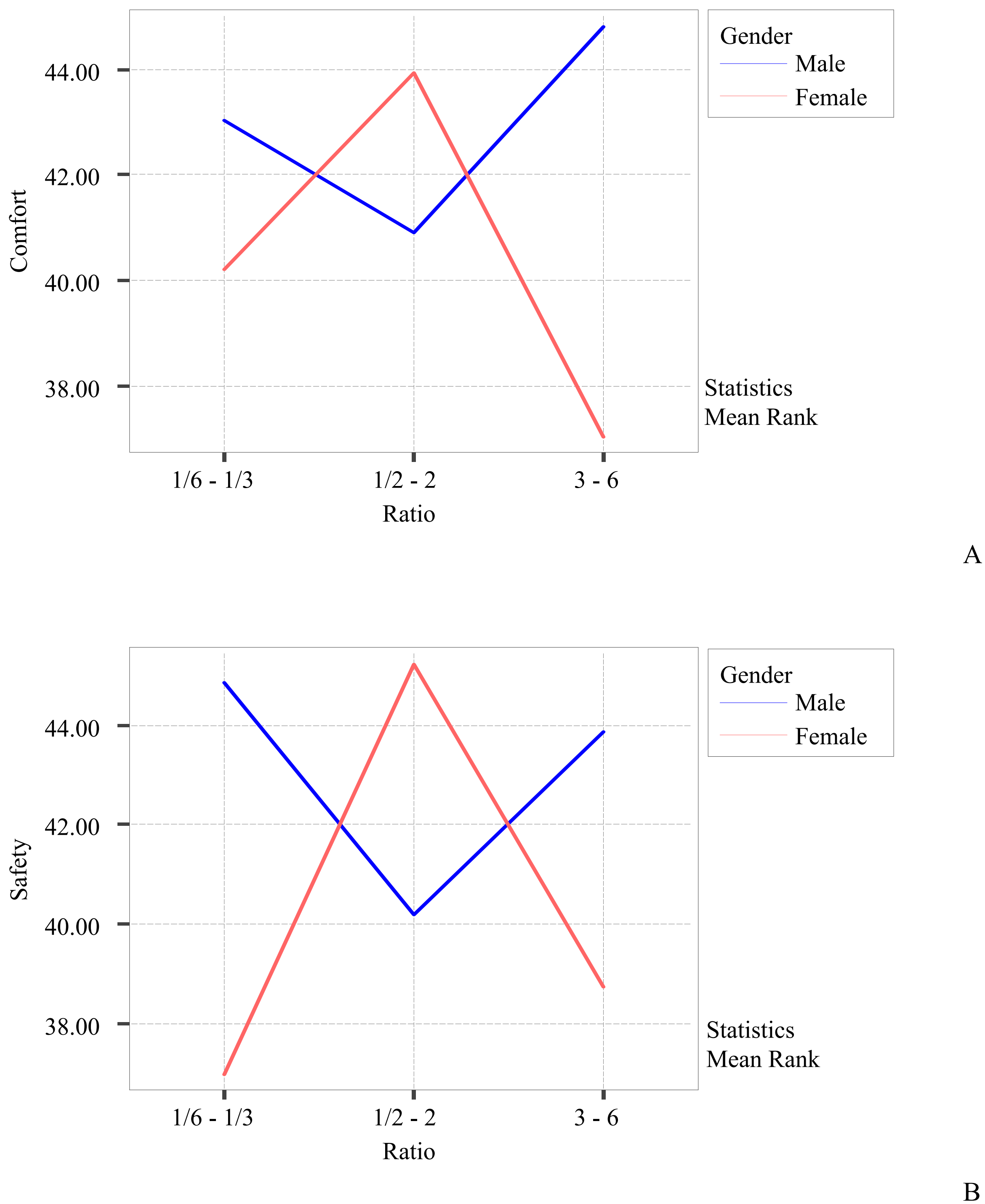
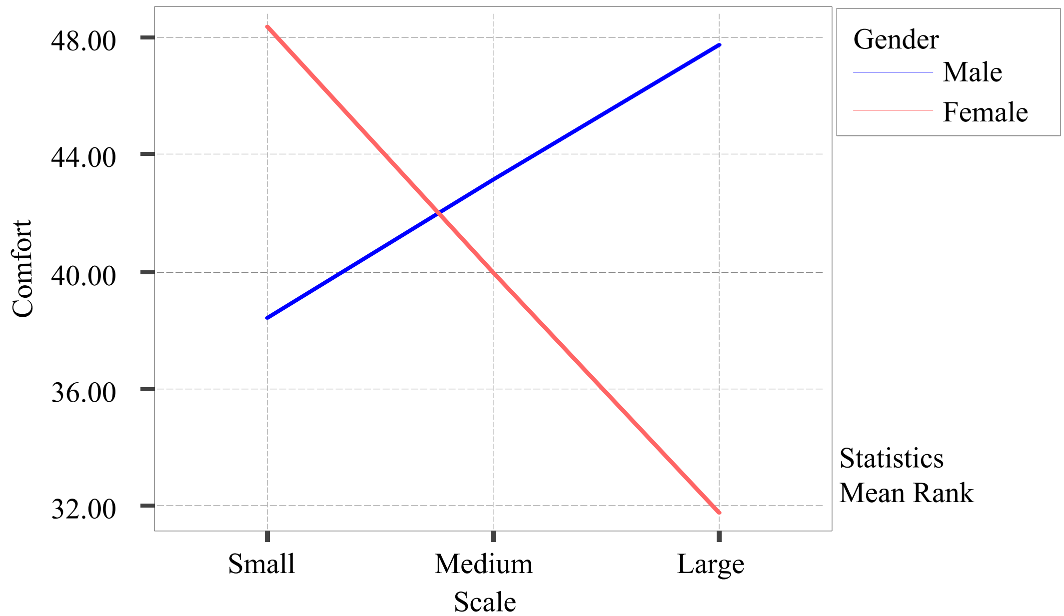
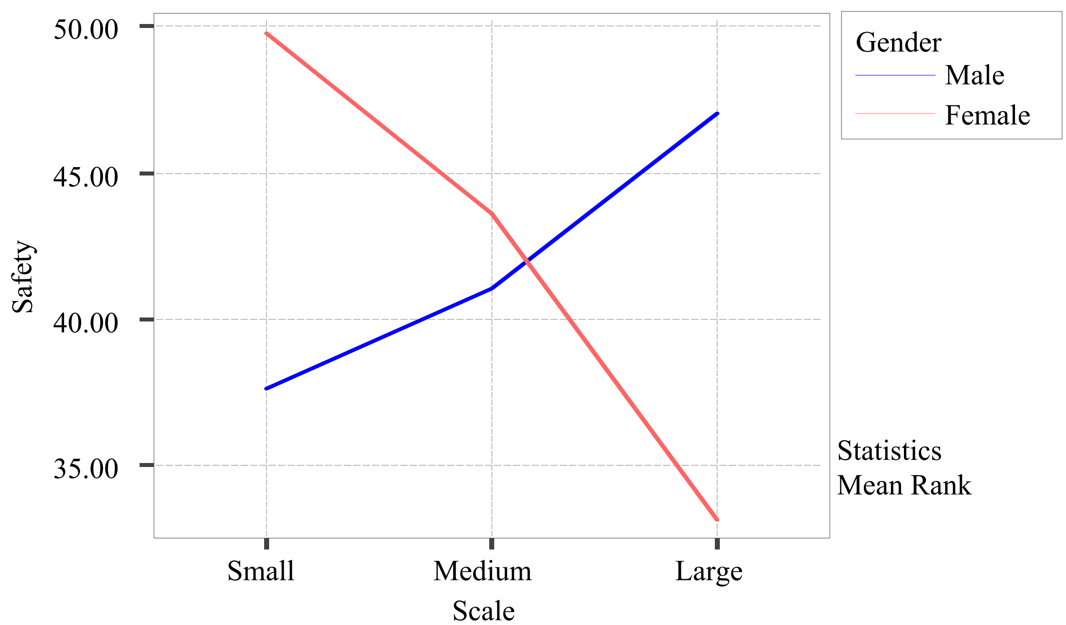


Figure D-1. Differences of comfort and safety mean ranks of men and women across 3 ratio categories. A) Comfort and ratio. B) Safety and ratio.

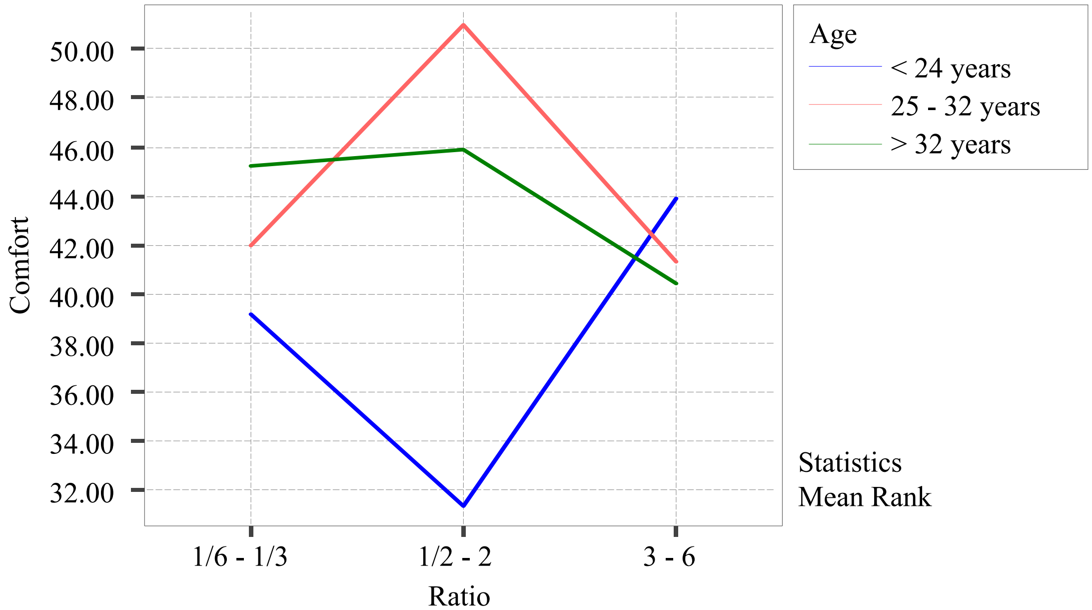


A



B

Figure D-2. Differences in comfort and safety scores of men and women across 3 scale groups. A) Comfort and scale. B) Safety and scale.



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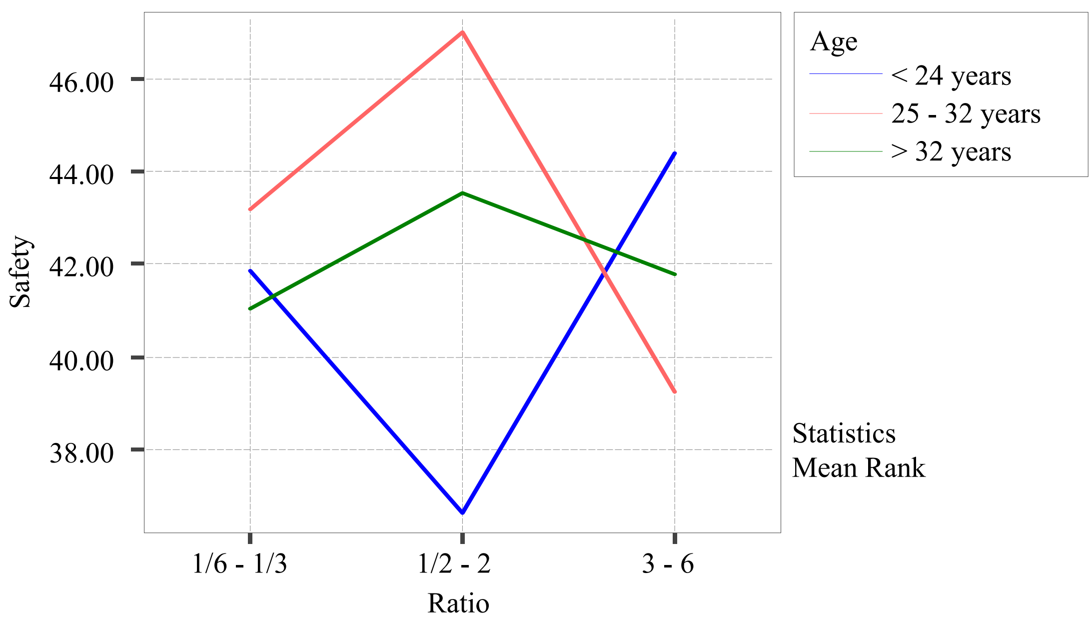
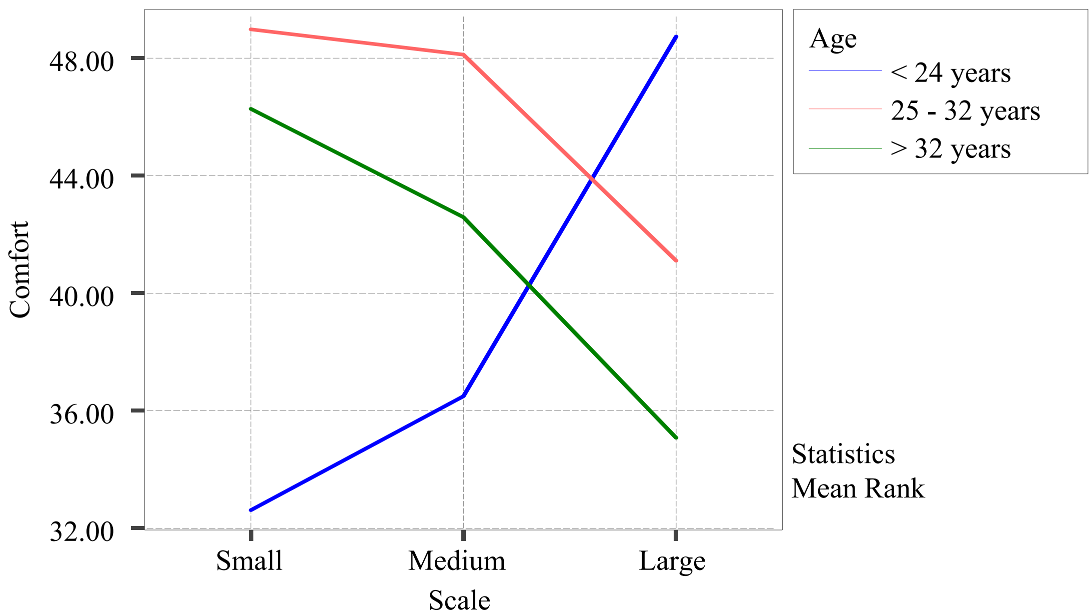


B

Figure D-3. Differences of comfort and safety mean ranks of age groups across 3 ratio categories. A) Comfort and ratio. B) Safety and ratio.



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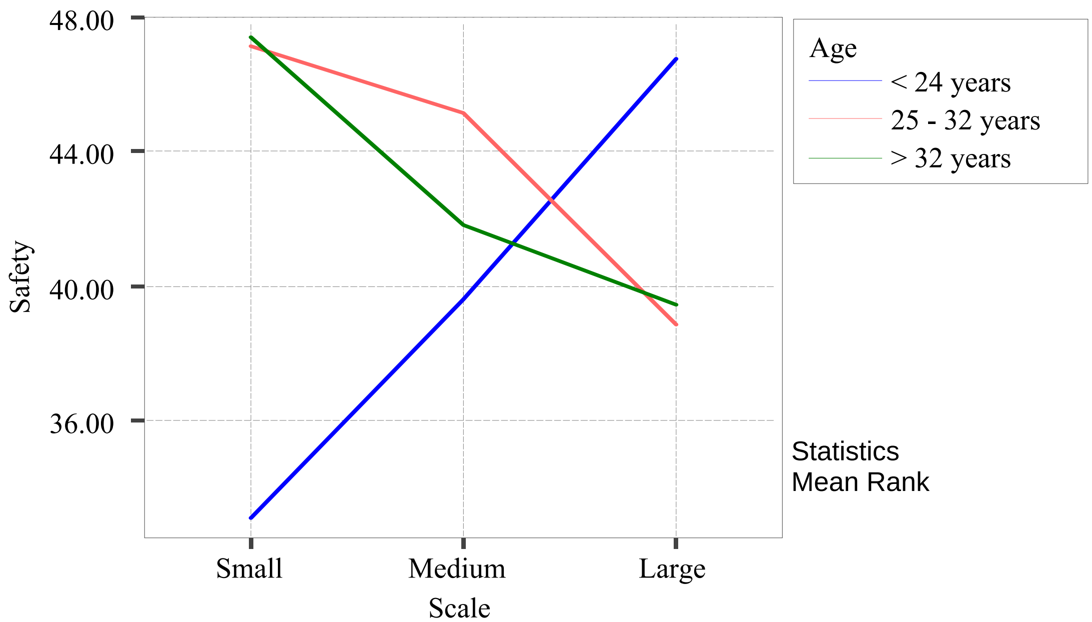
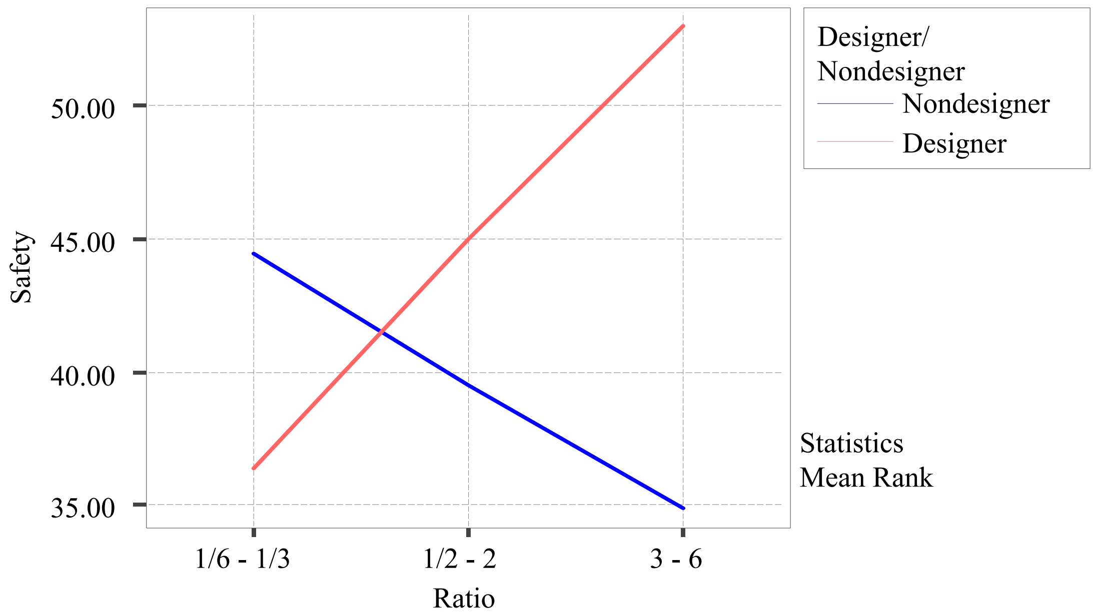


B

Figure D-4. Differences of differences in comfort and safety scores of 3 age groups across 3 scale groups. A) Comfort and age. B) Safety and age.



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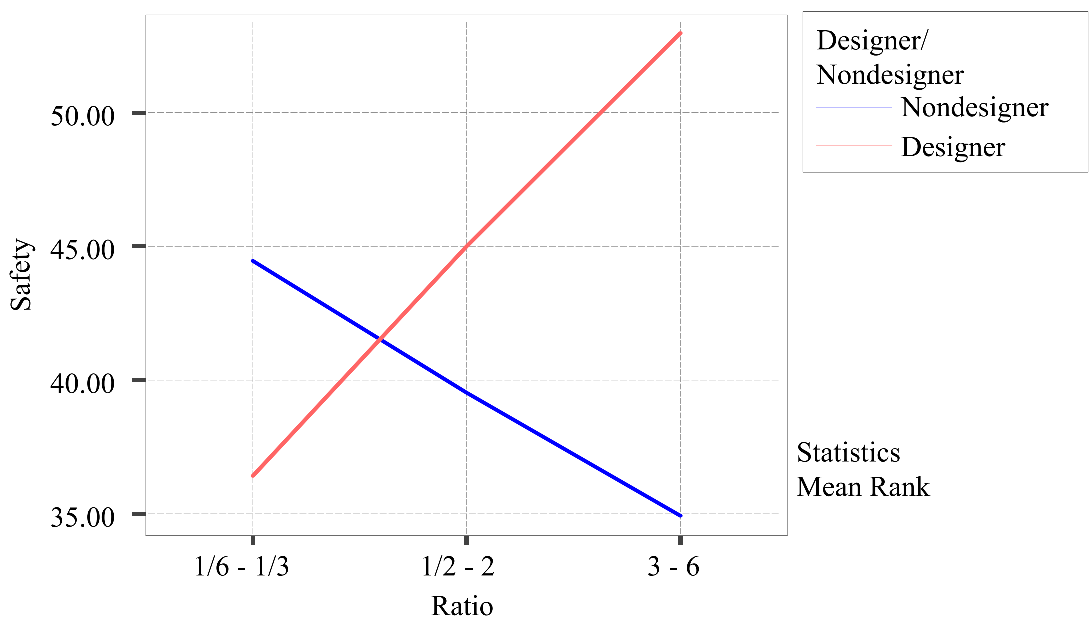
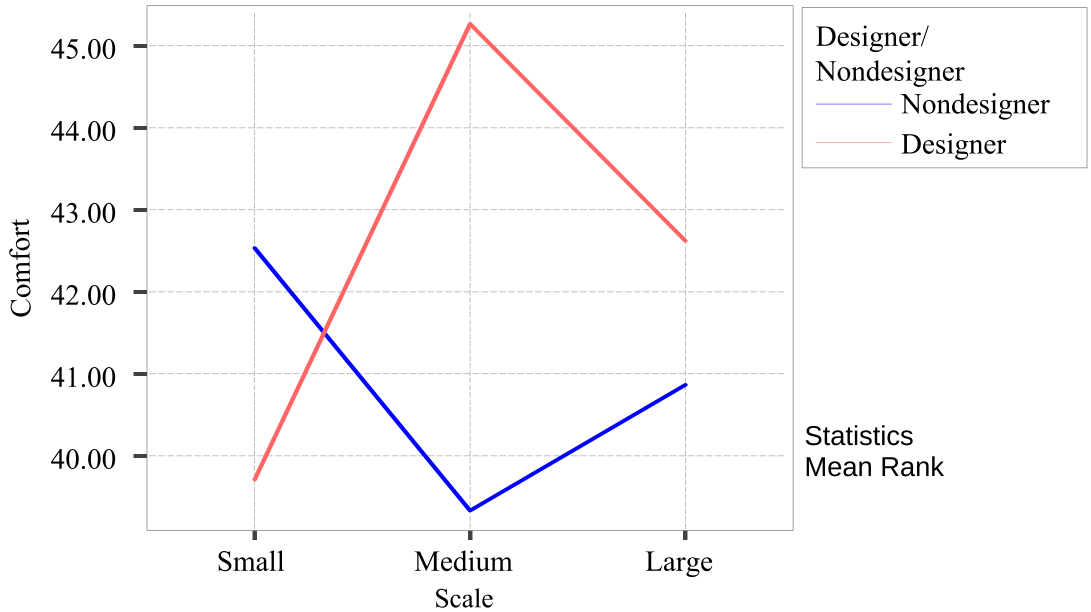


B

Figure D-5. Differences in comfort and safety scores of designers and non designers across 3 ratio categories. A) Comfort and ratio. B) Safety and Ratio.



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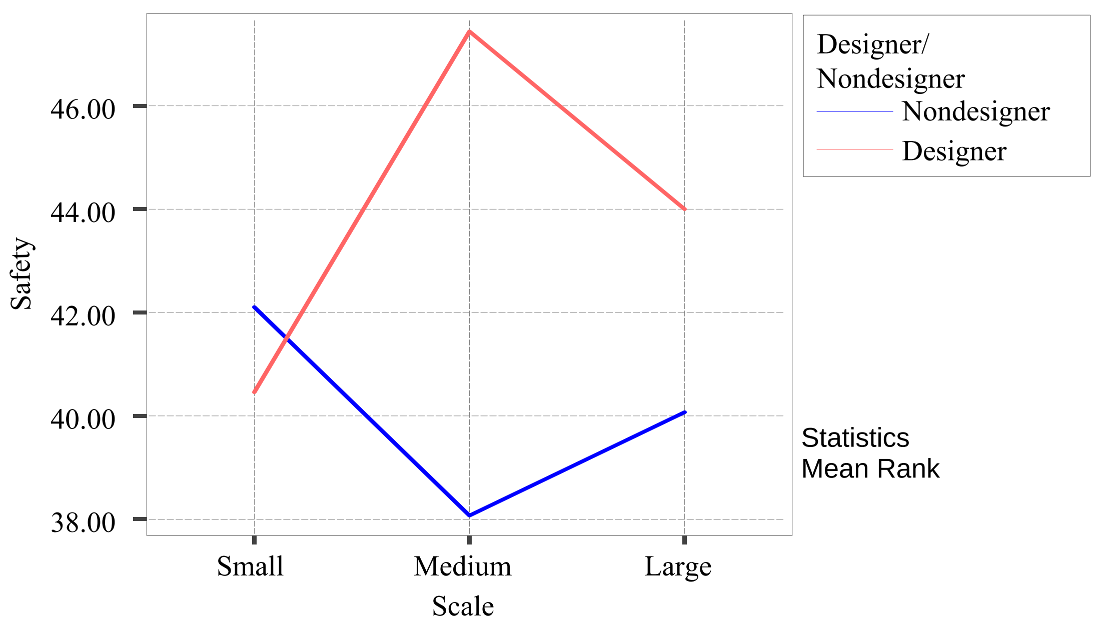

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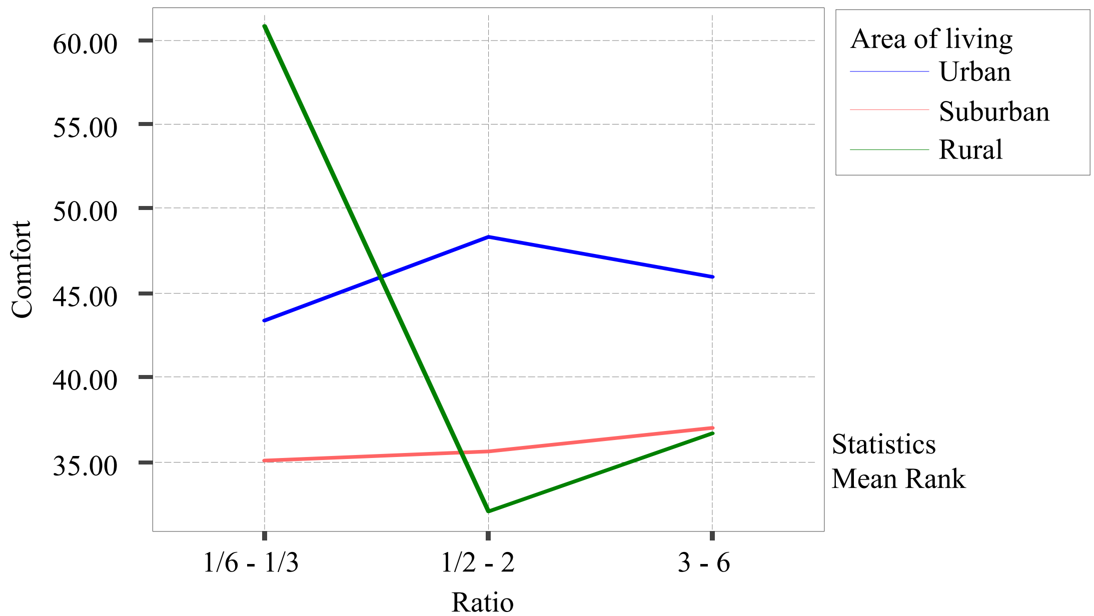
Figure D-6. Differences in comfort and safety scores of designers and non designers across 3 scale groups. A) Comfort and scale. B) Safety and scale.



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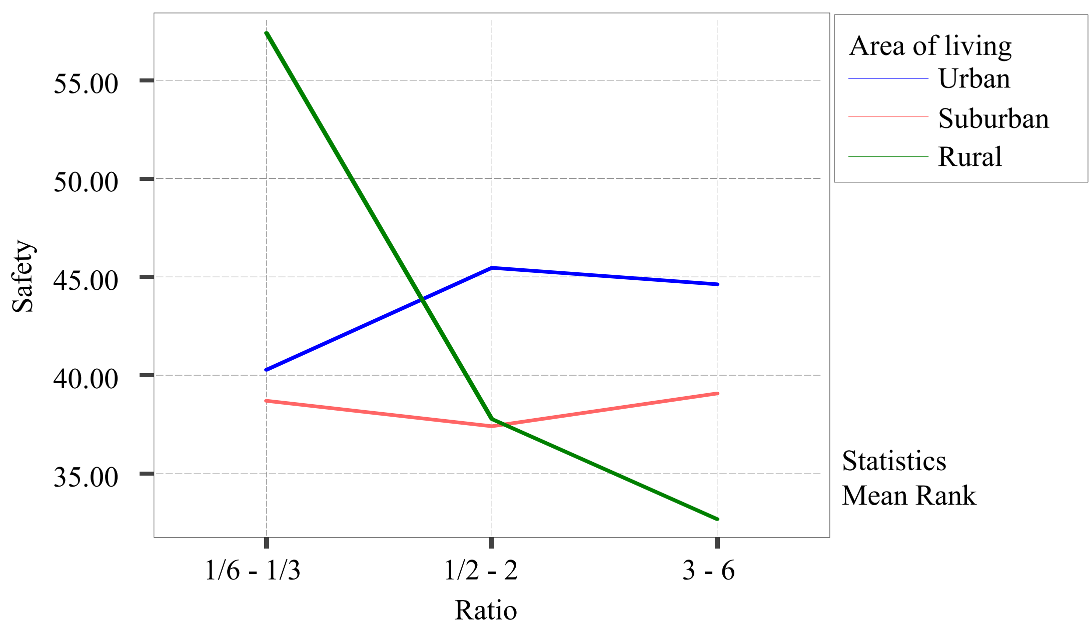
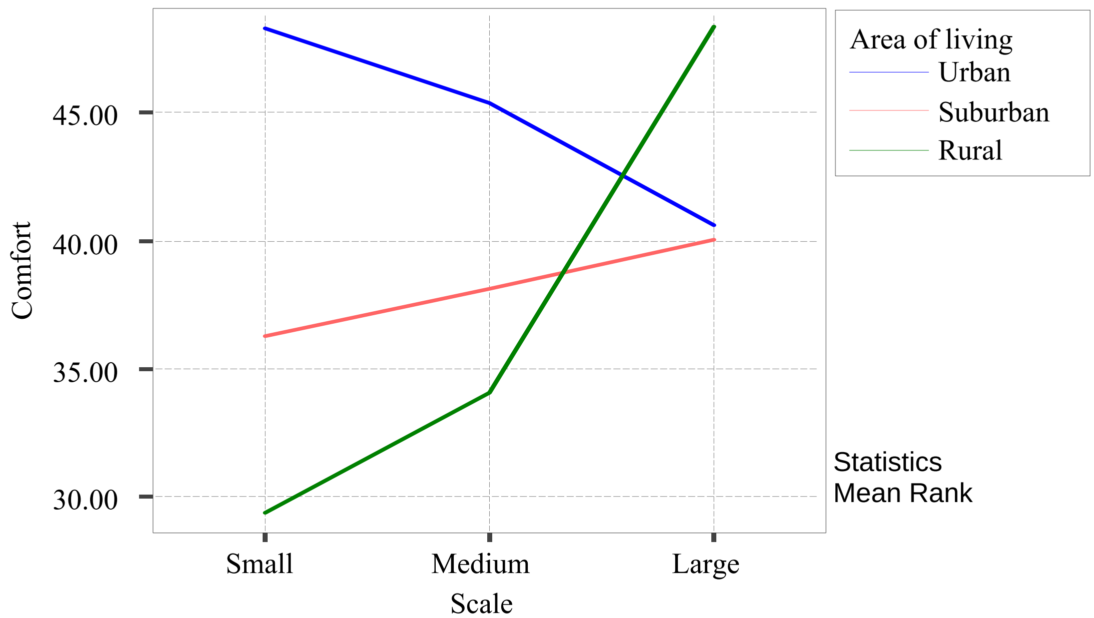


B

Figure D-7. Differences in comfort and safety scores relative to the types of living area across 3 ratio categories. A) Comfort and ratio. B) Safety and ratio.



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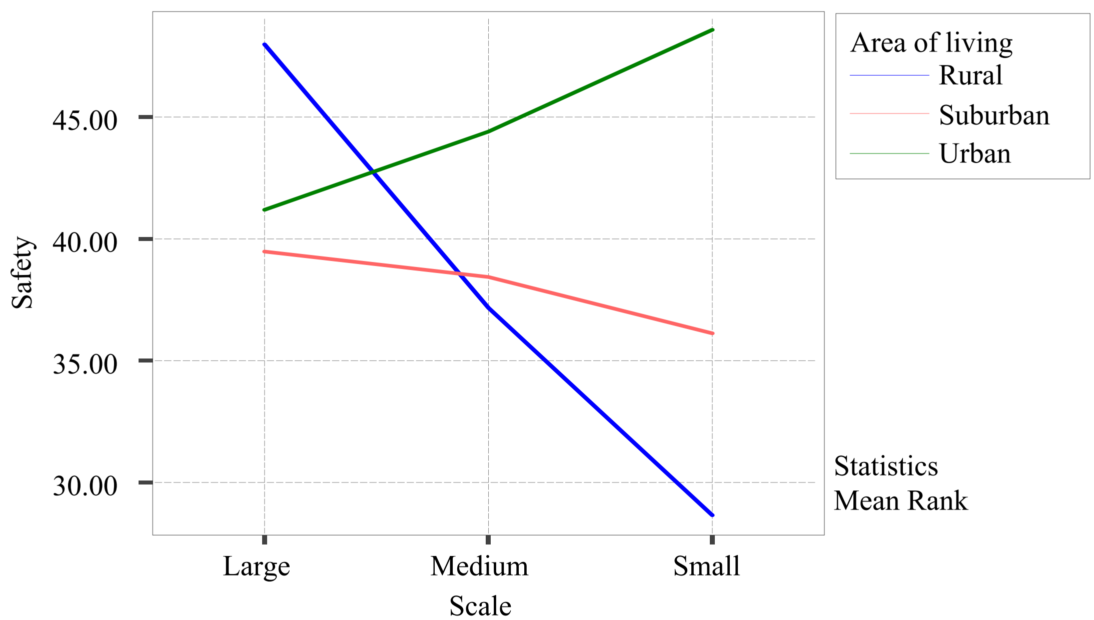
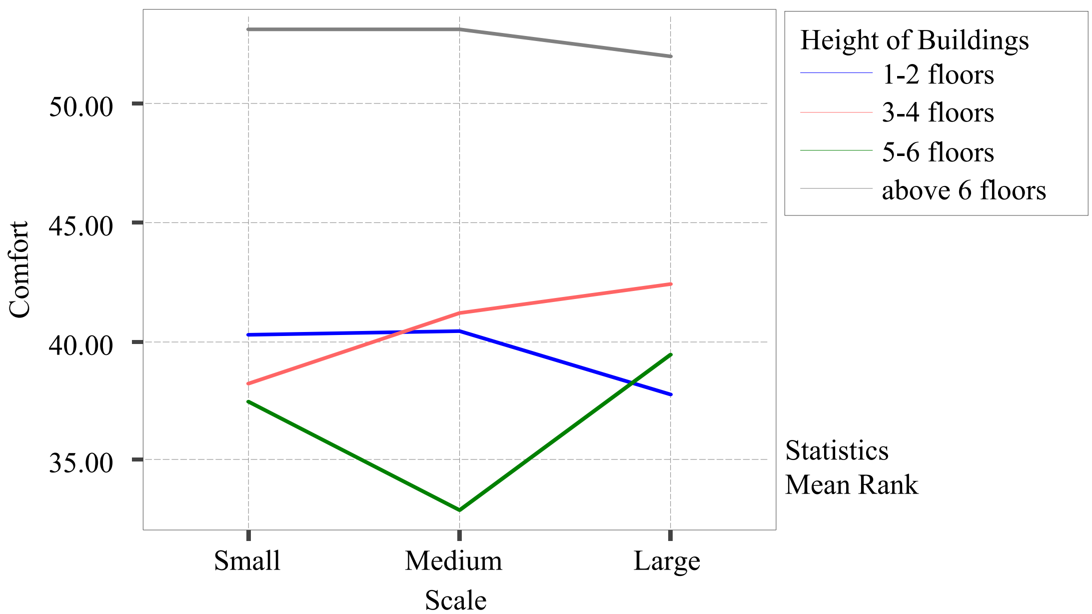
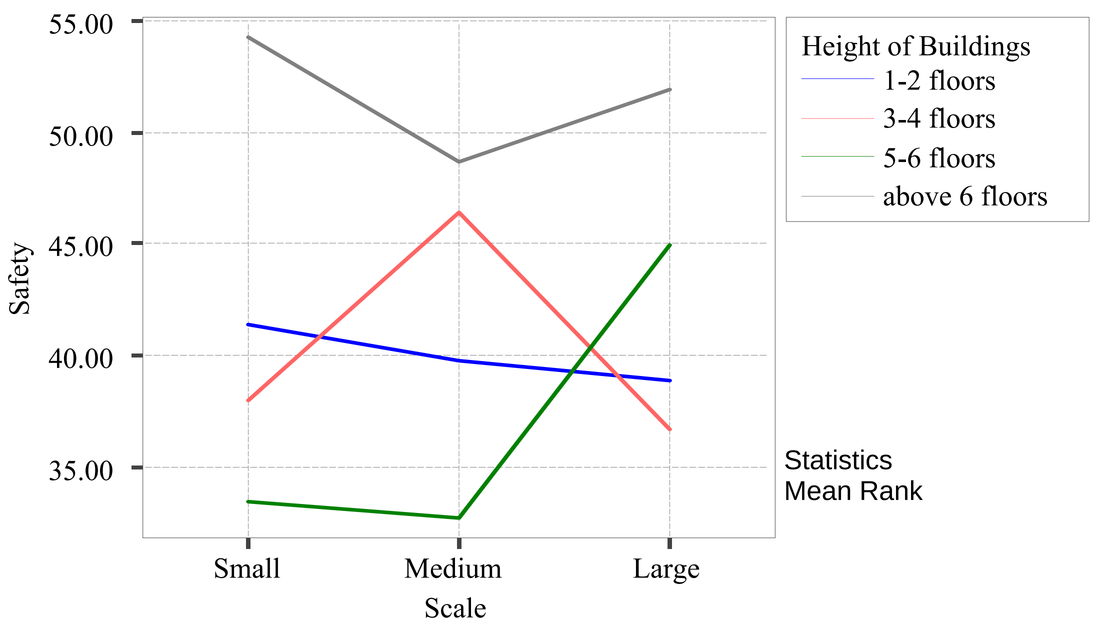


B

Figure D-8. Differences in comfort and safety scores relative to the type of living area across 3 scale groups. A) Comfort and scale. B) Safety and scale.

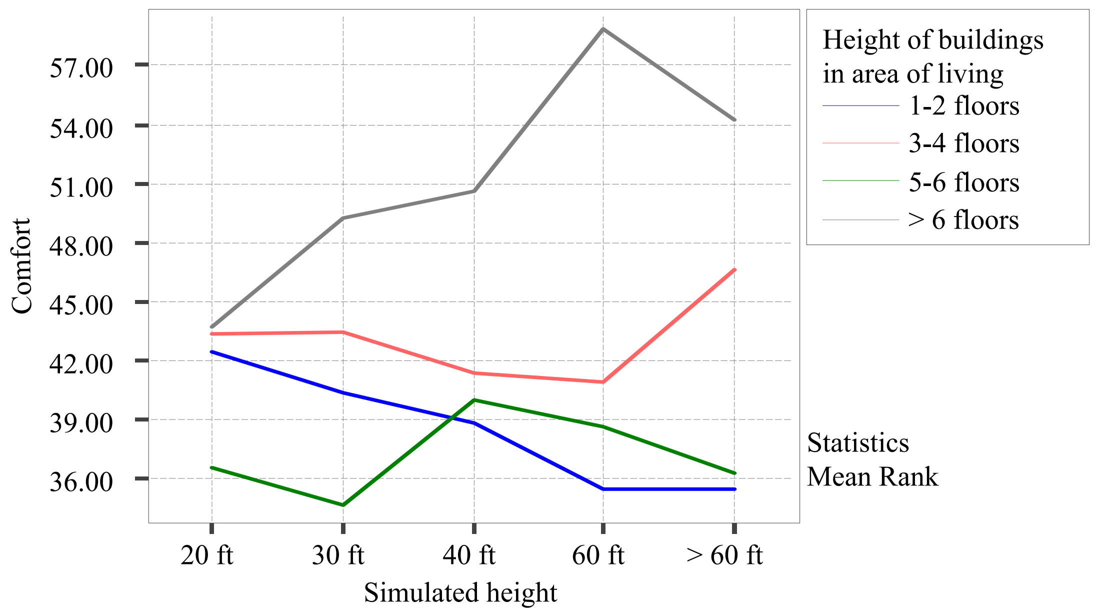


A

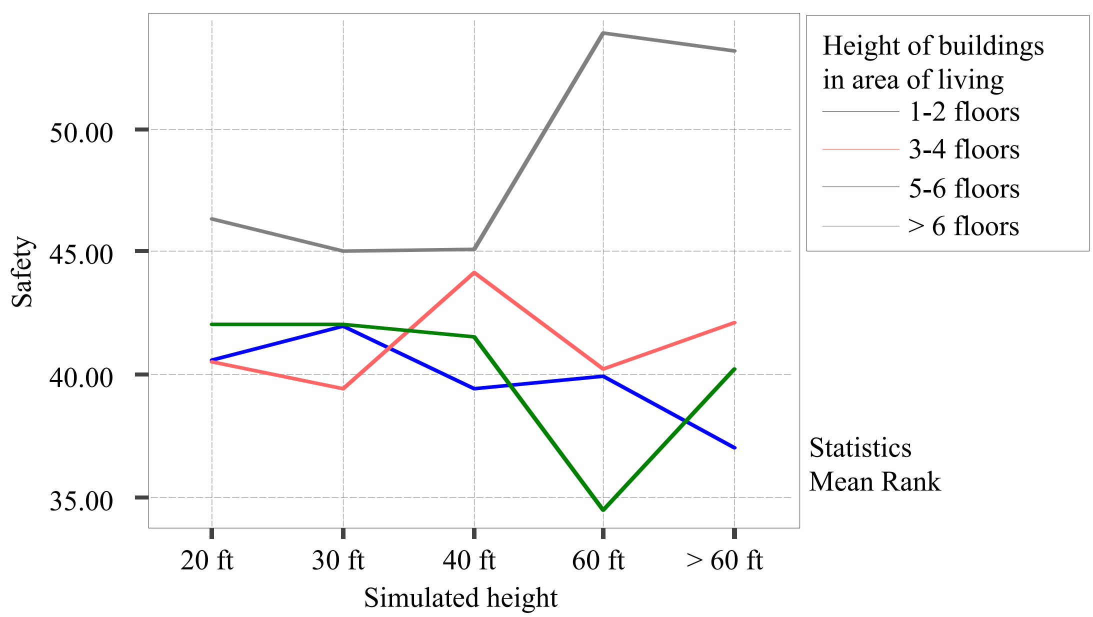


B

Figure D-9. Differences in comfort and safety scores relative to the height of buildings in the living area across 3 scale groups. A) Comfort and scale. B) Safety and scale.

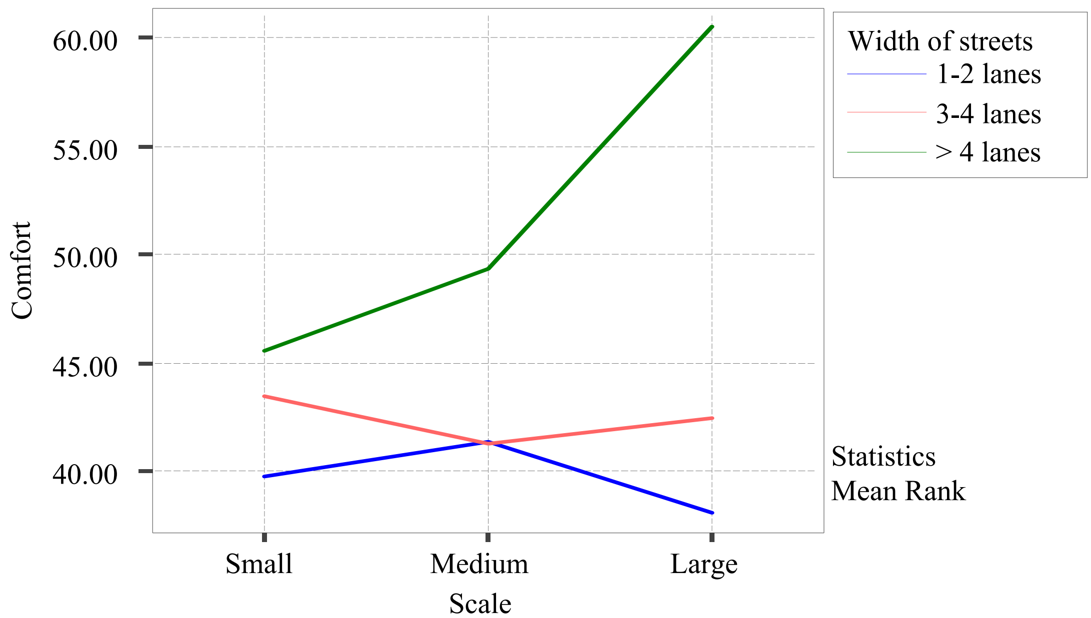


A



B

Figure D-10. Differences in comfort scores relative to height of buildings in living area across 7 simulated heights. A) Comfort and simulated height. B) Safety and simulated height.



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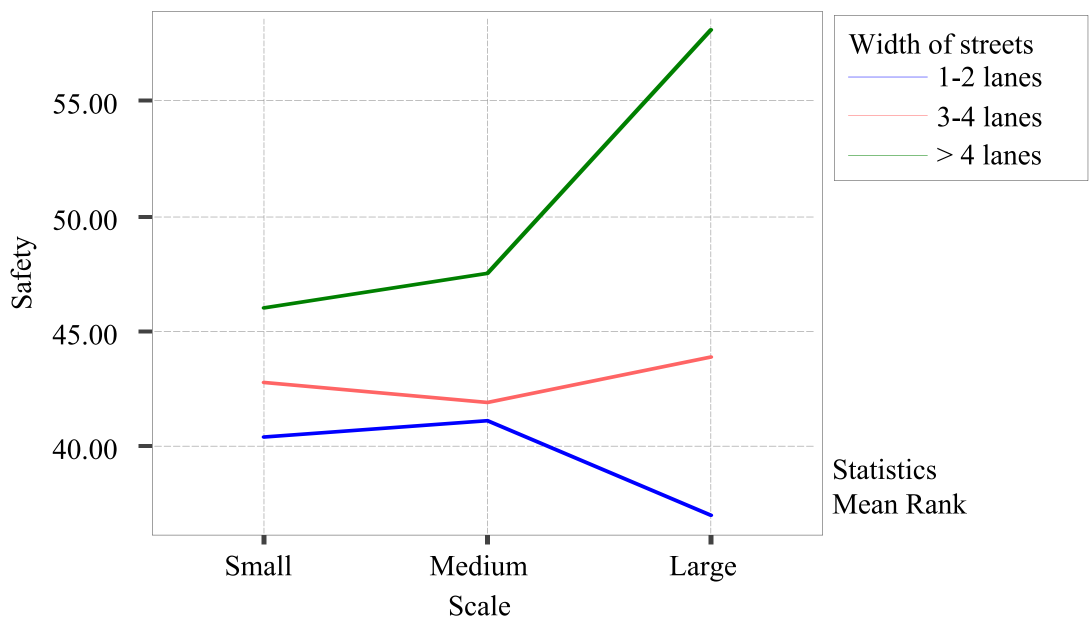
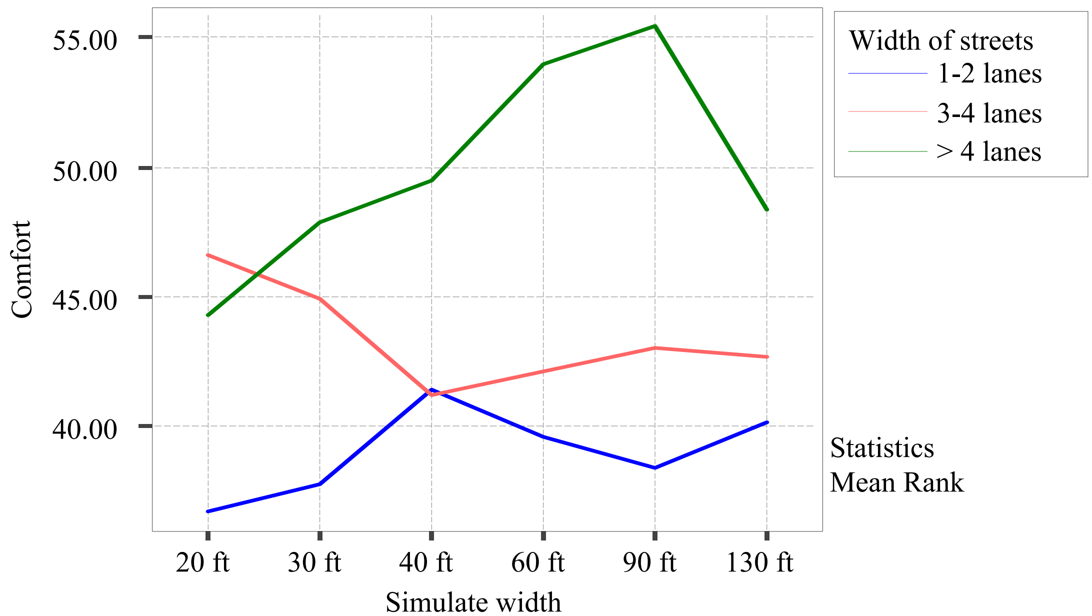


B

Figure D-11. Differences in comfort and safety cores relative to the widths of streets in the living area across 3 scale groups. A) Comfort and scale. B) Safety and scale.



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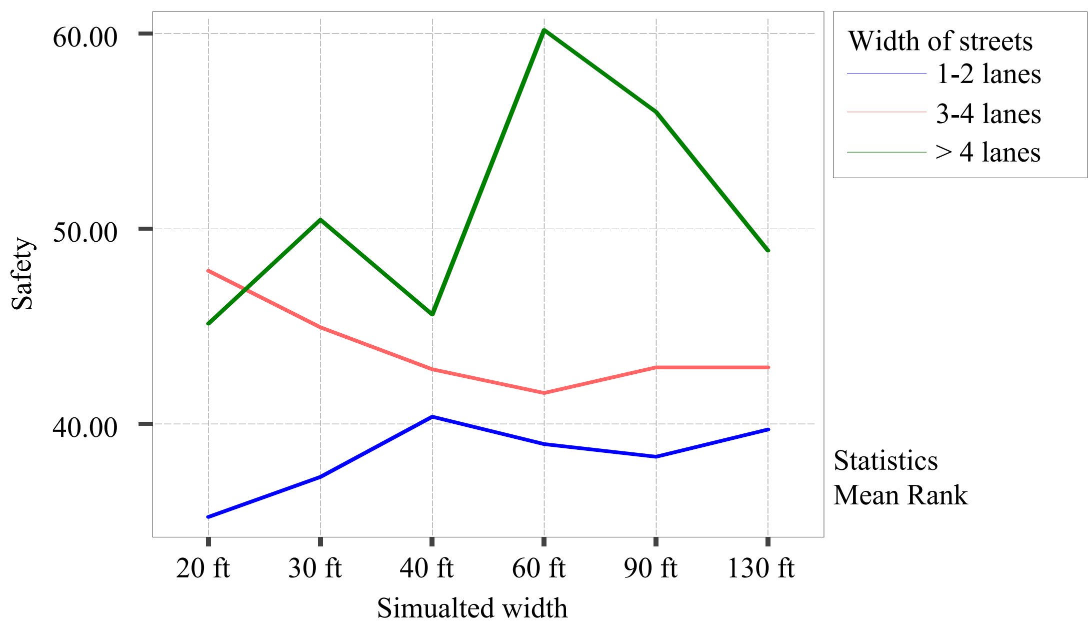

B

Figure D-12. Differences in comfort and safety scores relative to the widths of streets in the living area across 6 simulated widths. A) Comfort and simulated width. B) Safety and simulated width.

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BIOGRAPHICAL SKETCH

Majdi Alkhresheh is an architect and urban designer with teaching experience. In 1982, he received The Jordanian Ministry of Education Scholarship to pursue a bachelor's degree in architecture and planning at King Faisal University, Saudi Arabia. Upon graduation, he practiced architectural design in Jordan for 3 years before returning to academia, where he received a master's degree in urban design from the University of Jordan in 1995. Upon completion of the master's program, he joined the Department of Architecture at Al-Isra University, Jordan, as a faculty member for 8 years.

In 1993, Majdi Alkhresheh joined Mutah University, Jordan, as a lecturer for 2 years. In 2003, he was awarded the Fulbright Award of Foreign Students Program to study in the U.S. for 2 years; he joined the doctoral program at the College of Design, Construction, and Planning, Department of Urban and Regional Planning, at the University of Florida. He received Mutah University Scholarship for the last 2 years of the doctoral program. Upon completion of the PhD program, he will return to Jordan to teach at Mutah University, and to pursue urban design, computer applications, and GIS research.