CORRELATING URBAN DESIGN QUALITIES TO PERCEIVED RESIDENTIAL DENSITY USING 3D COMPUTER SIMULATION

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

2017

To my father

ACKNOWLEDGMENTS

First and foremost, I want to thank my advisor Professor. Ilir Bejleri. I appreciate all his contributions of time, ideas, and funding to make my PhD experience productive. His hardworking, vision and determination inspired me to stand against challenges and make this project a reality.

In addition to my advisor, I would like to thank the rest of my dissertation committee: Prof. Paul Zwick for his support during my PhD studies and for his follow up in finalizing this dissertation; Prof. Jack Stenner and Prof. Peter Prugh, for their insightful comments and encouragement.

I gratefully acknowledge the support of Palestinian Faculty Development Program coordinated by AMIDEAST (West Bank) and funded by USAID (United States Agency of International Development) and the OSF (Open Society Foundation). The unique opportunities, connections and guidance provided throughout the program, enriched my experience as a PhD student.

Last but not the least, I would like to thank my father who believed in me and advised me every single day in my life. I thank my husband, my kids, my brothers and my sisters for supporting me throughout the writing process. They helped me to accomplish what I started with their encouragement and kindness. As grateful as I am now writing these words as sad as I am for not sharing this accomplishment with my mom who passed away during my program, I thank you Mom!

Along this time, I was fortuned to be surrounded by great friends who shared with me difficult times and nice memories and whose words and advise empowered me to skip barriers and to keep going, thank you all for everything.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

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December 2017

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Major: Urban and Regional Planning

Perceived residential density is one of the main urban design qualities that affect people daily experience, their perception of the environment, and their ongoing interaction with and within their environment. Density in planning research has been defined it by numbers (dwelling units or building/ unit area) which is not easy to imagine by lay people or to create spatial perception about the actual space. Some recent research in perceived density used experimental methods to collect people input about indicators of perceived density. My research connected earlier studies in density perception that is based on psychological model related to reactions to high density situations and the new experimental methods in measuring perceptual input about people experience of certain urban spaces.

The study used a visual survey to present 3D (three dimensional) models for various combination of the study independent variables and collect feedback from participant about certain qualities of the scenes as judged by the participants. 3D models were created using 3D studio max; images used in creating texture of the building is captured from Atlantic Station, Atlanta, GA. 77 participants successfully

answered the survey, responses were used to analyze correlations between the independent and the dependent variables.

It concluded that the two variables: enclosure (height to width ratio) and the people existence in the scenes are the most correlated to perceived residential density and space crowdedness. When controlling for the facade details variable the number of intersecting street correlated positively to perceived residential density and space crowdedness suggesting that increasing number of streets by reducing width of buildings and increasing masses is read by people as increase of residential density. Life earned experiences and cultural meaning and expressions was found to relate largely to the concept of perceived residential density more than personal characteristics (gender, education).

The study advices that perceived residential density is better studied under situational experiment in which people get to express their feeling about a place based on their interaction and or exposure to certain social settings. Finally, it highlights certain design techniques that can contribute to improvement in people perception in higher residential density areas.

CHAPTER 1
INTRODUCTION

Problem Statement

Planners and policy makers generally use numbers to describe population density of proposed developments. When presenting anticipated population density within developments, a visual illustration is often missing or misleading for the viewer. Negative perceptions of density can happen when high density is sometimes (mistakenly) equated with crowding (Sussna, 1973; Chin, et. al., 1976; Carmona, et. al., 2003). Developments with high density are usually resisted, due to associations of density with crowding, crime, and other dreadful attributes. (Campoli and MacLean, 2002; Urban Land Institute, 2005). The resistance is justified by the known historical conditions associating high density projects, for example many of the developments that took place after World War II were dangerous and crowded (Zack, n.d.; Pader 2002; Flint, 2005; Churchman, 1999).

Few studies have focused on density as a perceptual element not only as a measure of how many dwelling unit exists per Acre or number of people per Acer. Density needs to be understood and comprehended based on peoples' understanding and interaction with a proposed environment (Jacobs, 1961; Rapoport, 1973; Churchman, 1999; Yang, et. al., 2005; Campoli & MacLean, 2002). In this way, density becomes a contextual and perception-based phenomenon that is attached to an environment and accommodates cultural and social experiences of the people using that environment. This contextual nature of density requires a certain level of subjectivity in defining density to accommodate people expectations of their environment.

Higher density development propositions usually assume positive outputs on social and physical levels of the environment. Considering the three-dimensional illustrations of these developments can anticipate peoples' reactions to higher density developments. This can be used in drawing conclusions to understand the relationship between physical settings and density perception. Consequently, the designer would manipulate the physical settings of these developments to relate to spatial interests. Few studies have addressed the relationship between perceptual dimensions of density and the design aspects of an environment (Campoli & MacLean, 2002; Urban Land Institute, 2005). These studies rely on showing existing forms of density and were used to inform people about the visual dimension of density and improve the way people understand the concept of residential density. Other studies have investigated the impact of change in certain physical qualities of the environment on comfort, safety, satisfaction or on the environment functions, such as increasing walkability or accessibility. However, these studies have not tested the impact of physical qualities on perceived residential density.

In this experimental study, a survey is used to collect data about participants' background (independent variables: socio-economic and contextual data) and perceptual data (dependent variables measures as provided by peoples' subjective evaluation for different 3D views). The relationship between independent variables (physical qualities and socio-economic variables) and dependent variables (perceived residential density, level of comfort, space crowdedness, space openness) is tested using the data collected in the survey instrument.

Research Purpose

Smart Growth, New Urbanism and Transit Oriented Developments advocate certain physical settings required to help build communities that are more sustainable. Residential density in such settings was emphasized as part of a vibrant environment. In this framework, density is illustrated by numbers or ratios and has been loosely defined. The logic adopted by high residential density advocates usually takes the shape of environmental, economic and social arguments. However, when it comes to implementation such efforts face opposition. The source of this opposition is fear from high residential density as a concept that perceived as undesirable crowding. Urban Land Institute (2005) argued that people interviewed about their opinion of high-density developments hold negative view, but when these developments are presented for them in images, people change their perceptions and prefer higher density over low density developments. Furthermore, planners utilize their land and policy experience in identifying appropriate number of people per acre for a proposed plan. The impact of these numbers on existing environment in terms of urban dorms is not easy to be imaged by planners who, in many cases, don't have design background.

Density is related to social interactions between people sharing an environment and using spaces and between people and the environment. In literature, the presence of people was linked to the success of public spaces, where everyone enjoys the urban space; in this way, individual people become one unit, that adds order and vitality to a space (Jacobs, 1961; Carmona, et. al., 2003). Embedded existence of people within buildings or urban spaces results from the physical arrangement of a development, and has a strong impact on the sociability of that development. The impact can also be seen in the level of comfort people feel when using a space, and thus affects perception of how dense or crowded an environment is.

Rapoport (1973) argued that density is a “perceived experience” and should be observed beyond mere units or numbers. The concept of perceived residential density incorporates people, spaces and conscious interaction and sharing of physical and cultural aspects of these spaces. The understanding of perceived residential density relation to measured density can help define best physical forms or aid in manipulating existing spaces to grasp different levels of density with less negative reaction from users.

This research tests the impact of changes in physical settings on the perceived residential density of a given environment. Computer modeling techniques will be used to represent a 3D model of a high density urban area. The independent variables (façade complexity, enclosure, intersecting streets, existence of people) will be changed throughout the experiment to provide a matrix of experimental conditions. The impact of each independent variable on the primary dependent variable (perceived residential density) will be measured based on participant’s survey responses as they view all the experimental conditions in term of visual displays.

Ultimately, this research will contribute to the methodological construct of perceived density and will provide the means to which the different physical qualities affect density perception. The output of this study could form a ground for creating visual tools that better describe spatial forms for different types of densities. Such tools could help planners and policy makers to comprehend the three-dimensional impact of proposed developments and consequently be able to translate policy and numbers into spatial forms. The study results could be used as a prototype for tangible or visual evidences of the applicability of high density developments.

Empirically, correlating physical form variables to the perceived residential density measure could further help guiding perceptual input and improve criteria for contemporary trends in planning and designing form-based codes and performance based design. These new trends currently depend on physical measures only, and still lack knowledge of possible perceptual input from users. This study will produce empirical findings based on feedback provided by people participated in the experiment, and will create guidelines for future research in perceived density. In sum, this dissertation aims at contributing to the perceived density research as follows:

First: It helps planners and policy makers to comprehend the three-dimensional impact of proposed developments on existing spaces, and consequently to be able to translate policy and numbers into spatial forms.

Secondly: The tool used will help provide people with tangible or visual evidence of the applicability of proposed development and will give alternative scenarios by which people can interactively select best fit development patterns that match their existing community.

Third: Correlating physical form variables to perceived residential density will help provide criteria for setting form-based codes that stem from participatory perceptual feedback from users.

Research Significance

High density has been a main component of new planning trends and studies, it was found to correlate positively to walkability (Jacobs, 1961; Belzer and outler, 2002; Brown, et. al., 2007; Moudon, et. al., 2003; Saelens, et. al., 2003; Cozens, et. al., 2008), sustainability (Krause and Sayani, 2006) reduced per capita vehicle miles traveled (Lopez and Hynes, 2003; Frank, et. al., 2001). A survey by the Sierra Club's Transportation Committee revealed that doubling neighborhood density results on 20 – 30 percent reduced vehicle miles traveled (California Planning Roundtable, 2002), reduced gasoline consumption (Newman & Kenworthy, 1999), neighborhood accessibility (Krizik, 2009), innovation and creativity (Liu, 2003; Carlino, 2001; Urban Land Institute, 2005; Krause and Sayani, 2006) and increasing productivity (Harris and Ionnides, 2000). Studying the perceptual dimension of density will help predict and understand the different components that contribute to successful higher density developments and spaces. Moreover, there is a need to further the experimental tools that relate physical forms to density measures; such tools need to emphasize perceptual components of density.

Understanding perceived density can guide improvements to the physical environment and aid in making decisions concerning changes to urban structures, which will increase or decrease perceived residential density. Consequently, designers and urban planners can relate to peoples' expectations of their environment (Baum and Davis, 1976; Churchman, 1999; Rapoport, 1977; Land Use Institute, 2005). Capturing perception of density can also help maximize the anticipated advantages of high density, such as increasing activities, bringing vitality for mix use, improving public facilities and transit systems (Jacobs, 1961; Yang, et. al., 2005).

Perceived residential density portrays the pattern of interaction between people and places and helps in reading the cultural and social variables that contribute to this interaction (Arc of innovation 495, n.d.; Yang, et. al., 2005; Campoli and MacLean, 2002). Further, it could reflect on concepts related to the convenience of that perceived environment, such as comfort, safety, health and refuge (Rapoport, 1977).

Research Hypothesis

Changes in certain physical qualities of the study area lead to psychological and perceptual reactions by study subjects. This is reflected in this research by different perceived information (overload, control level and level of freedom) captured through the dependent variables: perceived residential density, perceived comfort, space crowdedness, perceived openness. Previous literature highlights relationships between the independent and dependent variables, and suggest the testing of the following hypotheses:

- Perceived residential density increases when enclosure (length to width ratio) increases.
- Perceived residential density increases when façade complexity increases
- Perceived residential density increases when number of openings between buildings (or number of crossing streets) decreases.
- Perceived residential density increases when perceived existence of people and activities increases.

CHAPTER 2
LITERATURE REVIEW

Existing research and literature related to perceived density belongs to three different categories: theoretical research, visualization research and computerized research (experimental).

Theoretical Research

Perception is the channel between physical environment inputs and human reaction, and encompasses mental processing for environmental cues. In this process, the mind is stimulated to attach meanings and find suitable reactions to the different situations. Studies in human perception of an urban environment have been the focus for many researchers, who believed in the need to understand the human environment interaction to design good cities (Lynch, 1960; Jacobs, 1961; Rapoport, 1977).

The human mind is consciously interacting with the environment and creating decisions about where to go and what direction to take, or when to alter moods amongst happy, stressed or frustrated. This process is affected by the different experiences users have. A stranger could react differently to an environment in comparison to its inhibitors or frequent users. Bacon (1967) emphasized the importance of “continuity and movement” in the experience of a space as it helps in creating a connection between people and spaces and builds the image of the city in its’ inhabitants minds.

Previous research was concerned with the analysis of individual perceptual quality to understand how certain urban structures could affect perception for these qualities, and at the same time their overall perception of their environment. These qualities include perceived density (Rapoport, 1977; Churchman, 1999), perceived crowding (Stokols, 1973; Baum and Davis, 1976; Chin, et. al., 1976), perceived openness (Fisher-Gewirtzman, 2003; Hayward & Franklin, 1974) and perceived enclosure (Stamps, 2005A; Stamps, 2005B; Alkhresheh, 2007).

In the following sections, a theoretical discussion regarding environmental perception will serve as the contextual framework for perception and how it is created.

Space and Place

The American Heritage Dictionary defines space (from Latin *spatium*) as “a set of elements or points satisfying specific geometric conditions in a three-dimensional field of everyday experience; the distance between two points or the area of volume between specified boundaries” (Trancik, 1986). As people use a space, change it and give meaning to it, they are changing a space into a place. In addition, they construct emotional attachments to a place and a sense of identity, “rootedness” (Carmona, et. al., 2003, p.97). The way an environment and people interact has been described in three different concepts: environmental determinism, environmental possibilism, and environmental probabilism. The environmental determinism assumes that environment has a determining influence on behavior. The environmental possibilism suggests that an environment gives options for people from which they can find what best fits their lives. While the environmental probabilism implies that in a certain environmental setting some decisions become more likely to be taken than others (Carmona, et. al., 2003). Research has shown that there are levels of interpretability of human behavior, based on previously tested settings, such as building forms or greenery impact on human behavior (Nasar, 1994; Bacon, 1967). My study leans more toward environmental probabilism, because it assumes that specific environmental settings have a set of possible users’ reactions. The results of the study can be used to support design decisions.

Trancik (1986) suggests that designers should focus not only on creating spaces, but on creating places through synthesizing all components of an environment, including the social and cultural components. This is the base of the Place Theory in which human's needs are major components of the urban fabric, in addition to the physical and linkage components. Per the Place Theory, a space becomes place only when adding its contextual aspects to its physical structure; these contextual elements include peoples' visual perception, cultural and social values, and users' control over the urban environment (Trancik, 1986, p.98).

Perception in Urban Environment

Both Lynch (1960) and Rapoport (1977) argued that perception is an active process and not a passive reception; during this process the perceiver extracts information, analyzes it and redirects his actions. As interaction recurs a user could have a different course of action. Perceived environment, per Rapoport is the result of environmental perception and it constitutes the surface on which users' decisions are made.

Researchers emphasized the importance of perception in urban design because the environment is easy to manipulate based on users' needs and their perception of what defines a convenient space for their daily lives. Because people perceive things differently, they define problems and solutions in different ways; they define standards, such as safety or comfort differently, and they define ideas such as density or compactness differently and they define terms such as neighborhood or slum in different ways (Bacon, 1967; Rapoport, 1979; Zube, et. al., 1982; Ervin and Steinitz, 2003). Environmental perception involves current and stored stimulus information, current context information, perceivers' characteristics, previous experiences (fear, ambition, and hope), as well as real and imagined elements (Rapapport, 1977, p. 26).

Perception is used in evaluating environmental qualities in three different ways:

- Environmental Evaluation of preference: in this method perception is used to evaluate the environment, for example: evaluating environmental qualities to find the most likely preferred direction for migration.
- Environmental cognition: perception here is used to describe the way people learn, change and construct mental maps of the environment.
- Environmental perception: perception in this domain describes the direct interaction between people and the environment in which they exist at a given time (Rappaport, 1977).

By understanding individuals' images of their environment, one can understand the holistic image of that environment. According to Bacon (1960, p. 46) even though each individual image or perception is unique and has something that is hard to communicate, there is a level of similarities between perception on one general image or a series of public images. Bacon saw that form should be used to reinforce common meaning, and not to contradict it. Though, an opposing opinion regarding the value of environmental perception does in fact exist. Ravetz (1971) suspected the validity of operational values for human perception. He argued that if designers and survey respondents in an environmental study have different perception for the environment the result will be of no value for the design ideas (Rappaport, 1977).

This research builds on assuming existing similarities between users' environmental perception. It is not dealing with the complex cognitive processes behind environmental perception.

Perceived Residential Density

Density as one characteristic of a vital urban environment, has been a research focus as early as the sixties and seventies (Jacobs, 1961; Dean and Gunderson, 1975; Rappaport, 1975; Sussna, 1973). Its importance is a part of a comprehensive ideal of how a city should function. However, one needs to distinguish between density as physical diameter and perceived residential density (described, if negative, as crowding or isolation) as subjective and psychological experience (Dean and Gunderson, 1975; Jacobs, 1961). Density should also be distinguished from crowding; density is a physical limitation of space, while crowding involves the perception of the restrictive aspects of limited space (Stokols, 1976; Rapoport, 1975). The negative consequences of crowding include feeling of discomfort, restricted mobility and lack of control. Jacobs' (1961, p.221) suggested that performance of space defines proper residential density, and residential density should not be based on abstraction of how much land is needed for (X) number of people. She argued that high density means large number of dwellings per acre of land, while overcrowding means very large number of people in dwellings where space is in fact limited (1961). Interestingly, many researchers between the 1940s to the 1970s have studied the correlation between high density and increased social problems, but their research results and analysis were inconsistent (Schmidt, et. al., 1979). Generally, a dense environment with ill-defined spatial settings can negatively affect human behavior and physical wellbeing, leading to the experience of crowding (Chin, et. al., 1976; Stokols, 1972; Baum and Davis, 1976).

Recently, as high density is in different ways encouraged as an ingredient of new planning trends, acceptance for higher density design proposals becomes a major concern. Researchers, thereafter, start investigating the idea of density perception and how density could impact interaction and judgment of the environment (Churchman, 1999; Yang, et. al., 2005; Fisher_Gewirtzman, et. al., 2003). Subjective measures of a place as dense or not depends on different physical characteristics, such as degree of enclosure (Rapaport, 1977, p.96; Trancik, 1986, p.66), natural settings, space uses, and the provision of facilities (Marcus and Sarkissian, 1989; Rapoport, 1977, p.96), temporal rhythm, lighting, people traces, landscape, in addition to people preferences for these characteristics (Rapapport, 1977, p. 96).

Marcus and Sarkissian (1989) proposed few guidelines to improve perceived residential density. These guidelines include: relatively small development size, greater spacing between buildings, visual and functional accessibility from a dwelling unit to open spaces, produce privacy opportunities by design solutions, division into small clusters, a variety of façade designs, fewer number of households using the same entrance, minimal noise, well-located community facilities that do not interfere other activities, availability of parking, access to adequate open space. Existence of these aspects in an environment does not necessarily guarantee lower perceived residential density because of the multifaceted nature of the idea of perceived residential density. Other factors related to social and cultural dominant values can affect perceived residential density as well. Meanings attached to physical settings indicate level of stimulation and control could affect users' evaluation of a place as dense or not. Consequently, highly perceived residential density in some urban environments could lead to the feeling of threat or stress, especially when the presence of large numbers of people, along with other components of environment, generate information overload (Rapoport, 1977, p. 201). Rapport (1977) further suggested that design can help reduce the actual flow of information and consequently reduce the perceived residential density or the negative perception of density.

Studying the relationship between density and visibility, Martin and March (1973) concluded that ‘visual order’ theories of Camillo Sitte’s (1889) has influenced modern cities’ development density by establishing principles for city design based on artistic images and visual experiences; such images represents high density by using high rise buildings (Yang, et. al., 2005). Martin and March (1973) explored arrangements and strategies in designs with high density, by manipulating building typologies. They concluded that some site configurations could achieve more land-use efficient design solutions than other configurations. As city problems resulted from overcrowding in certain areas, that lack healthy designs, solutions start to appear. Scholars such as Raymond Unwin (1912) targeted the concept of overcrowding, and he wrote his essay “Nothing gained by overcrowding,” where he criticized the ideas of the Garden City that took place without regard to the need for open spaces and fresh air. Later, Rapoport’s argued that lower perceived residential density is one of the characteristics of high-quality environment (Rapoport, 1977).

Density in Planning

Density in planning is a reference of proportional numbers of units in a certain predefined set of finite space and time (Yang, et. al., 2005). Sometimes a development density is measured as gross density which is number of dwelling units per acre or the total dwelling units divided by lot area exclusive of right of ways. In other locations density is defined as net density which is the total dwelling units divided by overall area, (Forsyth, 2003). In other locations, density is given as Floor Area Ratios (FARs) and in others as number of people per acre (City of Boulder, n.d.). The use of the different measures for density depends on the purpose of the planner or the planning activity in which the concept of density is used.

Density as an urban form variable was used intensively in planning and in transportation research. It was used along with other variables for studying urban environmental impacts on travel choices, physical activities, walking in general, automobile trips, etc. Density was found to be correlated positively to walkability (Belzer and outler, 2002; Brown, et. al., 2007; Moudon, et. al., 2003; Saelens, et. al., 2003; Cozens, et. al., 2008; Forsyth, et. al., 2009), reduced per capita vehicle miles traveled (Lopez and Hynes, 2003; Frank, et. al., 2001; California Planning Roundtable, 2002) and neighborhood accessibility (Krizik, 2009).

In physical settings, having more buildings along the street creates vertical lines that could function as references for users (Jacobs, 1993). Also, having more buildings gives an opportunity for more diversity in shape and activities. Jacobs further emphasized that density and land use matters are very important for street design because streets are activated by people. One problem that Jacobs thought could affect density application is that zoning regulations require the provision of large open spaces, which in return will only allow high density dwellings to be packed in high rise buildings, that are not too diverse in design and at the same time does not support the urban street definition (Jacobs, 1993).

Generally, planning research has used density as a planning tool to support planning decisions, or to forecast future growth trends, and not as an indicator of human's perception about their spaces.

Visualization Research

Visualization in Urban Design

Visual simulation or visualization is a way of presenting design ideas that are still to be realized for users who, by viewing these simulations, can imagine the future spaces (Kwartler and Longo, 2008; Simpson, 2001). Visual information is very important for people to comprehend complex natural phenomena, ideas and abstract data because as estimated by Feldman, et. al. (1989) "one third of human brain is devoted to vision and visual memory" (Al-Kodmany, 2002).

Visual representations can be categorized into stationary or static simulation and dynamic simulation (Lang, 1994). Static simulation takes the form of photographs or models as seen by a static observer, while dynamic simulation shows the proposed design in terms of moving images, as seen by a moving subject (pedestrians) such as (video) or computer animation. Moving images in terms of videos or other media helps mimic pedestrian experiences (Ewing, et. al., 2006) and provides multiple perspectives for certain viewpoints rather than restricting users to one angle, compared to using static images (Lang, 1994). Nasar and Heft (2000) compared people responses for dynamic and static types of display, they found that willingness to explore and learn more about the scene is higher in cases of dynamic display, while curiosity and preference is in fact higher in cases of static display.

A study by Stamps (2000) reviewed empirical literature in simulation indicated that preferences for static color simulation is highly correlated to their preferences within actual site. He further asserted that strong correlation has been reported for the simulation used in judging “enclosure (r = .83), area (r = .90), and depth (r = .91)”. Similarly, safety evaluation based on site plans correlated at r = .89 with its evaluation onsite.

In discussion about the pedestrian experience of an area and the designer experience or the one reflected in classic representation models Bacon (1967, p 29) highlighted the need for establishing better techniques to present design concepts, which reflect as much real experience as possible. He also called designers attention to the need for establishing in depth ideas about the effect of design on users before making final decisions. Hence, visualization is used to help experts in evaluating the visual impact of a proposed project, showing ideas for the public and incorporating public opinion into expert decisions (Lang, 1994). However, visualization is more useful if it is used during the early stages of planning and before implementation (Lang, 1994). Further, visualization can empower a local community by shifting their attention to common concerns; it can lead to a more equitable land use policy and could reduce possible misunderstanding that might results from the use of 2D plans and elevations in presenting design to the community (Levy, 2009).

Visualizing Density

Recent researches related to perceived residential density try to move toward application of the idea in terms of visual presentation. Density visualization studies come as a response to the need for visual and easy to comprehend description of what numbers means. Campoli and MacLean (2007), in effort to bridge the gap between measured density and perceived residential density, have created a catalog that illustrates different neighborhoods configurations with various densities to show how design could affect perception of high density developments. They argue that the provision of a comprehensive collection of images for different densities and designs would be informative for planners and policy makers when discussing density levels. Densities covered in the catalogue range from less than one unit per acre to 134 units per acre. The catalogue includes 300 images of more than 80 neighborhoods from across the United States. For each case the catalog includes four views that show: block level details, context level, vertical view (landscape image taken from street level, almost two dimensional), and neighborhood level, that adds three-dimensional information to the vertical view. The inclusion of different scale views for each example in this catalogue stems from the need to grasp the context characteristics, as well as the block level characteristics for the sake of providing comprehensive understanding of density in the specific area. Yet, the catalog lacks analytical components, nor does it give preferences for one approach over others. Authors assert that this catalog can be used as a visual tool from which communities can simply decide on what design approach better matches their preferences. Another study was done by the Local Government Commission and the U.S EPA (2003), whose report discusses successful cases where higher density was implemented. In their report, each case's profile was discussed to show why high residential density has been a successful approach and what other design and planning characteristics are implemented. Visual tools were limited to few photographs taken for each case study to show few design alternatives used in these sites. The same limitations are seen in the Urban Land Institutes report (2005) on myths and facts of high density developments. Case studies are also used to illustrate how positive impact could be achieved through high densities when well-planned.

Earlier research in relating physical form to density measures were done by Martin and March (1973), who studied the different typological arrangement and their relationships to land use. They argued that different forms of buildings can generate the same population density and that some buildings form on a certain block size and shape can be seemingly dense and vice versa. These variations or possibilities, in their term, are important because it helps increasing the land use efficiency. They used three various factors to determine population capacity of a site: plot ratio (figure ground ratio of a site), general plan efficiency and floor space allocation per person. Furthermore, systematic analysis of building form relationship to site efficiency they divided building forms into three different types: pavilion (tower) which is limited in plan form, court (a building form that extends infinitely in two directions), and street (a building form that extends infinitely in one direction).

Previous and recent efforts for quantifying perceived residential density is a normal result of the common consensus between scholars, that perceptual quality of an al interaction.

Computerized Analytical Research

Visualization in Urban Design

There seems to be an agreement among researchers in visual simulation that computer based simulation is the most reliable and approximate to reality method to represent design ideas. Lange, 1994; Simpson, 2001; Levy, 2006; Budthimedhee, et. al., 2002; Stamps, 2005A). Three dimensional representations include 3D models, virtual reality and urban simulation can work as a common medium for interaction between users, designers and decision makers. The 3D modeling visualization is not interactive and is considered the simplest of the three, while the virtual reality and the urban simulation are interactive because they allow users to interact with the environment. The urban simulation has, in addition to interactivity, dynamic virtual processes with which users interact (Al-Kodmany, 2002). Inspired by technical possibilities there evolved different representations and modeling techniques in architecture and design that are based on internal logic and objectives that designers set forth ahead of design processes itself (Stavric and Marina, 2011). These techniques are sometimes described as generative, relying on computer processing for predefined objectives to generate different possible design alternatives, from which designers can choose appropriate configurations. This design process is referred to as parametric design and it involves “procedural, algorithmic description of geometry” and extensively defined design strategy (Kolarevic, n.d.). The task of designers in this way becomes to design not the shape of buildings, cities or landscape but to design standards that will be encoded as a parametric equation; the product is several design options which could be varied as needed (Stavric and Marina, 2011). From user’s perspective, there are two branches of parametric design: conceptual parametric design and constructive parametric design. In the conceptual parametric design, different values are given to the parameters so different configurations are generated. The parameters of a certain design are declared and not its shape. Software such as Maya or Rhinoceros offer script editors for this type of parametric design. Constructive parametric design involves embedding data to define relationships between the different elements of the design and the resulted 3D objects are predetermined (Woodbury, et. al., n.d; Starvic and

Marina, 2011). This type of parametric design can be realized in CAD software packages, such as Autodesk Revit, Soft Plan, Nemetschek, ArchCAD or Chief Architect (Starvic and Marina, 2011). Another software that can be useful to generate alternative façade treatments on building level is Rhino with its a new plugin, Riknowbot.

Parametric Design at Urban Level

The generation of architectural space from data input is called parametric design. The parametric design is based on certain criteria about site constrains, potentials and project goals; this process mirrors the emergence theory or the biological mode of genetic DNA combinations (morphogenesis) (Ottchen, 2009). Morphogenesis is a term used in biology, and it refers to the process of form generation. In design, this term was found relevant to the idea of designing based on bottom-up logic or what researchers called form finding or formation. The emphasis in this process is on optimizing performance of material and function before defining appearance in a bottom- up process (Leach, 2009).

In urban design parametricism is a contemporary term refers to urban design ideas generated using parametric design systems or standards (Schumacher, 2008). Nevertheless, on a large-scale design schemes, parametric design systems are less developed. One widely used software for fast modeling on large scales Google Sketchup has a parametric plugin called Modelur, it was created to build objects that embed detailed information about (built up area, number of floors, gross floor area). These parameters are internally related; if one parameter changes the related parameters change respectively. For example, if floor number changes the built-up area changes consequently. However, sketch up models generated in this way do not have generative capacity on micro level details such as streetscapes and facades treatments.

Similar in logic to Martin and March's (1973) method of finding the most efficient building design alternatives, contemporary design utilizes parametric design techniques to produce performance-based designs. These designs are generated based on target optimal performance standards (economical, ecological, structural, social, cultural and behavioral) rather than just the building form (Kolarevic, n.d.). The performance based design depends on embedding quantitative performance characteristics into the process of generating forms (Grobman, et. al.n.d.). In this process designer set forth performance criteria such as: degree of sun shading, maximizing certain views, they write scripts and set parameters accordingly (Ottchen, 2009).

Performance Based Design

The idea of performance here could expand beyond form and functions; Grobman (2008) suggests a multifold description of the idea to include: empirical, cognitive and perceptual dimensions. The empirical dimension is concerned with physical measurable characteristics such as temperature, light, strength and can be easily translated into computer language. While, the cognitive dimension is concerned with the way human cognition translate the space, the perceptual dimension focuses on the transition of human perception into space and vice versa. Cognitive and perceptual dimensions are in fact not possible to be directly translated to computer language, rather they need to be tested statistically. For the form to sustain its intended function, it should satisfy all three dimensions (Grobman, 2008).

Along the line of digital culture discourse, in which culture is seen as a series of events, performalism is seen as the capacity of architecture to become part of the ongoing events in a world that is more defined by occurrences rather than bare relations between objects (Grobman, 2008). The notion of performance in design is also attached to the idea of motion in the space; the movement of people around structures, the experience of the existence of these spaces by engaging people's eyes and body (Kolarevic, 2005).

Applications in Perceived Density

Human visual perception as measured from subjective input of people alone cannot be a reliable quantitative measure (Yang, et. al., 2005). Practically density perception needs to be represented by quantitative indicators using scalar built form dimensions and environmental visual qualities (Jie, et. al., 2005; Yang, et. al., 2005; Fisher- Gewirtzman and Wagner, 2003). As early as in the seventies researchers have empirically examined the impact of manipulating social and physical settings of an environment on the experience of crowding (Stokols, 1972; Baum and Davis, 1976; Baron, et. al.1976; D'atari, 1975; Dean, et. al.1975). Their findings show that the changes in social and physical settings can alter individual perception of crowding in a space.

Quality of an environment has been linked to the visibility of high quality features from the study viewpoints (Jie, et. al., 2005; Tuner, et. al., 2000; Ervin and Steinitz, 2002; Fisher_Gewitzman and Wagner, 2003). Different techniques were used to measure visibility such as Isovist field (Tuner, et. al., 2000; Batty, 2001) GIS spatial analysis (Jie, et. al., 2005; Yang, et. al., 2005; Ervin and Steinitz, 2002). Isovist is a term used to describe the area in a spatial environment visible in two dimensions from a viewer location within the space, it provides geometrical measures of the visual space (Batty, 2001; Ervin and Steinitz, 2002; Llobra, 2003; Bilsen, 2009). Even though most methods used to calculate Isovists have been two dimensional, the original definition of Isovist by Benedikt (1979) has been three or four dimensional. Bendikt explored different properties of the Isovists such as area, perimeter, occlusivity, variance, skewness and circularity, and he ‘mapped’ them to provide a spatial objective description of the visual space (Llobra, 2003).

Jie, et. al. (2005) have introduced a method for assessment of visual resources of high density development in Hong Kong. To calculate viewshed, spatial diversity and land use specification for each unit in the study area, they used 3D and spatial analysis tools in GIS. They also used GIS to generate maps for resource quality inventory, perception quality and visual quality indices distribution for each individual viewpoint or viewpoints group. The perceived density in their research was part of a general visual quality analysis. However, correlation between positive and negative perception of a dense environment with certain physical settings of that environment was not examined.

Along the same line, Yang, et. al. (2005) have tested the visual qualities of different 3D models of high density developments to create a perceived density index. Their study was based on visibility analysis for the different 3D models, by using the Viewsphere 3D Analyst to measure the volume of space or (volume of sight VoS) they were able to define and analyze segments of ambient photonic arrays spatially. The Viewsphere 3D Analyst is an analysis tool that was generated by customized GIS by the researchers. Yet, their analysis was limited to changes in visibility that is due to changes in the geometry of an urban form. For example, they concluded that more horizontally ‘enclosing’ typology will increase building height’s impact on perceived density and that when comparing the perceived density values with the planned ones on the same patterns they were found to be different. Their research has also shown limitation in terms of the effective range or area in which the measures can be taken and considered as valid. Yang, et. al. (2007) assert that previous visibility tools such as Viewshed have just used 2D or 2.5D analysis in GIS such as Viewshed and Isovist; hence they suggested that such tools are not reliable and that a 3D measure for visibility analysis can better describe spatial visibility. Maloy and Dean (2001) have also compared GIS Viewshed delineation techniques with field surveyed viewsheds and found that existing viewshed techniques produce less than 50% accuracy in predicting visibility.

In predicting perceived density for different space configurations Fisher-Gewirtzman and Wagner (2003) have used a quantitative index (Spatial Openness Index –SOI) that is based on 3-dimensional visual analysis. The SOI “a quantitative metric expressed in term of 3D visual spatial information: it measures the volume of free spaces potentially seen from a given point” (Fisher-Gewirtzman and Wagner, 2003). Their findings show that the interaction between a volume to its envelope is dependent on the ratio of that volume to its envelop. They based their analysis on the idea that higher level of spatial openness in a certain configuration would make it perceived as more spacious and less compressed, therefore would results in lower “perceived density”. Their research was limited to one measure of an environment which is openness.

The existing research on measuring perceived density has focused on calculating level of openness and or visibility based on the massing or (how built up is the area) while rarely integrating contextual aspects of the environment and social input. The visibility analysis, as criticized by Ervin and Steintiz (2003), can be described as “probabilistic rather than binary one” because of the inter-visibility that occurs between different viewpoints and the unpredictable and changing atmospheric effects of the environment from one viewpoint to the other.

Computerized research in perceived density has either used 3D models in combination with computer algorithm to run spatial analysis for different qualities and predict perceived density based on the output of the analysis (Fisher- Gewirtzman and Wagner, 2003) or has used GIS spatial analysis to measure level of visibility of good quality features from specific viewpoints as indicator of high or low perceived density (Jie, at. Al., 2005; Yang, et. al., 2005).

Measuring Environmental Qualities

Environmental qualities here refer to perceptual and physical characteristics of the environment; such characteristics could affect judgment of the environment as good or bad or as friendly or unfriendly. Different environmental qualities have been linked to human activities such as walking, socializing and children playing. Tools to measure or to operationalize these qualities is an area of concern for researchers in their try to predict the behavioral and social consequences of a design (Ewing, et. al., 2005; Neckerman, 2010; Tuner, et. al., 2000). Ewing, et. al. (2005) suggest that physical features of an environment are the ones who define urban design qualities (imageability, legibility, visual enclosure, human scale, transparency, linkage, complexity, coherence); and that these design qualities, together with perceptual qualities constitute people reactions to that environment. The quality of the environment is then measured based on the three components (people reaction, physical features and perceptual qualities). They used video clip for pedestrian level street views that show samples from different places with various design qualities. By measuring the physical features of each scene, the researchers correlate physical features of the scenes to urban design qualities in these scenes. One drawback of their research is that they rely on expert judgment for evaluating the scenes rather than lay people.

Purciel, et. al. (2009) have used GIS to apply Ewing's criteria in measuring urban design qualities on a large area. They sampled 588 block facades in New York City for which they have enough data about physical characteristics specified by Ewing to describe each urban design quality (Purciel, 2009). Such kind of research aims in producing planning decision support tools because it tries to find operational method to describe urban design qualities using existing resources and to integrate data about these with spatial information (land use, transportation networks, etc).

Finding an operational method for measuring environmental qualities has extended to interpret more specific relationships between physical features and environment perceptual qualities to define an objective model for understanding human behavior in different urban settings (Stamp, 2009; Nasar and Stamps, 2008; Ervin and Steinitz, 2002). In his research, Stamps (2009), has studied the relationships between perceived spaciousness and perceived with boundary permeability, amount of light, area, and boundary depth. His study was based on using interior spaces for the experiment inside a lab environment of an octagonal room for the varied stimuli. This kind of research aims at theorizing relationships between different components of an environment to understand the construct of good environmental qualities. The idea of environmental quality is related to people judgment of that environment which originates from complex interaction and experiences; perception is part of this interaction. Density perception along with other perceptual measures such as perceived openness, perceived imageability can work all together to contribute to primary judgment of an environment as good or bad.

Geographic Extent

The geographic extent in which study should takes place is dependent on the type of research questions. In planning literature two types of geographic areas were used for the study locations: Macro (metropolitan level) and Micro (neighborhood or street level). An auto-mobile level research would use a large-scale area to allow measuring the effect of large urban form elements that extends over long distances and could be even on regional level. For example, Lopez and Hynes (2003) have created sprawl index for all metropolitan areas using density values in urbanized census tracts, Carlino (2001) has used employment densities in urbanized metropolitan areas to investigate relationship between density and innovation.

A pedestrian oriented research would consider smaller scale geographic areas to test the effect of certain characteristics on micro level elements (Rapport, 1977; Krizik, 2009; Forsyth, et. al., 2009; Brown, et. al., 2007). Generally, level of consistency of the urban characteristics in a neighborhood is higher than in large scale areas (Rapoport, 1977). Krizik (2009) suggests a geographic limit of (1 Mile) for research that tests urban qualities at pedestrian level. However, the definition of neighborhood differs between users of the space, the limit of once neighborhood as perceived is also different than the formal boundaries defining it (Churchman, 1999). Hereon, a relevant scale for study area in urban form research should consider users' perception of what constitute their environment and its perceived boundaries.

Research Question

Generally, studies that focus on creating density index have not incorporate subjective values to their measures (Yang, et. al., 2005). Rather, studies have used existing tools to measure aspects related to density such as visibility or day light (Yang, et. al., 2005) or landscape qualities to calculate perceived density. A mere calculation for perceived density cannot work everywhere, and can lead to misrepresentation of how community perceives density because human perception involves more than seeing, it involves temporal, social and cultural dimensions. This research aims at answering the following questions:

- How does change of urban physical qualities affect perceived residential density?
- How does perceived residential density relate to traditionally measured density?

Challenges

For a higher residential density development to function and succeed it will need proper land use that can generate enough mix of use and spatial settings that allows social interaction. This coexistence of various components leads to a major challenge in quantifying urban form variables; increasing the difficulty in isolating the effect of each variable alone from other urban form variables (Saelins, et. al., 2003; Moudon, et. al., 2003; Khattak and Rodriguez, 2004; Shay, et. al., 2003; Rodriguez, et. al., 2004).

Socio economic factors are also important indicators of how an environment works. Researchers who study the relationship between different densities and other urban form variables on a certain activity, such as walkability or accessibility, have in most cases controlled for socio economic factors to avoid skewing the results and affecting the analysis (Khattak and Rodriguez, 2004; Rodriguez, et. al., 2004; Brown, et. al., 2007; Forsyth, et. al., 2009).

CHAPTER 3
METHODOLOGY

Physical environment, its spatial configurations, its qualities and its characteristics have been argued to have a major impact on the human perception and behavior (Alexander, et. al., 1987; Lang, 1994; Trancik, 1986; Gehl, 1987). Negatively judging an environment of being dense is in fact what Rapoport (1977) called “perceived density” and for him is read by its users through what it provides of indications or signs, or in his terms “cues”, leading to positive or negative judgment of density. “The sensory overload (crowding) or deprivation (isolation) is what shapes density perception, framed in social and cultural predefined values” (Rapoport, 1977). Therefore, perceived density is part of the human experience of his environment, and has been related to various aspects of an environment as discussed earlier.

Variables that affect perceived density can be listed under three different groups:

- Contextual variables: variables that depict area characteristics such as land use, design and adjacent neighborhood characteristics. As previously discussed, mix of use can add more activity to the area and encourage sociability of the space. Recent research on regional or metropolitan size studies have shown that specific trends of population distribution could occur based on existing resources or area characteristics. Density tends to increase in areas that have already existing high-density patterns, or in areas that have potential for infill developments, but at the same time are in proximity to activity centers, such as shopping centers, play grounds, public transit, recreational centers, etc.
- Socio-cultural and economical: The physical limitation of an environment alone is not the only constituent for a stressful spatial experience and the feeling of

crowding (Chine, et. al., 1976; Schmidt, et. al., 1979) There are personal and interpersonal factors that can stir feelings of restriction or limitation, especially in a competitive type of environment (Stokols, 1972). Furthermore, previous familiarity plays an important role in user experience, and therefore their judgments of crowding (Baum and Davis, 1976; Rapoport, 1975; Schmidt, 1979). A study regarding density perception needs to integrate social and economic factors to further enhance the development of human experiences in an environment. Such factors would include: gender, residential location type, age, employment, etc.

- Physical environment variables: Which are the measured characteristics of the environment that depict spatial relationships. These includes: block size, street width, length of buildings, width to length ratio (enclosure), open space ratios to masses, existence of street furniture and natural elements.

Unit of Study

Literature shows that pedestrian level studies should use appropriate area sizes to be able to measure micro level qualities, which in larger size areas could be hard to measure (Rapport, 1977; Krizik, 2009; Forsyth, et. al., 2009; Brown, et. al., 2007; Moudon and Lee, 2003). In studying accessibility, Krizik suggested a 1/4-mile grid as the unit of analysis to capture pedestrian level data, while Churchman (1999) suggested that the perceived boundaries need to be uncovered by incorporating perception of what constitute their own neighborhoods. In a study to correlate objective and perceptual variables to walkability Moudon, et. al. (2006) concluded that objective environmental measures significantly related to the perception of their existence, but only at 1 KM airline buffer, and is not significant at higher limits. Humans can be influenced by distant elements in an environment; pedestrians move slower than automobile, which makes their perception of the space and surrounding details more profound than a car rider's perception. In defining the study limits, it was important to consider that an adult, on average, walk in 250- 350 Feet per Minute or in average 3 Miles per Hour, his viewshed is wide and more precise about the surrounding visual sensors (Nellsen, 1993).

Conceptual Framework

The study examines correlations between physical components of the environment and the perceived residential density. Variations of the study scenes, that are different in the value of independent variables, will be used to analyze each effect of independent variables on perceived residential density.

Positive density perception is the one contrast the feelings of environmental limitations or crowding. From this viewpoint, researches have assumed positive density perception, if the spaces are seemingly open to each other and the sky is seen from different angles resulting in a higher level of ease and comfort for users of the environment (Yang, et. al., 2005; Fisher- Gewirtzman and Wagner, 2003). However, as previously discussed these studies have been limited to two dimensional measures (Yang, 2005) or to visibility measured in interior spaces (Fisher- Gewirtzman and Wagner, 2003). Furthermore, the analysis was not based on authentic human interaction with actual or simulated environments. The study was primarily based on computer algorithms, that measure one aspect of an environment, such as visibility or sky views.

The use of computer modeling in visualizing urban spaces for experimental studies dominates the work of Stamps and Smith (2002), Nasar and Stamps (2002), Alkhresheh, (2007) and Stamps (2009). Computer simulation facilitates controlling the different components of a study area; ithis is more effective than the use of real life settings or video tape for existing spaces, as reported in the works of Stamps and Smith (2002), Ewing, et. al., (005) and Nasar (2008). With the wide use of parametric design software, experimental design could be more flexible and the generation of alternative design components for experimental purposes is possible.

Study Design

The study area is based on real scenes taken from “Atlantic Station,” a mix use urban development in Midtown Atlanta – Georgia that extends over 138 Acre, (Figure 3-1). Atlantic station is described as a national model for Smart Growth where mix of affordable and upper scale housing exists along with different amenities (shopping, entertainment, restaurants) and office buildings (http://www.atlanticstation.com/).

The perception created in the human mind at an observation point could be influenced by certain features at distance point in the study area, taken that pedestrians move slowly compared to other modes of transportation. An adult, on average, walks in 250-350 feet per minutes or an average of 3 miles per hour. His viewshed is wide and more precise concerning the surrounding visual sensors (Nellsen, 1993). In this study, the unit of analysis is defined by a 500 Meter (1640 Feet) buffer around the subject viewpoint.

Physical Variable Measures

The physical variables in the research can be categorized into two different groups:

- Aesthetic: (amenities and design features, soft-scape such as trees and water elements)

- Geometric: includes block sizes, street dimensions and enclosures, the frequency of intersecting streets, distance between buildings, façade complexity and solid to void ratios

Aesthetic variables

The provisional amenities for pedestrians, such as sidewalks and tree lines have always been associated with well perceived environments and used to reduce stress, noise, and feelings of crowding (Jacobs, 1961; Churchman, 1999; Kaplan, 1987; Gehl, 1987). Other amenities, such as curbs and sidewalks encourage walking as they separate the pedestrian realm from traffic, and it adds definition and scalar references to the space. In this research, aesthetic elements will be added to all the scenes equally and will not be considered as an independent variable.

Geometric variables

Number of intersecting streets: As streets interlace with land, they reduce long blocks around urban street scene. Intersecting streets in an urban scene are also seen as a way for adding more public spaces to the existing fabric since streets are considered a public space and a space for social interaction (Jacobs, 1961; Churchman, 1999). Adding more intersecting streets at the pedestrian level gives people different choices in navigating the urban space (physical permeability), and it increases visual permeability to different visual qualities (Carmona, et. al., 2003). Jacobs (1993, p. 243) compared streets surrounded by long blocks that have few intersecting streets with streets surrounded by shorter blocks that have frequent intersecting streets, she concluded that frequent streets in an urban scene help in generating diversity by attracting mixture of users. As a pedestrian moves in the main street intersecting streets will introduce different spatial experience and affect his general perception of the space. The frequency of streets will be measured by 1-3 scale where one is the lowest number of intersecting streets in the scene and three is the highest number of streets in the scene.

Enclosure (height to width ratio): Jacobs (1961) stressed that the height of buildings along the “great streets” is less than 100 feet. Buildings acting as street walls allows streets to be well defined. Trees can also be used for the same purpose (Churchman, 1999; Jacobs, 1961). Within interior settings, Nasar (2008) argued that people perceive variations of enclosure more than variations in the area enclosed, when this change resulted from decreasing or increasing the height or permeability of the surrounding edges. Enclosure is considered one of the most important factors that affect human perception of an environment. It affects the volume of what humans can see and predict about their environment. Therefore, it affects the sense of safety, level of comfort and control over the space when navigating in the environment (Nasar, 2008; Stamps, 2005B). Empirical research has shown that a significant relationship exists between perceived comfort and safety with changes in enclosures (Stamps, 2005A; Alkhreshesh, 2007; Nasar, 2008). Enclosure, a mathematical term, is defined as the ratio between height to width of the space. In an urban setting, enclosure is the height of a building to the width of the street (Thiel, et. al., 1986). However, empirical studies proved that ratio is not the only determining factor of perceived enclosure; researchers have studied different factors in spatial settings that are hypothesized to relate to perceived enclosure such as scale of the area (a room or a street) (Hayward and Franklin, 1974; Stamps, 2005B; Alkhresheh, 2007), the level of lighting (Stamps and

Smith, 2001), level of complexity of the surrounding context such as the closest point of hiding and horizon visibility from observer's point of view (Stamps, 2005B).

Recent studies relate to this nonlinear relationship between measured enclosure and levels of comfort and senses of safety in urban settings; Alkhresheh (2007, p.18) showed that "moderate level of enclosure corresponds to higher level of comfort and safety, while both high and low degrees of enclosure correspond to lower level of comfort and safety." He tested different street compositions to find that the ideal ratio for width to height in urban streets is 3: 4, in which safety and comfort are on the highest range. Further he founds that a ratio of 1: 2.5, which is suggested by Carmona et al (2003) has a probability of comfort and safety of .81 and .75.

Accordingly, previous studies on comfortable width to height ratio bounced between 1:1 ratio and 1:2.5 as a balanced and acceptable value for observers to still feel enclosed and comfortable in urban streets. When the ratio exceeds 1:2.5 interactions and relations between buildings and spaces become hard to conceive (Carmona, et. al., 2003). In my research buildings will be given a rate of 1- 3 based on their measured enclosure where 1 is the lowest 1:1 and 3 is the highest 1:2.5.

Building facades complexity: A complex facade affects the character of the street; light passes through voids and reflected on the varying textures and design elements leading to a different pedestrian experience in comparison with facades that have simple designs and textures (Jacobs, 1961; Churchman, 1999). These propositions are consistent with the findings by Rapoport and Kantor (1967), where they saw that oversimplification of designs in interior spaces can lead to undesirable outcomes on peoples' perception of their environment (Baum and Davis, 1976).

Mumford (1953) suggested that lack of visual complexity especially like the ones seen in modern urban spaces can lead to “boring and relatively unstimulating cityscapes” (Baum and Davis, 1976) and will therefore eliminate possible alternative reactions that could result from peoples’ curiosity in exploring rich and complex environments. This kind of reaction demonstrated by different activity that takes place in urban spaces. The intensity and distribution of these activities are linked to the design and complexity of the façades framing that space (Gehl, 1987).

Empirically, Stamps (1999) has examined the expression of complexity as an objective measure that depends on other differing variables. He argued that usually in urban designs, discussions building facade complexity is vaguely and subjectively described. He tested the correlation between three different aspects related to façade complexity judgment: silhouette, surface complexity, façade articulation A silhouette is the number of turns or edges that constitute the frame of the façade. A surface complexity is the intensity of details, such as the windows, doors, frames and ornaments. Lastly, articulation is the existence of recessed surfaces in which certain parts of the façade are more emphasized to give an identity to the façade itself. His study proved that surface complexity has the highest significance in peoples’ visual preference of the façade.

Stamps (1999) method for measuring façade complexity was used in this research. Three elements of the façade were measured: ornament, door and window trim, and texture. Based on the existence of these elements, façades were given three levels from one to three: three was the rank for the facades with highest complexity (which has shingles, an ornament, a cornice and door and windows trim); one was the rank for façades with lowest complexity and is empty from any details except windows and doors openings, and two was the rank given for facades that have shingle and texture. In this research each building was given a rank for façade complexity separately. Each scene used in the visual survey included groups of buildings that share same level of complexity.

Peoples' existence: the number of people using a space and the type of activities they lead affect perceived density in that space (Jacobs, 1961; Churchman, 1999). Jacobs (1993) synthesis for great streets discussed the value of closeness and recognition of other people that are by default attributes of small spaces. On an urban spatial level, such spaces with high numbers of neighbors using the same walking area encourage social interactions and help creating community (Jacob, 1993). Regardless of the physical quality of an environment, if no human interaction exists, the space becomes lifeless. The urban spaces inhabited by people interacting with each other are always more simulating and full of experiences compared to those spaces with no people. The idea of floor area/site ratio or building density by itself does not convey how activities are distributed or concentrated (Gehl, 1987). Urban design can increase vitality of a space through properly emphasizing peoples' existence and activities.

To measure the independent variable people existence in the street researcher used three levels that are coded from one to three respectively: one: few people walking alone, two: few people, sometimes two people walking, and three: group of people interacting and talking or using street furniture such as benches.

Control physical variables

Some physical qualities of an environment could affect the perception or the measured effect of one or more of the study independent variables over the dependent variables. These qualities need to be treated carefully and not to be overlooked throughout the study experiment. To get the most accurate measure of the correlation between the independent variables over the dependent variables it was important to control aspects of the environment, as follows:

Spacing between buildings along the street: previous research shows that spacing between buildings on the street is more effective, when the space is tighter (Jacobs, 1961; Alexandar, et. al., 1977). The street wall seems more continuous and the space at street level seems more enclosed when buildings are closer to each other. In this experiment, the size of the study area does not allow large variations in building distances to be implemented. The number of intersecting streets is in away related to the distances between building variables, so spacing between buildings can be inferred from the number of intersecting street variables.

Percentage of masses: adding more masses helps in increasing the variety of design, which enriches the environment and makes it more enjoyable (Jacobs, 1961), helps in defining the urban spaces (streets, plazas), and helps in creating a coherent urban space apart from buildings and surrounding spaces (Trancik, 1986). Positive perception was argued to reflect levels of openness (Churchman, 1999). When people judge an environment as an open environment, they eliminate the expression of crowding. The solid and void configuration of a space forms the urban fabric, connects the various functions and affect perception about space openness. The study of openness of an environment needs to consider three dimensional structures (vertical dimension), not only horizontal ones. The percentage of mass to voids is not a quality that can be grasped easily on the eye level; therefore, a percentage of mass to void in the study scenes will be recorded for reference purposes only.

Mix use: by adding nonresidential buildings to the fabric of dwelling areas, additional active spaces are created (Jacobs, 1961; Churchman, 1999). In this manner, a mix of uses produce potential for interaction between people and reflect more activities in an environment, which leads to higher or lower perceived density. However, this variable is not geometrically measurable compared to the other independent variables in this study. Taking into consideration the important mix use role, the scenes will be equally similar in observed uses and will convey the same sense of activity.

Contextual Variables Measures

The contextual measure of the study area, as previously discussed, is a prerequisite for the success of high density development. Though, due to the size of the study area, the contextual measures could not be comprehensively included as independent variables. However, mixed use as a control variable will be controlled equally between the scenes. Based on findings of previous research in the field a mix use needs to be reflected in the study scenes to suggest a vibrant urban life. Other contextual aspects such as proximity to shopping, schools, activity centers, will not directly affect pedestrian level perception on the scale considered in this study. Future research might expand this study to include larger scale area where contextual dimension effect on perceived residential density can be further investigated.

Socio-Cultural and Economic Variables Measures

The number of people and social interactions alter the perception of density. However, the accepted level of interaction is culturally and contextually defined. The perception of physical limitation could be considered as a precursor to stressful crowding, but not necessarily a sufficient condition alone. Other aspects such as the persons' past experiences and personal attributes, duration of exposure to the dense environment and the type of activity that individual is planning could affect how individuals perceive physical density and limitations (Stokols, 1976; Proshansky, 1972; Zlutnick and Altman, 1972). Further, cultural differences characterize people with different levels of tolerance to higher density. For example, in Chinese culture the established behavioral and spatial standards reduce the need for large personal space, and the stress that could result from dense environment.

Higher levels of social heterogeneity increase unpredictability of the environment and will increase the time and effort required by users for information processing, which results on a higher "effective" perceived residential density. Aspects such as shared common cues of control over the environment play important roles in peoples' density judgment. These cues could be realized by environmental characteristics, such as existence of thoroughfare, permeability, perceived openness, etc. This is represented in physical terms as defense means, which enables control over interaction, when such control enabling configuration exists, density is perceived as lower because people face less stress in that environment (Rapoport, 1975). To understand the effects of the socio-economic and context measures, subjects will be required to answer questions about their age, gender, current housing, number of years spent in their current residence, race and employment.

Perceived Residential Density Measures

Perceived density, as discussed in literature and previous empirical studies, is framed by hypothetical constructs and is resulted from environment sensorial impact on users of the surrounding spaces. Users cannot pass judgment on the density of a place because density is often learned in a mathematical framework, which would lead judgment to be inaccurate. Therefore, perceived residential density in the study scenes will be inferred from other behavioral and verbal responses by the subjects. Distress resulting from sense of crowding (badly designed higher density areas) can be reflected in different ways. As suggested by Chin, et, al. (1972), measuring cognitive and perceptual indications of crowding (negatively perceived density) require “semi-direct method” of verbal reporting.

In trying to understand negative subjective experience of perceived density (crowding) researchers have used three different models. First: the behavioral constraint model; in this model, movement is restricted, or goal accomplishment is obstructed and in general freedom is reduced. The second model is the control- density model; in this model, unpredictable environments which allow less control over situations and over privacy, are evaluated as crowded (Rodin, 1976). Finally, the overall arousal model, which suggests that crowding occurs in situation where density generates excessive simulation that causes overload of sensory systems (Evan & Lepore, 1992; Churchman, 1999).

Different studies revealed that a combination of these three models could simultaneously exist and affect the overall density perception or the negatively perceived density “crowding”. Empirically, there are no previous findings on how much each of these models contributes to density perception, rather these models where tested empirically under controlled conditions of different levels of density and social situations. These models deal with psychological and behavioral reactions that are not measurable by numbers. Techniques used in these models focused on correlating human reaction to actual high or low-density environment.

The behavioral constraint model

The model of behavioral constraint or social interference speculates that when density or other conditions restricts or limits once activities in an environment are evaluated as crowded. This approach is based on the theory of psychological reactance, defined by Brehm (1966) as the need to maintain freedom of choice as an important motivating factor in human behavior and perception. According to him people tend to maintain or restore freedom when it is threatened and their behavior and reactions to a setting is a result of this maintenance and restoration process (Stokols, 1976). If this process is restricted stress occurs leading to unpredictable behavioral output, or as described by Proshansky (1972) the experience of crowding occurs when a number of people with whom individual is in contact is sufficient to prevent him from behaving in a certain way (restrict his freedom of choice).

The different studies in this area have linked aspects of spatial settings, the type of activity done in a space, or the amount time spent in a space to the level of stress encountered in a dense environment. Altman (1975) defined crowding as a condition in which interpersonal boundary control mechanism break down, such that achieved privacy is less than the level of privacy desired. Impinging

Overall arousal model

Overload is defined by Milgram (1970) as a situation in which the amount and rate of environmental inputs imposed on an organism exceed its capacity to cope with them

(Stokols, 1976). According to him, the user should react by coping to the situation by certain behavioral input or adjusting his personal expectations from an environment when exposed to overloaded conditions for him to survive such environment. From social interaction perspective, unfamiliar or inappropriate social contact leads as well to this form of stimulus overload (Dessor, 1972).

Density control model

Density control is the means by which individual augments space to reduce limitations of the environment (Stokols, 1976), or to reduce or increase social interaction (Zlutnick and Altman, 1972). High density could lead to reduced control over one's choices, or his freedom of choice. This reaction is described as crowding (Rodin, 1976). The control model related to physical settings of the space is more applicable in interior conditions where the space can be easily manipulated by users by moving furniture or changing locations or improving environmental conditions such as temperature or even by leaving the room seeking other conditions. Physical control becomes harder on urban level as street furniture, weather conditions and built environment is unchangeable directly by users. The control on urban level is more adjustable by altering the type of social activities that the place holds or that users involve in. The physical environment on urban level could offer possible solutions for people to overcome unwanted social interaction through utilizing the available thorough fares and shielded spaces or visual barriers.

The three models profoundly overlap in the control level over once social interaction, surrounding environment and behavioral choices. In the overall arousal model, individual reacts to the increase of environmental simulations by withdrawal or by shifting the type of activity he is involved in or changing direction of movement. In behavioral constraint models, individual’s control is higher when the environment still allows alternative behavior when the environment limits his primary expected behavior. In contrast, a high density with negative impact would lead to stress and limit behavioral adjustment and will not allow control over behavioral choices.

Based on the several studies in density’s psychological effects, my research hypothesizes correlates between perceived residential density and the models discussed above. Accordingly, three variables are to be used in trying to empirically obtain references for these models to perceived residential density. The dependent variable, space crowdedness, will contribute to understanding behavioral constrain, experienced by the participants in certain urban settings. The space openness could possibly contribute to how restricting or limiting one’s activity is. The level of comfort will help understand how the environment is affecting participants’ coping ability. The four dependent variables (perceived residential density, level of comfort, space crowdedness, openness) are measured in the study on a Likert scale from 1 to 6, while 1 is very low and 6 is very high.

Survey Instrument

The survey instrument is employed in this study to collect different data about participants’ characteristics and their perceptual input about the 3D displays presented. There are two sets of variables that will be measured by this survey: independent variables that reflect socio-economic and contextual data and dependent variables or perceptual input pertaining to perceived density and level of control.

The socioeconomic and contextual data: in the first section of the survey, respondents will be asked to answer questions about his social and economic background, about his living place, and the context of his daily environment.

The second section will be a visual survey section. Participants will be asked to view a different set of each scene in terms of static displays. The participant will be given enough time to view each scene and to answer questions about its perceptual measures (dependent variables) on a scale of 1-6. The use of an even number (6) as the limit for the Likert scale is commonly used to prevent bias by many participants selecting a middle point on the scale as neutral choice, which could happen if the scale is an odd number 1-5 or 1-7 (Rea and Parker, 2005; Fellows and Liu, 2008).

To create the experimental tool this study followed three procedures:

- Collecting needed images through field visits
- Use the captured images from field visits and prepare images library to be used in creating 3D models. The process includes editing photos of building facades using Photo editing software (Photoshop Cs 5)
- Creating 3D models: In this experiment 3D Studio Max is used to build 9 models that vary in 4 characteristics (independent variables). Each variable has 3 different levels, to create all the possible combination of the 4 variables while considering all 3 levels of each of them a sum of (3^4= 81 models) will be generated. The time required to generate this number of models is very long and by including all these models and variation in visual survey participants will be required to spend long time to answer the survey. To go about this problem a fraction of these experimental runs is selected following the Fractional Factorial design method, accordingly nine models were created. This step includes creation of nine 3D models, creating texture maps library using 3d modeling software (3D Studio max) and photo editing software

(Photoshoph), prepare textures library, applying textures to 3D models and finally creating environment for final render and the production of 3D model images.

Participants

The frame for the study sample is the University of Florida students and staff. A stratified random sample of the study population will be created; the stratification is done on the gender of participants to ensure equal presentation of males and females, because some research studies have shown differences between males and females in evaluating dense conditions (Schmidt and Keating, 1979). The type of experiment (within -subject) requires exposing the same group of participants to all the experimental conditions (all levels of the independent variables) (Fellows and Liu, 2008). Therefore, all participants will be asked to answer questions about all the scenes with various experimental conditions

Fractional Factorial Design

To satisfy all possible combinations of the four variables, and each variable has three different levels, it will be required to create 81 models. Fractional factorial design was a solution for this issue; it allows measuring the main effect of the independent variables on the dependent variables. That renders the study as a screening experiment from which important findings will be revealed. It can lead to pointing out the most effective factor among the four study factors on the value of perceived residential density.

The fractional factorial design suggested the following combinations of variable levels (0000, 0111, 0222, 1021, 1102, 1210, 2012, 2112, 2201). 1021 refers to the model that has the dependent variables: number of intersection level equal to 1, enclosure level equal to 0, façade complexity level equal to 2 and existence of people level equal to 1 where 0 is the lowest and 2 is the highest level. Following this design 9 three dimensional models were created and used for the visual survey (Table 3-1).

Field Visit

Researcher used images for building façades from Atlantic Station, Atlanta, Georgia. Atlantic Station was selected because it is an American example of a vibrant urban mixed-use environment. Using images from Atlantic station allows the creation of simulated environment that has reference to a real urban environment. A sum of 270 images were captured for the buildings surrounding the main street in the area (Atlantic Drive), and the building facades overlooking all intersecting streets. All façades for each building were captured with effort to reduce the number of objects that might block the view of the building, such as cars and pedestrians.

Three Dimensions Modelling

3D Studio Max software was used to create nine 3D models. 3D studio Max was used to create 9 models that have no details and no texture. Each model encompasses one main street that is 60 FT wide and in average 1500 FT long and intersecting streets that are 40 FT wide as well as buildings surrounding the main street. The street was set at 60 Ft width to accommodate 2 ways with one lane at each direction and 15 Ft side walk that includes space for streetscape and landscape as well as sidewalks.

To apply texture and material to the 3D models texture mapping technique was used. Texture mapping as explained earlier is useful when many models are needed and when detailed focus model is not required such as the case of urban design experimental models that cover large urban areas. The process of applying textures on 3D models includes six steps. First: each building in the models was exported as a .3DS separate file. Second: a 3D Studio Max modifier (Unwrap UVW) was used inside each separate file to flatten each building alone. Third: the Unwrap UVW modifier allows rendering a .TGA file extension of the resulted flattened models, TGA are images that embed coordinate data and scale data of the models that allows it to be placed on the 3D models as material on their designated surfaces after editing in Photoshop. Fourth: .TGA file is opened in Photoshop to allow creating texture on top of the model polygons. Fifth: the textured file is saved again in Photoshop as .JPG file. Sixth: the resulted file is used again in 3D Studio max as map in material editor and applied to the model. This process was repeated over each building in the nine combinations. After all buildings are prepared for each case they were imported back to the large model. Figure (3-6) shows one example of how the unwrapping/ texturing process was done, it summarizes the process of creating one of the nine models.

A 3d Studio max modifier (unwrap UVW) was used to flatten building facades, the resulted images were then exported to a Photoshop readable file format (TGA). The Unwrap modifier creates image files that embed coordinate data and scale of the texture, which allows it to be placed on the 3D models as material on their designated surfaces after editing in Photoshop. Facades have been later edited in Photoshop software using the existing image library as a reference and saved as JPG file format to be used as material in 3d Max for each specific building. Using 3D Studio Max, the created material was applied to buildings using material editor.

Photo Editing and Cleaning

Photoshop Cs5 software was used to correct and clean images taken from the field and to prepare images to be used in creating 3D model textures. In urban street settings, like the Atlantic Station, it was not possible to avoid barriers between camera and buildings while capturing façade views. Objects such as cars, plants, and people were erased, further image editing was done to prepare them to be used as material in 3D models (Figure 3-3).

To use images in 3D modeling software for the process of applying textures it is necessary that facades are orthogonal, and they should not have distortion or a perspective effect. For that reason, additional editing was required to minimize distortion and perspective effect in the images using Adobe Photoshop editing tools (Figure 3-4).

Some building facades need to be clipped to isolate other attached and or surrounding buildings, other facades needed to be created out of multiple images by joining them together and then editing them (Figure 3-5). As a result, a library of 80 different building facades was created from the Atlantic Station context to be used in creating the experimental models.

Texture Mapping Technique

Texture mapping is a process used to apply two dimensional images, referred to as bitmaps, to add textures for three dimensional models. It allows a more natural looking virtual space (Wang and Chen, 2009). For example, a 2D façade images are applied to polygons of a 3D box model to create a building in 3D modeling software. This method is commonly used in creating gaming environments, 3D avatars for games or training purposes or in large scale urban development projects. Texture mapping processes help increase the details of the 3D model without the need to model these details, which results in less number of polygons and reduces the render time required.

Each 3D model is unfolded (unwrapped) to 2D polygons on a flat surface. The process is identified in 3D studio max as UVW Unwrap modifier. The UVW is a coordinate system like XYZ space coordinate but it refers to surface coordinates which works as a grid on the model surface (Ingrassia, 2009). For this research, all model are primitive boxes therefor a basic unwrap process was needed. To unwrap a simple box, one selects edges to create seams for the model, based on these seams the box is unfolded, (Figure 3-6). Some of the polygons are deleted from the unwrap window, other polygons are going to have similar textures such as side facades of the buildings and the front and back of the buildings because the main façade of the buildings are the ones seen most clearly by the viewers. The unwrap modifier allows to copy and paste polygons on top of each other, accordingly similar texture applies for the similar polygons at the same resolutions and ratios. Figure (3-7) shows example of one building unwrap process; the unwrap modifier window shows the selected parallel polygon highlighted in red. The unwrap window has a Render UVW option in which the unfolded building layout can be saved as image in .TGA format. The .TGA file then can be edited in a Photoshop CS, (Figure 3-8). The resulted images are then used to apply on the building polygons at high resolution in 3D Studio Max in which final rendering is done and final 3D models are created to be used in the visual survey, (Figure 3-9).

Visual Survey

Through University of Florida's account researcher has access to Qualtrics online survey services for university-related use. Qualtrics features creation, delivering, collecting and analysis of online surveys (https://services.it.ufl.edu/task/all/online-survey). Survey is accessed through accessing the webpage (https://ufl.qualtrics.com/jfe/form/SV_blvExZ6AGHjdpZj). The University of Florida requires that all surveys that involve human subject participation needs to be approved by the IRB (Institutional Review Board); forms needed to obtain approval from The University of Florida IRB were completed before launching the survey.

The first page of the survey is an introduction about the survey and it includes an informed consent form on which participants need to agree. The consent form includes all information required to conform to Qualtrics terms of use for research purposes. The survey has two parts: the first is 15 visual questions; the second part, collect some personal and socio-economic data about each participant. The first question pertained to collect perceptual input about 9 different spaces. Each scene is displayed for participant from four different views and participants were required to rate qualities of space crowdedness, comfort level, openness and residential density for each space on a scale from 1 to 6 (Figure 3-10). This first group of questions is intended to measure participants' perception of the displayed spaces. Participants have been given simple definition of these qualities; technical definitions were avoided in order not to affect the rating and participants' perception of space. The four qualities were defined as follows:

Space crowdedness: How crowded does the space feel?

Level of comfort: How comfortable would you be when visiting or walking in the space?

Openness: How open or spacious does the space feel?

Residential density: What is the residential density of people living at this street?

The next two questions show 9 different spaces that are varied in terms of the four independent variables (enclosure, number of people and activity, level of façade complexity, number of streets intersections). Participants were asked to rank these spaces in the order of preference from 1 to 9 whiles being placed in an imaginary social situation: (one less formal such as meeting friends (in question 2); the second is more formal such as work-related meeting (in question 3). The purpose of these two questions is to discuss the association between perceived residential density as measured in the previous question with the psychological demand for a highly social situation such as friend gathering as well as association between perceived residential density and the demand of formal activity for a less active conditions or a more formal situation such as a work meeting.

Question 4 presents three top views of street plans in black and white (figure ground); the three street plans differ in the number of streets intersecting the main street and accordingly the size of masses included. Participants were required to rate these images from 1 to 3 from the least dense to the densest. The question pertains to further assess the effect of number of intersecting streets on perceived residential density when only using a simple black and white top view. This, to some extent could provide insight about participants' perception of residential density when looking to aerial image of a proposed development, (Figure 3-11).

People and façade details generally add richness to streetscapes and are always advocated as important factors in creating vibrant spaces. Further, people existence in street could be misleading when residential density needs to be evaluated and might affect results accordingly. These two facts suggest adding a question that measures how other aspects of space when isolated from people and façade detail influence the concept of residential density. Question 5 shows 9 different spaces; camera location was identical for all the 9 spaces. The spaces presented in this question are in grey scale colors and do not include people nor does it include façade details, (Figure 3-12).

The second part of the survey collects basic information about participants (between subjects' independent variables): (age, gender, design experience) and other information about where participants have been living (housing type and residential density of the places where they lived). This part of the survey is pertained to measure the effect of these demographic factors and people past experiences on residential density perception (between subjects' independent variables).

Expected Results and Analysis

The variation between actual density of the study area and the perceived residential density will be also tested. Per literature, perceived residential density is not expected to parallel actual density because physical, personal and contextual aspects affect how people see their environment; this study will help understand these variations and to highlight the most relevant visual qualities of an environment that affect people judgment of residential density.

Table 3-1. Independent variables levels used in fractional factorial experiment.

Independent variables			
Intersecting Streets	Enclosure	Façade Complexity	People Existence
0: scene has just one street in 250 Ft 1: two streets intersecting the main urban street every 250 Ft 2: scene has three streets intersecting the main urban street every 250 * 250 FT is measured from location of the viewer along sight line	0: when the ratio of the width of buildings to their height is in average 1:1 in the urban scene 1: when width to height ratio is 3:4 2: when width to height ratio is 1:2.5	0: facades are lowest in complexity and has plain material and no details (include just the main façade components). 1: some details included such as shingle texture 2: the highest in complexity (has shingles, ornaments, a cornice and door and windows trim),	0: very few people in the scene walking alone) 1: few people, but has some more social interaction such as group of two people walking and talking 2: moderate number of people, one can see people in cafés interacting and talking, or using street furniture such as benches or bus station
0	0	0	0
0	1	1	1
0	2	2	2
1	0	2	1
1	1	0	2
1	2	1	0
2	0	1	2
2	1	2	0
2	2	0	1

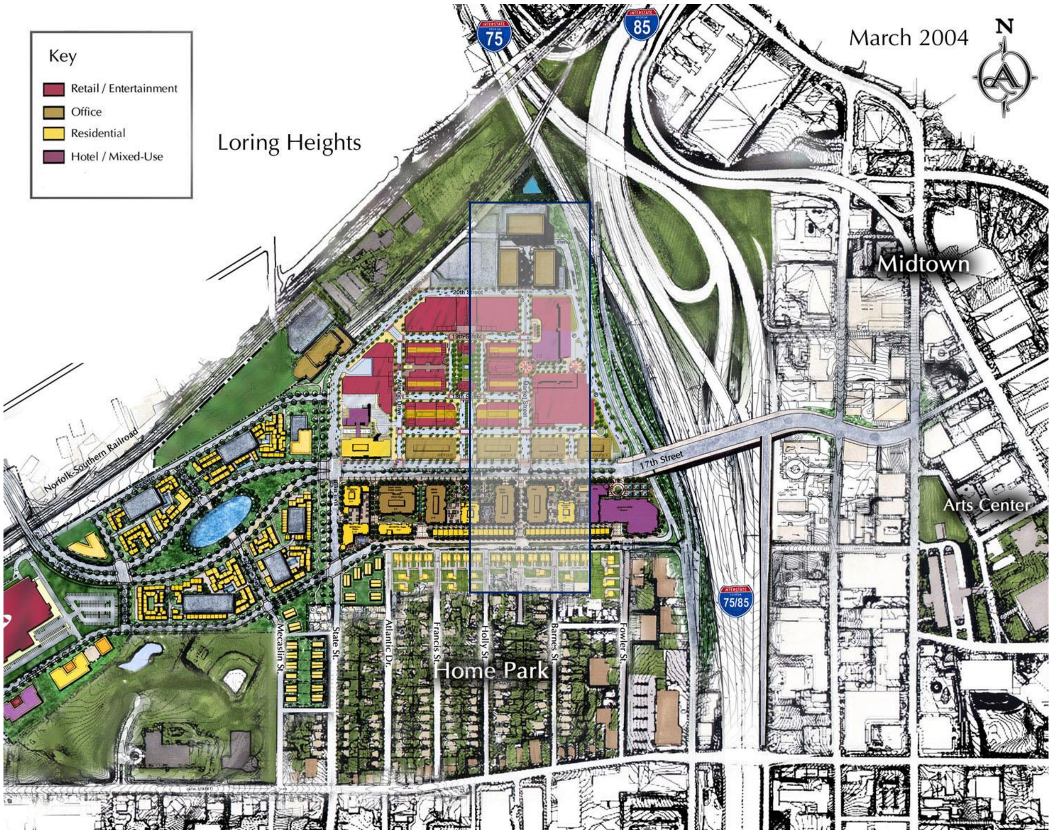


Figure 3-1. Atlantic Station plan (http://atlanticstation.com/)

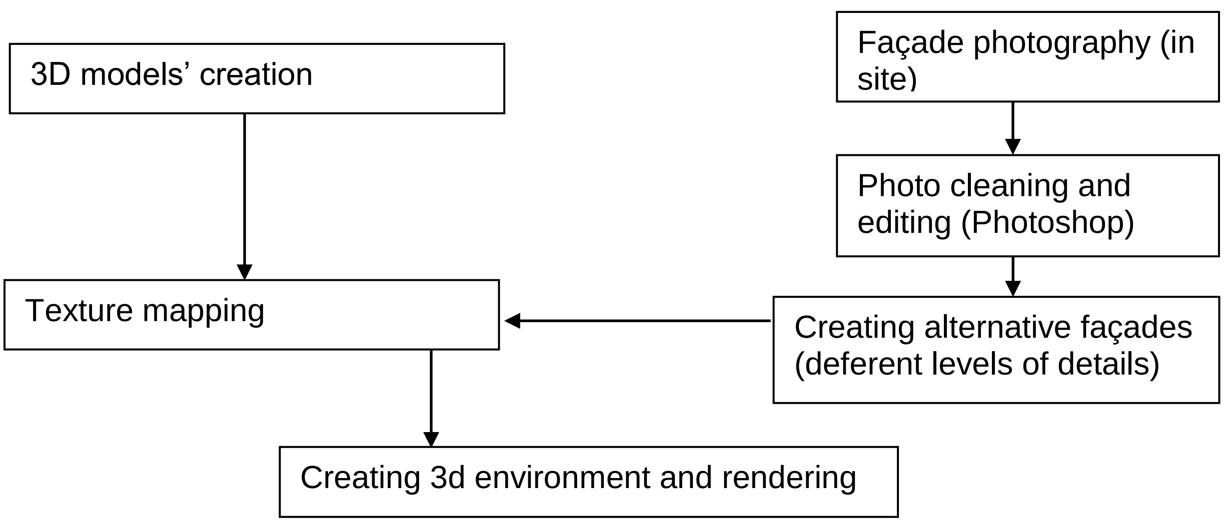


Figure 3-2. Flow chart of the procedure used in creating the visual survey.

Figure 3-3. Image cleaning process using Photoshop (before and after), (Atlantic Station, Atlanta, 2009).

Figure 3-4. Image editing for a multiple section building (before and after), (Atlantic Station, Atlanta, 2009).

Figure 3-5. Image editing that requires connecting different edited photos for large building (before and after), (Atlantic Station, Atlanta, 2009).

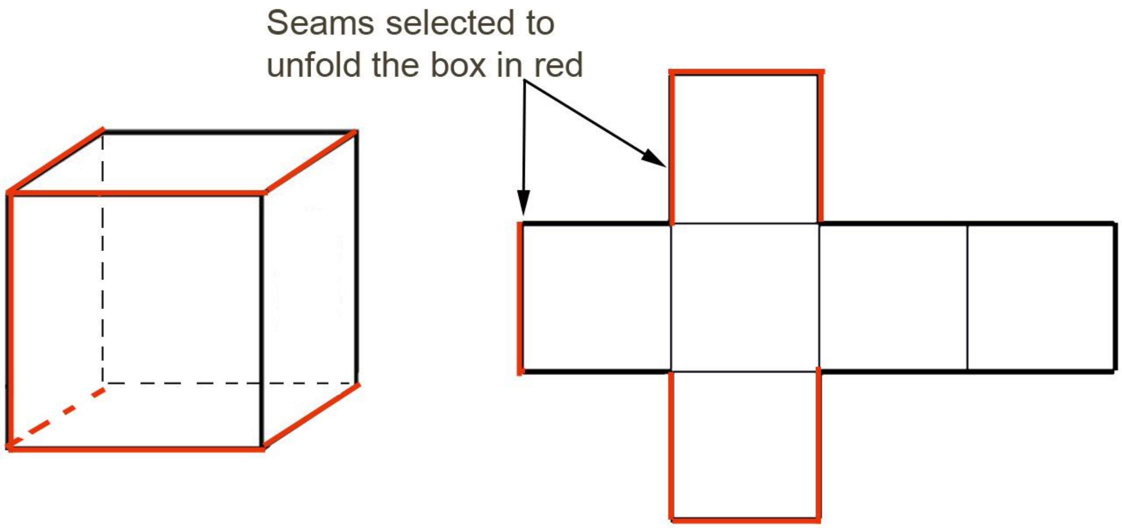


Figure 3-6. Box typical unfold method and the selection of edges as seams to use for the unfold method.

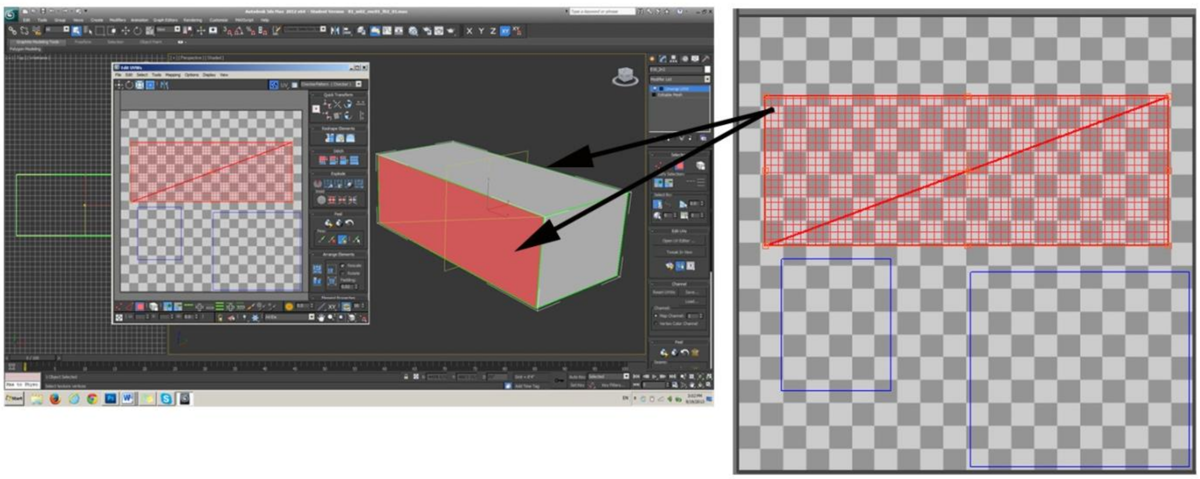


Figure 3-7. Screenshot for 3D max unwrap process for simple box model in 3D studio Max.

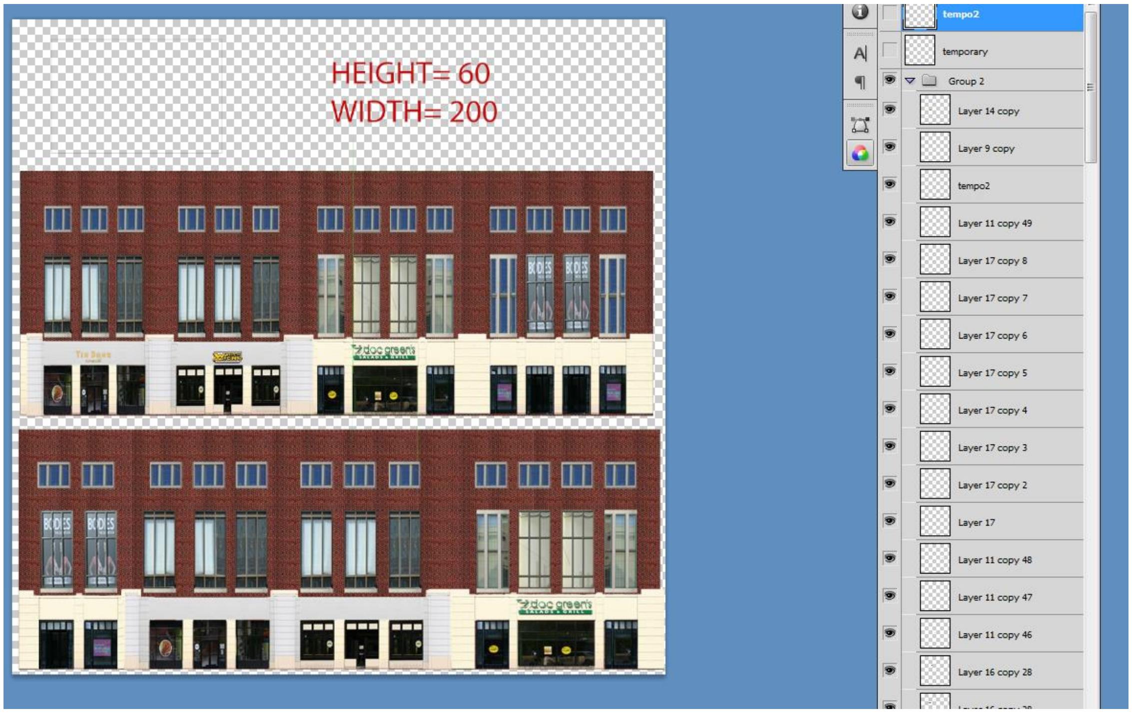


Figure 3-8. Applying edited facades into unfolded models faces in Photoshop.

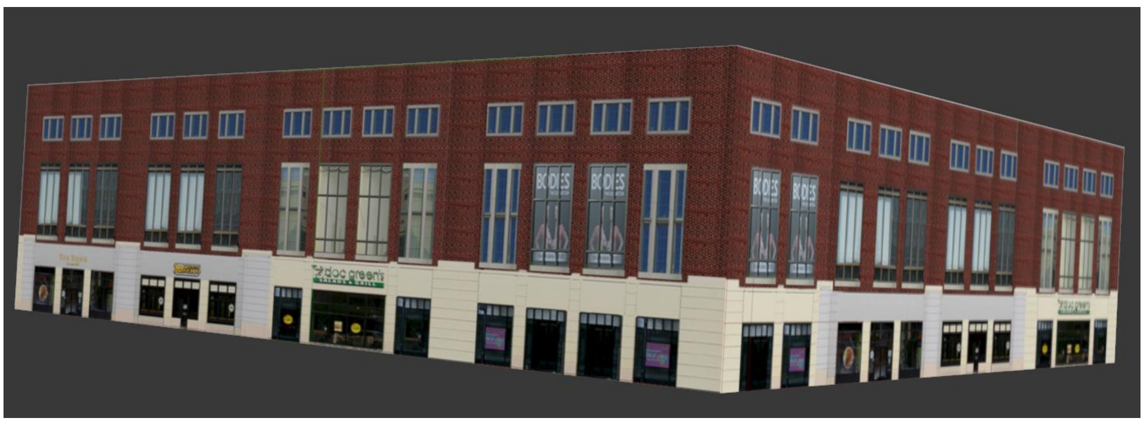


Figure 3-9. Using the material created in Photoshop to building models in 3D Studio Max.

Figure 3-10. Screenshot for one scene from the first question in the survey instrument (Online Survey, Question 1, Scene 1)

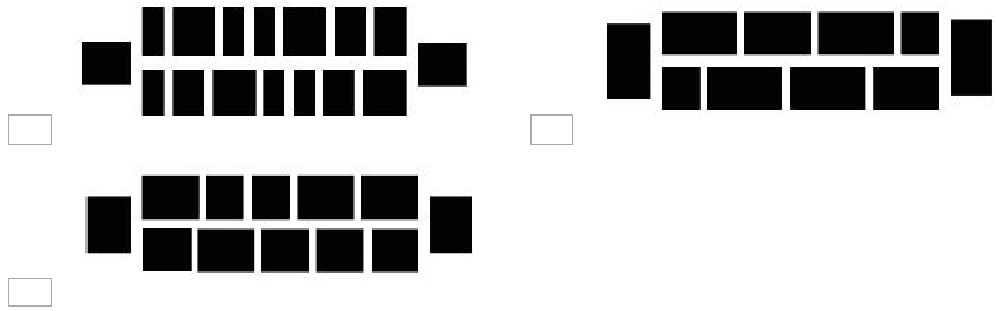


Figure 3-11. Black and white top view of a street (Online Survey, Question 3)

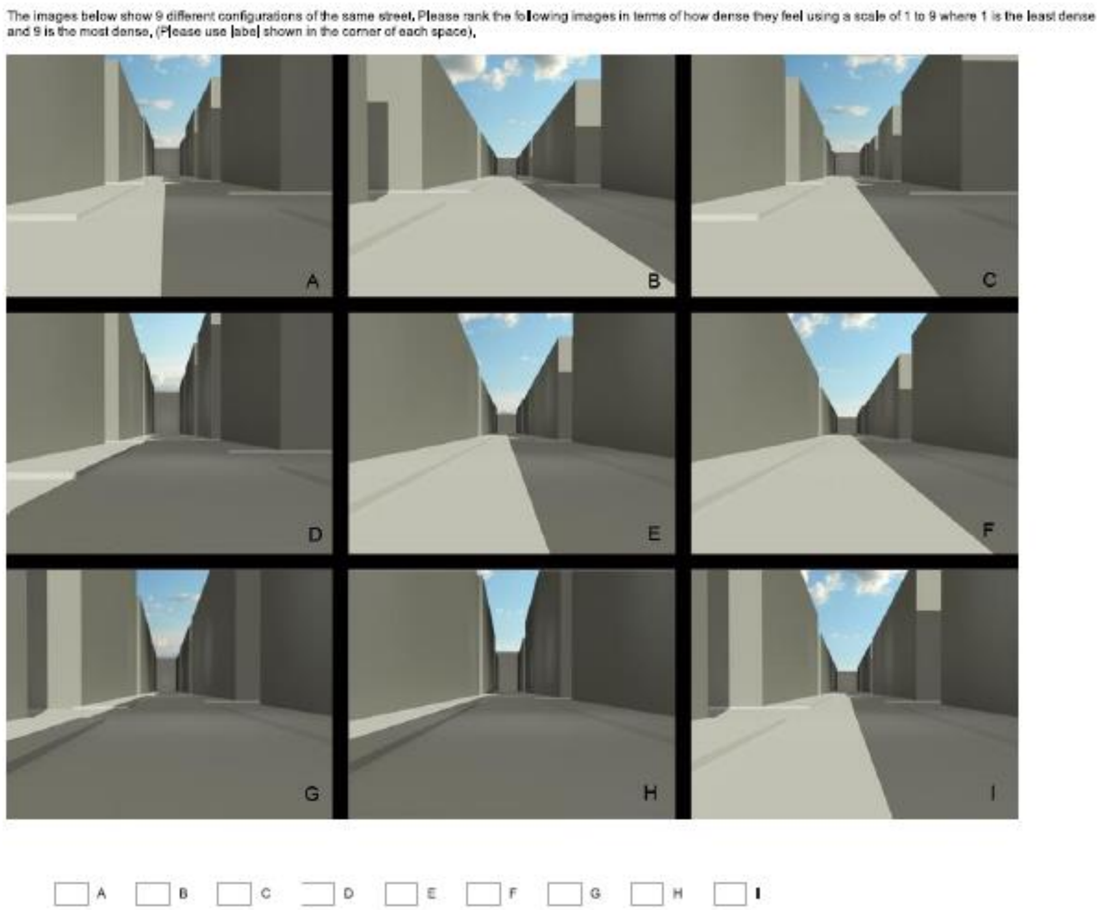


Figure 3-12. Nine scenes in grey color with no façade details or pedestrian included (Online Survey, Question 4)

CHAPTER 4
RESULTS

Research Hypothesis

Changes in certain physical qualities of the study area lead to psychological and perceptual reactions by study subjects. This is reflected in this research by different perceived information overload, control level and level of freedom captured through the primary dependent variables: perceived residential density, perceived openness, level of comfort and space crowdedness. Physical qualities of the environment are represented by the dependent variables (enclosure, façade complexity, number of intersecting streets, existence of people and activities).

Sample Characteristics

Data was tested for skewness and kurtosis and results showed that data was not normally distributed. Dividing skewness and kurtosis on their standard error returned values above 1.96 or below -1.96, which reflects non-normal distribution. Furthermore, the Shaprino-Walik test for normality showed significant variances in the data with p= .000, which is below 0.05 (Shapiro and Walik, 1965). This leads to rejecting the null hypothesis that the data is normally distributed.

Test of Reliability

To test reliability of the survey instrument researcher has used the Test, Retest Reliability, which is defined as “the ability of a measure to produce consistent results when the same entities are tested at two different points in time” (Field, 2009). For the research to be valid it should satisfy the requirement, Test_Retest Reliability; two questions were repeated and were answered by the same group of people who participated in the survey. Repeated ranks were then correlated; this correlation is known as Cronbach's Alpha, which is a measure of internal reliability of a scale. Nunnally (1978) stated that acceptable reliability was an alpha above .70 and unacceptable reliability was an alpha below .70. When running the analysis for the two repeated models the results were reliable for the variables (space crowdedness with alpha= 0.755 and slightly for level of comfort with alpha = 0.61) but were not reliable for space openness and perceived residential density with alpha around 0.5. When running the same analysis for each model separately the results returned for the model 0000 was higher in reliability (around 0.7) for all the four dependent variables than the model 1102.

For the dependent variable space crowdedness, the reliability test results reported were Alpha= 0.755, df= 153 and P=0000; For the dependent variable level of comfort the test of reliability returned significantly good correlation with alpha= 0.605, df= 153 and p=.0000. For the dependent variable openness, the test of reliability returned significant but rather low correlation with Cronbach's Alpha= 0.5, df= 153 and p=.0000. For the dependent variable Perceived residential density, the test of reliability returned significant but rather low correlation with Cronbach's Alpha= 0.41, df= 153 and p=.0000, (Table 4-3).

Assumption

The Spearman Rank Order Correlation was chosen to measure the correlational relationships between dependent and independent variables. A correlation coefficient ranges from -1.0 to +1.0; a positive correlation means that the two variables are increasing together while a negative correlation will mean that the one variable is decreasing when the other increase (Freedman, Pisani, & Purves, 2011). The Spearman correlation is used when at least one variable is ordinal, and the other is ordinal or ratio in level of measurement and this is the first assumption and it was met. The second assumption states that there must be a monotonic relationship between each set of hypothesized bivariate correlations. Monotonic is when both variables move in the same direction together or when one increases the other one decreases. Scatterplots are used to check for monotonicity and all met the assumption.

Data Analysis

Within-subject Independent Variables

The nine models used in the study have varied levels of enclosure, number of intersecting streets, no of people, level of façade complexity. Each of these independent variables have three levels from low to high, as their value coded as 0, 1, 2. The four dependent variables (perceived residential density, space crowdedness, perceived level of comfort, perceived openness) are expected to vary between the nine models as a result of changes in independent variables. Dependent variables are ranked by participants using a Likert scale from 1 to 6, where 1 is very low and 6 is very high. To test variances between the 9 models, the Friedman test was used for each of the dependent variables. For perceived residential density, variable analysis returned significant results at P= 0.0000, n=77, df=40. For space crowdedness results was also significant at p= 0.000, n=77, def=40, for the dependent variable sense of comfort the result was significant at p= 0.000, n=77 and df=40 and finally results were also significant for the variable space openness with p=0.000, n=77 and df=40. Model 2222 ranked the highest for perceived residential density and perceived space crowdedness; the model 1201 ranked the highest in level of comfort and perceived openness. In the other hand model 1021 ranked lowest in perceived residential density; model 0000 ranked lowest in perceived space crowdedness; model 1102 ranked lowest in perceived level of comfort and the model 2201 ranked lowest in perceived openness, (Table 4-4).

Testing Association

Enclosure association with dependent variables

Alternative Hypothesis: dependent variables (perceived residential density, space crowdedness, level of comfort, openness) are correlated with enclosure.

Enclosure is expected to be positively correlated with space crowdedness and residential density, but negatively with level of comfort and openness across the nine models. Dependent variables were measured on a Likert type scale with 1 being “very low” and 6 being “very high”. Enclosure is measured by length to width ratio and as the value increases, so does the level of enclosure. Since perceived residential density was measured on ordinal scales, the Spearman Rank Order Correlation was chosen to measure the correlating relationship between the five variables. A correlation coefficient ranges from -1.0 to +1.0 and a positive correlation means the two variables are increasing together. When enclosure levels increased so did the ratings of space crowdedness and residential density and when enclosure levels increased then the rate of level of comforts and openness decreased, so the hypothesis is fully supported (Table 4-5). Enclosure was positively correlated with space crowdedness (r = .116, p = 0.001) and residential density (r =.155, p < 0.0001); however, enclosure was negatively correlated with level of comfort (r = -.160, p < 0.0001) and openness (r = -.221, p < 0.0001).

In a different question, the researcher tested the impact of enclosure and number of intersecting street on the dependent variable (perceived residential density) to isolate the effect of these two variables from the effect of (existing people in the street and the level of façade complexity or details). Enclosure was significantly correlated with perceived residential density at (r = .450, p = 0.0001). This means as the models enclosure level increased, perceived residential density ratings also increased. The correlation was a little higher and that might be a result of reducing distraction caused by other details in the scene that maybe have disturbed participant's judgment, (Table 4-6).

Façade complexity association with dependent variables

Alternative hypothesis: dependent variables (space crowdedness, level of comfort, openness and perceived residential density) are correlated with the independent façade complexity across the nine models.

Façade complexity was measured on a Likert type scale with 0 being "low façade complexity" and 2 being "high façade complexity". Façade complexity increased as its value in the model increased. Perceived residential density was measured on a Likert type scale with 1 being "very low-density perception" and 6 being "very high-density perception."

Because perceived residential density and façade complexity were measured on ordinal scales, the Spearman Rank Order Correlation was chosen to measure the correlational relationship between the five variables. Façade complexity was positively correlated with the level of comfort (r = .163, p = 0.001), so the hypothesis was partially supported. This means as façade complexity increased, so did the ratings for levels of comfort. façade complexity was not correlated with space crowdedness (r = -.014, p = 0.721), openness (r = .036, p = 0.349) and perceived residential density (r = -.035, p = 0.362), (Table 4-7).

Number of intersecting streets correlation with dependent variables

Alternative Hypothesis: Dependent variables (space crowdedness, level of comfort, openness and perceived residential density) are correlated with the independent variable (number of intersecting streets).

The number of intersecting streets in a scene was ranked with 0 being “low number of openings” and 2 being “high number of openings”.

Dependent variables were measured on a Likert type scale with 1 being “very low” and 6 being “very high” because dependent variables and the number of openings were measured on ordinal scales, the Spearman Rank Order Correlation was chosen to measure the correlational relationship between the five variables. The number of openings is not correlated with space crowdedness (r = .005, p = 0.151), level of comfort (r = -.016, p = 0.683), openness (r = -.014, p = .715) and perceived residential density (r = -.002, p = .960) (Table 4-8). Thus, the hypothesis is not supported.

Since the level of details in a façade is expected to affect peoples’ perception, the scenes that have high level of façade details (level 2) was excluded and the test was run again. The test returned significant correlation between the independent variable intersecting street and the dependent variables (perceived residential density and space crowdedness) with r=.136, p= .003 and r=.271, p=.000 respectively. While no correlation was found between the independent variable intersecting street and the dependent variables openness and sense of comfort (Table 4-9).

Further investigation about correlation between intersecting streets and perceived residential density was done through ranking three black and white street views. The three street views of intersection A (highest number of intersections), B (lowest number of intersections), and C (medium number of intersections) will be looked at in terms of total perceived residential density. Perceived residential density was measured on a Likert type scale with 1 being “the least in residential density” and 3 being “highest residential density”. Perceived residential density is positively correlated to “number of intersection” (*r*=0.273, *P*=000, *n*=231) (Table 9-10). The positive correlation means that as intersecting streets increased space was perceived to be higher in residential density.

In a different question, the researcher tested the impact of enclosure and number of intersecting street using 3D scenes in grey color to isolate the effect of these two variables from the effect of (existing people in the street and the level of façade complexity or details), (Table 9-11). Number of intersecting streets was not correlated to perceived residential density (r=-.031, p= .418) when using grey scale 3D models' scenes not including façade details or people in the scene.

Number of people in the street correlation with dependent variables

Alternative hypothesis: **(**perceived residential density, space crowdedness, level of comfort, openness) are correlated with the number of people and activities across the nine models. The number of people and activities was ranked with 0 being “low number of people and activities” and 2 being “high number of people and activities”. Dependent variables were measured on a Likert scale with 1 being “very low” and 6 being “very high”. Since dependent variables and the variable number of people and activities were measured on ordinal scales, the Spearman Rank Order Correlation was chosen to measure the correlational relationship between the five variables. The number of people and level of activities was positively correlated with ratings of the dependent variable space crowdedness (r = .399, p = .001) and residential density (r = .188, p = .001). The hypothesis is partially supported and as the number of people and activities increased, in the models, so do the ratings of space crowdedness and perceived residential density. The number of people and activities was not correlated with Level of Comfort (r = .005, p = 0.886) and Openness (r = .027, p = .483) (Table 4-12).

Type of activity association to the dependent variable

The type of activity people has in a space is believed to affect their perception of the space qualities. It is expected that a social situation in which higher level of interaction is needed such as friends gathering will abide for higher density settings more than a situation where formal setting or a more organized and quiet setting is needed. For that purpose two imaginary scenarios of social activities was explained to participants and they were asked to rank the scenes in terms of their preference for the space in such social scenarios. Two alternative hypotheses were tested:

Alternative Hypothesis 1: Dependent variables (perceived residential density, space crowdedness, level of comfort, openness) are correlated with preference for social settings across the nine models. The perceived preference for social settings was ranked with 1 being “highest” and 9 being “lowest”. Perceived residential density, space crowdedness, level of comfort, and openness were measured on a Likert type scale with 1 being “very low-density perception” and 6 being “very high-density perception”.

Since dependent variables and the social settings and activities were measured on ordinal scales, the spearman rank order correlation was chosen to measure the correlational relationship between the five variables. The independent variable social setting is not correlated with space crowdedness (r = - .048, p = 0.204) and perceived residential density (r = -.061, p = .110) (Table 4-13). But a very small negative correlation was found between social preference and level of comfort and openness with (r = -.098, p = 0.010) and (r = -.078, p = .04) respectively this negative correlation means that as ranking of openness and comfort increase the preference for social settings increase because participants' preference for social space is from 1 to 10 as 1 is the most preferred and 10 is the least preferred space.

When testing correlation between preference for social space and the four independent variables, the results showed that enclosure is significantly correlated to preference for a social space with r= - 0.214, p=.000, as enclosure increases preference for a social space increases (because 1 is the highest preference and 10 is lowest preference). Number of people and number of intersecting streets in scene has correlated significantly with preference for social space with r=-.25, p=.000 and r=-0.23, p=.000 respectively which reflects positive correlation as well. Façade complexity has also small negative correlation r=.079, p=.000 (Table 4-14).

The results are also reflected in ranking means for the nine models (Table 4-15). It was seen that scene that has the highest mean rank has the lower enclosure and highest number of interesting street (model 2012). While the scene that received the least rank has the highest level of enclosure and lower number of people (1210).

Alternative Hypothesis: Dependent variables are correlated with preference for Work Space across the nine models. The perceived preference for Work Space was ranked with 1 being "highest" and 9 being "lowest". Dependent variables were measured on a Likert type scale with 1 being "very low" and 6 being "very high".

Since dependent variables and the variable (Preference for Work Space" were measured on ordinal scales, the Spearman Rank Order Correlation was chosen to measure the correlational relationship between the five variables. Preference for Work Space is not correlated with space crowdedness (r = .033, p = 0.388), Level of Comfort

(r = -.043 p = 0.260), Openness (r = -.013, p = .742) and Perceived Residential Density (r = .024, p = 0.502) (Table 4-16). Thus, the hypothesis is not supported.

When testing correlation between work space preference and the four independent variables it returns a very low significant correlation with the independent variable enclosure with r= 0.079 and p=.037, n=693. While no correlation was found between the other three independent variables and work space preference (Table 4-17).

Between Subjects Variables

Based on literature it is expected that between subject's variables such as age, gender, design experience and type of residence where participant live could affect how people perceive an environment. In the following section results of variance in these variables and correlation with dependent variables will be reported.

Gender

Alternative hypothesis: Men and women are different in their perception to density (residential density) and how comfortable they would feel in a dense space (woman prefer high density settings so the higher the density perceived in a space the higher the perceived level of comfort). For this end models that scored highest in perceived residential density were included in the analysis (337 cases out of 693) and the two groups (men and woman) was compared in their perceived residential density and level of comfort. When comparing (group1- male) with (group 2: Female) in their level of comfort at the cases when scenes where perceived high in density it was clear that women ranked the scenes that they perceived as high in density by higher level of comfort than men. Men results for Perceived Residential Density (M = 4.34, SD = .5335) and in Level of Comfort (M= 3.688, SD= .995) which is lower than (group2- Female) (M = 4.54, SD = 1.0657) and for level of comfort (M= 3.78, SD= 1.05).

However, Mann- Whitney U test of differences for the two groups (male, female) returned no significant difference between males and females in level of comfort at spaces that are ranked high in perceived residential density (Table 4-18). The null hypothesis that no different between male and female in level of comfort at a high residential density setting could not be rejected.

Time spent in USA

Alternative Hypothesis: people who lived long in the USA because of common believes and culture as well as the geography of USA are expected to associate higher perceived residential density to lower comfort and higher space crowdedness. 377 cases were used out of 693 cases, these cases are the scenes that ranked 4, 5, 6 in perceived residential density.

H1: time spent in USA is correlated to level of comfort: the longer people lived in USA the lower the level of comfort they have in higher density scenes.

H2: time spent in USA is correlated to space crowdedness: the longer people lived in USA the higher they rank sense of space crowdedness in higher density settings.

The time spent in USA was recoded into three groups instead of four where the last category (people live in USA more than 20 years was merged to the previous category). In comparing means between the three groups for the dependent variable (level of comfort) the difference between the three groups was not significant. The Krusal Wallis test returns no correlation with (Chi square= 1.912 and p=.384) (Table 4-19).

For the space crowdedness, there was a difference in the mean value for the three groups and the Krusal Wallis test results show a significant difference between the three groups with Chi square=9.884 and p=.007 (Table 4-20)

Analysis results could not reject the null hypothesis that people lived in USA longer would perceive high density spaces as less comfortable than people who live shorter in USA. However, the analysis results rejected the null hypothesis: there is no difference between people lived in USA for short time and people lived in USA for long time in their perceived space crowdedness at spaces with high perceived residential density.

Design background

People who are from background related to design are different in their perception to density than people from other professional background.

Alternative hypothesis: people with design background would be more comfortable in high density urban settings (people with design experience rank high density spaces higher in level of comfort than people with no design experience).

By comparing means for the two groups (a: people with design experience and group b: people with no design experience) the first group has smaller mean for perceived residential density which is in line with the study expected findings. However, Mann Whitney U test of difference results returns no significant statistical difference with p=. The results could not reject the null hypotheses that there is no difference between the two groups in level of comfort at high perceived residential density scenes (Table 4-21).

Age

Age is expected to correlate positively to perceived residential density and negatively to sense of comfort.

Alternative hypothesis 1: Older people will rank spaces higher in perceived residential density than young people.

Comparing means for age groups illustrated that mean rank for perceived residential density generally increase as the age increase. Krusal Wallis test also confirm this finding with significance variance and p=.002. This result rejects the null hypothesis that there is no difference between the age groups in their perceived residential density.

Alternative hypothesis 2: Older people will feel less comfortable in spaces that has ranked of higher perceived residential density than young people.

The same analysis was run to test association between age and sense of comfort in selected cases (scenes that has 4 – 6 perceived residential density rank). By comparing means for age groups, we found no significant variations in means for level of comfort. Krusal Wallis test also returned no significance variance with p=.354, (Table 4-23).

Type of living place

Alternative hypothesis: People who live in higher density locations would rank scenes higher in perceived residential density comparing to people who live in low density areas.

Comparing means between the four groups (where area type 1 has lower actual density and area 4 has the highest actual density) analysis shows difference in means which in general increase as density decrease. With the people who live in urban area and high actual density have mean for perceived residential density = 3.4 significantly different than that of people live in low density areas who have Mean= 4.8. The Krusal Wallis test shows significance variance with p =.010, (Table 4-24).

Further analysis was conducted to test people ranking for comfort in scenes that have higher rank in perceived residential density (337 cases) in which perceived residential density was ranked 4 or larger. Comparing means show significant variations between groups ranking for level of comfort. The Krusal Wallis test has also showed significant variance at p=.006. The null hypothesis is rejected, (Table 4-25).

Visual Density versus verbal Expression of Density (Validity test)

In this section people input about the residential density in the area they reside and their selection of visual illustration that they think represent or relate in some way to their living area is compared. These two questions aim at explaining the different between verbal expression of density (very high residential density, high, moderate, moderately low, very low) and visual one, (Figure 4-8). Both variables are coded 1 to 5 where 1 is low and 5 is high residential density. A Conbach's Alpha reliability test was conducted revealed very low reliability between the two variables (residential density area) and (visual expression of density) (Table 4-26).

Further descriptive statistics also emphasized the mismatch between the two variables which indicate that visual representation of residential density is not necessarily a reflection of actual density (Table 4-27). Another reason for this variation is the use of ranking measure for residential density instead of actual numbers.

Table 4-1. Results of skewness and kurtosis for dependent variables.

	Perceived residential density	Perceived comfort	Space openness	Space crowdedness
Skewness	-.038	-.308	-.017	.043
Std error of skewness	.093	.185	.093	.093
Kurtosis	-.372	-.308	-.339	-.554
Std error of kurtosis	.185	.0446	.185	.185

Table 4-2. Test of normality for the two groups of gender.

Dependent Variables	Gender	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Space crowdedness	1.00	.198	324	.000	.914	324	.000
	2.00	.152	369	.000	.931	369	.000
Level of comfort	1.00	.190	324	.000	.924	324	.000
	2.00	.194	369	.000	.921	369	.000
Space openness	1.00	.171	324	.000	.932	324	.000
	2.00	.171	369	.000	.929	369	.000
Perceived residential density	1.00	.194	324	.000	.922	324	.000
	2.00	.172	369	.000	.936	369	.000

a. Lilliefors Significance Correction

Table 4-3. Reliability testing for a (test retest correlation).

	Space crowdedness	Level of comfort	Space openness	Perceived residential density
Cronbach's Alpha	.755	.602	.498	.41
No items	2	2	2	2
Cronbach's Alpha	.755	.602	.498	.41

Table 4-4. Dependent variables test of variance.

Model No	Perceived residential density Mean		Space crowdedness Mean		Level of comfort Mean		Space openness Mean	
0000	3.2208		2.4935		3.7922		3.6234	
1111	3.2857		2.9740		3.7662		3.5714	
2222	4.0649		3.7013		3.8182		3.1818	
1021	3.0000		2.6883		4.0779		4.0000	
1102	3.7403		3.2857		3.1688		3.6753	
1210	3.1818		2.5455		3.2208		3.2078	
2012	3.5195		3.5844		3.9351		3.7143	
2120	3.3377		2.6753		3.8701		3.4805	
2201	3.7403		3.4026		3.4805		3.0649	
F Test	N	77	N	77	N	77	N	77
	Chi Square	114.2	Chi Square	158.7	Chi Square	104.9	Chi Square	133.21
	Df	40	Df	40	df	40	df	40
	Assymp Significant	0.0000	Assymp Significant	0.000	Assymp Significant	0.000	Assymp Significant	0.000

Table 4-5. Enclosure test of correlation with the four dependent variables.

		Sense crowdedness	Level of comfort	Perceived residential density	Space openness
Enclosure	Rho	.116**	-.160**	.155**	-.221**
	P	.001	.000	.000	.000
	N	693	693	693	693

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4-6. Enclosure correlation with perceived residential density for grey colored scenes.

		Perceived residential density
Enclosure	rho	.450**
	p	.000
	N	693

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4-7. Facade complexity test of correlation with the four dependent variables.

		Sense crowdedness	Level of Comfort	Perceived residential density	Space openness
Façade Complexity	Rho	- .014	.163**	.035	.036
	P	.721	.001	.362	.349
	N	693	693	693	693

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4-8. Number of intersecting street test of correlation with the four dependent variables.

		Sense crowdedness	Level of comfort	Perceived residential density	Spcae openness
No of intersecting streets	rho	. 005	.-.016	.002	-.014
	p	.151	.683	.960	.715
	N	693	693	693	693

Note. **. Correlation is significant at the 0.01 level (1-tailed).

Table 4-9. Intersecting street test of correlation with the four dependent variables when excluding cases that has high level of facade details.

		Sense crowdedness	Level of Comfort	Perceived residential density	Space openness
No of intersecting streets	Rho	.271**	-.026	.136**	-.077
	P	.000	.573	.003	.100
	N	462	462	462	462

Note. **. Correlation is significant at the 0.01 level (1-tailed).

Table 4-10. Intersecting street test of correlation with perceived residential density in a black and white street view.

		Perceived residential density
No of intersecting streets	rho	.273**
	P	.000
	N	231

Note. **. Correlation is significant at the 0.01 level (1-tailed).

Table 4-11. Intersecting street test of correlation with perceived residential density in 3D grey color images.

		Perceived residential density
No of intersecting streets	rho	-.031
	P	.418
	N	693

Table 4-12. Number of people and level of activities correlation with the four dependent variables.

		Sense crowdedness	Level of comfort	Perceived residential density	space openness
No of people	Rho	.339**	.005	.188**	.027
	P	.000	.886	.000	.483
	N	693	693	693	693

Note. **. Correlation is significant at the 0.01 level (1-tailed).

Table 4-13. Social situation correlation with the four dependent variables.

		Sense crowdedness	Level of Comfort	Perceived residential density	Space openness
Social situation	Rho	- .048	-.098**	-.061	-.078*
	P	.204	.010	.110	.040
	N	693	693	693	693

Note. **. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4-14. Social situation correlation with the four independent variables.

		Intersecting streets	Enclosure	Façade complexity	No of people
Social situation	rho	-.231**	-.214**	.079*	-.246*
	P	.000	.000	.000	.000
	N	693	693	693	693

Note. **. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4-15. Models ranking in case of social situation preference.

Model #	Mean	N	Std.Deviation	Variance
0000	4.87013	77	2.576976	6.641
0111	6.40260	77	1.995124	3.981
0222	5.16883	77	2.435497	5.932
1021	5.16883	77	2.022262	4.090
1102	4.50649	77	2.239733	5.016
1210	6.81818	77	2.366027	5.598
2012	2.42857	77	2.451791	6.011
2120	5.09091	77	2.059521	4.242
2201	4.54545	77	2.588159	6.699
Total	5.00000	693	2.583854	6.676

Table 4-16. Work space preference (formal situation) correlation with the four dependent variables.

		Space crowdedness	Level of comfort	Space openness	Perceived Residential Density
Work space preference	Rho	.033	-.043	-.013	-.024
	P	.399	.260	.742	.527
	N	693	693	693	693

Table 4-17. Work space preference correlation with the four independent variables.

		Intersecting streets	Enclosure	Façade complexity	No of people
Social situation	rho	-.070	.079*	-.069	.003
	P	.065	.037	.068	.940
	N	693	693	693	693

Note. *Correlation is significant at the 0.05 level (2-tailed).

Table 4-18. Test of differences between two groups of the independent variable (gender) in the level of comfort at high perceived residential density scenes.

Gender		Mean	St Dev
1		3.688	.995
2		3.78	1.05
Gender	Mann-Whitney U	13083	
	Asymp. Sig. (2-tailed)	.437	
	N	337	

Table 4-19. Test of differences between three groups of the independent variable (Time spent at USA) in the level of comfort at high perceived residential density scenes.

Time spent in USA	Level of comfort Mean	Std.Dev
1	3.79	1.0188
2	3.45	1.01076
3	3.74	1.03519
F Test	N	77
	Chi square	1.912
	Df	2
	Assymp significance	.384

Table 4-20. Test of differences between three groups of the independent variable (Time spent at USA) in the space crowdedness at high perceived residential density scenes.

Time spent in USA	Space crowdedness Mean	Std. Dev
1	3.62	1.13347
2	3.57	.95799
3	3.18	1.18319
F Test	N	77
	Chi square	9.884
	Df	2
	Assymp significance	.007

Table 4-21. Test of differences between two groups of the independent variable (design experience) in the level of comfort at high perceived residential density scenes.

Design experience		Mean (level of comfort)	St Dev
1		3.649	.929
2		3.840	1.1145
Gender	Mann-Whitney U	13162.5	
	Asymp. Sig. (2-tailed)	.223	
	N	337	

Table 4-22. Test of differences between four of the independent variable (age) in their perceived residential density.

Time spent in USA	Perceived residential density	
	Mean	Std. Dev
1	3.516	1.21044
2	3.498	1.19569
3	3.160	1.24408
4	3.60	.83195
5	4.11	.60093
F Test	N	77
	Chi square	17.424
	Df	4
	Assymp significance	.002

Table 4-23. Test of differences between four of the independent variable (age) in their perceived comfort at high perceived residential density settings.

Time spent in USA	Level of comfort	
	Mean	Std. Dev
1	3.7207	1.04595
2	3.8718	1.02165
3	3.5400	1.01439
4	3.6667	1.07083
5	4.0000	.53452
F Test	N	77
	Chi square	4.408
	Df	4
	Assymp significance	.354

Table 4-24. Test of differences between four of the independent variable (living place) and the perceived residential density.

Place of living	Perceived residential density Mean	Std. Dev
1	3.3846	1.22454
2	3.4775	1.10314
3	3.2222	1.42325
4	4.8889	1.45297
F Test	N	77
	Chi square	11.390
	Df	3
	Assymp significance	.010

Table 4-25. Test of differences between four groups of the independent variable (living place) and the level of comfort at high perceived residential density settings.

Place of living	Level of comfort Mean	Std. Dev
1	3.8696	.98695
2	3.6927	1.02813
3	4.1000	1.37032
4	2.7143	.48795
F Test	N	77
	Chi square	12.546
	Df	3
	Assymp significance	.006

Table 4-26. A Conbach's Alpha reliability test between visual and verbal expression of the residential density.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.177	.178	2

Table 4-27. Crosstabs for verbal and visual expression of residential density.

		Visual density					
		1.00	2.00	3.00	4.00	5.00	Total
Verbal	1.00	18	9	63	9	0	99
Density	2.00	27	9	45	9	0	90
	3.00	117	81	18	99	0	315
	4.00	9	81	36	36	0	162
	5.00	0	9	0	0	18	27
Total		171	189	162	153	18	693

CHAPTER 5
DISCUSSION

In this chapter, the study analysis and findings will be discussed and referenced to literature and research done in the field of perception in general and perceived residential density in specific. The first part of the chapter will cover discussion related to within-subject independent variables and their impact on dependent variables (perceived residential density, level of comfort, space crowdedness and space openness). The second part will discuss findings related to between-subjects' variables. It is important to note that most previous studies of perceived residential density have been done within psychological study domains. Most research in this area targets psychological reaction and social preference resulting from high levels of crowding.

The dependent variables in this research are selected based on the review of literature around perceived residential density, including the models used in examining psychological reactions to crowding. As discussed earlier, perceived residential density is a quality that is connected to a wide range of psychological and behavioral reactions. The multifaceted nature of perceived residential density and the variety of psychological and behavioral description of the concept of density suggests testing the association between the independent variables and four dependent variables (perceived residential density, space crowdedness, openness, and level of comfort). The four dependent variables of the study were enclosure, level of comfort, space crowdedness, and perceived residential density.

Enclosure and Dependent Variables

The statistical analysis shows that increasing level of enclosure lead to increase in the rank for space crowdedness and perceived residential density, and decrease of rank for level of comfort and openness. Enclosure was positively correlated with space crowdedness ($r = .116$, $p = 0.001$) and perceived residential density ($r = .155$, $p < 0.0001$), and negatively correlated with level of comfort ($r = -.160$, $p < 0.0001$) and openness ($r = -.221$, $p < 0.0001$).

The least enclosure used in the experiment was 1:1 width to height ratio, moderate level of enclosure was 3:4 and highest level of enclosure was 1:2.5. All level used are within the comfortable range as suggested by previous research done by (Alkhresheh, 2007, p.18; Carmona, et. al., 2003). Previous studies suggested that very high and very low enclosure levels rank low in perceived comfort and sense of safety which suggests nonlinear relationship between measured enclosure and level of comfort and sense of safety in urban settings (Alkhresheh, 2007, p.18).

In this study, the increase of enclosure was created by increasing height of buildings in relation to street width. The increase of height of building in the scenes has in fact added actual residential spaces which increase actual residential density. Enclosure correlation to perceived residential density was positive; when enclosure increases perceived residential density also increases and perceived space crowdedness increases. Enclosure correlation to comfort and openness was negative; as enclosure increases openness and level of comfort decreases. The lower enclosure used was (1:1) and it ranked the highest in level of comfort (Mean= 3.9) and openness (Mean= 3.8).

The two independent variables used in this study that are most related to physical configuration of a street (enclosure and number of intersecting streets in the scene) were isolated from the other two variables to further investigate their impact on perceived residential density. This was done by running the analysis using grey color models that has no façade details, no landscaping, street furniture and people. Enclosure in this case was significantly correlated to perceived residential density at (r = .450, p = 0.0001). This means as the models' enclosure level increased, perceived residential density ratings also increased. The correlation was a little higher than correlation found in the previous test. It is expected that level of façade complexity and details, traces of people activities as well as material, texture and color of buildings have affected correlation results between the independent variable (enclosure) and people judgement about residential density, (Table 4-6). This suggested that the visual richness of an urban environment contribute highly to the perceptual experience and users' judgment of the environment.

Enclosure was positively correlated to peoples' preference of a place for social activity, as enclosure increased preference for a social type of activity increased ($r=0.214$, $p=.000$). As enclosure in this study increases, so does actual residential density, and this suggests positive correlation between higher residential density and preference for an active social activity such as (meeting friends).

Facade Complexity and Dependent Variables

Façade complexity variable was used to check how the design elements; ornaments, articulations, material selection and colors of a facades could affect perception of residential density. In urban design theories, visual complexity of building façade contributes to space definition and judgment of the space as boring or rich, it also affects the type of activity that is stimulated to take place in these spaces. The use of façade details to manipulate the effect of building height or to improve pedestrian experience at street level is a common design practice (Jacob, 1961; Churchman, 1999). In connection to the dependent variables of this study the curiosity and or boredom that a space could infuse in users could be described in terms of how comfortable users are in a space and how dense a space is perceived.

Results shows positive significant correlation between level of comfort and façade complexity (*r* = .163, *p* = 0.001). No correlation was found between façade complexity and the other three dependent variables (space crowdedness, openness and perceived residential density). This could suggest that richness in façade design is not necessary leading to the feeling of discomfort. The increase of façade complexity is related to adding more details and elements to a façade which increases simulations around users. In relation to perceived residential density models; the overall arousal model suggests that sense of crowding occurs when environment generates excess of simulation and leads to overload of sensory system and that may lead to discomfort. The study findings did not relate to findings proposed in the perceived residential density models discussed earlier.

The nature of social situation and the social interaction expected to occur might affect people preference for space in these situations. The study tested the impact of independent variable (façade complexity) on people preference for spaces in different social situations (meeting a friend / work related meeting). Analysis results returned a small negative correlation between façade complexity and preference for social space; spaces that has higher façade complexity received lower user preference as a space more suitable for a social activity. While, users' preference for the imaginary work meeting situation analysis show no correlation between façade complexity and the preference for a place to attend a work meeting. In the two social situations, the correlation between façade complexity and the preference of users was not considerably high enough to be reliable.

Number of Intersecting Streets in the Scene and Dependent Variables

At urban level, the experience of pedestrian is affected by what street elements they see around them and how these elements define their movement and limit or control their use of the space. Intersection within the sight of pedestrian affect their feeling of control over their space and time and their freedom of movement and possibly the leisure of seeing through these intersection that could enrich the pedestrian experience of the urban space. When using all experimental cases there was no correlation between number of intersecting streets and the dependent variables. When excluding scenes which have high level of façade complexity the results show that number of intersecting streets has positive correlation with perceived residential density and space crowdedness with $r=.136$, $p= .003$ and $r=.271$, $p=.000$ respectively and has no correlation with openness and level of comfort. The increase of intersecting street observed in a scene caused increased in perceived residential density; this could be justified in that the increase of opening between buildings increase the observed number of masses (buildings) which may be read by pedestrian by extra residential or living spaces. This finding seems to agree with Martin and Nash (1973) proposition that different building forms and typological arrangement could affect how dense a space perceived by users. It was expected that the increase of openings around the street will increase the space openness by increasing access to the surrounding context and will contribute to reducing the space crowdedness as suggested by SOI -Spatial Openness Index_ by Fisher- Gewirtzman and Wagner (2003). However, it is possible that research results are affected by other elements in the scene such as number of people seen by participants.

Number of interesting streets correlated positively to people preference for social space with r=- 0.23; as number of intersecting streets increases people seem to prefer the space for a social situation that demands more interaction such as friend meeting. While it did not correlate to preference for work space. This suggests that number of intersecting street in the scene could affect people preference for activities that involved more social interaction.

Number of People in the Street and the Dependent Variables

The number of people seen in a scene and the type of activity they do is expected to affect the sense of space crowdedness and perceived residential density. The pattern of interaction between people in a space defines the culture of the place and creates; along with physical aspects of the space; meanings and character of the place (Rappoport, 1977). Taken the nature of the study experiment and the type of survey used the presentation of activity and number of people in the place was limited due to the static nature of the visual survey. The concept of people activities is difficult to express through static images because human expression, sounds, and the spontaneous nature of human movement is not easily experienced or imagined through static images.

However, it was important to include people and activities in the scenes for three reasons; first: to provide a scale reference to the scene, second: to find out if increasing number of people would affect perceived residential density and or perceived characteristics of the space (level of comfort, space crowdedness and openness) and finally to relate to the urban nature of the study area in which social activities and pedestrian movement is frequent.

The analysis results show positive correlation between the independent variable (number of people and activities in the street) with ratings of the dependent variable space crowdedness (r = .399, p = .001) and residential density (r = .188, p = .001). The number of people and activities was not correlated with Level of Comfort (r = .005, p= 0.886) and openness (r = .027, p = .483). The results could relate to the model of behavioral constraint or social interference in that higher sense of crowding is a result of feeling of restriction caused by increased number of people and activities (Brehm (1966, Stokols, 1976, Proshansky, 1972). This suggests that way people and activities are distributed in a space is very important for human perception about space and their positive or negative view of the space.

In a situation such as friend meeting the number of people in the street was found to correlate positively with the ranking of space as suitable for such situation (r=- .246, P=0.000). In a work meeting situation, the number of people in the space has no correlation to people preference for a work meeting place. This advocates that space that reflects on going social interaction is more attractive for people willing to spend time in socially engaged activities than a more formal activity.

Dependent Variable (Perceived Residential Density)

According to the analysis enclosure and the number of people in the street were significantly correlated to perceived residential density (r=.155), while façade complexity and number of intersecting streets in the view were not correlated.

It was only when controlling for the façade complexity through excluding scenes which have high level of facades complexity that the number of intersecting streets correlated positively to perceived residential density and space crowdedness.

The increase in the enclosure value was done by increasing the height of masses to the street width and accordingly increasing residential spaces and actual residential density. The positive correlation between enclosure and perceived residential density suggested that, for pedestrian, enclosure is a good predictor of residential density. Empirical studies related to perceived residential density defined perceived residential density in terms of the volume of free space seen from a given point quantitatively and described as (Spatial openness index), which is based on three-dimensional visual analysis (Fisher- Gewirtzman and Wagner, 2006). Their study is based on the idea that higher level of spatial openness in a certain configuration would make it perceived as more spacious and less compressed. The increase of enclosure in my study increases the amount of built up area to the free space and resulted in increase of perceived residential density and space crowdedness. It also found to correlate negatively to space openness and level of comfort which is in line with Fisher and Wagner (2006) findings. In this experiment buildings did not take irregular shapes, buildings followed straight line surrounding streets forming a wall like configuration. The study findings revealed the importance of enclosure in defining how open space is perceived and accordingly how comfortable it is. The corresponding increase of space crowdedness and decrease of level of comfort suggests negative physiological reaction to such configuration. It is expected however, that working toward increasing openness in urban configurations through alternative building configurations could reduce the negative impact. This is possible through introducing certain details such as recessed parts of building facades to break the continuity of masses (street walls).

When controlling for façade complexity by excluding scenes with very high level of façade complexity the number of intersecting streets in the scene correlates to the perceived residential density and space crowdedness. As number of intersecting streets increase the perceived residential density increase. When number of intersecting streets increase in the scene the number of masses (buildings seen by the participant) increases, and this is not necessarily a reflection of how much extra residential spaces added. In a different question, a top view of an urban street in black and white was displayed to the participants and again the street that has more intersecting streets and more masses was perceived as higher in residential density.

The results show that number of intersecting streets in urban space maybe read by pedestrian as more residential spaces reflected in larger number of smaller buildings even if the building width does not really reflect larger spaces. The number of people in the street and the level of interaction and level of activities in the scene was found to correlate positively to the perceived residential density. As number of people increase in the urban space perceived residential density increased. This increase in perceived residential density was parallel to increase in the space crowdedness. In relation to previous studies crowdedness was defined as the negative outcome of high density areas through limited freedom of choice and high level of social interaction that in certain situations not needed (Stokols, 1976; Zlutnick and Altman, 1972; Rodin, 1976). If the high level of space crowdedness is to be considered as negative psychological reaction to high density as proposed in previous studies, then the study results suggests that high number of people in the street could trigger such feeling and a reduced level of comfort.

Dependent Variables (Space crowdedness, Level of Comfort, Space Openness)

Based on literature these variables were considered as related and sometimes as a definition of how dense an environment perceived. The study results show that when enclosure correlated positively to perceived residential density and space crowdedness it correlated negatively to level of comfort and space openness. Since increasing enclosure in this experiment was done by adding height to the building and increasing the actual space for residential use the positive correlation between enclosure and space crowdedness and perceived residential density suggests that actual increase in density reflected by increasing building height to street width ratio has in fact led to increase of perceived residential density and caused higher sense of space crowdedness. A higher sense of space crowdedness is a negative aspect of higher residential density expressing people lack freedom and control in space (Stokols, 1976; Proshansky, 1972); again, this is declared by the results as a lower perceived sense of comfort and space openness.

Dependent variables space crowdedness and space openness did not correlate to the independent variable façade complexity. While a small positive correlation was found between façade complexity and the level of comfort (r = .163, p = 0.001). With façade, as one important design element of the urban environment, it is possible to argue that increase of façade complexity might have contributed to increasing level of comfort even in high density settings which is in away suggesting less negative experience of high residential density settings. This is in line with Rappor (1977) suggestion that design techniques and element can reduce the negative perception of density.

Again, number of intersecting streets in the scene was correlated to perceived residential density and space crowdedness with r=.136, p= .003 and r=.271, p=.000 respectively. No correlation was found between number of intersecting streets and sense of comfort and space openness. The independent variable number of intersecting streets was used to test the rule of visibility and boundary permeability on people perception of residential density. In logical connection to Stamps (2009) studies of interior space perceived spaciousness and enclosure to boundary permeability it was expected that the number of intersecting streets will contribute to increasing level of comfort and space openness through adding visibility to surrounding streets. Different questions were used to test the correlation between number of intersecting streets and the perceived residential density; findings illustrated that increasing the number of streets might increase perceived residential density and sense of crowding; this could be explained in that the increase of number of intersecting streets lead to increasing masses in the view creating a perception of more available residential spaces.

Space crowdedness and perceived residential density have been both affected by increasing the number of people in the scene; both were found to be positively correlated with (r= .399, p= .001) and (r = .188, p= .001) respectively. No correlation was found between number of people and level of comfort. But as crowding is one negative consequence of high residential density it is possible to suggest occurrence of stress as people in the scene increases which lead to judging the place as crowded.

This complies with (Rapoport, 1977) idea that increase of number of people in space can generate information overload leading to feeling of stress.

Type of Social Activity Association with Perceived Residential Density

To check for association between the type of activity people aim to have in a space and their perception of residential density two different social situations were suggested: one that requires higher level of social interaction (meeting friends) and another situation that require more formal interaction (work meeting). The study results show that in the case of friend meeting people preference of a space was not correlated to perceived residential density or to space crowdedness, but it was positively correlated to level of comfort and space openness. Research findings did not match with previous research related to social settings and crowding perception which; in contrast; suggests that changes of social settings could alter people perception to crowding (Stokols, 1972; Baum and Davis, 1976; Baron, et. al.1976; D’atari, 1975; Dean, et. al.1975). However, as people perceived space as more comfortable they gave it higher preference for meeting a friend, the same applies for openness confirming positive association between the level of comfort and preference for friend meeting and the same for openness.

Testing the correlation between the preference for social space and the four independent variables in case of friend meeting situation returns significant positive correlations with number of intersecting streets, number of people and enclosure, and a significant negative correlation with façade complexity; the positive correlation means that as the independent variable increases the space receives higher preference for the friend meeting. The increase in actual density by adding height to the buildings reflected in increase of enclosure led to increase of preference for a social situation such as friend meeting. This along with positive correlation between sense of comfort and preference for social situation suggests that a social situation that requires higher interaction and more active medium could fit better in high density settings.

In the case of work meeting people preference was not found to correlate to any of the four dependent variables (perceived residential density, space crowdedness, level of comfort and openness). When testing correlation between work space preference and the four independent variables it returns a weak negative significant correlation with only one independent variable: enclosure. The negative correlation means that as enclosure increase the preference for work space decrease; which might be read as: increase of actual density (increase of space available for residential use) might reduce preference for a formal social situation such as a work meeting.

Between-Subjects' Variables

Human perception is affected in many ways by personal characteristics and previous experiences. The impact of high residential density on people behavior, their ongoing interaction with the environment as well as on the psychological processes occur during this interaction is also relative. It is expected that between subjects' variables such as age, gender, type of residence, design background and the previous exposure to various type of environments will affect the way human experience a high residential density environment.

Women and men were expected to have different level of comfort at high residential density places. The study analysis did not confirm any difference between women and men in level of comfort at scenes with highly perceived residential densities. These findings do not relate to previous research in the field of crowding perception where women perception to crowding was found to be smaller than male perception to crowding under similar environmental and social settings and that women were more comfortable than men in completing tasks under high density settings (Stokols et al., 1973). Further, the study found no significant different between people with design background and those with no design background in their level of comfort in highly perceived residential density scenes.

With the growth of advocacy in favor of urban living and against sprawl the negative reactions against high residential densities is shifting. But there are still culturally defined and deep-rooted believes about undesirable expectations from higher residential densities that rise to the surface when people make actual decision about buying homes or when judging new high-density developments.

Accordingly, people who lived in USA for long time were expected to judge spaces with highly perceived residential density as less comfortable and crowded. Statistical analysis has shown that people lived in USA longer have judged spaces with higher perceived residential density as more crowded than people who lived in USA for short time with significant difference in mean values (Chi square=9.884 and p=.007). Further, significant difference between people perceived residential density was found between people from different age groups. Older people have more often ranked spaces as higher perceived residential density than young people. This could suggest that older people are affected by the negative aspects historically attached to higher density areas, another possible reading for this result is that older people are less adapting to fast based vigorous urban life style which slowly becoming a preference for younger generation.

People who live in places that are higher in actual densities (urban) have ranked scenes as lower in perceived densities than people who live in lower densities areas. They also have ranked highly perceived residential densities scenes with higher level of comfort. Significant difference between the two groups in their ranking for perceived residential densities and level of comfort can suggest that people living conditions and type of their residence affect their reaction to high residential densities; people who are familiar with higher residential densities are expected to cope better in high residential densities areas.

The differences found between people based on age, type of residence they have suggest that life earned experiences have large influence on how people perceive and environment and how residential density affect their interaction with an environment. The design experience and gender were not found to affect people judgment of high density spaces.

CHAPTER 6
CONCLUSION

This research aims at exploring perceived residential density, which is an important element in urban design and planning, because it affects decision making and people acceptance of proposed planning projects. The concept of residential density tied itself to multiple meanings in planning and design, due to the many changes in urban form theories, planning techniques, and ongoing social impacts on the environment.

Through using experimental approach this research tested the effect of change of four urban design qualities on peoples' perception for residential density and three other perceptual reactions which are expected to further explain peoples' reaction to high residential density. It concluded that the two variable enclosures (height to width ratio) and peoples' existence in the scenes, correlated to perceived residential density and the space crowdedness. It also proposed few design guidelines that can contribute to improvement in peoples' perception of higher residential density areas. This chapter will discuss research contributions to existing knowledge about perceived residential density and will recommend future development in the field, as well as, methodological drawbacks and lessons learned.

Perceived Residential Density and Human Experience

Human interaction with an environment, its continuity and its consequences, defines the quality of spaces and contributes to the success of a community at different levels. The human brain processes images and an ongoing interaction with an environment in a complicated way called perception; this process will shape and define peoples' satisfaction, belonging and appreciation of the space. With advancement of research methods and experimental techniques, contemporary research concern with improving the ability to interpret the impact of a design on the city function before even implementing it. It aims at mitigating any possible negative consequences on the space social experience.

Empirical research in perceived residential density can be traced back to the late sixties with research on impact of space crowdedness on human behavior and social interaction. It was seen that high densities described as space crowdedness, leads to unwanted social pressure and consequently increases stress, reduces productivity and weakens peoples' connections to their spaces. This body of research suggested a strong connection between high density and peoples' sense of comfort and control over their environment. My research illustrates that earlier research in crowding perception is very useful reference for contemporary experimental research. The study approach introduced important tools that could be further tested with more advanced techniques, such as parametric design software.

Perceived residential density and Urban Design Qualities

My research shows that manipulating certain urban design qualities can improve peoples' perception of residential density, and this was reflected in the results by low perceived residential density, low space crowdedness and high sense of comfort. Enclosure was found to be an essential element in the built environment, and could largely affect the perceived environment. Enclosure was manipulated by changing the height of buildings. When enclosure increased, the perceived residential density and the space crowdedness increased, while sense of comfort and space openness decreased. Increasing enclosure in the scenes leads to increase in the actual residential density because it was based on increasing height of the buildings and consequently increased potential spaces for residential use.

Analysis showed that increase of enclosure through increasing height of the buildings surrounding the street cause increase of perceived residential density and space crowdedness. This suggests that intended increase of density by increasing height of buildings should take into consideration the resulted enclosure and its impact on residential density perception. It is important to use design techniques that can reduce negative impact of height to width ratio on residential density perception. Some façade treatments such as recessing parts of the façade and creating voids allow to reduce rigidity of the masses surrounding streets. Another technique to help reduce enclosure is through increasing street width to maintain a sense of safety and comfort at proper levels.

The number of people in the scenes has also correlated positively to perceived residential density and to the space crowdedness, but did not correlate to the sense of comfort and space openness. This correlation suggests that peoples' existence and their activities and the concentration of social interaction in a space is an important factor in defining perception to residential density. Accordingly, people distribution in a space, type of activity and level of interaction should be a subject of attention for designers and should not be a byproduct of functional and financial demands of the design process.

Even though the façade complexity did not correlate directly to perceived residential density, it was found to positively correlate to sense of comfort, which suggests that manipulating façade designs might improve peoples' experience to high residential density spaces.

The number of intersecting streets in the scene was not found to correlate to perceived residential density and the other three dependent variables. But when excluding the scenes that have highest level of façade complexity, the analysis showed positive correlation between the number of intersecting street in the scene and the perceived residential density and space crowdedness. This is inconsistent with the Fisher- Gewirtzman and Wagner (2003) proposition that increasing the openings around the street will increase the space openness and will contribute to reducing the space crowdedness.

This research included visual survey that displayed 3D models, created using images captured from an urban area. The images used where colored and detailed to a high degree, and mimicked actual streetscape. On the other hand, the researcher added few questions in which detailed buildings were replaced with grey color masses to compare between correlation results in the two cases. The questions that used grey color images returned higher correlation between the dependent and independent variables comparing to the correlation results found in the realistic scenes. The difference in correlation suggests that the use of abstract models in visual survey could allow misleading results about correlation between urban design qualities and perceived qualities. This suggests that visual survey used in testing impact of urban design qualities on perceived qualities may produce more realistic results when using scenes that has façade details, material, landscape elements and street activities.

Perceived Residential Density and Type of Activity

The study reveals no correlation between perceived residential density and peoples' preference for a formal or informal meeting places. In the case of informal situation (meeting a friend) the study reveals positive correlation between people preference for informal meeting place and the two independent variables: sense of comfort and level pf openness. It also found positive correlations between peoples' preferences for space and the independent variables: level of enclosure, number of people in the scene, and number of intersecting streets, and a negative correlation with façade complexity. In a formal situation (such as work meeting), no correlation was found, except for small negative correlations between preference for work space and the independent variable: enclosure.

These findings suggest that social situations that demand more interaction are more spatially defined and are influenced more by the set up and design quality, than a formal situation that requires less social interaction. Further, activities which require higher levels of interaction are important for the creation of streets and for the daily experience of the spaces. In a design process; from the schematic design stage to the actual implementation of the design; a designer needs to take into consideration the different type of activities expected to occur in a space and the impact of these activities on the perception. When urban designers understand the expected type of activity in a street and the potential social interaction linked to these activities they become more involved in realistic design process.

Perceived Residential Density and Between Subjects' Variables

The study results show that no differences between participants perceived residential density based on gender and design experience. While it shows significant difference based on participants age, time spent at USA and the type of residence. This suggests that perceived residential density is based on daily living experiences and is highly influenced by cultural values.

Perceived Residential Density Versus Real Residential Density

One drive behind this research is to try to find a connection between real density and perceived residential density. However, the method used did not allow to accommodate that direction, and the type of scenes used in the experiment were all from urban areas and did not have reference to actual density. This suggests possible extension to this research by using actual scenes from different areas that have different actual residential densities and investigating various perceptual reactions and judgments of these scenes. This will require careful selection of scenes while taking into consideration other urban design qualities of the scenes.

Comments on The Research Method

The dependent variables used in the study were an ordinal type of data; 77 participants contributed to the visual survey and they ranked 9 scenes for four dependent variables (level of crowdedness, sense of comfort, perceived residential density and space openness) on a Likert scale from 1-6. The nine scenes were varied in characteristics based on four independent variables, which in turn have three levels each. Therefore, the experiment generated a total of 693 responses, for each level of the independent variables there was 231 responses out of the total. The research aimed at measuring correlation between the dependent and the independent variables. Based on the study assumptions the researcher used Spearman Rho correlation test to measure correlation between the dependent and the independent variables. Although Spearman rho test is the most popular non-parametric correlation test it is suggested that Kendall tau correlation test should be used when large number of tied rank exists (Field, 2009, p.181). For this reason, researcher conducted measure for tied rank in the data which shows that some variables have around 20% tied data (Tables 6-1, 6-2, 6-3, 6-4). To check for difference between the Spearman rho correlation results and Kendall tau rank correlation results researcher ran the analysis on same dataset using Kendall Tau correlation to compare its' results to Spearman results. The comparison shows very small difference between the two tests which suggests that Spearman rho does, indeed, increases the correlation because it does not correspond as good as Kendall tau to the number of ties in the data (Tables 6-5 to 6-20). However, the difference was very small to affect the study findings that reveal small to medium correlation between the dependent and independent variables. With improvement of the statistical packages the output between the two tests are almost the same. For example: in this study SPSS was used to run the two tests, SPSS advanced algorithms take into consideration tied ranks and correctly and automatically calculate them (Statistics Solutions, 2017).

This finding suggests that researcher should consider the issue of tied ranks in the data when working with correlation between ordinal and ranked data as early as in the study design stages.

Recommendation and Future Research Opportunities

The correlation between independent variables and the dependent variables were between moderate and weak due to small sample size and the small number of combinations used. The experiment relies on using 3D models created from scratch to simulate various combinations of the independent variables. Capturing photos from relevant study area, editing images and creating 3D models was time demanding for the researcher. It was also time demanding for people participating in the survey study to run through each question of 9 different combinations. Further analysis with larger sample and a larger number of combinations could contribute to improving understanding of the effect of the independent variables on perceived residential density. However, such research will require other presentation technique than the one used in my research. It can use walk through videos of the simulated environment to limit time needed; research can run the experiment over various sessions to allow enough time for larger number of combinations and to limit the effect of boredom on quality of answers.

The type of research I used (fractional factorial design) relies on using partial cases among many possible combinations of the factors studied. This reduces the accuracy of measure of impact of each independent variables on the dependent variables. For this reason, this study can be considered under the category of screening experiment in which different independent variables are tested to identify the ones that have larger impact on the dependent variables. Based on the results of this research a future research can test fewer number of variables to deliver some more specific findings such as testing enclosure and number of people in the scene effect on perceived residential density.

Life earned experiences and cultural meaning and expressions was found to relate largely to the concept of perceived residential density more than personal characteristics (gender, education). Age, type of residence where people lived, and time spent in the USA are factors that reflects people length of exposure to shared values and American culture that for long time supported lower residential density. This emphasizes the dominance of the social aspect on the concept of perceived residential density and advice that perceived residential density might be better studied under situational experiment in which people get to express their feeling about a place based on their interaction and or exposure to certain social settings. The research done in early seventies related to psychological reaction of people to different physical configurations and under different social settings can provide good guidance for future research in this area (Stokols, 1972; Baum and Davis, 1976; Baron, et. al.1976; D'atari, 1975; Dean, et. al.1975; Chin et. Al. 1976)

Table 6-1. Enclosure correlation with dependent variables (comparison between Kendall Tau and Spearman).

Dependent Variables	Kendall Tau-b	Sig. (2-tailed)	Spearman rho	Sig. (2-tailed)
Space crowdedness	.100**	.002	.116**	.002
Level of comfort	-.138**	.000	-.160**	.000
Space openness	-.190**	.000	-.221**	.000
Perceived residential density	.132**	.000	.155**	.000

Table 6-2. Façade complexity correlation with dependent variables (comparison between Kendall Tau and Spearman).

Dependent Variables	Kendall Tau-b	Sig. (2-tailed)	Spearman rho	Sig. (2-tailed)
Space crowdedness	-.014	.669	-.017	.660
Level of comfort	.142**	.000	.166**	.000
Space openness	.030	.357	.035	.356
Perceived residential density	-.036	.264	-.042	.270

Table 6-3. Intersecting street correlation with dependent variables (comparison between Kendall Tau and Spearman).

Dependent Variables	Kendall Tau-b	Sig. (2-tailed)	Spearman rho	Sig. (2-tailed)
Space crowdedness	.046	.152	.055	.151
Level of comfort	-.012	.705	-.016	.000
Openness	-.012	.702	-.014	.715
Perceived residential density	-.001	.971	-.002	.960

Table 6-4. Existence of people and activities correlation with dependent variables (comparison between Kendall Tau and Spearman).

Dependent variables	Kendall Tau-b	Sig. (2-tailed)	Spearman rho	Sig. (2-tailed)
Space crowdedness	.295**	.000	.339**	.000
Level of comfort	.003	.917	.005	.886
Space openness	.022	.493	.027	.483
Perceived residential density	.164**	.000	.188**	.000

Table 6-5. Cross tabulation to measure percentage of ties in the data between space crowdedness at different categories of enclosure.

		Space crowdedness						Total
		1	2	3	4	5	6	
Enclosure	0	27	*58	*78	45	20	3	231
	1	21	*50	*96	43	19	2	231
	2	28	36	*60	74	31	2	231
Total		76	144	234	162	70	7	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-6. Cross tabulation to measure percentage of ties in the data between level of comfort at different categories of enclosure.

		Level of Comfort						Total
		1	2	3	4	5	6	
Enclosure	0	4	19	*50	*95	41	22	231
	1	1	36	*68	*82	37	7	231
	2	5	38	*71	*79	28	10	231
Total		10	93	189	256	106	39	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-7. Cross tabulation to measure percentage of ties in the data between space openness at different categories of enclosure.

		Space openness						Total
		1	2	3	4	5	6	
Enclosure	0	2	26	*63	*83	44	13	231
	1	5	29	*73	*82	36	6	231
	2	20	46	*83	49	27	6	231
Total		27	101	219	214	107	27	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%)

Table 6-8. Cross tabulation to measure percentage of ties in the rank of space residential density at different categories of enclosure

		Perceived residential density						Total
		1	2	3	4	5	6	
Enclosure	0	14	35	*93	*62	23	4	231
	1	9	37	*76	*67	33	9	231
	2	13	32	47	*79	48	12	231
Total		36	104	216	208	104	25	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-9. Cross tabulation to measure percentage of ties in the rank of space crowdedness at different categories of number of intersecting streets.

		Space crowdedness						Total
		1	2	3	4	5	6	
No of intersecting streets	0	24	46	*80	*56	24	1	231
	1	36	*55	*75	43	19	3	231
	2	16	43	*79	*63	27	3	231
Total		76	144	234	162	70	7	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-10. Cross tabulation to measure percentage of ties in the rank of level of comfort at different categories of number of intersecting streets.

		Level of comfort						Total
		1	2	3	4	5	6	
No of intersecting streets	0	5	22	*57	*92	42	13	231
	1	4	46	*72	*66	28	15	231
	2	1	25	*60	*98	36	11	231
Total		10	93	189	256	106	39	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-11. Cross tabulation to measure percentage of ties in the rank of space openness at different categories of number of intersecting streets.

		Space openness						Total
		1	2	3	4	5	6	
No of intersecting streets	0	4	43	*74	*71	31	8	231
	1	18	23	*56	*76	46	12	231
	2	5	35	*89	*67	30	5	231
Total		27	101	219	214	107	25	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-12. Cross tabulation to measure percentage of ties in the rank of perceived residential density at different categories of number of intersecting streets.

		Perceived residential density						Total
		1	2	3	4	5	6	
No of intersecting streets	0	14	29	*69	*65	49	5	231
	1	11	46	*75	*71	16	12	231
	2	11	29	*72	*72	39	8	231
Total		36	104	216	208	104	25	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-13. Cross tabulation to measure percentage of ties in the rank of space crowdedness at different categories of number of façade complexity.

		Space crowdedness						Total
		1	2	3	4	5	6	
Façade complexity	0	20	48	*87	*51	24	1	231
	1	34	40	*71	*59	24	3	231
	2	22	*56	*76	*52	22	3	231
Total		76	144	234	162	70	7	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-14. Cross tabulation to measure percentage of ties in the rank of level of comfort at different categories of number of façade complexity.

		Level of comfort						Total
		1	2	3	4	5	6	
Façade complexity	0	5	42	*73	*70	30	11	231
	1	5	32	*61	*88	33	12	231
	2	0	19	*55	*98	43	16	231
Total		10	93	189	256	106	39	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-15. Cross tabulation to measure percentage of ties in the rank of space openness at different categories of number of façade complexity.

		Space openness						Total
		1	2	3	4	5	6	
Façade complexity	0	6	37	*80	*70	30	8	231
	1	16	31	*60	*78	38	8	231
	2	5	33	*79	*66	39	9	231
Total		27	101	219	214	107	25	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-16. Cross tabulation to measure percentage of ties in the rank of perceived residential density at different categories of number of façade complexity.

		Perceived residential density						Total
		1	2	3	4	5	6	
Façade complexity	0	11	30	*65	*74	44	7	231
	1	12	40	*78	*69	25	7	231
	2	13	34	*73	*65	35	11	231
Total		36	104	216	208	104	25	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-17. Cross tabulation to measure percentage of ties in the rank of space crowdedness at different categories of number of existence of people in the scene.

		Space crowdedness						Total
		1	2	3	4	5	6	
Existence of people in the scene	0	*50	*70	*61	31	17	2	231
	1	18	47	*98	49	18	1	231
	2	8	27	*75	*82	35	4	231
Total		76	144	234	162	70	7	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-18. Cross tabulation to measure percentage of ties in the rank of level of comfort at different categories of number of existence of people in the scene.

		Level of comfort						Total
		1	2	3	4	5	6	
Existence of people in the scene	0	8	37	*63	*68	35	20	231
	1	2	24	*60	*93	42	10	231
	2	0	32	*66	*95	29	9	231
Total		10	93	189	256	106	39	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-19. Cross tabulation to measure percentage of ties in the rank of space openness at different categories of number of existence of people in the scene.

		Space openness						Total
		1	2	3	4	5	6	
Existence of people in the scene	0	18	43	*59	*56	41	14	231
	1	5	31	*75	*79	35	6	231
	2	4	27	*85	*79	31	5	231
Total		27	101	219	214	107	25	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

Table 6-20. Cross tabulation to measure percentage of ties in the rank of perceived residential density at different categories of number of existence of people in the scene.

		Perceived residential density						Total
		1	2	3	4	5	6	
Existence of people in the scene	0	21	49	*64	*58	27	12	231
	1	10	37	*86	*64	30	4	231
	2	5	18	*66	*86	47	9	231
Total		36	104	216	208	104	25	693

* These values are considered high in number of ties as it represents more than 20% of the total data (within the group) counted as: percentage of ties= (count/ 231*100%).

APPENDIX A
VISUAL SURVEY

Survey for the research study “Effects of urban design qualities on perception of residential density” conducted by Alma Othman, Ph.D. student at the University of Florida, December 15th 2013 to February 28th 2014 This survey is part of a research study conducted by Alma Othman, a PhD student at the University of Florida-Department of Urban and Regional Planning (https://dcp.ufl.edu/). The study aims to measure and understand the effect of urban space qualities on perception of residential density. You are invited to participate in the study because you live in suburban, low density type of housing within my study target area. 80 participants will be enrolled in the study. Survey requires about 12-15 minutes for completion. Each participant will receive a check for 15 dollars for participating in this study to their mailing address provided by them. There is no anticipated benefit for participants; there are no known risk to participate in this study. Participation in the study is voluntary; you may decline to answer any questions you do not wish to answer. You may decide to withdraw from this study at any time without consequences simply by advising the researcher.   This is a two parts survey. In the first part, you will be shown some computer images of city streets and you will be asked to rank the images based on certain criteria. In the second part, you will be asked a few basic questions about you, such as age, gender, work experience and academic background. To answer the survey, you will have to open the survey link at your convenient time and place. If you decide to leave before finishing all the questions the system will save your answers; as you reopen the link it will start where you ended your answer the first time. Please answer the survey no later than February 28th 2014; after that date survey link will no longer be active. All study data will be collected through Qualtrics; an online survey program. Your identity will be kept confidential to the extent provided by law. All information collected in the survey will be stored in a password protected account. Data collected in this survey does not reveal participant identities or their computer IP addresses. Researcher will use the data only for scientific research purposes and will not share it with entities other than the research committee members and committee chair (Prof. Ilir Bejleri) from Urban and Regional Planning/ the University of Florida. Qualtrics’ privacy policy can be obtained at https://www.qualtrics.com/privacy-statement/   For questions about the study or survey procedure please contact me, Alma Othman by phone at 847-701-5031 or via email at alma.othman@ufl.edu. You may also contact my research advisor, Dr. Ilir Bejleri at ilir@ufl.edu. For questions or concerns about your rights as a research participant you may contact the IRB02 office, University of Florida, Box 112250, Gainesville, FL 32611-2250; phone (352) 392-0433

Q52 I have received the invitation letter to participate in this study. Based on the information I received in the invitation letter and in this survey introduction I voluntarily agree to participate in the study by answering an online survey and I have received a copy of this description by mail. I have had an opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. I understand that I may withdraw this consent at any time by informing the researcher without penalty or consequences and that I will receive a compensation of 15 dollars for participating in this study.

- ❑ I agree (1)
- ❑ I disagree (2)

Part 1:
In the following screens, you will be shown 11 different groups of computer images of the same urban space. Each group contains four images of the same space from different viewpoints. Based on your perception, please rate the space on a scale of 1 to 5 (where 1 is very low and 5 is very high) based on the following criteria:

a- Space crowdedness (How crowded does the space feel?)
b- Level of comfort (How comfortable would you be when visiting or walking in the space?)
c- Openness (How open or spacious does the space feel?)
d- Residential density (What is the residential density of people living at this street)

Please look carefully at the images before answering the questions In the following page you will see an illustration of 9 different spaces, the purpose of this illustration is to make sure you are familiar with the variations and the contexts of the spaces presented in the next 11 questions
click >>> to continue

Introduction: These are the spaces that you are going to see. We will ask various questions about these spaces.

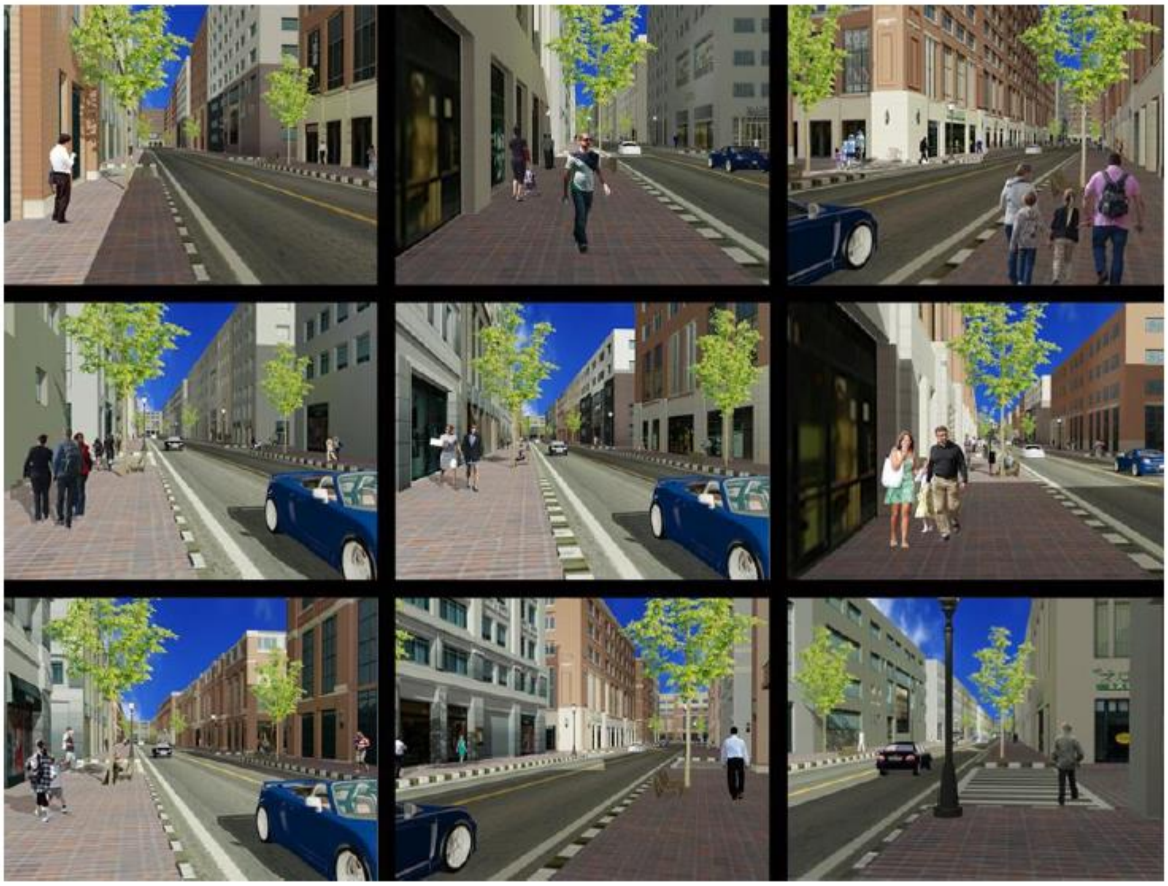


Figure A-1. Introduction page for the first question in the survey showing the type of images that will be presented in the study scenes to familiarize participants with the type of images.

Space 1 - shown from 4 different viewpoints

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-2. Question 1 of the survey (first scene) to rank the dependent variables.

Space 2 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-3. Question 1 of the survey (second scene) to rank the dependent variables.

Space 3 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-4. Question 1 of the survey (third scene) to rank the dependent variables.

Space 4 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-5. Question 1 of the survey (fourth scene) to rank the dependent variables.

Space 5 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-6. Question 1 of the survey (fifth scene) to rank the dependent variables.

Space 6 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-7. Question 1 of the survey (sixth scene) to rank the dependent variables.

Space 7 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-8. Question 1 of the survey (seventh scene) to rank the dependent variables.

Space 8 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-9. Question 1 of the survey (eighth scene) to rank the dependent variables.

Space 9 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-10. Question 1 of the survey (ninth scene) to rank the dependent variables.

Space 10 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-11. Question 1 of the survey (tenth scene) to rank the dependent variables.

Space 11 - shown from 4 different viewpoints.

(Note: Hover the mouse over the urban space qualities to see their definition)

	(very low) (1)	(low) (2)	(moderately low) (3)	(moderately high) (4)	(high) (5)	(very high) (6)
space crowdedness	❍	❍	❍	❍	❍	❍
level of comfort	❍	❍	❍	❍	❍	❍
openness	❍	❍	❍	❍	❍	❍
residential density	❍	❍	❍	❍	❍	❍

Figure A-12. Question 1 of the survey (eleventh scene) to rank the dependent variables.

Next, you will be shown 9 different spaces and you will be asked to put these spaces in order from your most preferred to the least preferred based on some questions.

Click >> to continue.

If you are going to meet a friend, which spaces would you prefer best? Please list spaces in the order of preference from the most preferred to the least preferred using a scale from 1-9 where 1 is your most preferred space and 9 is the least preferred space. (Please use label shown in the corner of each space).

______ A ______ B ______ C ______ D ______ E ______ F ______ G ______ H
______ I

Figure A-13. The first type of social activity in the second question of the survey, images used to measure connection between the preference of social activity and the dependent variables.

If you were to work in this area, which spaces would you prefer best? Please list spaces in the order of preference from the most preferred to the least preferred using a scale from 1-9 where 1 is your most preferred space and 9 is the least preferred space. (Please use label shown in the corner of each space).

______ A ______ B ______ C ______ D ______ E ______ F ______ G ______ H
______ I

Figure A-14. The second type of social activity in the second question of the survey, images used to measure connection between the preference of social activity and the dependent variables.

The image below shows three different views of a city street looking from above with black (buildings) and white (street and yard areas). Please rank each one of them from 1 to 3 where 1 is the least dense street and 3 is the densest street

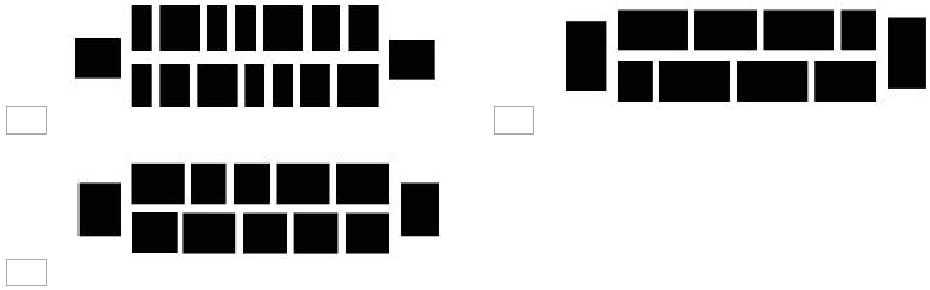
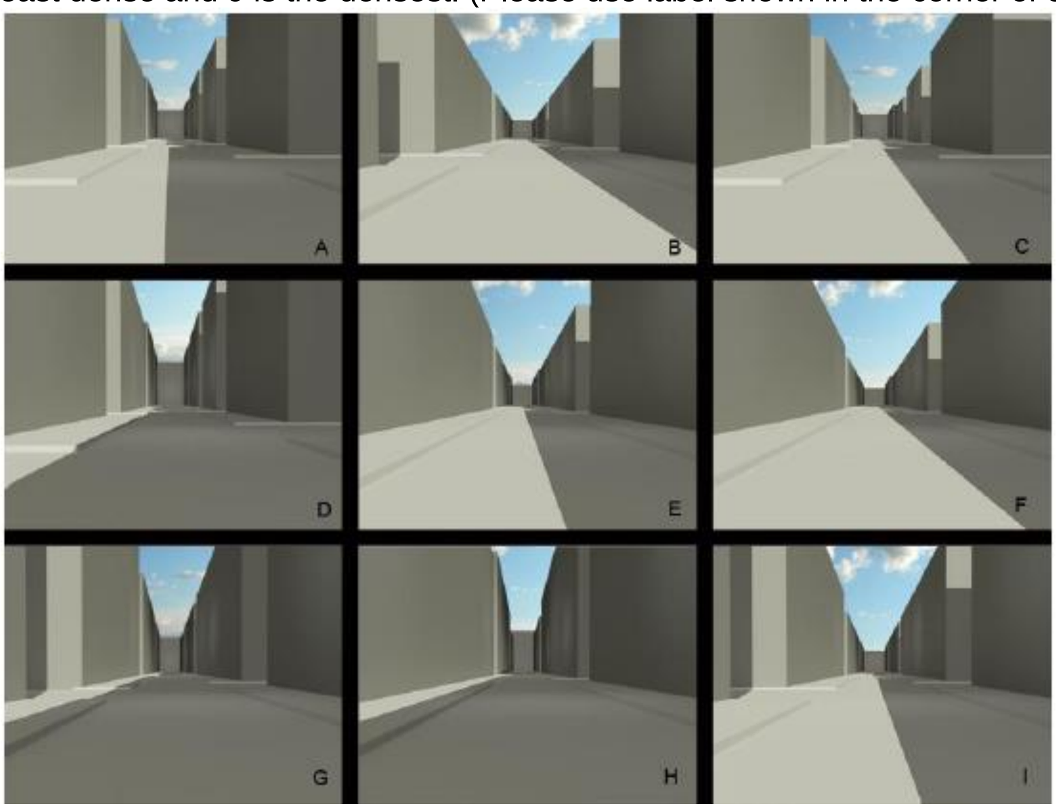


Figure A-15. The third question in the survey used to test correlation between number of intersecting streets and the perceived residential density.

The images below show 9 different configurations of the same street. Please rank the following images in terms of how dense they feel using a scale of 1 to 9 where 1 is the least dense and 9 is the densest. (Please use label shown in the corner of each space).



______ A ______ B ______ C ______ D ______ E ______ F ______ G ______ H
______ I

Figure A-16. The fourth question of the survey; grey color images used to measure correlation between street enclosure and number of intersecting streets with the dependent variables.

Part 2

In this section, you will be asked few questions about yourself and your experience.

What is your age
- ❍ 18-25 years
- ❍ 26- 35 years
- ❍ 36-45 years
- ❍ 45- 60 years
- ❍ more than 60 (5)

What is your gender
- ❍ Male
- ❍ Female

How long have you been living in the USA
- ❍ 1-5 years
- ❍ 6-12 years
- ❍ 13- 20 years
- ❍ More than that

Do you have any academic or professional design knowledge or experience?
- ❍ Yes
- ❍ No

Please choose one field or more from the following
- ❑ Architecture
- ❑ Urban Design
- ❑ Urban Planning
- ❑ Landscape Architecture
- ❑ Interior Design
- ❑ Other, please specify ____________________

Think about where you have lived during the last 10 years. Please answer the following questions based on your living experience of the last ten years: 1- I have lived mostly in
- ❍ urban area
- ❍ suburban area
- ❍ rural areas
- ❍ other please specify ________________

I have lived mostly in

- ❍ very high population density area
- ❍ high population density area
- ❍ Moderate population density area
- ❍ low population density area
- ❍ very low population density area

Residential density is measured by the number of dwelling units per acre; 1 acre is roughly 200 feet by 200 feet; for the metric system 1 acre is about 4,047 square meters or roughly 60 meter x 60 meter)
I have mostly lived in an area that has almost similar residential density to the following area:

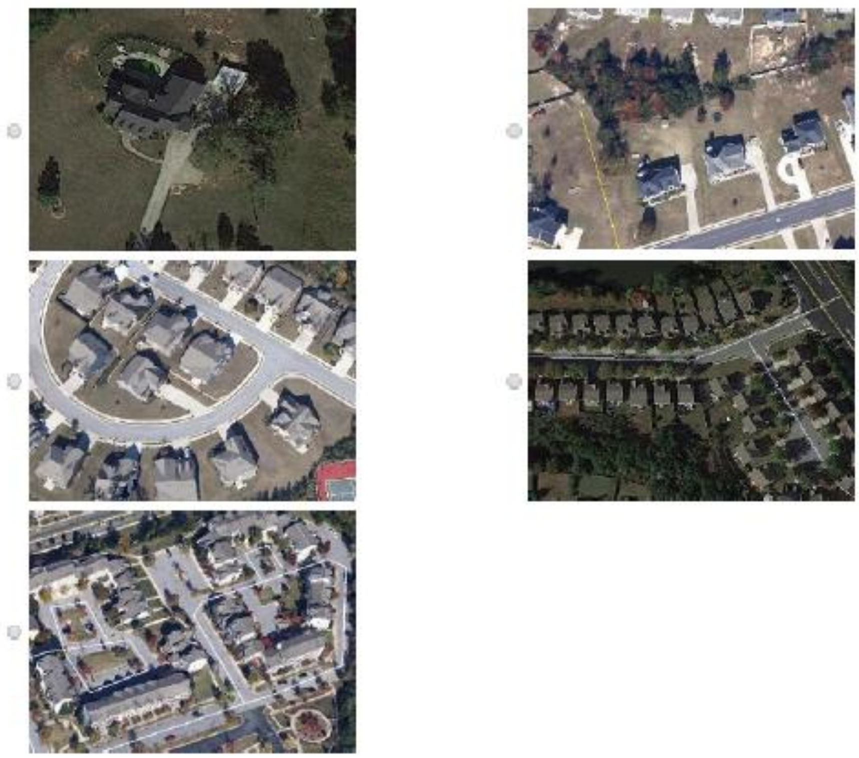


Figure A-17. Arial Images showing different type of residential areas with various residential density to test correlation between participants numeric expression and visual expression about residential density.

Note that once you click the next button to finalize this survey you will not be able to go back and revisit any of your answers.

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BIOGRAPHICAL SKETCH

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Between 2013 and 2016 Alma worked as Consultant in various planning assignments ranging from historic preservation to development of master plans and sectorial analysis for local government agencies to development of international reports about planning in Palestine. In 2017 she defended her dissertation at the University of Florida to complete her doctorate degree and to be ready to pursue a career in planning at the USA.