# Role of Visual Affordance of a Spatial Layout on Human Interactions at a Work Environment

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**Dedication**

This dissertation is dedicated to:

*My father,* ***Asadollah Motamed***

*&*

*My mother,* ***Molook Etezadi,***

For their endless love and unconditional support.

# Abstract

This study explores the impact of the spatial layout of a work environment on employees' interactions. The main research question is: *How does the visual affordance of the spatial layout of a work environment influence the way employees interact?* It was addressed quantitatively by means of quasi-experimental design and a cross-sectional survey design. A social interaction was selected as the unit of analysis. Spatial data was gathered through the use of a simple floor plan analysis as well as DepthmapX utilizing the theory of space syntax. Social data was collected by means of a controlled field observation (video-taping) and administration of a survey questionnaire. This study discovered that 1) visual control is an important issue to be considered in the design of work environments; 2) the theory of space syntax can be regarded as a reliable predictor of the interrelationship between spatial as well as social properties of the space; 3) results are not generalizable to other settings; 4) To achieve a robust statistical power, the unit of analysis can be set on an interaction or a spatial unit ; 5) more studies is required to identify generalizable trends on the interrelationship between spatial properties of work settings and their social attributes.

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# Introduction

The intense global competition faced by organizations today (for example, Blanding, 2011; Morone & Taylor, 2010) has made the design of work environments especially important, as they are shown to have positive influence on employees as well as organizational success. Literature on workplace design indicates that spatial design of work environments has an influential impact on human interactions at work which can bring advantages not only to the employees, but also to the organization (for example, Penn, Desyllas, & Vaughan, 1999; Peponis et al, 2007; Sailer, 2011; Sailer & McCulloh, 2012; Toker & Gray, 2008; Rashid, Kampschroer, Wineman, & Zimring, 2006).

Design can help organizations to successfully achieve their organizational goals. In fact, spatial layout of work environments can create spatial patterns that increases the quality as well as the quantity of interactions among employees. Many scholars put emphasis on the importance of spatial layout of a workplace on human interactions among employees, and especially its impact on the visibility as well as its ability to induce the formation of face-to-face interactions (for example, Parsons, 1976; Peponis et al, 2007; Toker & Gray, 2008; Rashid et al, 2006).

On the same vein, the trace of Steve Jobs' desire for innovation through collaborations and unplanned encounters is evident in the design of Pixar's and Apple's headquarters. In his biography, Steve Jobs stated that "if a building doesn't encourage [collaboration], you'll lose a lot of innovation and the magic that's sparked by serendipity. So we designed the building to make people get out of their offices and mingle in the central

atrium with people they might not otherwise see" (as cited in Pixar headquarters and the legacy of Steve Jobs, 2014). In Pixar's headquarters, a huge atrium space was designed to enable interactions and face-to-face encounters (Pixar headquarters and the legacy of Steve Jobs, 2014). Jobs' initial idea of having just one restroom for both genders is aligned to his goal of bringing all and everyone together to interact face-to-face and share their knowledge with one another. This idea was not included in the final design as the building has more than one restroom, but the thoughtful idea behind it is what draws attentions to it (Pixar headquarters and the legacy of Steve Jobs, 2014; Pixar Campus, 2014). In Apple's headquarters, what is very intriguing in regard to Steve Jobs' intention for improving the quantity as well as the quality of face-to-face interactions, is the overall shape of the building which is built in form of a huge ring. This ring, which is called the spaceship, can be seen from outer space. The inner courtyard provides the perfect place for everyone to bump into one another and mingle.

To investigate the role of space in affecting employees' interactions, this study specifically makes use of the concept of purview, i.e. direct purview and indirect purview (i.e. global purview), introduced by Peponis (2012). In the current research study, the influence of visual affordance of the space on employees' quality of interaction (i.e. duration of interaction), rather than the quantity of it (i.e. frequency of interaction), is the phenomenon of interest. Aside from the visual affordance of a space, the function of the space (for example, private or public use of the space) can be regarded as an important factor affecting interactions (for example, Laing, Craig, & White, 2011; Penn, et al, 1999; Parsons, 1976; Peponis, 2012; Peponis et al., 2007; Sailer & McCulloh, 2012; Sailer, 2011; Toker & Gray, 2008; Rashid, et al, 2006).

Many of these studies used the theory of space syntax to analyze the spatial layout. This theory was first introduced by Hillier and Hanson in1984 as a means by which the relationship between space and its use is formalized by means of topological graphs (Dawson, 2008). Based on this theory, computer software (such as Pesh and Depthmap) has been developed to analyze a space. DepthmapX, developed by Alasdair Turner at University College of London (UCL), was used in this research study.

The benefit of human interactions at work is widely discussed in the literature. Human interactions in work environments can lead to employees' health and well-being (for example, Anderson, 1991; Chen, Siu, Lu, Cooper, Philips, 2009; Cohen & Wills, 1985; Fitzgerald & Danner, 2012; Halbesleben, 2006; Oksanen et al., 2008; Park, Wilson, & Lee, 2004; Romero & Cruthirds, 2006; Suzuki et al., 2010; Taylor et al, 2013). Literature also indicates that interactions among employees can be generative toward higher levels of productivity and goal attainment at work, leading to employees' satisfaction (for example, Bach 1965; Brennan, Chugh, & Kline, 2002; Dean, 1977; Huang, Ping, & Wen, 2011; Laing, Duffy, Jaunzens, and Willis, 1998; Lehmann-Willenbrock & Allen, 2014; Lin & Kwantes, 2015; Oldham, 1988; Park, et al, 2004; Peponis et al., 2007, Romero & Cruthirds, 2006; Romero & Pescosolido, 2008; Van Kleef , 2010; Wong, Tschan, Messerli, & Semmer, 2013; Varlander, 2012).

Employees' health and well-being as well as their success in accomplishing more productive outcomes and attaining goals can lead to organizational success as indicated by the ability to innovate and to stand out in today's fierce competition that exists among firms. According to Blanding (2011), "it's more important than ever that companies figure out how to innovate if they are going to maintain their edge, or maintain their existence at all", (p.1).

In such a competitive world innovation is considered the most promising contributor to business success. Lack of innovation led to the bankruptcy of many business owners since their products and services could not win over their market competitors. For example, in late 2001 Polaroid declared bankruptcy due to the lack of innovation in their business model. Another important benefit of human interaction at work is the opportunity to share knowledge and learning from peers leading to individual creativity at work and consequently organizational innovativeness. Literature on workplace success puts a great emphasis on the importance of interaction among employees for knowledge acquisition and its impact on creativity and innovation (for example, Allen, 1984; Blanding, 2011; Brown & Duguid, 1991; Fischer, 2005; Gilbert, Pyka & Ahrweiler, 2001; Hargadon & Sutton, 1997; Heerwagen, Kampschroer, Powell, & Loftness, 2004; John-Steiner, 2000; Kanter, 1988; Mascitelli, 2000; Nonaka & Konno, 1998; Morone & Taylor, 2004; Mutz, 2006; Saint-Onge, 2005; Sonnenwald & Lievrouw, 1996; Toker & Gray, 2008; Tornatzky & Fleischer, 1990; Wilson, 2010).

Chapter 1: Literature Review provides an in-depth review of literature on aforementioned concepts, i.e. the benefits of interactions, the role of spatial layout and other factors related to work environments on human interaction, as well as the theory of space syntax. The review of literature provides a solid basis to formulate the main research question of this study. The main research question is: *How does the visual affordance of the spatial layout of a work environment influence the way employees interact?* The concluding remarks provide a recap on the overall findings of the literature review as well as critiques on the methodology, and limitations of these studies.

Chapter 2: Methodology, addresses the choice of quasi-experimental design as well as a cross-sectional survey design to examine the research question. It explains 1) the choice of the units of analysis, 2) how the study setting was chosen to be that with more variability in direct and indirect purview, 3) selection of the research variables, and 4) the methods for data processing and analysis.

Results of the statistical analysis as well as the descriptive statistical analysis of collected data are thoroughly reported in the Chapter 3: Results.

Results are discussed more in-depth in Chapter 4: Discussion and Conclusion. Here, the main findings of the study are thoroughly addressed in light of the results of previous studies and the implications are explored for design as well as future research. The concepts of of visual control, organizational policy, individual freedom, and multifunctional use of the space are brought together to answer the main question of research, i.e. *How does the visual affordance of the spatial layout of a work environment influence the way employees interact?*

# Chapter 1: Literature Review

This chapter reviews literature relevant to the purpose of this research study to provide a solid basis for the methodological investigations. The purpose of this study is to explore the impact of the spatial layout of a work environment on interactions among employees. To conduct the review of literature, a great variety of existing studies (such as peer-reviewed journal articles, and books) are found by searching through the university library systems. Further search also conducted by using Google Scholar as a popular search engine in academia. This resulted in a vast body of literature; therefore, the next step was to read through the abstracts and/or introductions to get an overall sense of their relevance to the purpose of this study. Selected literature was studied carefully to identify research methods as well as salient findings. Four major topics are explored, 1) the benefits of social interactions in work environments, 2) the impact of spatial layout on human interactions in work environments, 3) other factors influencing human interactions in work environments, and 4) the theory of space syntax. Relevant literature on the impact of spatial layout as well as other factors on human interactions in work environments is explored to compare and contrast the results of previous studies and learn from their findings. The theory of space syntax is studied to develop an understanding of its historical as well as its theoretical basis. In conclusion, discussion of the concise map of the findings is followed by examination of the limitations of methodological design.

## Benefits of Social Interactions in Work Environments

According to the literature, benefits of human interactions at work can mainly be recognized in three areas: 1) it can bring physical as well as psychological health and well-being to the employees, 2) it can lead to higher levels of productivity and goal attainment for the employees and consequently more employees' satisfaction at work can be achieved, 3) it can be a versatile source of learning from peers leading to higher individual creativity and consequently more organizational innovativeness. The following provides more information.

**Health and well-being.** The influential impact of workplace interactions on employees' health and well-being is supported by many scholars. For example, Oksanen et al (2008) investigated the impact of workplace social capital on employees' health. Social capital refers to the supportive features of a social unit facilitating collective actions among the members; and workplace is regarded as an important social unit in this regard because employees spend most of their waking hours at work (Oksanen et al, 2008). This study identified social capital as one of the predictors of health in work environments. Along the same vein, Suzuki et al (2010) identified mutual trust and reciprocity as components of social capital that can affect employees' health. The results of the study showed that lack of reciprocity by co-workers was reported to be associated with adverse health outcomes. Additionally, this research concluded that interactions with trustworthy coworkers not only can lead to feeling more secured and accepted within the work environment, but also it can facilitate the stress coping mechanism. (Suzuki et al, 2010). The positive effect of social interactions in work environments on reducing stress, depression, and burnout can also be directly and/or indirectly inferred from the results of studies conducted by many other

scholars (for example, Anderson, 1991; Chen et al, 2009; Cohen & Wills, 1985; Halbesleben, 2006; Park, et al, 2004; Romero & Cruthirds, 2006; and Taylor et al, 2013).

Social interactions can be a beneficial break from sedentary work. Taylor et al (2013) pointed to the beneficial impact of work breaks on employees' health and well-being as an effective solution for sedentary work. The authors stated that "increasing sedentary work has been associated with greater cardiovascular and metabolic risk, as well as premature mortality. Interrupting the sedentary workday with health-promoting work breaks can counter these negative health effects" (p.414). Work breaks can increase interactions among co-workers, and accordingly decrease the adverse impact of stress as well as of sedentary work.

Social interactions can positively affect employee's health and well-being through promoting humor. Humor enhances communication as well (Meyer 1997). According to Romero and Cruthirds (2006), humorous interactions reduce stress and increase group cohesiveness which can bring the support of mutual trust and reciprocity as Suzuki et al (2010) pointed out. The importance of workplace interactions on employee's health and well-being is also emphasized by Fitzgerald and Danner (2012) from an evolutionary standpoint. This research implicitly pointed to the inherent need of human being to socialize and interact with his/her counterparts.

**Productivity and goal attainment.** According to literature, workplace social interactions can impact employees' goal attainment as well as productivity. Results of studies conducted on this relationship show that humor and positive affect are mediating the impact of social interactions on employees' goal attainment and productivity. For example, according to Lehmann-Willenbrock and Allen (2014), "humor patterns, but not humor

statements alone, were meaningfully connected to relevant team performance outcomes, both immediately and across time" (p.1285). In addition, Huang, Ping, and Wen (2011) elaborated on the importance of humor in group cohesion and sense of unity among co-workers. In fact, humor is a social potential that can be activated through human interactions (e.g., Romero & Cruthirds, 2006; Romero & Pescosolido, 2008). Humor can lead to more effective interactions and consequently it increases productivity at work. Expressing positive emotions is another avenue by which social interactions can affect goal attainment. According to Wong et al (2013), in dealing with supervisors, expressing and amplifying positive emotions can lead to goal attainment. In explaining this phenomenon, the authors pointed to the study conducted by Van Kleef (2010), in which Emotion as Social Model was evaluated. According to this model, in an interaction, the expression of emotions can be regarded as a source of information about goals and motivations of the interaction parties. Meanwhile, if parties express their emotions positively, they can display their eagerness in a pleasant social interactions and consequently be reciprocated by favorable reactions from the other party. Therefore, the interaction is amplified toward attaining goals (Wong et al., 2013). Along the same vein, Lin and Kwantes (2015) argue that supervisors can develop more positive affects toward their subordinates through increased interactions. In fact, by getting engaged in more interactions, supervisors perceive similarities with their subordinates that can affect employees' performance ratings. Also, the authors believe that increased social interactions with co-workers can provide them with timely assistance from their counterparts which can directly affect their long-term productivity at work. Additionally, Park, et al. (2004) pointed to the direct and positive impact of social support on employees' psychological well-being (i.e. low depression) and organization productivity (i.e. high job performance).

**Learning, creativity, and innovation.** Knowledge developed by learning from peers, individual creativity, and organizational innovativeness can be considered as the most important benefits of workplace social interactions. Innovation is defined as a process in which firms create and carry out new products (Nelson & Rosenberg, 1993). Many thinkers agreed upon the importance of knowledge in the process of innovation (for example, Hargadon & Sutton, 1997; Heerwagen et al. 2004; Kanter, 1988; Mascitelli, 2000; Nonaka & Konno, 1998; Saint-Onge, 2005; Toker & Gray, 2008; Tornatzky & Fleischer, 1990). According to Gamal, Salah, & Elrayyes (2011), "innovation cannot take place without an understanding of the resources, tools, and technologies, materials, markets, and needs in the situation at hand" (p.8). Social scientists often consider the process of innovation as a combination of several pieces of information coming together in order to form a new concept. For social science researchers, the innovation process is a collective interactive rejoin of existing chunks of knowledge in new ways to develop over conventional ways of doing things (Schumpeter, 1934; Weitzman, 1998). Innovation is all about making use of existing as well as new knowledge (Oerlemans, Meeus, & Boekema, 1998; Howells, 2002). Firms' increasing reliance on knowledge as a key component of innovation is emphasized by scholars (for example, Pinch, Henry, Jenkins, & Tallman, 2003). "In recognition of the tremendous importance of knowledge to the innovation process, innovating organizations willingly spend significant amounts of resources on research and the acquisition of knowledge (e.g., intellectual property)" (Gamal et al, 2011, p.8). According to Toker and Gray (2008), in national or local levels, geographical proximity and concentration of different industrial and technological firms are regarded as an influential factor affecting innovation outcomes (Porter & Stern, 2001). Aligned to this path, Gilbert et al (2001) conducted a multi-

agent simulation incorporating the theory of innovation networks in which agents learn from each other. Agents represent firms in the innovation network. Results of this study revealed that firms can improve their innovation potential by fortifying their internal resources (for example their R&D units) or by learning from other firms. In addition, Morone and Taylor (2004) conducted a simulated study with a similar goal, i.e. to study the diffusion of innovation among firms, but with a different contribution to the body of knowledge. In their conclusion, they reported that the initial knowledge levels of firms matters. In fact, they realized that agents with very low initial levels of knowledge are ignored by other agents, yet agents with higher levels of knowledge could learn more. The researchers noticed that as the initial levels of the knowledge of agents increases, their contribution in sharing the information and knowledge they possess as well as the opportunity of learning from other agents can be increased dramatically.

The importance of human interaction in sharing knowledge is discussed by many scholars (for example, Allen, 1984; Sonnenwald & Lievrouw, 1996). According to Brown and Duguid (1991), individuals "construct their understanding out of a wide range of materials that include ambient social relations of the persons involved" (p.47). Additionally, in his study, Allen (1984) emphasized the pivotal role of consultation among research scientists in generating innovative outcomes. According to Sternberg (2009), a knowledgeable person is not necessarily a creative person, yet s/he should be able to interpret the knowledge in a creative way. The author argues that this ability can be cultivated through socializing and interactions with other individuals coming together from different backgrounds. Repko (2008) believes that interdisciplinarity helps us to reach consistency and unity in our understanding of sophisticated problems which belong to different disciplines.

None of these disciplines can overcome complex issues on its own. Palmer (2001) believes that "the real-world research problems that scientists address rarely arise within orderly disciplinary categories, and neither do their solutions" (as cited in Repko, 2008, p.3). Thus, social interaction among experts coming from different disciplines can cultivate creativity and consequently innovation.

Interactions among diverse groups of co-workers can also be considered as being positively influential on innovative outcomes. For example, Rogers (1995) introduces the concept of complexity as one of the internal characteristics of organizational structure driving organizational innovativeness. Complexity is the diversity of different levels of expertise and professionalism of the members of an organization. The higher is the complexity of an organization, the more innovative the organization would be. Although, complexity can hinder the innovation as the result of difficulties in achieving consensus, it can also encourage the members of an organizational system to propose creative thoughts and learn from one another.

Diversity of thought can also be regarded as an important avenue for learning and creative discussions. For example, Mutz (2006) points to the importance of workplace interactions in the formation of "cross-cutting political discourse" (p.142). Blanding (2011) believe that working in a multicultural environment leads to more creativity.

Wilson (2010) introduces the notion of social creativity and defines it as "a means of understanding how interaction across boundaries (including those of the creative industries) enables, motivates and constrains the reproduction and/or transformation of social values and the realization of human beings' creative potential" (p.368). The social dimension of

creativity has also been highlighted by thinkers such as John-Steiner (2000) and Fischer (2005) who argue that most innovation occurs through collaborative effort and effective communication among different individuals. Interaction and learning opportunities are also defined as attributes of organizational climate affecting employees' creativity and potentially organizational innovativeness (Amabile Conti, Coon, Lazenby, & Herron, 1996; Leenders, Van Engelen, & Kratzer., 2003; Monge, Cozzens, & Contractor, 1992). Thus, while creativity and innovation are not necessarily an outcome of social interaction, social interaction seems to be a necessary component for generating creativity and innovation in an organization. According to the literature, human interactions potentially can improve the innovativeness of work enterprises by providing possibilities for knowledge sharing within and across disciplines and learning from peers. In general, it seems that there is nearly a universal agreement on the influential impact of social interactions on the innovation outcomes of organizations.

**Impact of Spatial Layout on Human Interactions in Work Environments**

In their book, *The Social Logic of Space*, Hillier and Hanson (1984) argue that "the ordering of space in buildings is really about the ordering of relations between people.… through the ways in which buildings, individually and collectively, create and order space, we are able to recognize society" (p.2). Along the same vein, Hilier and Penn (1991) articulate that "one can see that society actually has a certain rudimentory "spatial logic" (p.27). These quotes suggest the relationship between spatial and social properties, however the number of studies investigating this relationship is very scarce in comparison with its importance. Existing research has been conducted at different scales of built environments ranged from urban to interior spaces. At an urban level, for example, Hillier (2012)

investigates the relationship between the form of a city (organic or geometric) and the mental processes of its inhabitants. He argues that "The city is…the creation of economic and social processes…these processes operate within an envelope of geometric possibility defined by the human mind in its interaction with spatial laws that govern the relations between objects and spaces in the ambient world" (p.12).

In a smaller scale, Peponis et al (2007) investigates the relationship between productivity and the spatial layout of a communication design organization. By deploying data from self-assessment questionnaires, field discussions, and space syntax, researchers were able to create network and spatial analysis. This research study concludes that designing the spatial layout of workplaces can create spatial patterns that fortify interactions, and facilitate flows of knowledge.

A media corporation is studied by Sailer (2011) before and after different buildings of the firm were joined together. He reports that the relocation of employees led to a better and more effective interactional behavior among them. In a recent study by Sailer and McCulloh (2012), the spatial properties of offices in different knowledge based work environments were analyzed. They concluded that spatial layout of work environments has an influential impact on the formation of ties among participants. Penn, et al (1999) also studied movement and interactional pattern of employees in a work environment. According to the authors, the way individuals move within the space and make use of it, can directly affect the frequency of encounters among them.

**Visibility and face-to-face interactions.** In the study conducted by Toker and Gray (2008), the impact of the spatial layouts of research laboratories on human interactions are

explored. Six university research centers (URCs) with different spatial layouts are evaluated through a mixed-method research design including multivariate predictive and multiple case comparisons. The authors identified seven types of interaction under two major categories (i.e. face-to-face interactions as well as interactions through e-media):

1. Face-to-face interaction
    - Un-programmed encounters
        - Unscheduled meetings in offices or near workstations by stopping by without an appointment.
        - Coincidental interactions by bumping into each other in public spaces such as corridors.
    - Programmed encounters
        - Office meetings with appointments
        - Prescheduled group meetings
2. Interactions through e-media
    - Emails
    - Phone/video calls

The authors conclude that face-to-face interaction was the most practiced as well as the most preferred type of encounters among scientists. They acknowledge the influential impact of spatial variables on the creation of face-to-face interactions among scientists. According to Toker and Gray (2008), "higher rates of face-to-face consultation and network connectivity are associated with higher scores on …innovation process outcome scales" (p.326). Multivariate analysis revealed that spatial accessibility, visibility and shorter walking distances improve the chance of unplanned face-to-face interactions. Multiple case studies

demonstrated that existing university research centers encompass high levels of spatial accessibility, shorter walking distances, and open spaces which lead to more face-to-face interactions, and consequently more innovations.

However, results of study conducted by Rashid et al. (2006) on the interrelationship between spatial layout of work environments on face-to-face interactions by means of statistical analysis of four office settings show that "spatial layout have consistent effects on movement, but inconsistent effects on visible co-presence and face-to-face interaction…and that functional programs have little or no effect on the culture of face-to-face interaction in these offices" (p.825). They also found visible co-presence as an important factor in predicting the occurrence of face-to-face interactions. The importance of visual accessibility on increasing face-to-face interactions among colleagues was emphasized by many thinkers (for example, Parsons, 1976; Peponis et al, 2007; Rashid et al, 2006). Face-to-face interactions play a pivotal role for innovation potential (Allen, 1984; Toker & Gray, 2008) through creation and reinforcement of organizational culture (Allen, 1984; Cross & Borgatti, 2002; Sundstrom & Altman, 1989; Wineman & Serrato, 1998). Ancona and Caldwell (1992) put emphasis on the importance of face-to-face human interactions on team performance at work.

***Purview.*** Peoponis (2012) elaborates on the concept of purview by stating that "to have purview over space means to be able to judge space as a potential field of access, movement, search, encounter, and co-presence" (p.15). In this study, the author posits two important concepts of direct and global/indirect purviews. While direct purview is a local measure, indirect purview is a global measure and both of them together can predict the intelligibility of the space. Direct purview is "our ability to survey available space through

sight" (Peponis, 2012, p.15). It is based on what is visually available to the users of a space in regard to their immediate environment surrounding them. According to Peponis (2012), having purview over space is not just the matter of direct visibility; it incorporates the indirect visibility of the space as well. Indirect purview is our overall perception of the visual accessibility of the layout and is the mean minimum number of visual turns one can take to reach all other spaces of the layout from the original space. According to Peponis et al (2007), visual turns in fact signifies the change of direction while getting to all other spaces of the spatial system from the original location. Thus, indirect purview is about the directional accessibility of the space, or the degree of simplicity of approach from a given direction. According to Peponis (2012), it "captures an objective property that can be inferred from repeated trajectories of perception over times as they inform cognitive schemata" (p.15). Dealing with both the actual as well as the perceptual nature of visibility makes the concept of direct and indirect purview a solid basis for analyzing the visibility of the space.

**Function.** According to Mustafa, Hassan, and Baper (2010), "we should define space into two types: public and private. Public space is defined as the space that applies no restriction to interaction and communication, whereas isolated space (private space) is the one that completely constrains communication" (p.158). Intermediate levels of privacy (Georgiou, 2006) are referred to as semi-public/private spaces. Design of multifunctional spaces is in accordance with the "serendipitous communication model" that recommends including public nodes for informal interactions in addition to private workspaces for more concentrated works (Peponis et al, 2007). The importance of having different types of spaces (public and private spaces) accommodating different needs of employees throughout the creative process is identified in additional literature as well. For example, a media

corporation is studied by Sailer (2011) before and after different buildings of the firm were combined into one location. He examined the relationship between the spatiality of the work environment and creativity of employees through (a) the affordance of the space for generating interactions; (b) the balance between public spaces, which can improve interactions, and private spaces which elevate concentration when needed. According to Sailer (2012), the creative process has four distinct stages i.e. preparation, elaboration, incubation, insight, and evaluation and elaboration. While preparation and elaboration steps need both public and private work spaces, incubation and insight steps utilize private spaces. This is what Laing, et al.(2011) concluded in their study of work environments as well. These studies put emphasis on the importance of the functional use of the space in the quality of interactions among employees.

**Personal control.** Ganster (1989) has defined personal control as "the ability to exert some influence over one's environment so that the environment becomes more rewarding or less threatening" (p.3). According to Warr (2007), psychological studies have confirmed the necessity of having personal control over the environment. For example, Lee and Brand (2005) discovered that employees' perceived control over their workplace has a positive impact on the job as well as workplace satisfaction. According to Steele (1986), design decisions made for facilities can be affected by controlling rules and policies established by the organization for the use of buildings; "when and how spaces can be used and by whom, what authority it takes to gain access to a resource, what individuals can or cannot do to influence their own immediate work settings, what groups can do to decorate or alter their total space, and so on" (p.17). Scholars such as McCoy and Evans (2002), MacKinnon (1962), Barron (1969), and Amabile (1989) argued that a static environment is defined as the

one that cannot be adaptable to professional needs of employees, and does not support freedom of movement and change. This notion has been identified by many researchers. For example, by studying interactional patterns of a UK based media company before and after a relocation and refurbishment project, Sailer (2011) concluded:

> "The lack of choice of workplace environments that suited people's work processes and tasks [was the main problem]. Since every individual had been assigned a fixed desk depending on team affiliation and locations in the building, each desk and therefore each workstation for a member of staff always had the same exposure to interactive potential on the one hand, or the same amount of privacy on the other hand, independently of the stage of the creative cycle a person might have been engaged in" (p.15).

Literature on organizational theory has emphasized the negative impact of restrictions and constraints, and the positive impact of freedom (Amabile, 1996; Isaksen, 2009) for work climates supporting creativity. For example, Woodman, Sawyer, and Griffin (1993), regard the individual creative performance to be related to organizational cultures supporting risk taking behavior. According to Isaksen (2009), "freedom is defined as the independence of behavior exhibited by the people in the organization" (p.175). Organizational policies restricting employees' freedom can adversely affect organizational outcome. MacKinnon (1962) and Baron (1969) referred to the sense of freedom as being essential for the revolutionary, unstable, and eccentric cognitive processes precede creative thoughts. "Creative persons must free themselves from orthodox means of solving problems, from given structures and rules" (Meusburger, 2009, p. 131). Relatively, Varlander (2012), elaborated on the importance of personal flexibility in career success and job performance.

The author believes that spatiality is an important aspect of individual flexibility which "is grounded in recent researchers' call for a need to study organizations as discursive–material interactions, where organizational action emerges from the interplay between (cognitive and social) individuals and the context in which they are immerged" (p. 34).

## Other Factors Influencing Human Interactions in Work Environments

Aside from spatial factors affecting human interactions at work, the review of literature revealed the impact of non-spatial factors on the quality, quantity, and the formation of interactions among employees in work environments. The following provides more information in this regard.

**Personality.** Personality traits of employees is one of the important factors driving the quality of social interactions in work environments. Despite its importance, literature investigating the impact of personality traits on workplace social interactions is scarce. For example, according to Lin and Kwantes (2015), the social behavior of employees can highly be impacted by individual factors such as a proactive personality. According to Crant (2000), a proactive personality takes measures to improve an undesired situation or create a suitable one. An employee with a proactive personality tends to influence his/her environment (Bateman & Crant, 1993, Chan, 2006) through social networking, soliciting peer supports, and attempting to bond with powerful individuals in higher positions (Ferris et al., 2004).

There are personality inventories by which the personality traits of employees can be measured as well as studied. The use of a short personality measures in research studies conducted in work environments is appropriate if (a) time is of a high priority, and (b)

investigating personality traits of employees is not the central concern of this research study and may be used as possible explanations of observed behaviors.

***Short version of the Big Five Inventory.*** According to John, Naumann, and Soto (2008), Big Five model is a comprehensive framework that gathers research findings on personality psychology under the same umbrella and contains extroversion, agreeableness, conscientiousness, neuroticism, and openness to experience, as its core trait domains (Chiorri, Bracco, Piccinno, Modafferi, & Battini, 2015). Several questionnaires are devised based on this model, such as NEO Personality Inventory Revised (Costa & McCrae, 1992a, 1992b) that is a 240-item inventory and later on accompanied by its shorter versions, i.e. the 60-item NEO Five Factor Inventory (Costa & McCrae, 1992b) and the 44-item BIG Five Inventory (John, Donahue, & Kentle, 1991).

Shorter inventories can be advantageous where time and also respondent fatigue are of concerns. For example, in organizational research, managers may be concerned about the completion of work and are reluctant to allocate a considerable amount of time to be spent by their employees to answer research questionnaires. Also, asking respondents to answer a long questionnaire with repetitive items can lead to their boredom and frustration (Crede, Harms, Niehorster, & Gaye-Valentine, 2012). To satisfy the need, several very short measure personality inventories are devised that can be completed in a few minutes. However, these personality inventories can compromise the psychometric validity of the study although they show acceptable reliability levels (Guido, Peluso, Capestro, and Miglietta, 2015). According to Guido et al (2015), “it has been argued that poorer psychometric properties could be tolerated if ‘brevity represents an unusually high priority’ in research (Saucier, 1994, p. 515), as well as when personality is not a central construct to investigate” (p.135).

These inventories can be as short as a 5-item measure. Crede et al (2012), argue that 10-item measures are much more robust than 5-item ones in regard to criterion validity although they are just a bit longer and only take a few minutes more to be completed. Among several versions of short (yet longer than a 5-item inventory) personality measures are:

- BFI-10 by Rammstedt and John (2007) is a 10 item short version of Big Five Inventory. This measure inquires about the respondents' subjective experiences at work and is consisted of close-ended matrix questions with rankings to prioritize responses (Frankfort-Nachmias & Nachmias, 2008). BFI-10 has a German version, an English version (Rammstedt & John, 2007), as well as an Italian version (Guido et al., 2015).

- Ten Item Personality Inventory or TIPI devised by Gosling, Rentfrow, and Swann in 2003.

- BFI-S which is a 15-Item adaption of BFI-10 and in German (Hahn, Gottschling, & Spinath, 2012).

Among all of these inventories, BFI-10 and TIPI are English measures and their validity and reliability are tested in English contexts and with English speaking respondents. However, according to Guido et al. (2015),

> The BFI-10 appears to be a better alternative to Gosling, Rentfrow, and Swann's (2003) TIPI scale, as it was found by its authors to be psychometrically superior to the latter…Furthermore, the BFI-10 showed a stable five-factor structure, which never clearly emerged for the TIPI scale.

Among personality factors of Big Five Inventory, openness, extroversion, and conscientiousness traits have been shown to have greater impact on social interactions at work. According to Wanberg and Kammeyer-Mueller (2000), openness to experience was linked to proactive actions such as openness to peer evaluations and feedbacks (Lin & Kwantes, 2015). Bateman and Crant (1993) argue that differences in personality traits result in different initiatives taken by employees. According to Lin and Kwantes (2015), highly extraverted employees tend to be more proactive at work and value social encounters to build relationships and network. They also are prone to engage in more interactive environments (Westerman & Simmons, 2007). Conscientiousness is another personality trait that is important in building social connections at work. Conscientious employees are more likely to volunteer for extra work (Van Scotter & Motowidlo, 1996), help their colleagues (King, George, & Hebl., 2005) and seek highly interactive work environments (Westerman & Simmons, 2007).

**Gender.** There are contrasting findings in existing literature regarding the impact of gender on human interaction at work. Some of the previous research studies argue that men are more talkative in work environment and do not support the steriotype that women tend to talk more than men. (for example, Hall, 1984; and James & Drakich, 1993). However, in a 2010 study conducted by Bowers, Waddell, and McCarthy, the authors found that female brain has 30% more of a protein (foxp2) than men considered to be the main reason behind talkative behavior of women in comparison with men. In explaining reasons behind discrepancies between results of their study and previous research studies, the authors pointed to the mediating impact of operational difinitions which are specific to each study and lead to different results. Another mediating factor was the contextual differences in

which men and women are brought up and interacted with. In a recent study by Onnela et al (2014), the authors argued that the gender difference in regard to talkativeness is situational. Results of their study indicated that women are more likely to communicate with other women in collaborative settings. In collaborative settings and specially in a smaller group, women tend to be significantly more talkative than men. However, no significant difference was found between the two genders in non-collaborative settings.

**Size of the social group.** Size of a social group is considered to be important in the quality of human interactions at work wnvironment. For example, according to Amason and Sapienza (1997), the smaller is a group, the lower is the potential for dissimilarity among it's members. As the result, cognitive as well as affective conflicts decrases among the members of the group which can impact the quality and quantity of their social interactions. "Cognitive conflict is task-oriented and arises from differences in judgment or perspective. Affective conflict is emotional and arises from personalized incompatibilities or disputes" (Amason & Sapienza,1997, p.496). Relatively, Lin and Kwantes (2015) argue that "the influence of the social context itself may overpower the influence of individual personality differences. Trait activation theory suggests that perceptions of the situation may moderate the effect of personality" (p.243). For example, high quality relationships at work (which can be the result of the size of the social group) can make employees with lower scores of conscientiousness to get engaged in helping behaviors as a means of "reciprocity norm" (Lin & Kwantes, 2015). The impact of size on human interactions at work is also noted by Onnela et al (2014) arguing that women employees tend to be more communicative in smaller work groups.

**Role.** Role or position of employees can be regarded influential on employees interactions at work. For example, according to Toker and Gray (2008), "individuals who

serve as important sources of … information in the organization and facilitate information flow" (p.320-321), are the "key communicators" engaged in high number of interactions in work settings(Allen, 1984; Toker & Gray, 2008).

Many of the studies investigating spatial properties of physical environments make use of the theory of space syntax to analyze space. Space syntax is the leading theory for the analysis of space and the social life within. This study also employs the theory to answer the research question, as addressed in the following review of literature.

**Space Syntax Theory**

According to Bafna (2003), "space syntax is best described as a research program that investigates the relationship between human societies and space from the perspective of a general theory of the structure inhibited space in all its diverse forms: buildings, settlements, cities, or even landscapes" (p.17). This theory was first introduced by Hillier and Hanson in 1984, however the development of it dates back to 1970s (Hillier & Hanson, 1984). According to Bafna (2003) space syntax originated from the idea of human societies occupying spaces as means of organization. Hillier and Hanson (1984) articulated that:

> The ordering of space in buildings is really about the ordering of relations between people. Because this is so, society enters into the very nature and form of buildings. Architecture is not a social art simply because buildings are important visual symbols of society, but also because, through the ways in which buildings, individually and collectively, create and order space, we are able to recognize society: that it exists and has a certain form. (p.2)

Space syntax makes use of graphical and mathematical representations to analyze spatial configurations. According to Hillier and Penn (1991), configuration is one of the most important ways by which social knowledge is integrated into domestic spaces. Configuration "is defined as, at least, the relations between two spaces taking into account a third and, at most, the relation between all spaces in a complex taking into account all others…It is configuration that space syntax analysis seeks to express in numerical and model form" (Hillier & Penn, 1991, p.30). Hillier and Hanson (1984) stipulated that an inhibiting space needs to be configured, which means converting the continuous space into interrelated individual units labeled distinguishably. Each unit can be assigned to different individuals and/or groups of people as well as different functions, cultures, and/or behaviors. A configured space (a bounded space) is typically an enclosable room with a door (corridors and implied spaces may also be considered a cell) which lends itself to the functional use of the space (Brown, 1991). Space syntax offers algorithms for measuring individual as well as collective configuration of the space through graph theory (Hillier & Hanson, 1984).

Since the theory of space syntax makes it possible for the researcher to analyze configured spaces by converting it to an abstract format (Bafna, 2003), this theory can be considered to fit at an analytical level. In addition, due to its objective approach, the theory of space syntax generates a positivistic methodology (quantitative method). In applying the theory, configured spaces are abstracted in order to be studied topologically (Bafna, 2003). Reliance of space syntax theory on observation rather than robust theoretical reasoning (Bafna, 2003) can be regarded as one of its limitations challenging the objectivity of its results. Therefore, the space syntax theory is more prone to the objective side of the spectrum (i.e. objective/subjective continuum).

The theory of space syntax introduces the following components as a system of meanings through which it can connect to real world practices. According to Brown (1991), "this approach uses pattern recognition and network analysis techniques as a basis for precise systematic descriptions of large- and small-scale spatial systems" (p.2). This theory makes it possible to study configuration in regard to individual spaces and the overall relation between spaces.

**Intelligibility.** According to Toker and Gray (2008), intelligibility of a spatial system "signifies to what extent all spaces are highly integrated and highly connective to another space at the same time" (p.317). This definition signifies the importance of two other spatial measures of the theory of space syntax, i.e. integration as well as connectivity.

***Integration.*** As a global measure, integration is "a measure of the tendency for one particular space to pull together or separate (integrate or segregate) the entire spatial network" (Brown, 1991, p.9). In other words, integration is the degree to which a single space remains on paths among other spaces (Hillier & Hanson, 1984; Toker & Gray, 2008). Accordingly, Bafna (2003) argued that "integration is the average depth of the spatial unit from all other spatial units within a given system" (p.27).

*Depth.* As the building block of the integration value, the depth of a space can be measured in relation to another space by counting the number of spaces located between them. Spaces having the same depth are regarded to be symmetrically related; in contrast, spaces having different depths are regarded to be asymmetrically (hierarchically) related (Bafna, 2003). "The spaces that are hierarchically lower have a greater degree of control"

(Bafna, 2003, p.21). Depth and integration values are inversely related. Spaces located in deeper positions in a spatial layout are less integrated (Rashid et al, 2006).

***Connectivity.*** Connectivity is a local measure and is defined for each single space and signifies the number of spaces directly connected to it (Hillier & Hanson, 1984; Banfa, 2003).

**Control.** Control is "[a] measure of the tendency of one particular spatial node to dominate neighboring spatial nodes" (Brown, 1991, p.9). A space can control its adjacent spaces, or be controlled by them.

**Visibility Graph Analysis (VGA).** According to Turner (2003), "visibility analysis is an intuitively attractive way to investigate the environment as it seemingly gives one the perspective of the (able-sighted) occupant…it would appear to allow us to apply mathematical certainty to the experience of urban and building environments" (p.657). The methodological approach taken by Benedikt (1979), i.e. the isovisit, was the backbone for the conceptualization as well as the application of visibility in recent studies. According to Bafna (2003), "the isovist of a position is simply the polygon created by delineating the area visible to an observer in that position, most often assumed as having a 360-degre field of vision" (p.26). The visibility of a space can be quantified through measuring the area of the related polygon. According to Turner (2004), Benedikt believed that isovist maps can be predictive toward how the users of a space navigate through the space.

By combining this logic with the logic of the theory of space syntax on the interrelationship between spatial properties and movement, Turner and Penn (1999) "decided to combine isovist fields with space syntax to provide a measure of how well integrated

isovists themselves are within a plan of an environment" (Turner, 2004, p.1). Visibility Graph Analysis is formalized out of further advancement of this concept (Turner, Doxa, O'Sullivan, Penn, 2001). According to Turner (2004), Visibility Graph Analysis overlays a grid of points on the plan to create a graph in which each point is directly connected to other visible points. "Due to its providence, it was hypothesized that VGA would give a good indication of how people might interact with space _either moving through it (Desyllas & Duxbury, 2001) _or standing, discussing or generally occupying it" (Turner, 2004, p.2).

The theory of space syntax has been studied within different disciplines (for example, design, GIS, psychology, and anthropology) as well as in relation to various scales of the physical environment ranging from interior spaces to urban settings. These varied applications of the theory of space syntax since its formation in 1970s, made it a very versatile theory to be used in different research studies. In general, due to the socio-spatial nature of the theory of space syntax, this theory seems to be applicable to the proposed study exploring the impact of spatial layout of work environments on employees' social life. The incorporation of this theory in suggested study will be discussed in-depth within the following chapters.

**Conclusion**

Results of this literature review suggest that human interactions in work environments can be beneficial toward employees' health and well-being as well as goal attainment and productivity. It can also lead to learning opportunities, individual creativity, and organizational innovativeness. Additionally, the review of the existing literature revealed that the physical work environment has an influential impact on social behavior of

employess, specifically on the formation, the quality, as well as the quantity of face-to-face interactions. However, there exist contrasting opinions in this regard. While results of many studies emphasize the impact of spatial layout of work environments on face-to face interactions among employees (such as Toker & Gray, 2008), some other studies point to the opposite direction, specifically in regard to the impact of the visual affordance of the spatial layout on face-to-face interactions (such as Rashid et al, 2006). Also, these studies are mostly focused on the local measures of visibility and disregard the importance of global and cognitive properties of visibility in work environments. These studies only introduce and analyze context-specific properties of the space instead of taking a holistic approach to investigate the impact of spatiality of the space on social interactions at work (Rashid et al, 2006).

Additionally, in these studies the phenomenon of interest in relation to face-to-face interaction was the frequency (quantity) of its occurrence and its duration (quantity) was disregarded. In regard to the importance of the duration of interaction in measuring the quality of employees' interaction in work environments, literature is scarce. Only two studies (i.e. Morris & Feldman (1997); Zammuner & Galli, 2005) were found measuring the duration of interactions between employees and clients/customers in relation to the concept of emotional labor. Although these studies and the way they defined the importance of duration of interactions are not related to this study, a general conclusion can be made in that the more durable interactions intensify the advantages/disadvantages of interactions. In fact, the duration of an interaction signifies its strength.

This study posits that the visual affordance of the spatial layout of work environments can have an influential impact on the quality of face-to-face interactions among employees.

So, the crucial question here is: *How does the visual affordance of the spatial layout of a work environment influence face-to-face interactions among employees?* This question will be answered through the application of the theory of space syntax making it possible to analyze spatial as well as social affordances of the work setting in relation to one another; i.e. space is shaping and at the same time being shaped by the social life of its users.

The review of literature showed that in most of these studies, results are generated out of qualitative descriptive analysis methods which although adding value to the study of the impact of spatial layouts on social interactions at work, lack statistical power to ensure internal validity. Even those studies that employ quantitative methods completely or partially disregard the inclusion of control variables in the analysis. Thus, results do not account for the impact of controlling factors that can potentially influence the relationship between spatial and social properties of the space. This seems to be an important problem as the study of human interactions in work environments has not been conducted in a controlled experimental setting to rule out the impact of control factors. In other words, work environment has not been studied as natural settings in which human interactions can be affected by factors other than merely the physical design of the setting. For example, the majority of these studies failed to include demographics (such as age, gender, personality traits, etc), and/or particular spatial factors (such as perceptual aspects of visibility) or social factors (such as number of people interacting, and/or duration of interactions) in the analysis of their research findings. This can greatly impact the internal validity of these studies. Therefore, research studies investigating the impact of spatial layout on the social behavior of employees taking control variables into account are needed.

There are problems with the external validity of the existing studies as well. Results of these studies are not only specific to the selected research context, but also include a diverse array of participants. Thus, the external validity of the findings can be questioned as their findings cannot be generalizable to other settings with different groups of participants. In this situation, it seems crucial to increase the number of similar results to elevate the external validity of the findings. Therefore, additional research investigation in this area, is desired.

# Chapter 2: Methodology

The purpose of this study is to explore the visual impact of the spatial layout of a work environment on the social behaviors of its employees. Based upon the fundamentals of the theory of space syntax, this chapter introduces the methodological approach used to design research that can address its main "inferential question" (Creswell, 2014). The research question addressed by this study is:

*How does the visual affordance of the spatial layout of a work environment influence the way employees interact?*

As the mode of inquiry, this inferential question makes use of abductive logic, as opposed to "declarative logic—that is, inductive and deductive reasoning" (Martin, 2009, p.64). An abductive line of reasoning is a bottom up process starting from existing evidence of problems/needs and works toward finding solutions/explanations addressing them. This type of reasoning, and accordingly the way the question is formulated as an inferential question, seems to resonate well with the purpose of this study. According to Martin (2009),

> To [American philosophers such as William James and John Dewey], the acquisition of knowledge was not an abstract, purely conceptual exercise, but one involving interaction with and inquiring into the world around them. Understanding did not entail progress toward an absolute truth but rather than an evolving interaction with a context or environment" (p.64).

## Elements of Research

In this section, research variables (spatial, social, and control variables) as well as the unit of analysis will be identified and introduced as important elements based on which this research study is designed.

**Research variables.** The spatial properties of the space in which social interactions occur, social attributes of interactions, as well as control variables affecting social interactions at work are regarded to be the study's variables. The following introduces and provides definitions for the variables of this study.

***Spatial variables*.** Based on the research question, this study investigates the impact of visual properties of a spatial layout on the social behavior of employees. According to the literature review, Peponis (2012) introduced direct and indirect purviews as the two important visual parameters of a layout that can predict the potential for interaction and co-presence. To measure and analyze these two spatial variables, Peponis made use of the theory of space syntax enabling the analysis of space through the use of computer software called DepthmapX (more information on this software will be provided later in this chapter).

*Direct purview*. According to the literature review, direct purview is the portion of the two dimensional space immediately available to the sight.

*Indirect purview.* As mentioned in the literature review, indirect purview is an overall perception of the visual accessibility of the entire layout.

*Function.* Direct and indirect purviews cover both the perception of the potential visual accessibility of the overall spatial layout as well as the actuality of what is immediately

available to the sight. Another spatial data that can be surveyed through sight is the awareness of the function of a space that can be informative toward understanding the potential social use of that space. Thus, function can be considered as another visual attribute of the indirect purview of the setting complementing the definition of indirect purview.

***Social variables.*** According to the review of literature, visual attributes of a spatial layout can be influential on co-presence and face-to-face interactions. Therefore, this study counts on this specific kind of interaction (i.e. face-to-face interactions) and considers programmed and un-programmed types of face-to-face encounters that were referred to by Toker and Gray (2008). This study does not consider online and distant encounters through emails, phone calls, and among others as they are not based upon the visibility of the space.

***Control variables.*** According to Frankfort-Nachmias and Nachmias (2008), "control variables are used to test the possibility that an empirically observed relation between two variables has not been caused by the independent variables (IVs) identified in the hypothesis" (p.50). As discussed in the literature review, gender, personality traits, role/position of employees, and number of people interacting (size of the social group) are regarded influential factors on human interactions at work. The duration of employment, as well as time of the day (morning or afternoon) in which the interaction occurred are additional control variables added to this study. However, the search of the literature did not yield any information in regard to the impact of these two factors (i.e. duration of employment, and time of the day) on human interaction at work.

**Unit of analysis.** For the purpose of this study a social interaction is identified as the unit of analysis for the data collection procedure as well as the analysis of the outcomes. A

social interaction is regarded to be the study's unit of analysis for measuring the duration of an event of interaction (hereafter, "duration of interaction"). The frequency of interaction could be another measurement that the study could benefit from, however for measuring the frequency of interactions, a space should be the unit of analysis. But there are not enough spatial units in the selected setting to reach the required sample size. Also, there were not enough individual employees in the selected setting to set the unit of analysis on individuals.

By comparing the interactions in relation to their visual potentials as well as their social attributes, this study aims to find out if variations in visual potential of the space can affect the duration of interactions. This investigation will be informed by the overall design and structure of the methodological approach influencing the process of collecting as well as analyzing spatial, social, and control data sets.

**Design and Structure of Research**

Drawing on the aforementioned lack of studies taking quantitative approach for analyzing the impact of spatial layouts on social properties of work settings, this study adopts a quantitative approach. To do so, all of the identified variables will either be measured in or transformed to numerical values. The following provides more insights.

**Quasi-experimental design.** A quasi-experimental design seems to resonate well with the purpose of this study. That is mainly because the phenomenon that are of interest in this study (i.e. the impact of visual properties of the space on its social potentials), are "not amenable to the straightforward application of experimental designs" (Frankfort-Nachmias & Nachmias, 2008, p.114). The existing spatial layout of a workplace (and its associated visual properties) is a static reality that cannot be manipulated to become an appropriate context for

a controlled experiment. More specifically, this study is designed around a controlled field observation making use of panel design and a time-sampling strategy that allows for controlling the specific location and time-frame in which research data is collected. The time-sampling strategy is incorporated in the current study to ensure "the representativeness of the ongoing activities observed" (Frankfort-Nachmias & Nachmias, 2008, p.194). Panel design as well as a time-sampling strategy will be discussed more in-depth in this chapter.

**Cross-sectional survey design.** According to Frankfort-Nachmias and Nachmias (2008), in survey designs "researchers are simply trying to describe the pattern of relationship between variables" (p.116). Also, Creswell (2014) describes it as a means by which attitudes and opinions of the participants can be disclosed. These insights resonate well with the purpose of using a survey design in this study. Not only does the survey provide insights on control variables and their interrelationship, but also it strengthens the external validity of the findings of quasi-experimental design (i.e. controlled field observation) through the use of triangulation method (Frankfort-Nachmias & Nachmias, 2008). According to Frankfort-Nachmias and Nachmias (2008), triangulation makes use of two or more methods of data collection and consequently can "minimize the degree of specificity or dependence on particular methods that might limit the validity or scope of the findings" (p.189).

In general, drawing on the advantages of the quasi-experimental as well as cross-sectional survey designs, quantitative data (on the syntactical properties of the space as well as its associated social properties) are gathered. The following provides more information on techniques and tools by which the quantitative data are collected. Also, the specific design of a research study, including the data collection procedure, can determine the strength of internal and external validity of the study. According to Frankfort-Nachmias and Nachmias

(2008), while the internal validity answers the question of "whether changes in the independent variable did, in fact, cause the dependent variable to change" (p.95), the external validity of a study concerns the extent to which the results are generalizable. Therefore, it seems crucial to identify possible caveats of the current design in regard to its internal and/or external validities.

## Data Collection

While building plan analysis was utilized to gather data on spatial variables, a controlled field observation was conducted to collect data for the social variables of the study. Also, a survey questionnaire was administered to the employees to gather data on control variables. Data were gathered for either an interaction, an individual, or a space in which the interaction happened. Because the unit of analysis is an interaction, data collected from the space as well as individuals involved in each interaction are averaged to get a unique measure for each unit of interaction. More detailed information is provided in this chapter.

**Spatial data.** Quantitative data on direct and indirect purviews are collected through the application of DepthmapX software, which is a computer program to run visual analysis of built environments and was first developed by Alasdair Turner at University College of London (UCL). This software operates based on the theory of space syntax. According to Turner (2004),

> Space syntax analyses examine the relationships between components of space; each analysis starts with a representation of the spatial components, then makes a graph of

these components, and finally analyzes this graph using, for the most part, conventional graph theoretical measures (p.iii).

Direct and indirect purviews are calculated out of measures generated by DepthmapX. The following provides more information on the procedure by which these two spatial variables are calculated.

***Direct purview.*** Peponis (2012), calculates this measure in square meters by adding one unit to Depthmap's connectivity measure, and multiplying the result by the area of each tile (in DepthmapX software, layouts are covered by a grid of tiles, as units of analysis). Each tile has exactly the same areas; i.e., tile area is a constant. However, an spatial unit is covered by several tiles. For each space, a unique measure of direct purview, which averages the direct purview values of all the tiles included in each space, will be calculated as follows:

$$ADP = [AC + 1] \times A$$

Where ADP= Average Direct Purview, AC = Average DepthmapX Connectivity, and A = Area of a single tile in square feet.

***Indirect purview.*** To calculate the indirect purview (which is the number of visual turns), Peponis (2012) posits that "turns are equals to depth -1" (p.20), which was calculated in regard to each individual tile as the unit of analysis of his study. For a spatial unit consisting of a group of tiles covering the space, the measure of indirect purview will be calculated as a unique measure averaging the values of indirect purviews of all the tiles covering the space. Therefore:

$$AIP = AMD - 1$$

Where AIP =Average Indirect Purview and AMD = Average DepthmapX Mean Depth.

***Function.*** According to the result of the literature review, three general categories are defined to identify different functions of the layout. They are mainly categorized based on the social use of the space, i.e. public, semi public/private, and private.

Now that the processes and the techniques of data collection on spatial variables are introduced, a specific work environment should be chosen to serve as the study's research setting to collect the data from. The following provides more information in this regard.

***Selection of the research setting.*** To select an appropriate setting for the study, several companies were contacted (through mutual connections) to get their permission for a visit. Only three of them responded. All of them were visited and the contact persons were informally interviewed to know more about the overall layout and the use of their work settings. Despite several attempts to request information, one of the companies did not provide adequate information (floor plans) for the researcher to proceed. So, the other two companies were selected, i.e. company W and company B (initials are used for confidentiality purposes). To choose among them, robust selection criteria addressing the main research question were selected. Aligned to this goal, direct and indirect purviews were key criteria because they are assumed to have impacts on face-to-face interactions and co-presence of employees (Peponis, 2012), which is the study's main purpose of investigation. In other words, it is assumed that the variability of direct and indirect purview (across the entire layout) can potentially predict the variability in face-to-face interactions. This

assumption allows conclusions to be drawn on the relationship between spatial aspects of the layout and the social dynamics among the employees.

To compare the variability of direct and indirect purviews within the two selected layouts, the range as well as the standard deviations of the values of connectivity (as the building block of direct purview) and mean depth (as the building block of indirect purview) are calculated and compared. According to Utts and Heckard, (2006), while range is the difference between the lowest and highest values, standard deviation is conceptualized as "the average distance values fall from the mean" (p.40). To be able to make the comparison, two separate floor plans were drawn for each setting, i.e. a Visibility plan as well as a Walkability plan. Direct purview is defined as the space immediately available through sight. Accordingly, the Visibility plans analyze the values of direct purview at the eyelevel. However, indirect purview is defined as a cognitive map helping in estimating mean minimum visual turns needed to go from one point to all other points in a setting. Therefore, the Walkability plans show the values of indirect purview at the knee-level. Therefore, of the two settings, the range and the standard deviation of connectivity values (taken from visibility plans in the eye level) as well as mean depth values (taken from walkability plans in the knee level) are compared and the setting with the higher variability is chosen.

*Internal validity caveats.* In measuring direct and indirect purviews of W's floor plan, issues of practicality may cause some problems in regard to the internal validity of the study. In fact, "selection effects" (Frankfort-Nachmias & Nachmias, 2008), can be problematic as some spaces cannot be observed (for example the restroom). These spaces will be excluded from the process of observation. Also in W, the layout has two separate divisions connected through a public corridor of a mall. For the analysis of the space, just a part of the corridor

connecting the two parts of W's layout is considered (not the entire length of other paths branched out from this corridor). Additionally, in both of the selected floor plans, some open spaces can hardly be considered as a spatial unit confined by a definitive boundary. These spaces will be broken down into smaller spaces. The reconfiguration of these open spaces to smaller spatial units can be done in different ways leading to different results in spatial analysis.

The next step after selecting the right setting and collecting direct and indirect purview values is to gather social data. The following provides more information on the techniques and the procedure of collecting social data.

***Social data.*** Frankfort-Nachmias and Nachmias (2008) define spatial behaviors as the way people behave and interact with one another in relation to their immediate physical environment. The duration of interactions is an extra-linguistic behavior (Frankfort-Nachmias & Nachmias, 2008) collected through a controlled field observational method in which "clear and explicit decisions made as to what, how, and when to observe" (Frankfort-Nachmias & Nachmias, 2008, p.196). This observational procedure is designed in a way that can increase the internal validity of the study.

The first important factor to be considered is that because the social potential of the space is not a static reality and changes through time, a methodological solution should be considered to elevate the validity of social data. According to Frankfort-Nachmias and Nachmias (2008), a panel design is a rigorous solution to this problem "in which the same sample is examined at two or more time intervals" (p.123). Therefore, the goal should be to collect social data more than once, which can be fulfilled by the quasi-experimental design of

this study. In fact, according to Frankfort-Nachmias and Nachmias (2008), quasi-experimental designs "usually involve the study of more than one sample, often over an extended period of time" (p.118). Therefore, this type of design seems to fit well with the purpose of this research as the study is conducted over a course of time. Frankfort-Nachmias and Nachmias (2008) argue that the main problem with the panel design is

> Panel conditioning -- the risk that repeated measurements may sensitize the respondents to give a set of answers…One possible safeguard to panel conditioning is to give members of a panel only a limited panel life (i.e. participation period) and then to replace them with persons taken randomly from a reserve list of the same general population. (P.124)

This information can also inform the procedure of data collection in that the social data needs to be collected from different groups of participants. This requirement is also met in this study as the observation is conducted over several blocks of time on different days involving different groups of employees. The following provides more information on the social data collection procedure:

*Controlled field observation.* According to Frankfort-Nachmias and Nachmias (2008),

> The main advantage of observation is its *directness*; it enables researchers to study behavior in real time, as it occurs…this enables the researcher to collect data firsthand, thereby preventing 'contamination' or distortion of the data by factors or events standing between him or her and the object of research (p.190).

In addition, the authors argue that observational methods enable the researcher to study the phenomenon in a natural setting. According to Zeisel (2006), "[o]bserving behavior means systematically watching people use their environments: individuals, pairs of people, small groups, and large groups. What do they do? How do activities relate to one another spatially? And how do spatial relations affect participants?" (p.191). The procedure undertaken to collect data comes forth; however, there are concepts for which more precise definitions should be offered.

*Definitions.* Adapted from the study conducted by Chapple (1940) on measuring interactions among individuals, these definitions help to provide consistency throughout the process of data collection as well as analysis. According to Chapple (1940), interactions are composed of any muscular actions (such as facial expression, words, gestures, etc) taken by individuals in relation in close proximities. Chapple (1940) believes that as far as a single action is distinguishable, we should not be concerned about further analysis of human behavior. "An event, therefore, is the period from the beginning to the end of observed interaction" (Chapple, 1940, p.23) which is in fact the dependent variable of this study (more information will come later in this chapter). Thus, the beginning and the end of an event of interaction should be defined as well. While the start of an event of interaction is distinguishable by manifesting a unit of action by an individual in order to interact with another, "the end of an event is recorded when the individuals no longer manifest units of action which follow each other in time" (Chapple, 1940, p.29). The duration of interaction is calculated in seconds and can be measured by subtracting the time at the origin of an event from the time at the end of it.

Face-to-face interaction is defined as "engaging in any reciprocal exchanges involving two or more people along a path of observation and in the spaces along it" (Rashid, et al, 2006, p.827). The definitions of the two types of interactions, i.e. programmed and un-programmed interactions are taken from the study conducted by Toker and Gray (2008) on the impact of face-to-face interactions on innovation outcomes. According to the authors, while programmed interactions are office meetings with appointments as well as prescheduled group meetings, un-programmed interactions consist of unscheduled meetings in offices or near workstations by stopping-by without an appointment as well as coincidental interactions by bumping into each other in public spaces such as corridors.

*The procedure of video documentation.* The observational data was recorded through video recording to capture the natural setting of the work environment. One of the advantages of this method is that the researcher could replay a recording and pause it when necessary. Also, even the smallest nuances of the phenomenon were saved and can be referred to at a later time. However, in the method of personal observation, the observer may overlook an important behavior or may not be aware of the importance of that behavior and consequently ignore it without recording it.

For the purpose of this study, twenty spatial units are identified by breaking down the floor plan of the firm into smaller spatial units. Every spatial unit was observed via videotape in four different blocks of times throughout a workday, which is referred to as "time sampling schedule". According to Frankfort-Nachmias and Nachmias (2008), "time sampling refers to the process of selecting observation units, [and] specific points in time at which to make observations" (pp.193-194). Because the recording capacity of the tape is an hour long, each session needs to have the same length of an hour due to this instrumental limitation. To

spread observations evenly between morning and afternoon times of the day, two morning and two afternoon blocks of time are considered for the observation. Observational block of time can happen between 9:30 am and 10:30 am (morning block of time), and 11:00 am and 12:00 noon (morning block of time) and between 1:00 pm and 2:00 pm (afternoon block of time), and 2:30 pm and 3:30 pm (afternoon block of time) on weekdays. Each space will be randomly assigned to one of the four blocks of times on a weekday. Having four blocks of time per day made it possible for all of the twenty spatial units of the layout to be observed once within a week. This random assignment was repeated three more times.

It was expected that the minimum required number of interactions can be obtained within these blocks of observations. But because this expectation was not fulfilled, the process of random assignment as well as the observations were continued until the number of observation reached the minimum required sample size (which will be discussed later). In this process, two sets of data collection were introduced.

In the first set, data was collected from all of the twenty spatial units of the selected floor plan. After three rounds of observation, which were expanded throughout three weeks, lack of observed programmed interactions, for the purpose of achieving a robust statistical result, led to the second set of data collection. In the second set of data collection, spaces in which programmed interactions were observed in the first set of data collection were considered, including spaces with the same spatial use; for example, all of five private offices were considered in the second round of data collection because in the first round, programmed interactions were observed in one of them. Twelve spaces were identified and observed. This process was repeated three times, with the exception that a space cannot be observed on the same day/time of each week.

In the process of recording data, the following specific decisions were made by the researcher to add more structure and consistency to the process of data collection/recording.

1. If an interaction took place between two or more employees of which at least one of them was standing on the threshold of identified spatial units, that interaction would be recorded for the space that was being videotaped.
2. If an interaction occurred between two or more employees of which at least one of them was out of the spaces being recorded, that interaction would be recorded for the space that was being videotaped.
3. The duration of interactions was recorded in seconds of time.

*Internal validity caveats.* There are some disadvantages associated with videotaping a setting. If people are aware of the camera and know that they are being observed, they may alter their behaviors that can adversely affect the outcome of the observation. Since the recording camera cannot be left unattended, the observer will also be present within the setting. Zeisel (2006) calls this type of observer a "recognized observer" as s/he will be noticed by those being observed.

As mentioned before, the employees being observed may alter their behavior due to the presence of the observer as well as the camera recording them. They may even avoid going to the space. This phenomenon is called the Hawthorne effect (Zeisel, 2006), or "The reactive effect of observation" (Frankfort-Nachmias & Nachmias, 2008, p.96). In addition, maturation as well as mortality can cause validity concerns. According to Frankfort-Nachmias and Nachmias (2008), while "maturation involves…social processes that produce changes in the individuals or units studied with the passage of time" (p.96), "mortality refers

to dropout problems that prevent the researcher from obtaining complete information on all cases…the final sample…may be biased" (p.96).

In the same vein, because the observation is happening through time, changes in human resources can happen if some employees leave (mortality) or are added (maturation) to the company. This change can sometimes dramatically affect organizational culture and climate if a key role player (such as the CEO) is replaced. This kind of change can introduce a different interactional behavior among the employees (for example, the new boss is very controlling, which can reduce the un-programmed interactions among employees). In this setting, one employee left the company and another was newly hired (of which none of them was a key role player).

***Survey data.*** The purpose of collecting survey data is to gather data on control variables, as defined previously. The rapid turnaround in data collection coupled with its low-cost design make the internet-based method of surveying a suitable option (Frankfort-Nachmias & Nachmias, 2008). The survey data were gathered from a questionnaire consisting of a series of structured questions. The firm recruits the respondents by sending them an email in which a link to the questionnaire is included. The cover letter of the questionnaire is in fact the consent form in which the respondents were given enough information about the research project and were asked for their consent of participation (Appendix A). The questionnaire is administered to the respondent online via Survey Monkey. The survey questions are divided into four parts of background questions, behavioral/attitudinal questions, personality questions, and vignette questions. For this research study, data collected and analyzed from background questions as well as personality questions. The reason is choosing an interaction as the unit of analysis for this study. Because

behavioral/attitudinal and the vignette questions are open ended questions answered by the respondents, the data collected from them can be assigned to each respondents, but not to an interaction. Also, because of the limited number of respondents (18 total), no meaningful pattern could be recognized in the answers given to these questions.

*Background questions*. These are a series of structured factual questions (Frankfort-Nachmias & Nachmias, 2008) inquiring the respondents about their age, gender, role/position at the firm, and the length of their collaboration with the firm.

*Personality questions.* Following the literature review, personality traits of the employees are identified through the use of BFI-10 by Rammstedt and John (2007) because of its short length, which takes just a few minutes to be completed by the employees. The short length of the BFI-10 does not get in the way of respondents accomplishing work-related tasks, and it also prevents the frustration and boredom that can occur when responding to a long questionnaire with several seemingly similar items. BFI-10 also shows robustness in regard to reliability measures. Among personality factors of Big Five Inventory, openness, extroversion, and conscientiousness traits are selected because they have been shown to have greater impact on social interactions at work.

Data collected on all of the variables defined for this research study (i.e. spatial, social, and control variables) need to be processed and analyzed to answer the main question of this study, i.e. *How does the visual affordance of the spatial layout of a work environment influence the way employees interact?*

**Data Processing and Analysis**

To process the data, a data set, in which each recorded interaction has a single value for each variable, is created. To do so, the first step is to calculate the mean as well as standard deviation of IVs with more than one value for an interaction (as there was more than one person involved in each interaction). But, because some of the variables do not hold numeric values, they are to be transformed to numbers. The hierarchical position of employees' role is one of these variables for which numeric values of 1 to 5 is assigned to each level of organizational hierarchy associated with each position; where 5 indicates the positions located at the top of the hierarchy, 1 indicates the positions located at the bottom. Therefore, for each individual employee involved in each interaction there is a hierarchical number for his/her position. So, to get a unique value for each interaction, the hierarchical number of all of the employees involved in the interaction is averaged and the standard deviation of them is calculated. In addition, personality traits of the employees, including extroversion, conscientiousness, and openness, which are taken out of BFI-10 (Appendix A), have 2 items each, one is direct and the other is reverse. Defined by a five-level Likert scale, these items are assigned a number between 1 to 5 ranging from strongly disagree (1) to strongly agree (5). Numbers were reversed for the reversed items. Therefore, for each of the three personality traits, there is a direct as well as a reverse number for each individual employee. The sum of these numbers generates a single total number for each of the selected personality traits for each employee. To get a unique value for each interaction, the total numbers assigned to each individual involved in the interaction, is averaged for each of the selected personality traits. The standard deviation of them is calculated for each interaction as well. For gender, the proportion of females participated in each interaction is considered. Therefore, each variable has a single value per interaction.

**Statistical Analysis.** This study makes use of Multiple Linear Regression (MLR) analysis to answer the main research question. According to Tabachnick and Fidell (2007), "regression analyses are a set of statistical techniques that allow one to assess the relationship between one DV and several IVs" (p.117). This definition resonates well with the purpose of this study in which there is one dependent variable (DV), i.e. the duration of interactions and several independent variables (IVs), i.e. spatial, social, and control variables. If all of these independent variables are included into one regression model, there is a good chance that none of the independent variables had regression coefficients that are statistically significant. This could happen because they all share so much variance of the dependent variables in common that none of them accounts for a unique amount of variance in the dependent variables that is statistically significant (even though several of the independent variables have statistically significant bivariate correlations with the dependent variables). So at this point, the independent variables that are worth being included in the regression model will be identified through the use of a statistical technique called Forward Regression (which will be explain later in this chapter). However, before creating the final regression model through Forward Regression, dependent variables should be tested for the assumption of normality. A descriptive statistical analysis will follow the statistical analysis of multiple linear regression where appropriate, to provide more in-depth explanations of the statistical findings. Several different methods including VGA (visibility graph analysis) graphs, statistical graphs and tables (such as correlation matrix) will be used.

***Testing the assumption of normality of the dependent variable.*** One of the important assumptions for multiple regression is the normal distribution of the dependent variable. This is because if the dependent variable has a normal distribution, the residuals from the

regression model tend to have a normal distribution as well. To identify normality, the distribution of the dependent variable will be plotted in a qqplot, a boxplot, a histogram, as well as a density plot to inspect the normal distribution of the dependent variable.

***Creating the regression model.*** In Forward Regression, a matrix of bivariate correlations (Appendix B) will be used to build the regression model by adding one independent variable at a time, starting with independent variable with the largest correlation value. If the contribution of the independent variable in the regression model is statistically significant, it is kept in the model; and if not, it is omitted and the next independent variable with the next highest correlation value is added. All of the independent variables should be tested in the regression model, because even if the bivariate correlation between an independent variables and the dependent variable is not statistically significant, the independent variable might still account for additional variance in the dependent variable when it is added to the regression model. The procedure is continued until the model consists of all independent variables that are statistically significant when included in the model.

Once a set of independent variables has been identified through Forward Regression, additional independent variables representing the cross products of each pair of independent variables in the model (i.e. interactions) are added to the regression model to check for their significance. This is to test the nature of the relationship between each pair of independent variables with the dependent variable. In fact, if there is no interaction between a pair of independent variables, the relationship between each pair of independent variables and the dependent variable is the same in all levels of both independent variables. But, if there is an interaction between a pair of independent variables, it can be concluded that the nature of

relationship between the pair of independent variables and the dependent variable is changing for different values of each independent variable.

Before running the regression test in R, the necessary data conditions need to be verified through a prescreening procedure in which the assumptions for normality, linearity, and homoscedasticity of residuals are tested. According to Tabachnick and Fidell (2007), "examination of residuals scatterplots provides a test of assumptions of normality, linearity and homoscedasticity between predicted DV scores and errors of prediction" (p.125). Therefore, a scatterplot is generated by R in which predicted values of dependent variables (duration of interactions) will be shown on the horizontal axis, while values of residuals (errors) will be demonstrated on the vertical axis.

*Sample Size.* Once the number of independent variables are determined, the minimum sample size can be calculated by rules of thumb. According to Tabachnick and Fidell (2007), N (sample size) should be larger than or equal to 50+8m (m is the number of independent variables) for testing multiple correlations and for testing individual independent variables N should be larger or equal to 104+m. The minimum sample size is the largest number calculated through these two equations.

***Running the regression model.*** The next step is to run the regression analysis in R to determine how the independent variables can define the variance in the dependent variable. According to Tabachnick and Fidell (2007),

> One needs to compare the total relationship of the IV with the DV, the unique relationship of the IV with DV, and the correlations of the IVs with each other in order to get a complete picture of the function of an IV in regression. (Pp.144-145).

So, the relationship between independent variables and the dependent variables are articulated as sub-questions by breaking down the main research question. These sub-questions can be structured around the overall effects of the independent variables on the dependent variables. Or, it can be formulated as a multivariate relationship between each independent variables and the dependent variable, after the effects of other independent variables are taken into account. Therefore, the sub-questions are as follow:

1. *How is the total effect of selected independent variables related to the dependent variable (duration of interactions)?*
2. *How is each of the selected independent variables related to the dependent variable (duration of interactions) after the effects of all other independent variables are taken into account?*

The importance of independent variables (how strongly each of them affects the dependent variable) can be determined by either partial or semi partial correlation coefficients. (Tabachnick & Fidell, 2007). According to Tabachnick and Fidell (2007), the squared semipartial correlation coefficient is a better evidence of the importance of independent variables. “In a semipartial correlation, the contribution of other IVs is taken out of only the IV. Thus, squared semipartial correlation expresses the unique contribution of the IV to the total variance of the DV” (p.145). We can use the squared semipartial correlation coefficient as the effect size and compare contributions of each independent variable. The confidence interval (calculated by R) can also be helpful to limit expectations of where to find the true mean of the population, to a high degree of confidence (commonly 95%). It is always beneficial to check for the statistical power of the test conducted. The higher is the statistical power, the higher is the reliability and the validity of results.

# Chapter 3: Results

This chapter reports the results of applying the research methods described in the previous chapter on collected data. Throughout this process, additional decisions were made and new strategies for analyzing and interpreting the data were devised. As such, descriptive analyses of VGA (visibility graph analysis) graphs coupled with several numeric tables and visual diagrams are offered as well. The following provides more information not only on the outcomes, but also on the procedures by which further analysis and interpretations of data is conducted.

## Selection of the Research Setting

It was argued in the previous chapter that the setting with the largest variability in the spatial variables (direct and indirect purview) would provide the greatest potential for identifying relationships between spatial and social variables. The results of the statistical analysis conducted by R revealed that the floor plan of one of the settings (company W) shows higher variability (in regard to the range as well as the standard deviation) in both direct and indirect purview measures (i.e., connectivity and mean depth). Therefore, Company W was selected as the study's research setting. Table 4.1, summarizes the results:

*Table 4.1 Variability measures and comparisons of the two settings (B and W).*

| Floor Plans | Spatial Values | Variability | Setting B | Setting W | Comparison |
|---|---|---|---|---|---|
| Visibility | Connectivity | Stand. Dev. | 729.8353 | 1015.774 | W>B |
| | | Range | 2962 | 3997 | W>B |
| Walkability | Mean Depth | Stand. Dev. | 0.4440202 | 0.6729882 | W>B |
| | | Range | 3.730644 | 3.962586 | W>B |

**Test of Normality for the Dependent Variable**

As evident in Figure 4.1, the distribution of the dependent variable is highly skewed (Skew=5.38, Kurtosis=36.79). One of the recommended solutions to decrease the skewness of the dependent variable is the square root transformation of the dependent variable. Therefore, the next step is to try a square root transformation of the dependent variable.

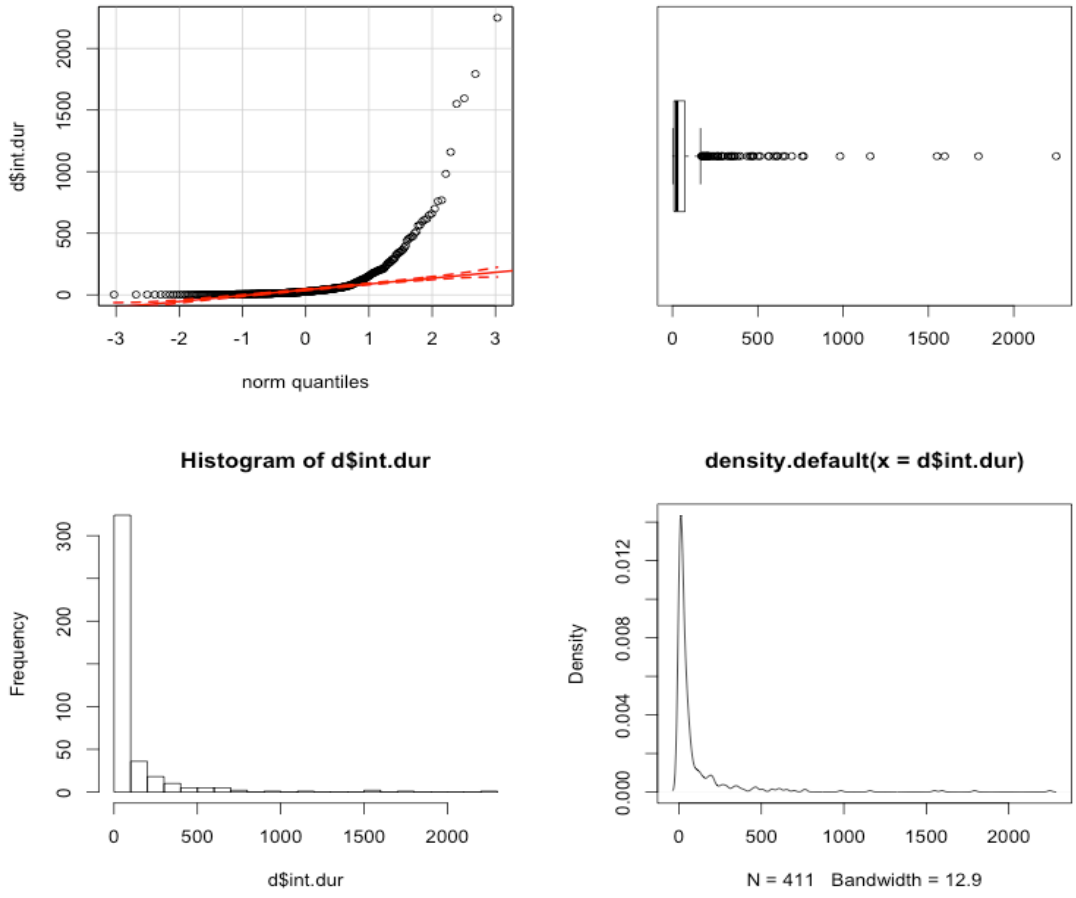



*Figure 4.1 Statistical plots, i.e. qqplot (top-left), boxplot (top-right), histogram (bottom-left), density plot (bottom-right) to test assumptions for the distribution of the original dependent variable (duration of interaction).*

*Square root transformation of the dependent variable*. As evident in Figure 4.2, with the square root transformation, the distribution of the dependent variable is still highly skewed (Skew=2.42, Kurtosis=7.7). Another recommended solution to decrease the positive skewness of the dependent variable is to log transform it. Therefore, the next step is the log transformation of the original dependent variable.

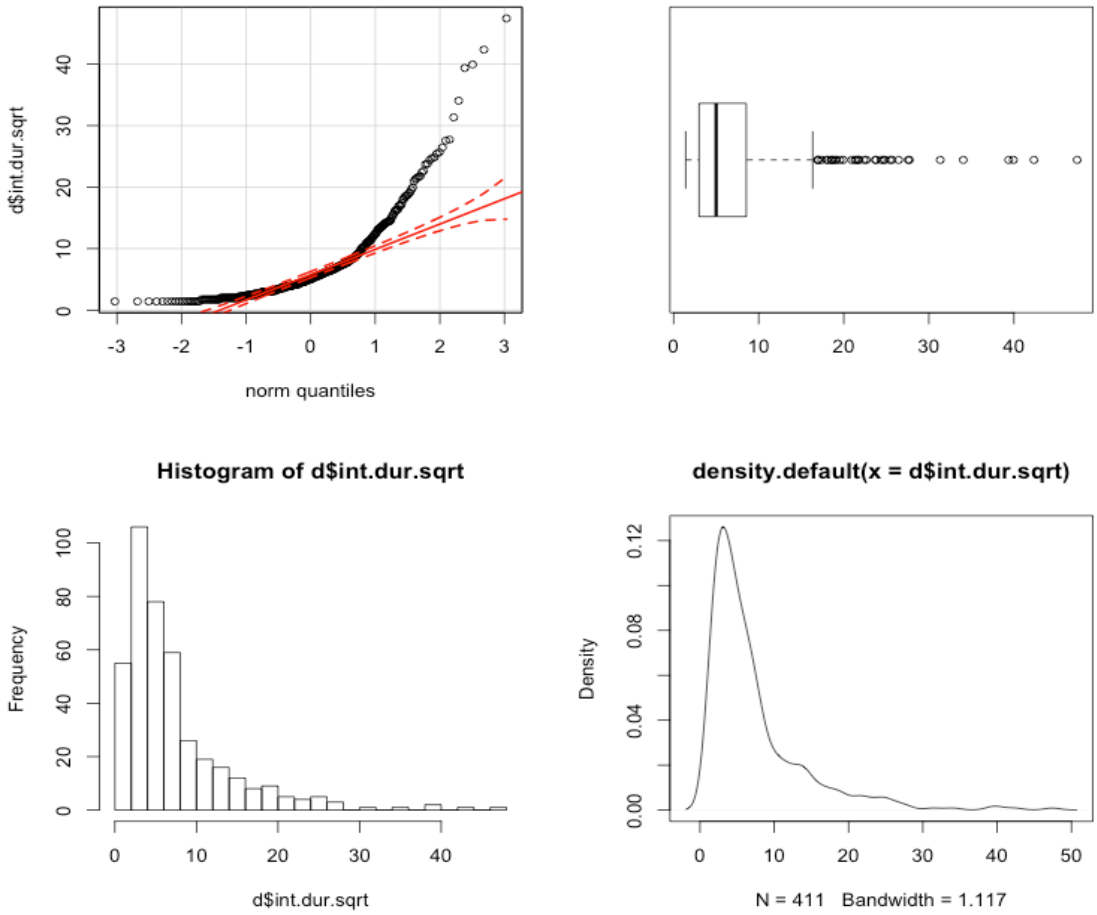



*Figure 4.2 Statistical plots, i.e. qqplot (top-left), boxplot (top-right), histogram (bottom-left), density plot (bottom-right) to test assumptions for the distribution of square root transformed dependent variable (duration of interaction).*

*Log transformation of the dependent variable.* As also evident in Figure 4.3, the log transformation of the dependent variable appears to produce a more normally distributed

variable (Skew=0.14, Kurtosis=-0.45). Therefore, the next step is to run a forward regression analysis with the log transformed dependent variable.

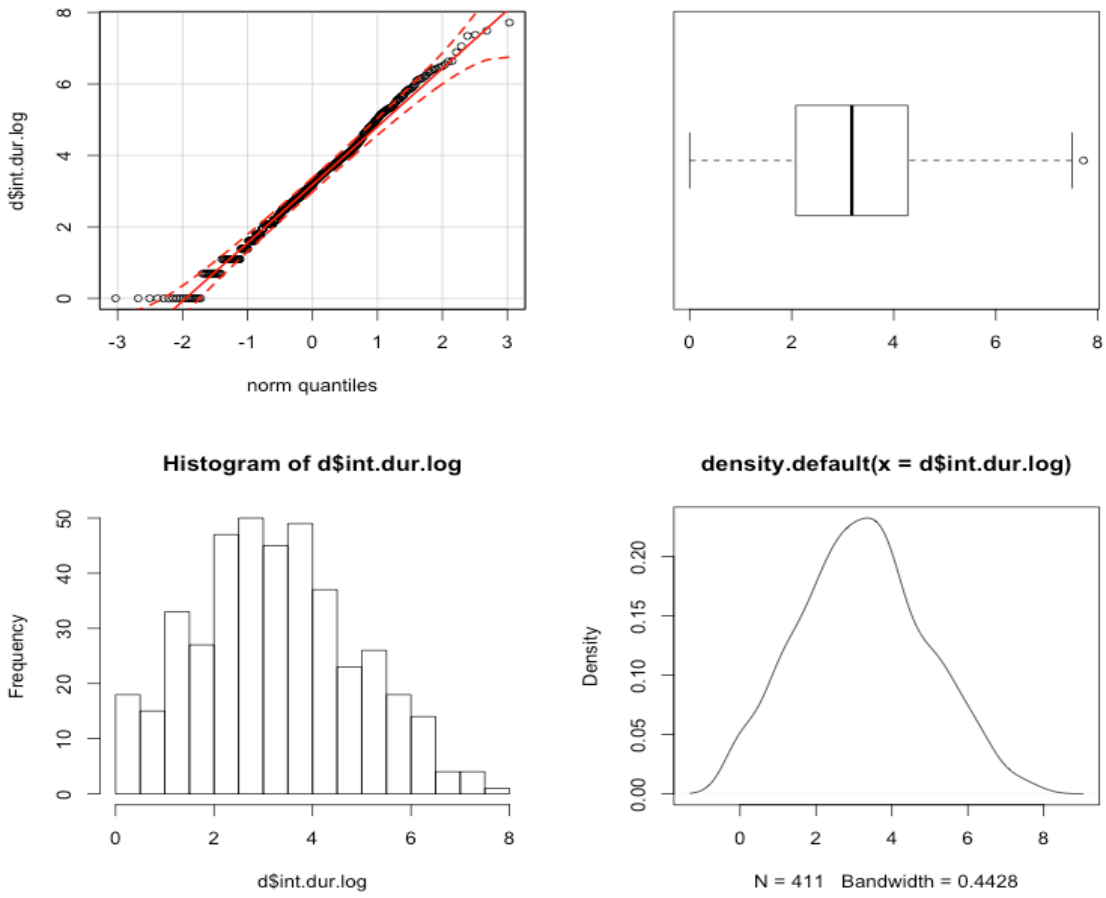



*Figure 4.3 Statistical plots, i.e. qqplot (top-left), boxplot (top-right), histogram (bottom-left), density plot (bottom-right) to test assumptions for the distribution of log transformed dependent variable (duration of interaction).*

**Creating the Final Model**

The result of the forward regression led to the generation of the final regression model which has four independent variables, i.e. average indirect purview (AIP) of the space, function of the space, type of interactions, and the proportion of females in interactions. The dependent variable is the log transformed duration of interaction. The corresponding statistics

are reported in Table 4.2. Test for interactions for the four main independent variables led to six pairs of interaction variables that were added to the model one by one for their significant contributions. However, none of the interactions showed statistically significant contributions to explaining variance of the dependent variable (the log transformation of the duration of interaction). Therefore, there are no interaction variables in the final model. Testing assumptions for the new model showed that the linear model was a good fit.

*Table 4.2 Corresponding statistics of the final regression model with the log transformed dependent variable (duration of interaction).*

| | Sums of squares | Degrees of freedom | F-Statistics | P-Value |
|---|---|---|---|---|
| Type of interaction | 224.61 | 1 | 114.813 | < 0.001 |
| Average Indirect Purview (AIP) | 12.19 | 1 | 6.232 | 0.013 |
| Function of the space | 13.64 | 2 | 3.4856 | 0.032 |
| Proportion of females | 10.44 | 1 | 5.338 | 0.021 |
| Residuals | 792.29 | 405 | | |

**Test of assumptions.** As it is evident in Figure 4.4, the loess line is within the 95% confidence interval band. Although the loess line is slightly curved, its shape is very close to a straight line which shows that the condition of linearity is plausible. The condition of homoscedasticity of the residuals is also plausible as, residual values can be fit within a band and the ratio of the width of the two ends of this band (2.19) does not exceed three (Tabachnick & Fidell, 2007). Another evidence on the homogeneity of variance is that there appears to be fairly even and the same amount of variability of the residuals at all levels of the predicted values. Also, the modified Levene's test of homogeneity of variance is not statistically significant ($p$= 0.656). Additionally, all three graphs (histogram, density, and qqPlot) shows that the distribution of residuals is fairly symmetric and follows a normal distribution very well with slight deviation from normality at both ends of the distribution

(Figure 4.4). Therefore, there does not appear to be an extreme violation of assumption of normality.

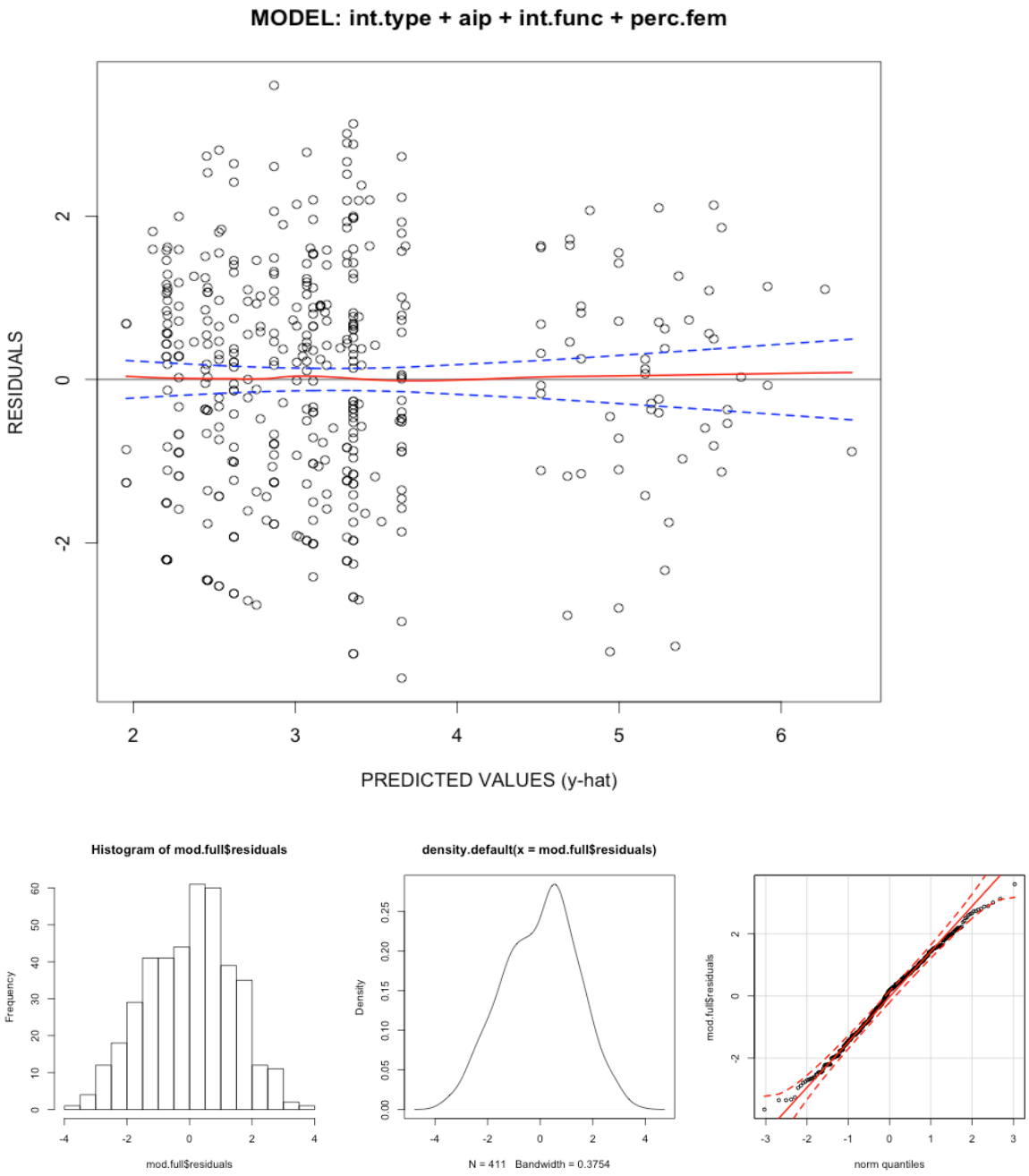



*Figure 4.4 Statistical plots, i.e. residual plot (top), histogram (bottom-left), density plot (bottom-middle), qqplot (bottom-right), to test assumptions for the distribution of residuals.*

**Interpretation of the Final Model**

Based on the final model, the research sub-questions can be restructured and restated as follow:

1. How is the mean duration of interactions related to the total effect of the average indirect purview (AIP), type of interaction, function of the space, and the proportion of females?
2. How is the mean duration of interactions related to the overall perception of the directional accessibility of the layout (AIP) after the effects of the type of interaction, function of the space, and the proportion of females are taken into account?
3. How is the duration of interactions related to the proportion of females after the effects of the type of interactions, average indirect purview (AIP), and the function of the space are taken into account?
4. Is there a difference between the mean duration of the two types of interactions (programmed and un-programmed interactions) after the effects of average indirect purview (AIP), function of the space and the proportion of females are taken into account?
5. How is the mean duration of interactions related to the different functions of the space (public, semi public/private, and private) after the effects of the type of interactions, average indirect purview (AIP), and the proportion of females are taken into account?
    a. Is there a difference in mean duration of interaction between public and private functions of the space after the effects of average indirect

purview (AIP), type of interactions, and the proportion of females are taken into account?

b. Is there a difference in mean duration of interaction between public and semi public/private functions of the space after the effects of average indirect purview (AIP), type of interactions, and the proportion of females are taken into account?

c. Is there a difference in mean duration of interaction between semi public/private and private functions of the space after the effects of average indirect purview (AIP), type of interactions, and the proportion of females are taken into account?

Before answering the above questions, the dependent variable is compared before and after the log transformation to find out how to interpret the model thoroughly. Figure 4.5 depicts the relationship between the original dependent variable (duration of interaction) and the log-transformed dependent variable. As it is evident in this plot, the relationship is not linear. So the interpretation of the model cannot be done by simply describing the R-squared values as well as the correlation coefficients. A reverse transformation was carried out to describe the model in the original metric (seconds) of the dependent variable. At this point, to interpret the data, the relationship between each independent variable with dependent variable will be discussed assuming that all of the other independent variables are held constant in their typical values, i.e. the mean for average indirect purview (AIP), and the most common values for proportion of females, type of interaction, function of the space. So, the typical values for the independent variables are (frequencies are reported in parentheses):

1. Mean of average indirect purview (AIP) which is equal to 2.356.

2. Semi public/private function as the most frequent function of the space (199), as oppose to Public (133) and private (80) functions.
3. Un-programmed interactions as the most typical type of interaction (354) as oppose to programmed interactions (58).
4. 0.5 for the most frequently recorded proportion of females (144) as oppose to other proportions, i.e. 0 (125), 0.25 (7), 0.33 (18), 0.67 (31), and 1 (86).

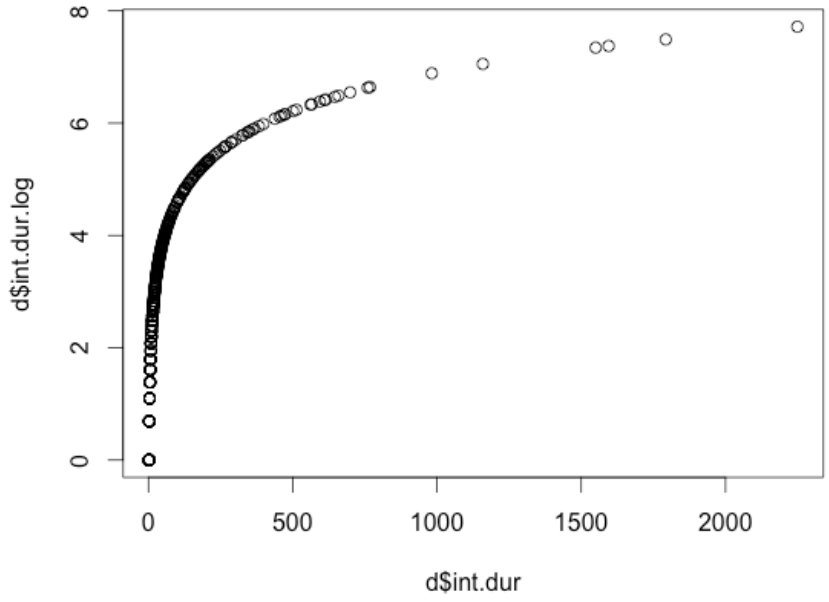



*Figure 4.5 The relationship between the original dependent variable (duration of interaction) and the log-transformed dependent variable (duration of interaction).*

1. *How is the mean duration of interactions related to the total effect of average indirect purview (AIP), type of interaction, function of the space, and the proportion of females?*

To answer the first question, the total R-squared is calculated for this model (0.300). The total R-squared indicates that all of the four independent variables (i.e. average indirect purview (AIP), type of interaction, function of the space, and the proportion of females)

account for 30% of the variance in the dependent variable (i.e. duration of interaction). This, in fact, is the effect size for the total contribution of the independent variable in the dependent variable. Almost 7% of the variance is shared among independent variables. The following questions discuss the unique contribution of each independent variable in variability of the dependent variable.

2. *How is the mean duration of interactions related to the overall perception of the directional accessibility of the layout (AIP) after the effects of the type of interaction, function of the space, and the proportion of females are taken into account?*

The semi-partial squared correlation for average indirect purview (AIP) is 0.011 which indicates that average indirect purview (AIP) uniquely contributes to only 1% of the total variance in the duration of interaction. Figure 4.6 shows the increase in predicted duration of interaction for average indirect purview (AIP). As it is evident in the plot, the more durable interactions occurred in spaces with higher values of indirect purview, when the impact of type of interaction, the function of the space, and the proportion of females involved in the interactions are held constant at their typical values. Although the relationship between the predicated values of the duration of interactions and indirect purview is not linear, an ascending trend is evident in the duration of interactions if indirect purview increases. The descriptive analysis of the actual values of duration

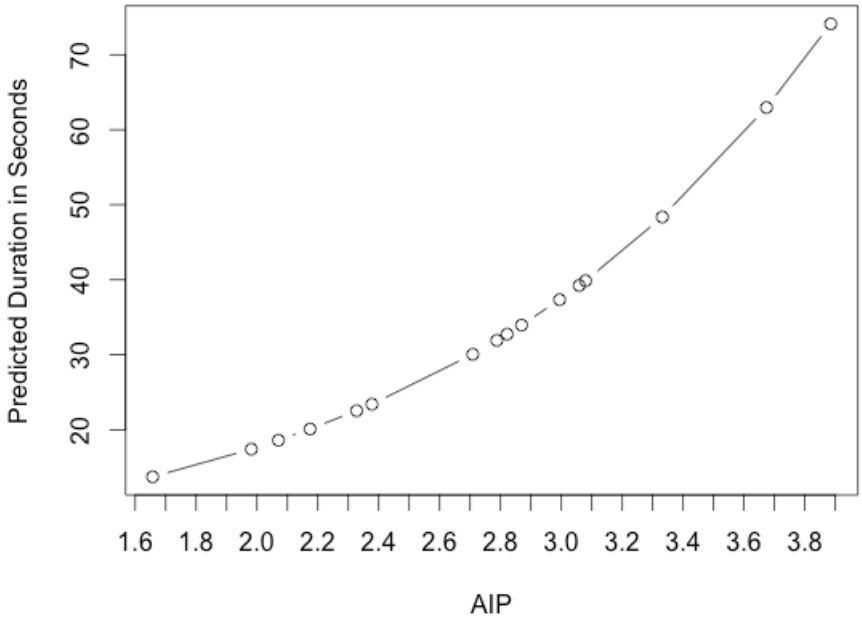



*Figure 4.6 The relationship between the predicted duration of interaction (in seconds) and the average values of indirect purview (AIP).*

DepthmapX's measure of controllability seems to be relevant. According to Turner (2004), VGA (visibility graph analysis) graph of controllability (Figure, 4.7) picks out areas that are visually dominated. Because the measure of mean depth is directly associated with values of indirect purview, DepthmapX's graph of mean depth (Figure 4.8), can represent variability of indirect purview values of the layout. As evident in the graphs, lower values of controllability are associated with higher values of mean depth, and consequently higher values of indirect purview as well as longer interactions. It seems employees talked longer in spaces that are less visually exposed. It is worth reminding that measures of integration and depth are inversely related. So, in this research study, it is expected that more durable interactions happen in less integrated spaces (Figure 4.9) which is also associated with lower levels of controllability (Figure 4.7).

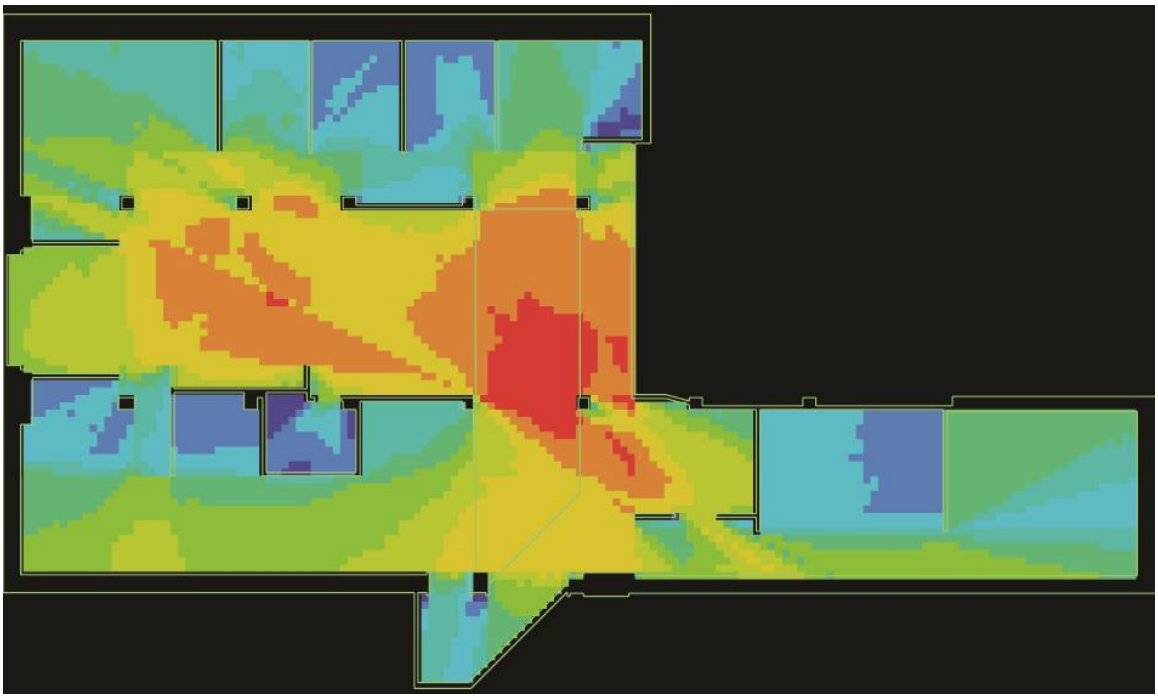


*Figure 4.7 DepthmapX graph of controllability measure.*

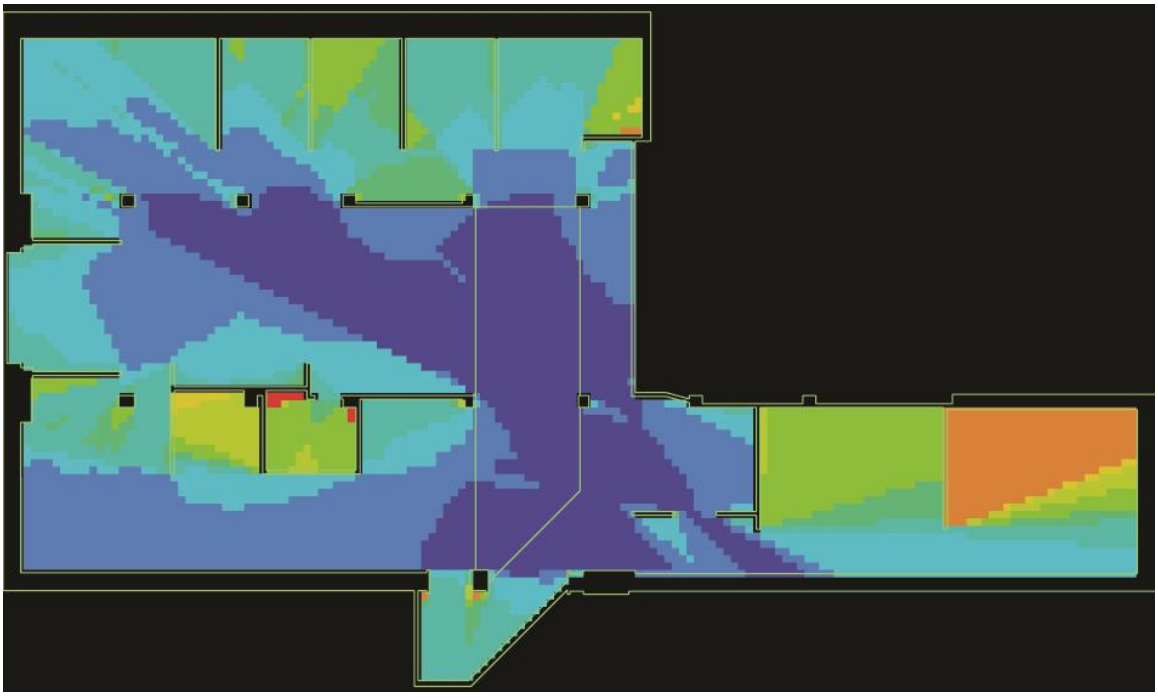


*Figure 4.8 DepthmapX graph of mean depth measure.*

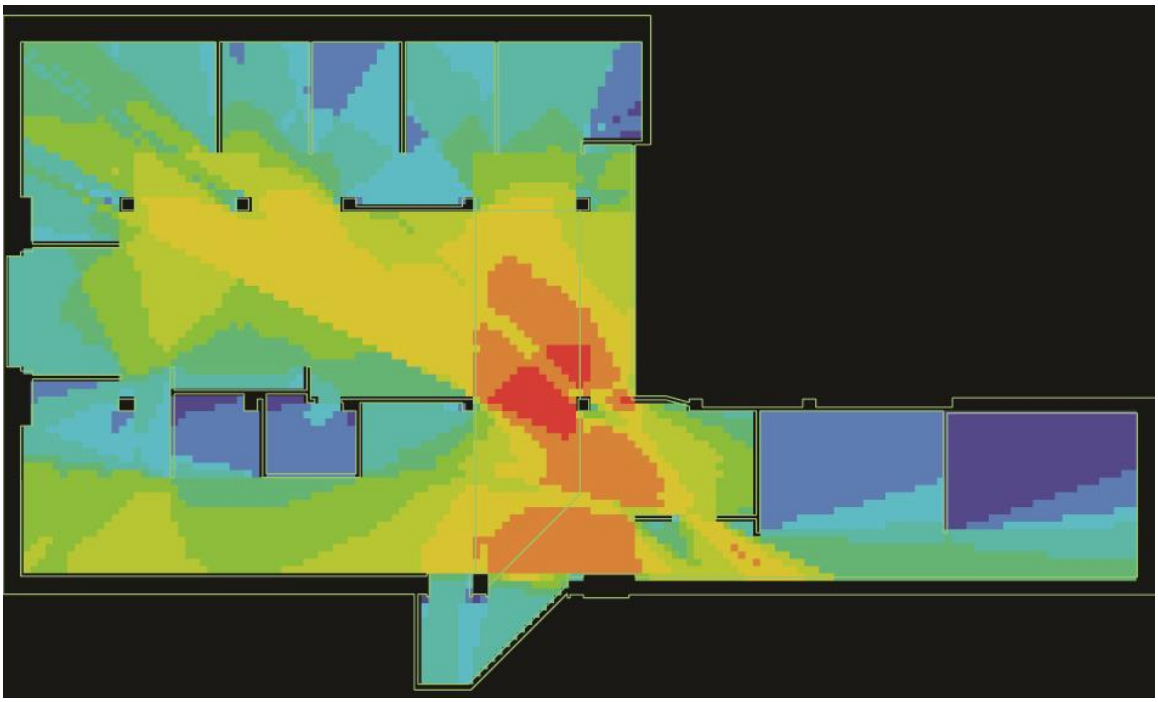


*Figure 4.9 DepthmapX graph of integration measure.*

As evident in the correlation matrix (Appendix B), there is a moderate to strong significant correlation between average indirect purview and average direct purview, in opposite directions ($p < 0.001$, $r = -0.63909$) which indicates that the higher levels of one is associated with lower levels of the other; i.e. the higher is the indirect purview of the space, the lower is the direct purview of the space and vice versa. In other words, the longer is the visual path of directional accessibility of a space from all other spaces in the spatial layout, the lower is the direct visual accessibility of that space. Also, it can be concluded that although the bivariate correlation of average indirect purview with the dependent variable is lower than the bivariate correlation of average direct purview with the dependent variable, according to the result of forward regression, the contribution of indirect purview turned out to be more significant in the dependent variable than direct purview. Therefore, it seems that

directional accessibility of the space (indirect purview) is more important than direct visual accessibility (direct purview) in regard to their impacts on durable interactions.

Here, DepthmapX's notion of visual control can be considered relevant. According to Turner (2004), the VGA (visibility graph analysis) graph of control (Figure 4.10) points to visually dominating areas. As argued, the syntactical measure of connectivity is the building block of direct purview. So, the VGA (visibility graph analysis) connectivity graph can represent values of direct purview of the space (Figure 4.11). By comparing the two VGA (visibility graph analysis) graphs of control and connectivity, it is evident that higher degrees of direct purview are in accordance with higher values of control. So, it seems that spaces with higher values of direct purview are more visually dominating, but they accommodate shorter interactions.

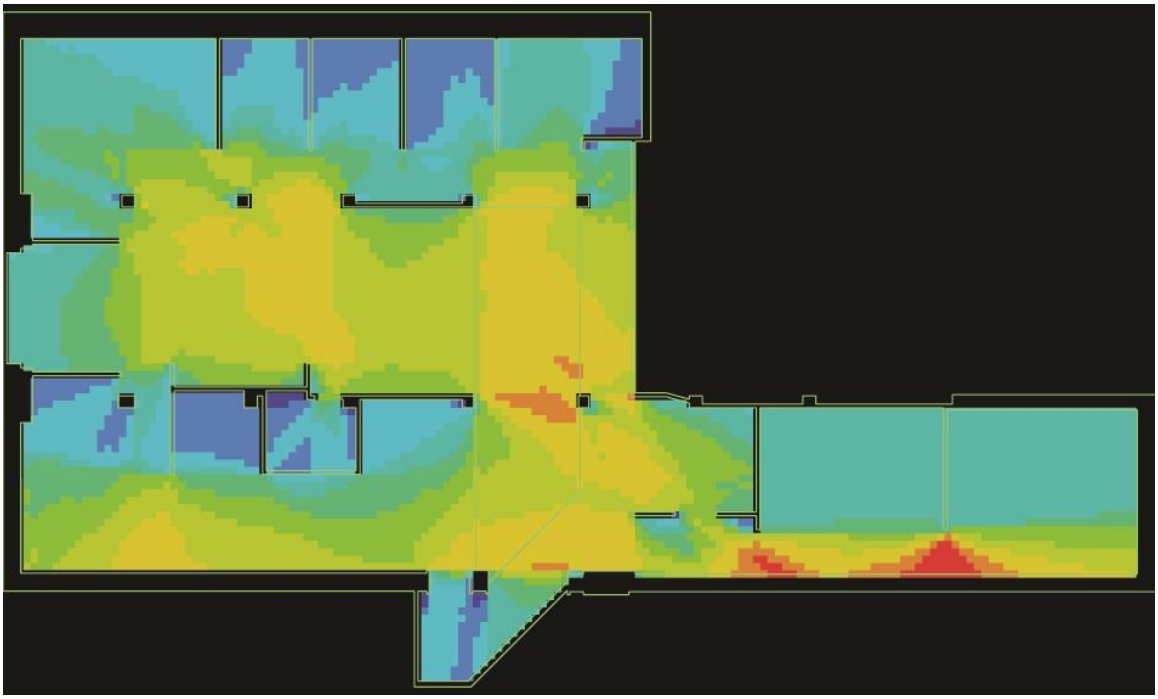


*Figure 4.10 DepthmapX graph of control measure.*

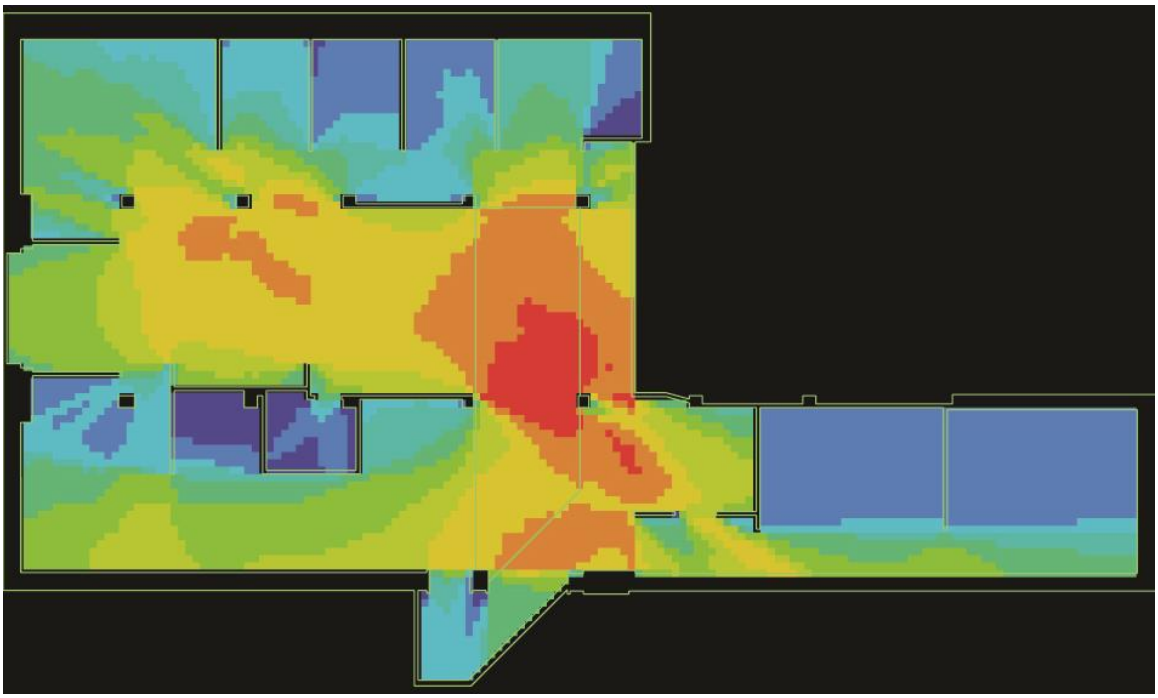


*Figure 4.11 DepthmapX graph of connectivity measure.*

3. *How is the duration of interactions related to the proportion of females after the effects of the type of interactions, average indirect purview (AIP), and the function of the space are taken into account?*

The semi-partial squared correlation for proportion of females is 0.009, which shows the proportion of females in interactions is uniquely responsible for only about 1% of the total variance of the dependent variable (i.e. duration of interactions) after the effects of the type of interactions, average indirect purview (AIP), and the function of the space are taken into account. The plot of the proportion of females in interaction against the duration of interactions is shown below (Figure 4.12). As it is evident in the plot, the duration of an interaction decreases as the proportion of females in an interaction increases. Although there

is a slight curvature to the plot, the descending values of the duration of interaction is evidently related to the increase of the number of female employees in interactions. It seems that male employees engage in more durable interactions than women.

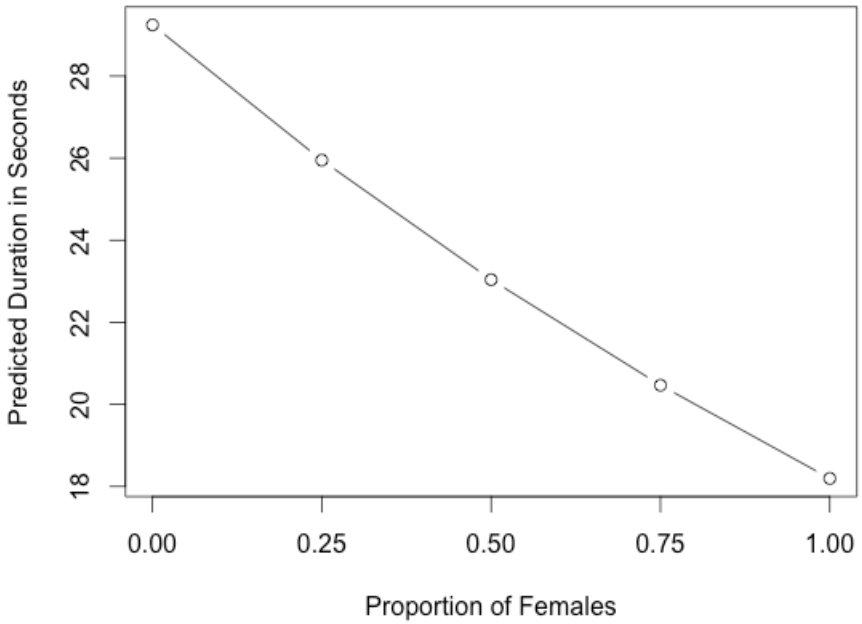



*Figure 4.12 The relationship between the proportion of females in interaction against the duration of interactions.*

4. *Is there a difference between the mean duration of the two types of interactions (programmed and un-programmed interactions) after the effects of average indirect purview (AIP), function of the space and the proportion of females are taken into account?*

Considering the semi-partial squared correlation for the type of interactions (0.198), it can be concluded that the type of interaction uniquely accounts for about 20% of the total variance of the duration of interactions if the effects of average indirect purview (AIP), function of the space and the proportion of females are held constant at their typical values.

The mean difference between the predicted durations of programmed and un-programmed interactions (estimated by the regression model while all other independent variables were constant in their typical value) is 184.103 seconds meaning that programmed interactions are predicted to be 184.103 seconds (about 3 minutes) longer than the un-programmed interactions, on average.

Another way of calculating the difference between the duration of programmed and un-programmed interaction is to use the actual duration values. The mean duration of all programmed interactions was 373.6 seconds (6.23 minutes), while the mean duration of all un-programmed interactions was 52.6 seconds (0.88 minutes). Therefore, although the number of programmed interactions (58) is 6 times less than un-programmed encounters (353), programmed interactions lasted more than 6 times longer than un-programmed interactions, on average.

By taking a close look at Figure 4.13 depicting the relationship between the actual observed values of indirect purview and the duration of both types of interactions occurred in each space, it is evident that programmed interactions are mostly cluttered in the left half of the graph where indirect purview is higher. It means programmed interactions mostly happened in spaces with higher degrees of indirect purview.

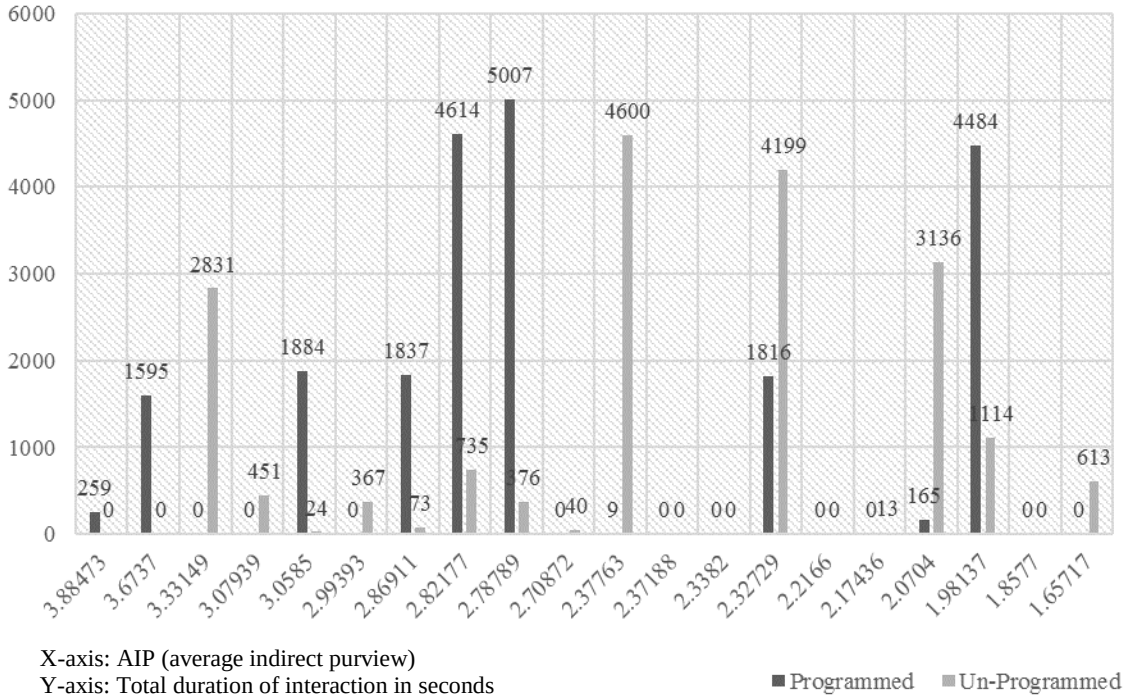



*Figure 4.13 Total duration by indirect purview (AIP) for both programmed and unprogrammed interactions.*

5. *How is the mean duration of interactions related to the different functions of the space (public, semi public/private, and private) after the effects of the type of interactions, average indirect purview (AIP), and the proportion of females are taken into account?*

For the function of the space, the semi-partial squared correlation is 0.012, which means 1.2% of the total variance in the duration of interaction is uniquely accounted by the function of the space after the effects of the type of interactions, average indirect purview (AIP), and the proportion of females are taken into account. To compare the difference between public, semi public/private and private function of the space in regard to the duration of interactions the following questions are to be answered. Figure 4.14 depicts different

functional use of the layout. According to the observed use of spaces, corridors, entrance foyer, kitchen, lounge, storage and the production studio are considered public spaces; work stations/shops as well as meeting rooms are categorized as semi public/private spaces; and private offices are considered to be private spaces.

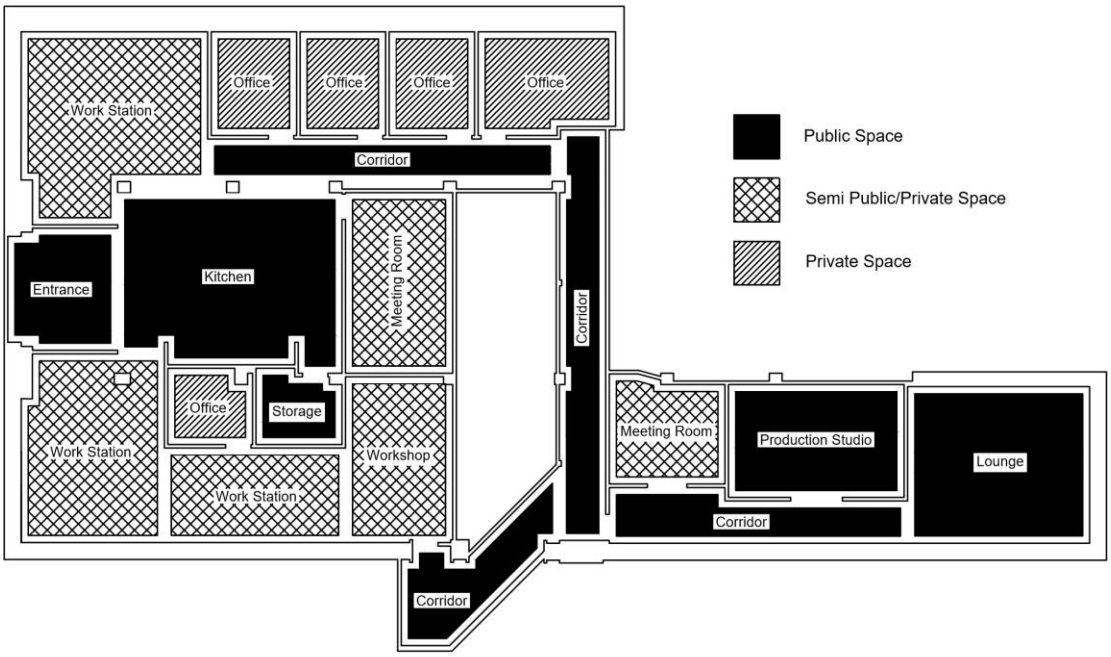



*Figure 4.14 Floor plan analysis in regard to its functional use, i.e. public, semi public/private, and private use.*

a. *Is there a difference in mean duration of interaction between public and private functions of the space after the effects of average indirect purview) AIP, type of interactions, and the proportion of females are taken into account?*

On average, the duration of interactions in public spaces are predicted to be 1.6 seconds longer than interactions that take place in private spaces. Although minimal,

generally longer interactions occur in public spaces (such as the kitchen) than private spaces (such as a private office).

b. *Is there a difference in mean duration of interaction between public and semi public/private functions of the space after the effects of average indirect purview (AIP), type of interactions, and the proportion of females are taken into account?*

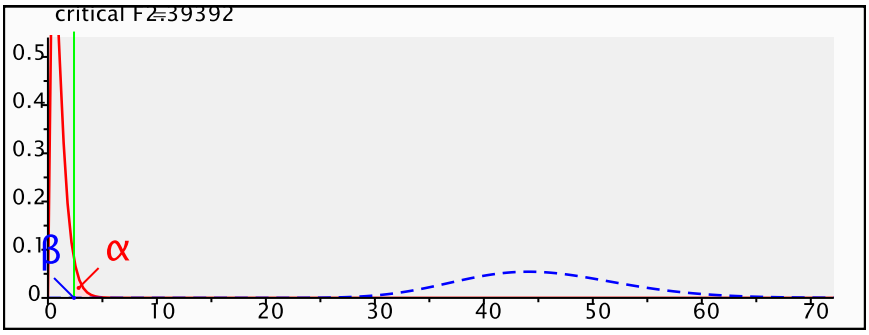
There is a considerable difference of 6.4 seconds between the duration of interactions occurred in public spaces versus those interactions happened in semi public/private spaces. Interactions that happened in semi public/private spaces (such as work areas) were longer, on average, than interactions occurred in public spaces (such as the kitchen).

c. *Is there a difference in mean duration of interaction between semi public/private and private functions of the space after the effects of average indirect purview (AIP), type of interactions, and the proportion of females are taken into account?*

In comparing the duration of interactions between semi public/private and private functions of the space, the average duration of interactions occurred in semi public/private spaces (such as a work area) is 8 seconds longer than those of interactions happened in private spaces (such as a private office). This is the largest difference found among different functions.

**Post-hoc Power Analysis**

Because the number of independent variables in the final model is 4, the minimum sample size for achieving an adequate level of statistical power is estimated to be 108 social interactions. In this study, the number of recorded interaction was 411, which is much more than the minimum required sample size. This can result in high statistical power and consequently stronger evidence on the generalizability of the results. The outcome of a post hoc power analysis using G*Power (Heine, 2016) indicated that the reliability of the results reached the statistical power of 100%. Detail output from G*Power are presented in Figure 4.15. A high degree of statistical power was expected because the obtained sample size was based on including all of the potential independent variables in the model and also because the selected independent variables account for a large percentage of variance in the dependent variables (30%).




**F tests -** Linear multiple regression: Fixed model, $R^2$ deviation from zero

| | | | |
|---|---|---|---|
| **Analysis:** | Post hoc: Compute achieved power | | |
| **Input:** | Effect size $f^2$ | = | 0.4291856 |
| | α err prob | = | 0.05 |
| | Total sample size | = | 411 |
| | Number of predictors | = | 4 |
| **Output:** | Noncentrality parameter λ | = | 176.3953 |
| | Critical F | = | 2.3939174 |
| | Numerator df | = | 4 |
| | Denominator df | = | 406 |
| | Power (1-β err prob) | = | 1.0000000 |

*Figure 4.15 Detailed output from G*Power for an ad-hoc power analysis.*

# Chapter 4: Discussion and Conclusion

The chapter aims to answer the main research question, (i.e. *how does the visual affordance of the spatial layout of a work environment influence the way employees interact?)* through unveiling the rationale behind results of the statistical as well as the descriptive analysis. As such, results of this study are compared and contrasted with results of previous research, to construct a solid rational basis for the findings. Concluding remarks on implications of findings as well as limitations of this study will wrap up this chapter at the end.

In this chapter, primarily visual properties of the space are elaborated in the discussion as well as the concluding remarks. Although type of interaction is not a visual property of the space, it can be considered related to visibility measures of the space because type of interaction signifies different categories of face-to-face encounters which, according to the literature, is directly related to the visibility of the spatial layout. Also, based on the results of the statistical analysis, type of interactions is the most influential factor predicting the duration of interactions. Although the contribution of the proportion of females participating in interactions turns out to be significant in predicting the duration of interaction, because it is not a visual property of the space or at least a related factor, it is not discussed in this chapter. However, the inclusion of this variable (i.e. proportion of females) as a control variable in the regression model helped in achieving a clearer picture about the contribution of visual properties of the space on the duration of interactions among employees.

**Impact of Direct and Indirect Purview on Duration of Interactions among Employees**

According to the results of the statistical analysis, the more durable interactions are expected to occur in spaces with higher degrees of indirect purview, if the impact of type of interaction, the function of the space, and the proportion of females involved in the interactions are held constant at their typical values. It is worth reminding that mean depth is the building block of indirect purview. Because higher degrees of indirect purview are associated with higher degrees of mean depth, the ascending trend in the relationship between indirect purview and the duration of interaction indicates that more durable interactions are predicted to occur in spaces located in deeper positions within the spatial layout. Since deeper spaces are less visually accessible, it can be argued that more durable interactions are expected to happen in spaces that are less visually dominated.

Also, according to results of this study, lower values of controllability are associated with higher values of indirect purview and consequently more durable interactions. In other words, it seems that employees feel more comfortable to have longer conversations in spaces that are harder to be dominated visually. Also, results of this study showed that less integrated spaces are more desirable places in the firm to have longer interactions. This resonates well with Rashid et al (2006) results. The authors found that less integrated spaces accommodated more interactions. In explaining employees' behavior, the authors stated that fewer interactions were observed in spaces "with higher integration values… It is as if they avoided interacting with others in spaces and being seen with others from spaces with more visibility and accessibility" (Rashid et al, 2006, pp.840-841).

As mentioned in Chapter 4: Results, higher values of indirect purview are correlated with lower values of direct purview as well as longer duration of interactions, so it can be argued that the longer is the visual path of directional accessibility of a space (i.e. indirect purview) from all other spaces in the spatial layout, the lower is the direct visual accessibility of that space (i.e. direct purview). In addition, according to findings of the statistical analysis, the contribution of average direct purview (AIP) in the dependent variable turned out to be more significant than average direct purview (ADP). Therefore, it seems that indirect (perceptual) visual accessibility of the space (i.e. indirect purview) is more important than direct (actual) visual accessibility of the space (i.e. direct purview) in regard to their impacts on durable interactions. In other words, it seems that in comparison with areas employees could see around them (i.e. area of the surrounding environment immediately available through sight), employees' perception of directional accessibility of the layout (i.e. the perception of the depth of the space) was of greater help to them to mentally pinpoint deeper places of the layout in which they could feel less visually exposed to their surrounding environment to freely talk for a longer time. It is worth mentioning that direct purview of a space is about the potential of the space to visually dominate spaces immediately connected to it; it is not about how much the space is being visually dominated. But from the user's perspective, it can be argued that the less s/he can see of the surrounding spaces, s/he may assume that s/he is less exposed to others as well. Technically, this perception does not always stand correct. But this perception may put the user of the space at ease of having a desired level of privacy, hence s/he can freely talk for a longer time.

As reported in Chapter 4" Results, higher values of control are associated with higher degrees of direct purview of the space. This means spaces with higher values of direct

purview are more visually dominating, but can accommodate shorter interactions, as users of highly controlling spaces may feel too exposed to make long interactions. This finding is aligned with results of Rashid et al (2006) in which the authors argued that employees were more socially active in less connected spaces. To explain their findings, Rashid et al (2006) stated that employees were seemingly reluctant to interact in highly connected spaces where they are more visually exposed. Here, it seems necessary to note that although the study by Rashid et al (2006) was about the frequency (quantity) of interactions at work, the outcome of their study can also be insightful in relation to the results of this study exploring duration (quality) of interactions at work (this stands true for the rest of discussions in this chapter as well).

**Impact of the Type of Face-to-face Interaction on Duration of Interactions among Employees**

According to the results of this study, programmed interactions are significantly longer than un-programmed interactions. On average, programmed interactions lasted over six times longer than un-programmed interactions although the number of programmed interactions were about six times less than un-programmed interactions. This is not an unexpected result because programmed interactions, such as scheduled meetings or other planned encounters, are longer in nature than un-programmed interactions, such as ad-hoc unplanned encounters created by bumping into one another or quickly stopping by desks/offices. Results of the study conducted by Peponis et al (2007) on the interrelationship between the spatial layout and employees' interactions at work also pointed to the longer duration of planned interactions.

According to previous studies, while programmed interactions were mostly observed to happen in meeting rooms or individual offices, i.e. enclosed spaces (Bartlett & Ghoshal, 1998; Varlander, 2012), un-programmed interaction happened almost anywhere as the result of co-presence and movement (Peponis et al, 2007; Peponis & Wineman, 2002). Results of this study show that programmed interactions are mostly occurred in spaces with higher degrees of indirect purview located in deeper positions of the layout which are mainly enclosed spaces. This is because programmed interactions cannot happen anywhere as they need to be scheduled to happen in a specific space so everyone knows where to find others. Programmed interactions require higher degrees of privacy, so they need to happen in enclosed spaces such as meeting rooms or private offices. This can be regarded as another explanation for why more durable interactions were observed to happen in deeper spaces with higher degrees of indirect purview. In fact, because programmed interactions are to happen in enclosed and more private spaces, spaces located in deeper positions in the layout could potentially be more appropriate for programmed interactions, which are longer in nature. Therefore, higher degrees of visual privacy (or lower degrees of visual exposure) may not always be the reason behind the occurrence of longer interactions in visually controlled/dominated spaces. According to the statistical results of the study, while AIP (average indirect purview) uniquely accounts for only 1% of the total variance of the dependent variable, type of interaction uniquely accounts for about 20% of it. This clearly shows that in predicting where more durable interactions are to happen in the layout, type of interaction is much more important than the perception of having more visual privacy (that can be found in spaces located in deeper locations due to their lower visual exposure).

**Impact of the Functional Use of the Space on Duration of Interactions among Employees**

Aligned to the findings of the study conducted by Rashid et al (2006), results of this research study showed that although functional program of the space does not have a strong impact on interactions, it can be regarded as a predictor of the occurrence of durable interactions. Among the three types of functions (i.e. public, semi public/private, and private), semipublic/private use of the space seems to have a higher potential to hold more durable interactions with considerable difference with the other two functions of the space, i.e. public and private functions.

This result can be explained by considering that semi public/private spaces are more socially active in relation to the diversity of space use. This is because semi public/private territories accommodate both of the public as well as private uses. Rashid et al (2006), argue that recent office designs encompass small private offices to push the interaction out to semi public/private and public territories. The authors believe that this may be due to the controlling policies of the organizations willing to visually control interactions among their employees. This explanation can also be regarded as a valid reason for the more durable interactions to happen in semi public/private spaces. This is because W also encompasses small private offices. In addition, most of the dividing partitions and walls were made of transparent materials to allow for maximum visibility which may be because of the firm's policy in regard to the visual control of its employees. However, this cannot be the only reason behind finding more durable interactions in semi public/private spaces in W, because if so, there should not be a considerable difference between semi public/private spaces and public spaces in holding more durable interactions in them. Since the results of statistical

analysis show the difference is statistically considerable (specially in relation to inconsiderable results of public and private territories), it can be concluded that the social/functional use of the space is an importance predictor of more durable interactions.

**Conclusion**

In this research study, visibility of the spatial layout is considered in mental/perceptual and actual/visual capacities. While as a perceptual quality, visibility is the mental map of the layout signifying the directional accessibility of the space (i.e. indirect purview of the space), as a visual quality, visibility is the actual space surveyed through sight (i.e. direct purview of the space). Both direct and indirect purviews are regarded as influential on employees' perception of visual control in the space. Because direct purview is based on actual visibility of the space, it signifies the level of visual control/access a space may provide for its users. Indirect purview is related to the depth and directional accessibility of the space, so it signifies spaces that can be dominated visually.

In regard to the user experience, users of spaces with lower degrees of indirect purview consider themselves to be visually dominated; also, users of spaces with higher degrees of direct purview can feel to be visually exposed, (although in actuality they are visually dominating their surroundings). As discussed, the findings of this study as well as previous studies point to the impact of visual control on interacting behavior of employees. It seems that employees tend to talk shorter and less frequently in spaces that are dominated visually (spaces with lower values of indirect purview) or felt to be visually exposed (spaces with higher values of direct purview). These findings highlight the importance of

organizational policies in regard to the visual control of employees that has the potential to limit their freedom at work.

Another form of perceptual visibility of a spatial layout is the perception of the functional use of a space (i.e. public and/or private use of the space) that can affect employees' interacting behavior. As discussed, semi public/private spaces are predicted to accommodate more durable interactions. According to literature, the benefit of multifunctional spaces is that they bring together public and private uses, adding flexibility and autonomy to employees' work environments. Previous studies point to advantages as well as disadvantages of merely public and/or merely private spaces. For example, Varlander (2012) argued that on one hand an open office layout can improve interactions among employees by providing higher degrees of visual affordance of the space, as well as bringing more number of employees together to interact, on the other hand, an open office layout can hinder privacy and increase peer as well as supervisor surveillance which can be destructive to employees' freedom and individual flexibility. Thus, while a merely open/enclosed space may be desirable to some employees, it can be undesirable to others at the same time. Therefore, a flexible work environment accommodating both types of the public and private uses can be regarded as a suitable work setting as it can address employees' changing needs. However due to the diversity of use, semi public/private territories cannot function successfully if the organizational policy does not respect personal control of employees over their immediate work environments which is directly affected by design. As discussed in the review of literature, organizational policies can define constraints hindering employees' freedom and autonomy regarding the use of workplaces. Design-related controlling policies try to enforce a single solution to everyone regardless of individual and situational

differences that may exist among employees. In fact, these restrictions make the physical environment a static reality that does not have the capability to accommodate everyone's needs. Therefore, in order for semi public/private places to function well and can be regarded as an organizational resource in improving the quality, quantity, as well the formation of interaction among employees, individual freedom and personal flexibility in relation to the use and the interactions with the physical work environment should be regarded as important considerations in organizational policy.

In general, although the overall spatial layout of a work environment is a static reality, the potential functional use as well as the visual affordance of it can be flexible. Affordance of the space in providing desirable functional use and visual control is an important factor for perceiving a spatial layout as an organizational asset in supporting employees' professional as well as social needs at work. Results of this study can be insightful for practitioners to not have a simplistic perspective on the influential impact of spatial layouts on organizational changes leading to success. The naïve notion of an open design layout cannot always be considered beneficial to organizations, as also noted by Varlander (2012). Therefore, a flexible design that accommodates the different professional as well as personal needs of its employees seems to be a suitable strategy in addressing individual flexibility and freedom at work. However, this design strategy cannot be achieved without changes in organizational policies that restrict employees' freedom in personalizing their work environments.

In regard to the limitations of this study, an external validity caveat should be taken into consideration. Because results are specifically descriptive to W's layout, it cannot be claimed that the cases (here, the interactions) "reflect the characteristics of the population"

(Frankfort-Nachmias & Nachmias, 2008, p.97). Thus, the external validity of the findings can be questioned. In fact, because the impact of spatial layout on human interactions at work is to study in a natural setting, results cannot be generalizable to other work environments although statistical findings are mathematically generalizable. However, it seems crucial for future studies to consider the application of statistical analysis in their research studies (quantitative or mixed-methods studies) as it can make it possible for the researcher to get a clear understanding on even the smallest nuances in the variability as well as the predictability of research phenomena. If researchers are to take advantage of statistics in their research endeavors, a close attention should be paid to a large enough sample size to appropriately represent the population in order to reach a robust statistical power. This requirement was not met in many of the research studies conducted investigating the impact of spatial properties on social interactions at work, in which space was considered as the unit of analysis. Because the lack of enough spatial units in small work environments can cause validity issues, researchers can consider larger corporate offices (such as corporate headquarters) to conduct their studies if they are to set the unit of analysis on spatial units. As this study suggests, interactions can also be chosen as the unit of analysis. The advantage of adopting an interaction as the unit of analysis is that the data collection procedure can be continued until a large enough sample size is acquired. However, in order for he finding to be generalizable across the research settings, the number of similar studies should be increased. Trends generalized from multiple studies, can explain the relationship between spatial properties of work settings and their social attributes. this calls for more systematic research studies on the impact of spatial layout on human interactions at work.

## Bibliography


Allen, T. J. (1984). *Managing the flow of technology: Technology transfer and the dissemination of technological information within the R&D organization.* Cambridge, MA: MIT Press.

Amabile, T. M. (1989). The creative environment scales: Work environment inventory. *Creativity Research Journal, 2,* 231–253.

Amabile, T. M. (1996). *Creativity in context.* Boulder, CO: Westview Press.

Amabile, T. M., Conti R., Coon, H., Lazenby. J., & Herron, M. (1996). Assessing the work environment for creativity. *The Academy of Management Journal, 39,* 11 54-1184.

Amason, A., & Sapienza, H. (1997). The effect of top management team size and interaction norms on cognitive and affective conflict. *Journal of Management, 23,* 495-516.

Ancona, D. G., & Caldwell, D. F. (1992). Bridging the boundary: External activity and performance in organizational teams. *Administrative Science Quarterly , 37*, 634-665.

Anderson, J. G. (1991). Stress and burnout among nurses: A Social network approach. *Journal of Social Behavior and Personality, 6*, 251-272.

Bach, F. W. (1965). The whys and wherefores of the open-plan office. *Kommunikation*, *1*, 103-106.

Bafna, S. (2003). Space syntax: A brief introduction to its logic and analytical technologies. *Environment and Behavior , 35* (1), 17-29.

Barker, M.L. (1968). *Ecological psychology*. Stanford, CA: Stanford University Press.

Barron, F. (1969*). Creative person and creative process*. New York: Holt, Rinehart & Winston.

Bartlett, C. A., & Ghoshal, S. (1998). Beyond strategic planning to organization learning: Lifeblood of the individualized corporation. *Strategy & Leadership*, *26*, 34-39.

Bateman, T. S., & Crant, J. M. (1993). The proactive component of organizational behavior: A measure and correlates. *Journal of Organizational Behavior, 14*, 103–118.

Benedikt, M. L. (1979). To take hold of space: Isovists, isovist fields. *Environment and Planning B: Planning and Design , 6*, 47-65.

Blanding, M. (2011). *Getting to eureka!: How companies can promote creativity?* Boston: Harvard Business School.

Bowers, M., Waddell, J., & McCarthy, M. (2010). A developmental sex difference in hippocampal neurogenesis is mediated by endogenous oestradiol. *Bioogy of Sex Difference, 1*(8). Retrieved from http://www.bsd-journal.com/content/1/1/8

Brennan, A., Chugh, J. S., & Kline, T. (2002). Traditional versus open office design: A longitudinal field study. *Environment and Behavior, 34*, 279-299.

Brown, M. G. (1991). Multi-cell analysis.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization Science , 2* (1), 40-57.

Chan, D. (2006). Interactive Effects of Situational Judgment Effectiveness and Proactive Personality on Work Perceptions and Work Outcomes. Journal of Applied Psychology, 91(2), 475-481.

Chapple, E. D. (1940). Measuring human relations: An introduction to the study of the interaction of individuals. *Genetic Psychology Monographs*, 22, 3-147.

Chen, W., Siu, O., Lu, J., Cooper, C., and Philips, D. (2009). Work stress and depression: The direct and moderating effects of informal social support and coping. *Stress and Health, 25*, 431-443.

Chiorri, C., Bracco, F., Piccinno, T., Modafferi, C., & Battini, V. (2015). Psychometric properties of a revised version of the ten item personality inventory. *European Journal of Psychological Assessment, 31*(2), 109–119.

Cohen, S., and Wills, T. A. (1985). Stress, informal support, and the buffering hypothesis. *Psychological Bulletin, 98,* 310-357.

Costa, P. T., & McCrae, R. R. (1992a). Four ways five factors are basic. *Personality and Individual Differences, 13,* 653-665.

Costa, P. T., & McCrae, R. R. (1992b). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual.* Odessa: Psychologycal Assessment Resources.

Crant, J. M. (2000). Proactive behavior in organizations. *Journal of Management, 26,* 435–462.

Crede, M., Harms, P., Niehorster, S., & Gaye-Valentine, A. (2012). An evaluation of the consequences of using short measures of the Big Five Personality Traits. *Journal of Personality and Social Psychology, 102*(4), 874–888.

Creswell, J. W. (2014). Research design: Qualitative, quantitative and mixed methods approaches. LA: Sage.

Cross, R., & Borgatii, S. P. (2002). Making invisible work visible: Using social network analysis to support strategic collaboration. *California Management Review , 44*, 25-46.

Dawson, P. C. (2008). Unfriendly architecture: Using observations of inuit spatial behavior to design culturally sustaining houses in arctic Canada. *Housing Studies, 23*(1), 111–128.

Dean, A. O. (1977). The pros and cons and future prospects of open landscaping. *AIA Journal, 66*, 46-47.

Desyllas, J., & Duxbury, E. (2001). Axial maps and visibility graph analysis. In *Proceedings, 3rd International Space Syntax Symposium* (Vol. 27, pp. 21-13).

Ferris, G. R., Treadway, D. C., Kolodinsky, R. W., Hochwarter, W. A., Kacmar, C. J., Douglas, C., & Frink, D. D. (2004). Development and validation of the political skill inventory. *Journal of Management, 31*, 126–152.

Fischer, G. (2005). Social creativity: Making all voices heard. Boulder, CO, USA.

Fitzgerald, C. J., & Danner, K. M. (2012). Evolution in the office: How evolutionary psychology can increase employee health, happiness, and productivity. *Evolutionary Psychology*, *10*(5), 770-781.

Frankfort-Nachmias, C., & Nachmias, D. (2008). *Research Methods in the Social Science.* New York: Worth Publishers.

Gamal, D., Salah, T., & Elrayyes, N. (2011). *How to measure organizational inoovativeness.* Cairo: TIEC.

Ganster, D. C. (1989). Worker control and well-being: A review of research in the workplace. In S. L. Sauter, J. J. Hurrell, and C. L. Cooper (Eds.), *Job control and worker health* (pp.3-23). Chichester, Uk: Wiley.

Georgiou, M. (2006). Architectural privacy: A topological approach to relational design problems. *M.Sc. thesis*, London: University College London (UCL).

Gilbert, N., Pyka, A., & Ahrweiler, P. (2001). Innovation networks--A simulation approach. *Journal of Artificial Societies and Social Simulation , 4* (3), 1-21.

Gosling, S. D., Rentfrow, P. J., & Swann, W. B. (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality, 37*, 504–528.

Grajewski, T. (1992). *Interaction in the work environemnt.* London: Unpublished PhD Thesis, University College London.

Guido, G., Peluso, A. M., Capestro, M., & Miglietta, M. (2015). An Italian version of the 10-item Big Five Inventory: An application to hedonic and utilitarian shopping values. *Personality and Individual Differences, 76*, 135–140.

Hahn, E., Gottschling, J., & Spinath, F. M. (2012). Short measurements of personality – Validity and reliability of the GSOEP Big Five Inventory (BFI-S). *Journal of Research in Personality, 46*, 355–359.

Halbesleben, J. R. B. (2006). Sources of social support and burnout: A meta-analytic test of the conservation of resources model. *Journal of Applied Psychology*, *91*, 1134–1145.

Hall, J. A. (1984). *Nonverbal sex differences: Communication accuracy and expressive style*. Baltimore: The Johns Hopkins University Press.

Hargadon, A., & Sutton, R. I. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly , 42*, 716-749.

Heerwagen, J. H., Kampschroer, K., Powell, K. M., & Loftness, V. (2004). Collaborative knowledge work environments. *Building Research and Information , 32* (6), 510-528.

Heine, H. (2016). *Allgemeine Psychologie und Arbeitspsychologie*. Retrieved from G.Power: http://www.gpower.hhu.de/en.html

Hillier, B. (2012). Studying cities to learn about minds: Some possible implications of space syntax for spatial cognition. *Environment and Planning B: Planning and Design, 39*, 12-32.

Hillier, B., & Grajewski, T. (1987). *The application of space syntax to work environment inside buildings.* London: University College London.

Hillier, B., & Hanson, J. (1984). *The social logic of space.* Cambridge: University Press.

Hillier, B., & Penn, A. (1991). Visible colleges: Structure and randomness in the place of discovery. *Science in Context , 4*, 23-49.

Howells, J. R. (2002). Tacit knowledge, innovation and economic geography. *Urban Studies , 39* (5-6), 871-884.

Huang, K., & Kuo, W. (2011). Does humor matter? From organization management perspective. *Journal of social Sciences, 7* (2), 141-145

Isaksen, S. G. (2009). Milieus of creativity: Exploring the relationships between problem-solving style and creative psychological climate. In P. Meusburger, J. Funke, & E. Wunder, *Milieus of Creativity: An Interdisciplinary Approach to Spatiality of Creativity* (pp. 169-188). Springer.

James, D., & Drakich, J. (1993). Understanding gender differences in amount of talk: A critical review of the research. In D. Tannen (Ed.), *Gender and conversational interaction* (pp. 281-312). New York: Oxford University Press.

John, O. P., Donahue, E. M., & Kentle, R. L. (1991). *The Big Five Inventory - Version 44 and 54.* Berkeley: University of California at Berkeley, Institute of Personality and Social Research.

John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative Big-Five trait taxonomy: History, measurement, and conceptual issues. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), *Handbook of Personality: Tjeory and Research* (pp. 114-158). New York: Guilford Press.

John-Steiner, V. (2000). *Creative collaboration.* New York: Oxford University Press.

Kanter, R. M. (1988). When a thousands flowers bloom: Structural, collective, and social conditions for innovation in organization. In B. Staw, & L. L. Cummings, *Research in Organizational Behavior* (pp. 196-211). New York: JAI Press.

King, E. B., George, J. M., & Hebl, M. R. (2005). Linking personality to helping behaviors at work: An interactional perspective. *Journal of Personality, 73*(3), 585–608.

Laing, A., Craig, D., & White, A. (2011). *High-performance office space.* New York: Harvard Business Review.

Laing, A., Duffy, F., Jaunzens, D., & Willis, S. (1998). *New environment for working: The redesign of offices and environmental systems for new ways of working.* Construction Research Communications Ltd., London.

Lee, S. Y., & Brand, J. L. (2005). Effects of control over office workspace on perceptions of the work environment and work outcomes. *Journal of Environmental Psychology, 25,* 323-333.

Leenders, R. T. A. J., Van Engelen, J. M. L., & Kratzer, J. (2003). Virtuality, communication, and new product team creativity: A social network perspective. *Journal of Engineering and Technology Management, 20,* 69–92.

Lehmann-Willenbrock, N., & Allen, J. A. (2014). How fun are your meetings? Investigating the relationship between humor patterns in team interactions and team performance. *Journal of Applied Psychology*, *99*(6), 1278.

Lin, I. Y., & Kwantes, C. T. (2015). Potential Job Facilitation Benefits of "Water Cooler" Conversations: The Importance of Social Interactions in the Workplace. *The Journal of psychology*, *149*(3), 239-262.

MacKinnon, D. (1962). The nature and nurture of creative talent. *American Psychologist, 17,* 484–495.

Martin, R. L. (2009). *The design of business: Why design thinking is the next competitive advantage*. Boston: Harvard Business Press.

Mascitelli, R. (2000). From experience: Harnessing tacit knowledge to achieve breakthrough innovation. *Journal of Product Innovation Management , 17,* 179-193.

McCoy, J. M., & Evans, G. W. (2002). The potential role of the physical environment in fostering creativity. *Creativity Research Journal , 14,* 409–426.

Meusburger, P. (2009). Milieus of creativity: The role of places, environments, and spatial contexts. In P. Meusburger, J. Funke, & E. Wunder, *Milieus of Creativity: An Interdisciplinary Approach to Spatiality of Creativity* (pp. 97-153). Springer.

Meusburger, P., Funke, J., & Wunder, E. (2009). The spatiality of creativity. In P. Meusburger, J. Funke, & E. Wunder, *Milieus of Creativity: An Interdisciplinary Approach to Spatiality of Creativity* (pp. 1-10). Springer.

Meyer, J. C. 1997. Humor in member narratives: Uniting and dividing at work. *Western Journal of Communication,* 61(2): 188–208.

Monge, P. R., Cozzens, M. D., & Contractor, N. S. (1992). Communication and motivational predictors of the dynamics of organizational innovation. *Organization Science, 3,* 250–274.

Morone, P., & Taylor, R. (2004). Knowledge diffusion dynamics of face-to-face interactions. *Journal of Evolutionary Economics , 14,* 327-351.

Morone, P., & Taylor, R. (2010). *Knowledge diffusion and Innovation: Modelling complex entrepreneurial behaviors.* Northampton, MA: Edward Elgar.

Morris, A., & Feldman, D. (1997). Managing emotions in the workplace. *Journal of Managerial Issues*, *9*(3), 257-274. Retrieved from http://www.jstor.org/stable/40604147

Mustafa, F. Hassan, A., Baper, S. (2010). Using Space Syntax Analysis in Detecting Privacy: A Comparative Study of Traditional and Modern House Layouts in Erbil City, Iraq. Asian Social Science, 6(8), 157-166.

Mutz, D. C., & Mondak, J. J. (2006). The Workplace as a Context for Cross-Cutting Political Discourse. *Journal of politics*, *68*(1), 140-155.

Nelson, R. R., & Rosenberg, N. (1993). technical innovation and national systems. In R. R. Nelson, *National innovation systems: A comparative analysis* (pp. 3-22). Oxford: Oxford University Press.

Nonaka, I., & Konno, N. (1998). The concept of "ba": Building a foundation for knowledge creation. *California Managament Review , 40*, 40-54.

Oerlemans, L., Meeus, M., & Boekema, F. (1998). Learning, innovation and proximity. *Eindhoven Center for Innovation Studies, The Netherlands* , Working Paper 98.3.

Oksanen, T., Kouvonen, A., Kivimäki, M., Pentti, J., Virtanen, M., Linna, A., & Vahtera, J. (2008). Social capital at work as a predictor of employee health: multilevel evidence from work units in Finland. *Social science & medicine*, *66*(3), 637-649.

Onnela, J.-P., Waber, B., Pentland, A., Schnorf, S., & Lazer, D. (2016). *Using sociometers to quantify social interaction patterns.* Retrieved from Nature.com: http://www.nature.com/articles/srep05604#ref15

Oldham, G. R. (1988). Effects of changes in workspace partitions and spatial density on employee reactions. A quasi-experiment. *Journal of Applied Psychology*, *73*, 253-258.

Park, K., Wilson, M., Lee, M. (2004). Effects of social support at work on depression and organizational productivity. *American journal of health behavior, 25*(5), 444-455.

Parsons, H. M. (1976). Work environments. In I. Altman, J F Wohlwill, *Human behavior and environment: Advances in theory and research* (pp.163-209). New York: Springer.

Penn, A., Desyllas, J., & Vaughan, L. (1999). The space of innovation: Interaction and communication in the work environment. *Environment and Planning B: Planning and Design , 26*, 193-218.

Peponis, J. (2012). Building layouts as cognitive data: Purview and purview interface. *Cognitive Critique*, *6*, 11-51.

Peponis, J., Bafna, S., Bajaj, R., Bromberg, J., Congdon, Ch., Rashid, M., Warmels, S., Zhang, Y., Zimring, C. (2007). Designing space to support knowledge work. *Environment and Behavior, 39*(6), 815-840.

Peponis, J., & Wineman, J. (2002). The spatial structure of environment and behavior. In R. Bechtel & A. Churchman (Eds.), *Handbook of Environmental Psychology* (pp. 271-291). New York: John Wiley and Sons.

Pinch, S., Henry, N., Jenkins, M., & Tallman, S. (2003). From "industrial districts" to "knowledge clusters": A model of knowledge dissemination and competitive advantagein industrial agglomeration. *Journal of Economic Geography , 3*, 373-388.

*Pixar Campus.* (2014). Retrieved March 20, 2014, from all about Steve Jobs.com: http://allaboutstevejobs.com/pics/stevesplaces/pixar.php

*Pixar headquarters and the legacy of Steve Jobs.* (2014). Retrieved March 20, 2014, from Office Snapshots: http://officesnapshots.com/2012/07/16/pixar-headquarters-and-the-legacy-of-steve-jobs/

Porter, M. E., & Stern, S. (2001). Innovation: Location matters. *MIT Sloan Management Review , 42*, 28-36.

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality, 41*, 203–212.

Rashid, M., Kampschroer, K., Wineman, J., & Zimring, C. (2006). Spatial layout and face-to-face interaction in offices--A study of the mechanisms of spatial effects on face-to-face interaction. *Environemnt and Planning B: Planning and Design , 33*, 845-844.

Repko, A. F. (2008). Defining interdisciplinary studies. In A. F. Repko, *Interdicsiplinary Research* (pp. 3-26). Thousand Oaks, CA: Sage Publications, Inc.

Rogers, E. M. (1995). *Diffusion of Innovations.* New York: The Free Press.

Romero, E., Cruthirds, K. (2006). The use of humor in the workplace. Academy of Management Perspectives, 58-69.

Romero, E. J., & Pescosolido, A. (2008). Humor and group effectiveness. *Human Relations, 61,* 395–418. doi:10.1177/0018726708088999

Sailer, K. (2011). Creativity as social and spatial process. *Facilities , 29*, 6-18.

Sailer, K., & McCulloh, I. (2012). Social networks and spatial configuration-How office layouts drive social interaction. *Social Networks , 34*, 47-58.

Saint-Onge, H. (2005). *Collaborative knowledge and competitive advantage.* New Paradigm Learining Corporation.

Saucier, G. (1994). Mini-Makers: A brief version of the Goldberg's unipolar Big Five markers. *Journal of Personality Assessment, 63*(3), 506-516.

Schumpeter, J. (1934). *The theory of econimic developement.* Cambridge, MA: Harvard University Press.

Sonnenwald, D. H., & Lievrouw, L. A. (1996). Collaboration during the design process: A case study of communication, information behavior, and project performance. In P. Vakkari, R. Savolainen, & B. Dervin, *Information seeking in context: Preceedings of an international conference on research in information needs, seeking and use in different contexts* (pp. 179-204). London: Taylor Graham.

Steele, F. (1986). *Making and managing high-quality workplace: An organizational ecology.* New York and London: Teachers College Press.

Sternberg, R. J. (2009). Domain-generality versus domain-specificity of creativity. In P.Meusburger, J. Funke, & E. Wunder, *Milieus of creativity: An interdisciplinary approach to spaciality of creativity*. 25-38.

Sundstrom, E., & Altman, L. (1989). Physical environments and work-group effectiveness. *Research in Organizational Behavior, 11*, 175-209.

Suzuki, E., Takao, S., Subramanian, S. V., Komatsu, H., Doi, H., & Kawachi, I. (2010). Does low workplace social capital have detrimental effect on workers' health?. *Social science & medicine, 70*(9), 1367-1372.

Tabachnick, B. G., & Fidell, L. S. (2007). Using multivariate statistics, 5th.*Needham Height, MA: Allyn & Bacon*.

Taylor, W.C., King, K.E., Shegog, R., Paxton, R.J., Evans-Hudnall, G.L., Rempel, D.M., Chen, V. and Yancey, A.K., (2013). Booster Breaks in the workplace: participants' perspectives on health-promoting work breaks. *Health Education Research, 28*(3), 414-425.

Thiel, P. (1961). A sequence experience notation for architectural and urban space. *Town Planning Review, 32*, 33-52

Toker, U., & Gray, D. (2008). Innovation spaces: workspace planning and innovation in US university research centers. *Research Policy , 37,* 309-329.

Tornatzky, L. G., & Fleischer, M. (1990). *The Process of Technological Innovation.* Lexington: Lexington Books.

True, S. (1966). A study of the relation of general semantics and creativity. *Journal of Experimental Education , 34,* 34-40.

Turner, A. (2003). Analyzing the visual dynamics of spatial morphology. *Environment and Planning B: Planning and Design, 30*, 657-676.

Turner, A. (2004). Depthmap4: A researcher's handbook. London. Retrieved from http://www.vr.ucl.ac.uk/depthmap/depthmap4.pdf

Turner, A., Doxa, M., O'Sullivan, D., & Penn, A., (2001). From isovists to visibility graphs: A methodology for the analysis of architectural space. *Environment and Planning B: Planning and Design 28*(1) 103-121

Turner, A., & Penn, A., (1999). Making isovists syntactic: Isovist integration analysis, *Proceedings of the 2nd International Symposium on Space Syntax (3),* Universidad de Brasil, Brasilia: Brazil

Utts, J. M., & Heckard, R. F. (2006). *Statistical Ideas and Methods.* Belmount: Thomson Brooks/Cole.

Wanberg, C. R., & Kammeyer-Mueller, J. D. (2000). Predictors and outcomes of proactivity in the socialization process. *Journal of Applied Psychology*, *85*(3), 373–385.

Van Kleef, G. A. (2010). The emerging view of emotion as social information. *Soc. Pers. Psychol. Compass* 4, 331–343.

Van Scotter, J. R., & Motowidlo, S. J. (1996). Interpersonal facilitation and job dedication as separate facets of contextual performance. *Journal of Applied Psychology*, *81*, 525–531.

Värlander, S. (2012). Individual flexibility in the workplace a spatial perspective. *The Journal of Applied Behavioral Science*, *48*(1), 33-61.

Warr, P. (2007). *Work, happiness, and unhappiness.* Mahwah, N.J.: Lawrence Erlbaum Associates Publishers.

Weitzman, M. L. (1998). Recombinant growth. *The Quarterly Journal Economics , 113* (2), 331-360.

Westerman, J. W., & Simmons, B. L. (2007). The effects of work environment on the personality–performance relationship: An exploratory study. *Journal of Managerial Issues*, *19*(2), 288–305.

Wilson, N. (2010). Social creativity: Re-qualifying the creative economy. *International Journal of Cultural Policy , 16* (3), 367-381.

Wineman, J. D., & Serrato, M. (1998). Facility design for high performance teams. In E. Sundstrom, *Supporting work team effectiveness: Best management practicesfor fostering high performance* (pp. 271-298). San Fransisco, CA: Jossey-Bass.

Wong, E., Tschan, F., Messerli, L., & Semmer, N. K. (2013). Expressing and amplifying positive emotions facilitate goal attainment in workplace interactions. *Frontiers in psychology*, *4*, 188.

Woodman, R. W., Sawyer, J. E., & Griffin, R. W. (1993). Toward a theory of organizational creativity. *Academy of Management Review, 18,* 293–321.

Zammuner, V. L., & Galli, C. (2005). Wellbeing: Causes and Consequences of emotion rehulation in work settings. *International Review of Psychiatry, 17*(5), 355-364.

Zeisel, J. (2006). *Inquiry by Design.* New York: W. W. Norton & Company, Inc.

***Appendix A: Recruitment Email, Consent form, and the Questionnaire***

*Recruitment Email*

Dear Sir/Madam,

Mandana Motamed, is a PhD candidate at University of Minnesota. College of Design. Coming from an architecture background, Mandana's research concerns the relationship between spatial layout of work environments and social interaction of employees. Specifically she is asking "How does the visual accessibility of the spatial layout of a work environment influence the way employees interact?"

To answer the above research question, a survey questionnaire will be administered to all of the employees of W. Please find the link below. Ms Motamed will also conduct a behavioral observation by videotape. More information is provided in the consent form (i.e. the cover letter of the questionnaire below). The researcher is required to comply with the consent form. Participation is voluntary and you may opt out at any time.

Please note that all records of this study will be highly confidential. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Your creative ideas and works will be protected under restricted confidentiality. Research records will be stored securely and accessible only to the researcher, protected by passwords changed regularly to insure the highest data security. All records will be used only for research purposes and will not be displayed in other settings such as classrooms (for teaching) or conference presentations.

To complete the questionnaire, please click on the following link:

<>

You participation is appreciated.

Best regards,

W

*Consent Form*

**Role of visual affordance of a spatial layout on human interactions at a work environment**

You are invited to be in a research study of workplace design. You were selected as a possible participant because you are an employee at W. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Mandana Motamed, College of Design, University of Minnesota

**Background Information**

The purpose of this study is to explore how having visual access (in the form of a direct visual access to adjacent areas or a mental visual map of the workplace) can influence interactions among colleagues at work. The quality of the visual access is directly related to the way spaces are designed in relation to one another (i.e. the spatial layout of the workplace) and this study is designed to discover how this visual access affects the way employees interact with one another.

**Procedures**

If you agree to be in this study, we would ask you to fill out a questionnaire. The researcher (Mandana Motamed) will also videotape interactions that take place in each individual space. The video recorder will be attached to a wall. This procedure may take a few weeks until all of the required data is collected. While the device will record both visual and audio material, only the duration and the frequency of the visible interactions happening in each individual space is of interest to this research study not the acoustic content (spoken word) of these interactions. It is expected that those being taped will act normally and ignore the camera.

**Risks and Benefits of being in the Study**

There is no risk to participants and the findings of the study will reveal how the spatial arrangement of an office affects interaction between workers

**Confidentiality**

All records of this study will be highly confidential. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Your creative ideas and works will be protected under restricted confidentiality. Research records will be stored securely and accessible only to the researcher, protected by passwords changed regularly by the researcher to insure the highest data security. All records will be used only for research purposes and will not be displayed in other settings such as classrooms (for teaching) or conference presentations.

**Voluntary Nature of the Study**

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota or W. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

**Contacts and Questions**

The researcher conducting this study is Mandana Motamed who is a PhD candidate at the University of Minnesota, College of Design. If you have any questions or concerns, you are encouraged to contact her via her email address: <the researcher's email address was displayed here>. Also, Dr. Julia Robinson (the researcher's academic advisor was displayed here) is a full professor at University of Minnesota, College of Design and can be contacted either by her office phone number <the advisor's office phone number was displayed here>, her cell phone number (the advisor's cell number was displayed here) or via email: <the advisor's email address was displayed here>

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Research Subjects' Advocate Line, <the contact information of advocate line was displayed here>

***You will be given a copy of this information to keep for your records.***

**Statement of Consent**

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature:_____Date: _____

Signature of Investigator:_____Date: _____

*Questionnaire*

**Background Questions**

1. How old are you?
2. Please specify you gender (male or female).
3. What role/position are you currently hold at W?
4. How long have you been working at W?

**Behavioral/Attitudinal Questions**

1. In a typical workday, how many interactions (in average) you may have with your colleagues? And in which rooms/spaces are most of these interactions happening?
2. How do you think that visual access to your surrounding environments can affect your interactions with colleagues? Please explain.
3. How do you think that interaction with colleagues at work can be beneficial to you? Please explain.
4. When you work, do you like to be alone or you prefer to share a space with other people? Please explain.
5. Do you work mostly at your assigned work station/desk or do you move to other areas of the firm to work? Please explain.

**Personality Questions (BFI-10)**

Instruction: How well do the following statements describe your personality?

| I see myself as someone who… | Disagree Strongly | Disagree a little | Neither agree nor disagree | Agree a little | Agree strongly |
|---|---|---|---|---|---|
| … is reserved | (1) | (2) | (3) | (4) | (5) |
| … is generally trusting | (1) | (2) | (3) | (4) | (5) |
| … tends to be lazy | (1) | (2) | (3) | (4) | (5) |
| … is relaxed, handles stress well | (1) | (2) | (3) | (4) | (5) |
| … has few artistic interests | (1) | (2) | (3) | (4) | (5) |
| … is outgoing, sociable | (1) | (2) | (3) | (4) | (5) |
| … tends to find faults with others | (1) | (2) | (3) | (4) | (5) |
| … does a thorough job | (1) | (2) | (3) | (4) | (5) |
| … gets nervous easily | (1) | (2) | (3) | (4) | (5) |
| … has an active imagination | (1) | (2) | (3) | (4) | (5) |

**Vignette Questions**

***Vignette 1***

K who has recently graduated from the University, began working at W 3 days ago. Aside from spending some times to get to know the new work responsibilities as well as his colleagues, he is in the process of making himself familiar with the interior space of W to be able to find his way around! Based on the limited time that K has spent at W, how will being unfamiliar with the overall interior layout (to know where to find what/who he needs) affect the frequency of his interaction with his colleagues? Please explain.

***Vignette 2***

D is considered an "old hand" at W as she began working here 5 years ago. She is highly familiar with the interior space of W and can easily find her way around! Based on the long time that D has spent at W, how familiarity with the overall interior layout (to know where to find what/who she needs) can affect the frequency of her interaction with her colleagues? Please explain.

***Appendix B: Correlation matrix of all of the tested independent variables after log transformation of dependent variable (duration of interaction). Significant code: no asterisk=p > 0.05, * = p < 0.05, ** = p < 0.01, *** = p < 0.001***

| | Type of interaction | Function of the space | Average Direct Purview (ADP) | Average Indirect Purview (AIP) | Time of the day (Morning/Afternoon) |
|---|---|---|---|---|---|
| Log transformed duration of interactions. | p < 0.001 *** r = -0.47245 | p = 0.16711 r = -0.06502 | p = 0.02485 * r = -0.11209 | p < 0.001 *** r = 0.3062 | p = 0.17075 r = 0.06372 |
| Type of interaction | | p = 6e-05 *** r = 0.19634 | p = 0.71287 r = 0.01852 | p = 0.00016 *** r = -0.18504 | p = 0.00238 ** r = -0.14842 |
| Function of the space | | | p < 0.001 *** r = 0.52189 | p < 0.001 *** r = -0.44329 | p < 0.001 *** r = -0.33726 |
| Average Direct Purview (ADP) | | | | p < 0.001 *** r = -0.63924 | p = 0.07796 r = -0.08799 |
| Average Indirect Purview (AIP) | | | | | p = 0.76992 r = -0.01465 |

| | Number of people | Average hierarchy of positions | SD of the hierarchy of positions | Average age of people | SD of the age of people |
|---|---|---|---|---|---|
| Log transformed duration of interactions. | p = 8e-04 *** r = 0.16369 | p = 0.522 r = 0.0288 | p = 0.4548 r = -0.0421 | p = 0.07755 r = 0.08597 | p = 0.5445 r = -0.03109 |
| Type of interaction | p = 0.001 ** r = -0.16152 | p = 0.00022 *** r = -0.18507 | p = 0.23727 r = -0.05896 | p = 0.23069 r = -0.05981 | p = 0.22732 r = 0.06127 |
| Function of the space | p = 0.40657 r = -0.04006 | p < 0.001 *** r = -0.45273 | p < 0.001 *** r = -0.24983 | p < 0.001 *** r = -0.45272 | p = 0.37146 r = -0.04521 |
| Average Direct Purview (ADP) | p = 0.60863 r = -0.02576 | p = 0.00745 ** r = -0.13591 | p = 0.80916 r = -0.01308 | p < 0.001 *** r = -0.29402 | p = 0.34449 r = -0.04799 |
| Average Indirect Purview (AIP) | p = 0.13218 r = 0.07442 | p = 0.00165 ** = 0.15848 | p = 0.458 r = 0.03751 | p < 0.001 *** r = 0.38402 | p = 0.32909 r = 0.04947 |
| Time of the day (Morning/Afternoon) | p = 0.05672 r = 0.09303 | p = 0.48471 r = 0.03276 | p = 0.26251 r = 0.05404 | p = 0.88137 r = 0.00493 | p = 0.29503 r = 0.05299 |
| Number of people | | p = 0.26534 r = -0.05781 | p = 0.17452 r = 0.06784 | p = 0.54019 r = -0.0323 | p = 0.08039 r = 0.08871 |
| Average hierarchy of positions | | | p < 0.001 *** r = 0.49538 | p < 0.001 *** r = 0.73517 | p < 0.001 *** r = 0.27289 |

| | | | | | |
|---|---|---|---|---|---|
| SD of the hierarchy of positions | | | | p < 0.001 *** r = 0.40467 | p < 0.001 *** r = 0.6463 |
| Average age of people | | | | | p = 3e-05 *** r = 0.21032 |

| | Proportion of females | Average duration of employment | SD of the duration of employment | Average extroversion | SD of extroversion |
|---|---|---|---|---|---|
| Log transformed duration of interactions. | p = 0.00509 ** r = -0.13792 | p = 0.83004 r = 0.00734 | p = 0.79088 r = 0.01185 | p = 0.0714 r = -0.09731 | p = 0.96929 r = 0.00227 |
| Type of interaction | p = 0.01022 * r = -0.12656 | p = 8e-05 *** r = -0.197 | p = 0.00293 ** r = -0.14953 | p = 0.00028 ** r = -0.18179 | p = 0.55533 r = -0.02993 |
| Function of the space | p = 0.18144 r = -0.06605 | p < 0.001 *** r = -0.33599 | p = 4e-05 *** r= -0.20403 | p < 0.001 *** r = -0.22792 | p = 0.088 r = 0.08608 |
| Average Direct Purview (ADP) | p < 0.001 *** r = 0.16174 | p = 0.72657 r = -0.01846 | p = 0.38763 r = 0.04344 | p = 0.26274 r = 0.05573 | p = 0.03409 * r = 0.107 |
| Average Indirect Purview (AIP) | p < 0.001 *** r = -0.34473 | p = 0.56771 r = -0.02913 | p = 0.47611 r = -0.03617 | p < 0.001 *** r = -0.24403 | p = 0.00523 ** r = -0.14059 |
| Time of the day (Morning/Afternoon) | p < 0.001 *** r = 0.22307 | p = 0.04375 * r = 0.09958 | p = 0.03582 * r = 0.10507 | p = 1e-05 *** r = 0.21358 | p = 0.01477 * r = -0.12287 |
| Number of people | p = 0.26738 r = -0.05497 | p = 0.82122 r = 0.01037 | p = 0.12025 r = 0.07834 | p = 0.25248 r = -0.06002 | p = 0.39426 r = 0.04331 |
| Average hierarchy of positions | p = 0.17398 r = -0.06889 | p < 0.001 *** r = 0.77887 | p < 0.001 *** r = 0.63479 | p < 0.001 *** r = 0.25135 | p = 0.06068 r = 0.09514 |
| SD of the hierarchy of positions | p = 0.93986 r = -0.00383 | p < 0.001 *** r = 0.35738 | p < 0.001 *** r = 0.48593 | p = 0.00142 ** r = 0.15769 | p = 0.00448 ** r = -0.14344 |
| Average age of people | p < 0.001 *** r = -0.40696 | p < 0.001 *** r = 0.41512 | p < 0.001 *** r = 0.42743 | p = 0.00944 ** r = -0.13484 | p = 0.32286 r = 0.0503 |
| SD of the age of people | p = 4e-05 *** r = -0.20602 | p =1e-05 *** r = 0.21786 | p < 0.001 *** r = 0.37089 | p = 0.0381 * r = -0.10544 | p = 0.17004 r = -0.06952 |
| Proportion of females | | p = 0.03335 * r = 0.10764 | p = 0.09196 r = -0.08534 | p < 0.001 *** r = 0.84219 | p = 0.99829 r = -0.00011 |
| Average duration of employment | | | p < 0.001 *** r = 0.784 | p < 0.001 *** r = 0.4177 | p = 0.20867 r = 0.06389 |
| SD of the duration of employment | | | | p = 0.00154 ** r = 0.15835 | p = 0.00319 ** r = 0.14868 |
| Average extroversion | | | | | p = 0.97363 r = -0.00139 |

| | Average conscientiousness | SD of conscientiousness | Average openness | SD of openness |
|---|---|---|---|---|
| Log transformed duration of interactions. | p = 0.04756 *<br>r = -0.10561 | p = 0.30242<br>r = 0.04706 | p = 0.01364 *<br>r = 0.1281 | p = 0.02847 *<br>r = -0.11268 |
| Type of interaction | p = 0.07144<br>r = -0.09008 | p = 0.1455<br>r = -0.07245 | p < 0.001 ***<br>r = -0.25106 | p = 0.04095 *<br>r = 0.10385 |
| Function of the space | p < 0.001 ***<br>r = -0.23447 | p = 0.0693<br>r = -0.08891 | p = 0.02134 *<br>r = -0.11837 | p = 0.3554<br>r = 0.04783 |
| Average Direct Purview (ADP) | p = 0.3632<br>r = -0.04715 | p = 0.05518<br>r = -0.09827 | p = 0.5844<br>r = 0.02836 | p = 0.66<br>r = -0.02263 |
| Average Indirect Purview (AIP) | p = 0.28976<br>r = -0.05393 | p = 0.00609 **<br>r = 0.13841 | p = 0.45943<br>r = 0.03769 | p = 00091 ***<br>r = -0.16715 |
| Time of the day (Morning/Afternoon) | p < 0.001 ***<br>r = 0.29433 | p = 0.33889<br>r = -0.05257 | p = 0.04585<br>r = 0.10344 | p = 0.23433<br>r = -0.06149 |
| Number of people | p = 0.12621<br>r = -0.07931 | p = 0.06094<br>r = 0.09353 | p = 0.38936<br>r = 0.04475 | p = 0.99158<br>r = -0.00102 |
| Average hierarchy of positions | p = 4e-05 ***<br>r = 0.2031 | p = 0.83158<br>r = 0.00742 | p = 0.10493<br>r = 0.08413 | p = 0.97877<br>r = 0.00041 |
| SD of the hierarchy of positions | p = 0.00118 **<br>r = 0.16066 | p = 0.06983<br>r = 0.08851 | p = 0.05649<br>r = 0.09883 | p = 0.25102<br>r = -0.05937 |
| Average age of people | p = 0.40033<br>r = 0.03973 | p = 0.03656 *<br>r = 0.10272 | p = 0.98465<br>r = 0.00082 | p = 0.53053<br>r = 0.03094 |
| SD of the age of people | p = 0.27538<br>r = 0.0552 | p = 0.37022<br>r = 0.04532 | p = 0.57572<br>r = -0.02831 | p = 0.00023 ***<br>r = -0.18543 |
| Proportion of females | p < 0.001 **<br>r = 0.74141 | p < 0.001 ***<br>r = -0.25404 | p = 0.05421<br>r = 0.09757 | p = 0.16485<br>r = 0.07047 |
| Average duration of employment | p = 0.00158 **<br>r = 0.15665 | p = 0.47556<br>r = -0.03949 | p = 0.0035 **<br>r = 0.14935 | p = 0.43857<br>r = -0.04023 |
| SD of the duration of employment | p = 0.32165<br>r = 0.04897 | p = 0.0339 *<br>r = -0.10892 | p = 0.00727 **<br>r = 0.13648 | p = 0.24123<br>r = -0.05983 |
| Average extroversion | p < 0.001 ***<br>r = 0.65746 | p < 0.001 ***<br>r = -0.23379 | p < 0.001***<br>r = 0.23219 | p = 0.64281<br>r = 0.02218 |
| SD of extroversion | p = 0.63389<br>r = -0.02393 | p = 0.21915<br>r = 0.06263 | p = 0.86556<br>r = -0.00874 | p = 0.00061 ***<br>r = 0.17258 |
| Average conscientiousness | | p < 0.001 ***<br>r = -0.32702 | p = 0.09603<br>r = 0.08696 | p = 0.1398<br>r = -0.07622 |
| SD of conscientiousness | | | p = 0.01447 *<br>r = -0.12132 | p = 0.18637<br>r = -0.06851 |
| Average openness | | | | p < 0.001***<br>r = -0.56226 |