

## Workplace productivity and office type: an evaluation of office occupier differences based on age and gender

HAYNES, Barry <<http://orcid.org/0000-0003-3740-4159>>, SUCKLEY, Louise <<http://orcid.org/0000-0003-2577-3731>> and NUNNINGTON, Nick

Available from Sheffield Hallam University Research Archive (SHURA) at:

<http://shura.shu.ac.uk/15133/>

---

This document is the author deposited version. You are advised to consult the publisher's version if you wish to cite from it.

### Published version

HAYNES, Barry, SUCKLEY, Louise and NUNNINGTON, Nick (2017). Workplace productivity and office type: an evaluation of office occupier differences based on age and gender. *Journal of Corporate Real Estate*, 19 (2), 111-138.

---

### Repository use policy

Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in SHURA to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

# **Workplace productivity and office type: An evaluation of office occupier differences based on age and gender**

Barry Haynes<sup>1</sup>, Louise Suckley<sup>2</sup>, Nick Nunnington<sup>3</sup>

## **Abstract**

### **Purpose**

Open plan office environments are considered to offer workplace productivity benefits because of the opportunities that they create for interaction and knowledge exchange, but more recent research has highlighted noise, distraction and loss of privacy as significant productivity penalties with this office layout. This study aims to investigate if the purported productivity benefits of open plan outweigh the potential productivity penalties.

### **Design/methodology/approach**

Previous research suggests that office environments are experienced differently according to the gender and age of the occupier across both open-plan and enclosed configurations. Empirical research undertaken with office occupiers in the Middle East (N=220) led to evaluations to establish the impact different offices had on perceived productivity. Factor analysis was used to establish five underlying components of office productivity. The five factors are subsequently used as the basis for comparison between office occupiers based on age, gender and office type.

### **Findings**

This research shows that benefits and penalties to workplace productivity are experienced equally across open-plan and enclosed office environments. The greatest impact on perceived workplace productivity however was availability of a variety of physical layouts, control over interaction and the 'downtime' offered by social interaction points. Male occupiers and those from younger generations were also found to consider the office environment to have more of a negative impact on their perceived workplace productivity compared to female and older occupiers.

### **Originality/value**

The originality of this paper is that it develops the concept of profiling office occupiers with the aim of better matching office provision. This paper aims to establish different occupier profiles based on age, gender and office type. Data analysis techniques such as factor analysis and t-test analysis identify the need for different spaces so that occupiers can choose the most appropriate space to best undertake a particular work task. In addition, it emphasises the value that occupiers place on 'downtime' leading to the need for appropriate social space.

**Keywords:** Office layout, Open Plan, Workplace Productivity, Gender difference, Age difference, Privacy.

---

<sup>1</sup> Sheffield Hallam University, Department of the Natural and Built Environment, Sheffield, UK.  
[b.p.haynes@shu.ac.uk](mailto:b.p.haynes@shu.ac.uk) +44 (0) 114 2254006 Corresponding author

<sup>2</sup> Sheffield Hallam University, Sheffield Business School, Sheffield, UK. [l.suckley@shu.ac.uk](mailto:l.suckley@shu.ac.uk)

<sup>3</sup> Nottingham Trent University

## **1.0 Introduction**

The challenges facing organisations to meet increasing customer requirements, and shortened lead times to market, has led to an increased emphasis on how organisations speed up their knowledge creation and transfer processes. In response to this trend office environments are now widely considered to be a key component in the facilitation of knowledge creation and knowledge transfer (Martens, 2011; Parkin et al., 2011; Boutellier, 2008; Haynes, 2007). The concept of the open-plan office environment is often cited as the most conducive environment for knowledge creation as it allows its occupants to interact and collaborate in a spontaneous manner (Openshaw, 2013; Cummings & Oldham 1997; Dunbar, 1995) however there is growing research evidence to suggest that such environments are leading to increasing office occupiers' dissatisfaction (Bodin Danielsson & Bodin, 2008; Bodin Danielsson et al., 2015; Kim & de Dear, 2013). The open plan concept presented to organisations is that it will facilitate interactions and collaborations. However, this assumes two things: that collaborative work is more productive than individual focussed work; and that office collaborations in open-plan environment are what people do most of their time.

The main benefits purported for an open-plan environment are financial benefit and organisational (Hedge, 1982; Heerwagen, 2000; Veitch et al., 2007). The financial benefits are obtained through less space provided per person; and the organisational benefits obtained through greater knowledge sharing and team working (Heerwagen et al., 2004; Lansdale et al., 2011). In addition, less space requirements may lead to less energy consumption. There appears to be a need for balance. Whilst open-plan environments may be suitable for certain work activities they are not suitable for all work activities. The fundamental flaw with the open-plan concept is to expect that all work could be undertaken in one office type.

The aim of this paper is to evaluate whether the purported productivity benefits of open plan environments of increased collaboration and knowledge sharing outweigh potential productivity penalties caused by increased noise, distractions and loss of privacy. The experiences of those occupying different office configurations will also be examined in terms of the specific factors that are considered to affect perceived productivity; and these experiences will be further evaluated according to the gender and age of the office occupants to ascertain whether these characteristics are influential. Therefore, the research questions addressed in this paper are:

1. What is the impact of different office layouts on the perceived productivity of the office occupants?
2. What are the underlying concepts that underpin the evaluation of the impact of office layout on office occupiers' perceived productivity?
3. Do differences exist between office occupiers' perceived productivity based on gender, age and office type?

### **1.1 Researching the office environment**

Many studies have been undertaken on the impact of the physical office environment on occupants and as such there are a wide range of variables taken into consideration. Broadly however measurements tend to focus upon two main areas: office layout and office comfort (Haynes, 2008).

As an example, Kim and de Dear (2013) based their Indoor Environmental Quality tool on the Post-Occupancy Evaluation (POE) survey developed by the CBE (Center for the Built Environment) at the University of California. This included a range of variables such as office layout, furnishings, lightings, thermal comfort and acoustics (Brager & Baker, 2009; Zagreus et al., 2004).

A meta-analysis of 75 research studies undertaken by Oseland and Burton (2012) aimed to identify the impact of design parameters on worker productivity potential gains. The increased performance ranged from 0.30 – 160%. They decided to weight the studies and concluded that most single environmental factors had a weighted mean effect on productivity in the order of 1 to 2% (Oseland, Burton 2012). In addition, they went on to propose that any additional variables had an impact on productivity gains, but to diminishing effect.

The World Green Building Council (WGBC) productivity research Identified (Alker et al, 2014):

- **Air quality** - better air quality can improve employee productivity by 8 – 11%. There are clear health benefits from good Indoor Air Quality (IAQ).
- **Thermal comfort** - employees experience a 4% reduction in performance at cooler temperatures and 6% at warmer temperatures.
- **Lighting** - office workers with windows sleep an average of 46 min more per night. Similar to thermal comfort, individual control over lighting levels is deemed to be an important element in workplace lighting satisfaction.
- **Noise** - office workers performance drops by 66% when exposed to distracting noise. The office layout links very closely to the amount of noise distraction caused
- **Office Layout** - 69% of Generation Y workers report an increase in productivity from 'funky' office fit outs.

However, the measurement of the impact of the office environment is a challenging area as it is not clear how to define inputs and outputs in a modern office. An extensive review of the literature undertaken by Centre for Building Performance Research identified that researchers had used a number of different ways of evaluating the impact of the office environment on its occupant's (Sullivan, Baird, & Donn, 2013). These included:

- *ratings perceived productivity;*
- *cognitive performance tests (e.g. working memory, processing speed, concentration);*
- *monitoring computer activity (e.g. keystrokes, mouse clicks);*
- *absenteeism;*
- *presenteeism;*
- *reported frequency of health issues;*
- *time lost to issues affecting productivity;*
- *mood;*
- *sleepiness;*
- *job satisfaction;*
- *job engagement;*
- *intention to quit; and*
- *turnover.*

An additional measure of productivity is the concept of “downtime” and can be defined as effectively time wasted due to poor design and management of the office environment (Oseland, 2004). Some of the downtime elements defined by Oseland (2004), i.e. waiting for lifts, walking between buildings, interruptions, and copier machines, could actually be opportunities for ad hoc conversations and knowledge transfer (Haynes, 2008b). In addition, “downtime” could also offer the opportunity for the office occupier to take a break.

Whilst there appears to be no universally accepted means of measuring office productivity, there does appear to be acceptance that a self-assessed measure of productivity is better than no measure of productivity (Oseland, 1999; ; Leaman & Bordass, 1999; Clements-Croome 2006, Haynes, 2008).

The attempts made to link the physical environment with the productivity of its occupants falls into two main categories: those of office layout and office comfort (Haynes, 2008). The literature relating to the office layout appears to revolve around two main debates: those of open-plan versus cellular offices, and the matching of the office environment to the work processes. It could be argued that the open-plan debate has led to cost reduction as the prevailing paradigm with regards to office environments (Haynes, 2007).

In addition to the office comfort and office layout is the behavioural aspect of the office environment (Haynes 2008). It is the behavioural elements that can potentially lead to productivity gains through increased collaboration and knowledge sharing. However, it is these increased interactions that can also lead to the often cited productivity penalties of loss of privacy, increased noise and the distractions (Haynes 2008). There is a need to establish when an interaction stops being a productivity gain and turns into a distraction leading to a productivity penalty.

This paper evaluates productivity gains and penalties for different office types. In addition, it evaluates statistical differences based on age, gender and office type allowing for the development of occupier profiling.

## **1.2 Privacy**

There are certain work activities that require disruption free working where office occupiers need to submerge into deep level of thinking, such as writing reports, scoping projects or reviewing cases. These tend to be activities that require a period of concentration. However, in the office environment, these periods of concentration can be interrupted in a number of different ways. There are digital interruptions through e-mail, phone calls; physical interruptions from co-workers; and auditory interruptions caused by background noise. Research undertaken by Wajcman and Rose (2011) evaluated the number and type of interruptions experienced by today's office worker which they categorised as either face-to-face interaction or through communication media i.e. mobile phone, landline phone, desktop PC. They also found that on average there were around 12 interruptions from other colleagues per day, and the most frequent communication activity (20% of the work day) was face-to-face which they classified as ‘unscheduled meetings’ and involved interaction with people working in or going to office cubicles.

It is important to understand the context of the interruption as not all interruptions can have a negative effect on the office occupiers' performance. If the interruption is directly related to the task at hand, then this may have a positive impact on the performance of the task (Mark, Gudith et al. 2008). However, if the interruption is related to a completely different matter then this requires a shift in

cognitive processes and can be a disruptive interaction (Mark, Gudith & Klocke, 2008). An experimental study undertaken by Gudith et al (2008) identified that after only 20 minutes of interrupted performance participants reported significantly higher stress, frustration, workflow, effort and pressure. An interruption of no more than two seconds can be enough to break someone's train of thought (Altmann, Trafton & Hambrick, 2014). Once distracted from a task it could take on average 25 minutes to return to that task (Mark, Gonzalez, & Harris, 2005). In addition, once the train of thought has been broken it can potentially take up to an additional 15 minutes to get back into the same flow state they were in before the interruption took place (Lister & DeMarco, 1987). The ability to handle interruptions and minimise their destructive influence has been linked to an office occupiers' personality type (Furnham & Strbac, 2002; Maher & von Hippel, 2005). For example, a personality that is open to new experiences and has less requirement for personal structure (therefore more flexible) can minimise the negative impact of interruptions (Mark, Gudith & Klocke, 2008). This suggests a need for customised office solutions given the personality difference with regards to interruption tolerance.

Working in a private office allows the occupier more personal control over the level of privacy that they experience as well as other features such as air quality, noise, lighting and temperature. Occupiers of open-plan office environments usually do not have the same amount of control over such factors which consequently leads to a higher degree of dissatisfaction with the office environment (Kim & de Dear, 2013; Samani, 2015).

### **1.3 Noise**

Noise has been identified as one of the variables with which open plan office workers have least satisfaction (Frontczak et al., 2012; Hongisto, Haapakangas & Haka, 2008; Pejtersen et al., 2006); and can also impact negatively on the productivity levels of office occupiers (Hongisto, 2005; Mak & Lui, 2012). Office noise can be disruptive and so be detrimental to people's ability to focus and concentrate on their work activity (Banbury & Berry, 2005; Seddigh et al., 2014) which can then lead to feelings of frustration and increased levels of stress (Leather, Beale, & Sullivan, 2003; Seddigh et al., 2014; Witterseh, Wyon & Clausen, 2004).

Whilst office sound can be measured in a very tangible way, office noise (that which is considered detrimental) can be considered a subjective phenomenon as it is dependent on the individual's perception of the sound (Frontczak et al., 2012). This can be influenced by a number of factors including the occupiers' ability to control the noise, the type of work activity being undertaken, their gender, and their personality type (Banbury & Berry, 2005; Block & Stokes, 1989; Bodin Danielsson et al., 2015). Unless ear defenders or headphones are worn, there is the instinctive auditory capacity to constantly scan background noise, and speech is identified as being the most disruptive sound source (Hongisto et al., 2008). A test simulation undertaken by Veitch et al (2002) identified that in open plan offices, acoustic satisfaction increases as subjectively rated speech intelligibility decreases; and Marsh et al (2009) found that meaningful speech background sound caused higher distraction than irrelevant speech. This suggests that office occupiers should be located with those performing contrasting roles so their speech is of less relevance or that speech privacy is required in open plan offices.

Office noise can affect people physiologically (headaches, tiredness); psychologically (short term memory failures, lack of concentration, relief from stress), cognitively (knowledge transfer, asking,

advising and listening to others); and socially (sense of belongingness) (Rasila & Jylha, 2015; Evans & Johnson, 2000). Studies on the effects of noise in the open plan office environment tend to focus on the negative aspects, but there are some studies that also suggest that noise has a positive impact. Rasila and Jylha (2015) evaluated the impact of noise levels in a contact centre and found that although a sudden noise distracted workers from their duties, it also increased their performance by providing timely and relevant feedback. Klemmer and Snyder (1973) also argued that communication is more effective when there is the possibility to talk to colleagues while working. There is also the social benefit of noise and the sense of belongingness that it creates for office occupants (Hedge, 1982).

There is the need therefore to get the right balance of noise appropriate for the environment, rather than one that is silent. However, it will be difficult to find this balance given that perceptions of noise are influenced by context, work and personality.

#### **1.4 Interaction**

In contrast to the need for privacy in an office environment, there is also the need for interaction to exchange knowledge and information, and is one of the main reasons for the existence of offices. Interaction can be planned through formal meetings which are located in specific meeting spaces and allow the occupants to manage their time and concentration levels. Interactions can also be unplanned and serendipitous, taking place in a wide range of locations and can be much difficult to control for an occupier.

Office layout can be designed to support interaction and communication across different occupiers. Peponis et al (2007) outlined two models of workspace design: the 'flow model' and the 'serendipitous model'. The first model supports the view that the workspace should be designed to support the flow of information between occupiers, so those people who work together should be located in close proximity. In this way interaction is encouraged between a small number of individuals, but the proximity means that 'creative eavesdropping' can take place. This supports the research undertaken by Allen and Henn (2006) that found that face to face communication tends to decrease if the individuals are more than 30 meters apart. This approach to workspace design is more difficult when occupiers work with a wide range of people that cannot all be accommodated in close proximity. The serendipitous model designs the workspace to encourage chance interactions between a much wider range of occupiers. Using this approach teams that work together are located at much greater distances so that they have to physically move from their desk/ office to interact with 'destination' colleagues and on their journey to this destination they may bump into another colleague. Using this model could be considered less efficient in terms of time, and can encourage workers to use internal telephone or email communication as opposed to face to face interaction, though it is valuable for cross-disciplinary team working and creativity (Dobson et al., 2013; Penn et al., 1999; Wineman & Serrato, 1998).

The use of inanimate objects known as 'actants' (Latour, 2005) can also be used to encourage interaction in the workplace, both planned and unplanned. Objects such as printers, photocopiers, water-coolers and kitchens can be positioned in the office to draw people towards them. The location and accepted use of these actants have a huge impact on their effectiveness however in supporting social interactions. Gladwell (2000) suggests that actants such as kitchens should be located in the centre to draw from the most disparate parts. Dobson and Suckley (2015) however found that the

proportional size of the actant determined the effectiveness of this central location. A kitchen too big for the space acted as a physical and auditory barrier in the office space, instead of the intended central hub. Actants also need to demonstrate specific affordances for their use to be legitimised as facilitators of interaction. According to Fayard and Weeks (2007) the actants need to be accessible; in close proximity; have perceived visual and auditory privacy; have a good level of functionality; and occupiers must feel that it is acceptable by the organisation for them to be used.

## **1.5 Occupier Differences**

There are a number of ways that office occupiers can be categorised as a way of understanding their unique and individual differences. One such way is by exploring datasets for gender differences, and another is by the age of the respondents.

These characteristics have been considered in previous studies of workplace conflicts and in particular the impact of office design on these conflicts. Bodin Danielsson (2015) found the noise levels generated in different office designs had a more significant impact on female occupants than male occupants as a potential source of workplace conflict. Kaarala-Tuomaala et al (2009) found that female office occupants reported more noise disturbance than their male counterparts. Other studies have also found gender differences in the office environment around a lack of social coherence (Peterson & Beard, 2004) and the ability to personalise the workstation (Wells, 2000; Wells, Thelen & Ruark, 2007) caused by intermittent and flexible work patterns which are often held by female workers.

Another area where gender has been considered in office environment research relates to Sick Building Syndrome (SBS) (Stenberg & Wall, 1995; Zweers et al., 1992). SBS usually refers to the physical symptoms in occupants of fatigue, headache, irritated or dry eyes/nose/throat and skin symptoms. A review of the literature undertaken by Kim and de Dear (2013) established that female occupants of office environments generally reported a higher prevalence to the SBS symptoms than the male office occupants. In their examination of 12 Indoor Environmental Quality (IEQ) indicators, Kim and de Dear (2013) also reported statistical differences between male and female responses where the female respondents were consistently less satisfied than male occupants. An IEQ factor where dissatisfaction was clearly identified was thermal comfort. Karjalainen (2007) identified similar findings with regards to thermal comfort where they found, in both field studies and laboratory studies, females expressed more dissatisfaction than males in the same thermal environment. However, no significant gender difference existed in terms of neutral temperature. In addition, females were less satisfied than males in cooler conditions and more sensitive to deviations from the optimal thermal environment. This supports the notion that females have a greater need for individual control over their own thermal environment than males (Van Hoof, 2008).

An alternative way of identifying occupier differences and preferences is by the use of the office occupiers' age (Haynes, 2011; McElroy & Morrow, 2010). However, categorising office occupiers by their age is an area of developing research with some authors categorising office occupiers by age group (Rothe et al 2012), and others categorising people by their different generation (Bennett, Pitt & Price, 2012; Joy & Haynes, 2011).



Whilst it is acknowledged that researchers use differing years when defining the different generations (Wong et al., 2008), there are a number of workplace researchers that have adopted the definitions identified by office furniture manufacturer Steelcase (Bennett et al., 2012; Haynes, 2011; Joy & Haynes, 2011). The generations can be categorised as:

- *Traditionalists*: - Born 1922 - 1945; also known as veterans, are characterised as being dedicated, stable and loyal, but also resistant to change and reserved.
- *Baby Boomers*: - Born 1946 - 1964; are characterised as being optimistic, team players and service driven. However, they are generalised to be technologically challenged and value their own space such as a private office.
- *Generation X*: - Born 1965 - 1978; are characterised as independent, self-reliant and entrepreneurial. They are adaptable, and comfortable with technology, but are also considered impatient and quick to criticise.
- *Generation Y*: - Born 1979 - 2000; also known as 'millennials'; are characterised as being confident, knowledge thirsty and technology savvy. They require instant feedback and constant guidance. They thrive in informal work environments. (Joy and Haynes, 2011,p217)

A study undertaken by Rothe et al (2011) surveyed more than 1,100 office employees and found significant differences between age groups with regard to personal services, commuting, collaboration, restaurant services and the adjustability of indoor air climate. In addition, the study also identified areas where no significant differences existed between the younger and the older employees relating to privacy and the virtual environment. Generational differences were identified by McElroy & Morrow (2010) in a quasi-field experiment to evaluate the impact of a redesigned office compared to a cubicle office environment. They found that the Generation X and Baby Boomers reported less room and more distractions in the redesigned office compared to their Generation Y counterparts. The suggested explanations for the difference in responses were that Generation Y have less experience of other office environments and therefore have no other terms of reference; or that Generation Y are more attuned to multitasking and so can filter out any distractions in the office environment (McElroy & Morrow, 2010). Joy and Haynes (2011) found that office occupiers from younger generations preferred more informal meeting areas to facilitate knowledge working compared to their older counterparts' preference for more formal meeting spaces for this type of work. No generational differences have been found with regards to team-based working environments (Appel-Meulenbroek, 2010) with all generations seeing the benefits of being located near to one another, i.e. co-presence, in knowledge transfer and the facilitation of tacit knowledge through "creative eavesdropping" (Haynes, 2011).

Rasila and Rothe (2012) explored the views of Generation Y workers on open-plan office environments in the areas of noise, privacy, density and crowding, distraction, presence of others, social settings, inefficiency and increased workload, and ambient conditions. The research generally confirmed that Generation Y employees acknowledge similar problems with open-plan office environments previously identified through the literature however, the Generation Y employees saw the limitations and problems of open-plan as a fair trade-off against the benefits of open-plan (Rasila & Rothe, 2012). Although the same problems and issues of working in an open plan environment were acknowledged, the Generation Y employees interpreted them in a different way. For example, the noise levels in the open plan environments were a positive sign of things actually happening; and a high density office environment meant you could be the sitting next to your best friend (Rasila & Rothe, 2012).

The differences in office occupiers according to age are important research areas given that for many developed countries the future workforce will increasingly be made up of workers over the age of 50 (Erllich & Bichard, 2008). This demographic shift can be attributed to factors such as shrinking pension funds, retained knowledge, legislation and people living longer (Smith, 2008). The implications on the physical working environment of the changing physical and mental state of older knowledge workers has been considered by Smith (2008) who argues that organisations need to focus upon the areas such as vision, hearing, physical ergonomics, cognition, health and well-being in the workplace design.

## 2.0 Methods

A survey was undertaken with the employees of a significant company with operations across the Middle East region, collected from the United Arab Emirates (UAE) offices. The anonymity of the company is covered by a non-disclosure agreement. This research is unique in that it collects data from office occupiers in the Middle East and most studies of this nature tend to be from western cultures. A web-based survey tool was developed that assessed the impact of various aspects of the office environment on occupants' perceived productivity. A self-assessed measure of productivity was used, since there appears to be no universally accepted measure of productivity (Whitley et al., 1996; Oseland, 1999, 2004; Leaman & Bordass, 2000). The categorical and evaluative variables included in the survey were developed from the literature review. Respondents were asked to evaluate their current office environment. As this research aimed to establish the occupier perspective the survey questions asked the respondents how each evaluative variable impacted on their productivity (Haynes 2009). The office environment aspects included office facilities, such as storage space, quiet areas and position relative to colleagues; office environmental conditions, such as lighting, temperature and cleanliness; and other office variables such as privacy, interruptions and work interaction. These items have been used previously in research undertaken with western cultures, as shown in the literature review, and their relevance to offices in the Middle East, will be explored through this research. Occupants were asked to rate on a five-point scale whether the variables had a 'very negative' (coded as 1) effect on their productivity to a 'very positive' (coded as 5) effect on their productivity. Table 1 summarises the questionnaire items used in the analysis for this study and the Perceived Productivity Impact (PPI) variables that they form.

PPI variable	Survey question
Temperature	In your opinion how does <i>indoor temperature (summer)</i> affect your productivity? In your opinion how does <i>indoor temperature (winter)</i> affect your productivity?
Lighting	In your opinion how does <i>natural lighting</i> affect your productivity? In your opinion how does <i>artificial lighting</i> affect your productivity?
Internal Noise	In your opinion how does <i>internal noise (equipment and telephones)</i> affect your productivity? In your opinion how does <i>internal noise (conversations and people movement)</i> affect your productivity?
Storage	In your opinion how does <i>personal storage</i> affect your productivity? In your opinion how does <i>general storage</i> affect your productivity?
Proximity to Manager	In your opinion how does <i>position relative to your immediate</i>

	<i>supervisor</i> affect your productivity? In your opinion how does <i>position relative to senior management</i> affect your productivity?
Air Quality	In your opinion how does <i>ventilation</i> affect your productivity?
Formal Meeting Space	In your opinion how do <i>formal meeting areas</i> affect your productivity?
Informal Meeting Space	In your opinion how do <i>informal meeting areas</i> affect your productivity?
Quiet Areas	In your opinion how do <i>quiet areas</i> affect your productivity?
Crowding	In your opinion how does <i>crowding</i> affect your productivity?
Interruptions	In your opinion how do <i>interruptions</i> affect your productivity?
Privacy	In your opinion how does <i>privacy</i> affect your productivity?
Social Interaction	In your opinion how does <i>social interaction</i> affect your productivity?
Work Interaction	In your opinion how does <i>work interaction</i> affect your productivity?
Physical Comfort	In your opinion how does <i>overall physical comfort of your workstation, desk, chair etc.</i> affect your productivity?
Colours & Textures	In your opinion how does <i>office decor</i> affect your productivity?
Cleanliness	In your opinion how does <i>office cleanliness</i> affect your productivity?
Position to Colleagues	In your opinion how does <i>position relative to colleagues</i> affect your productivity?
Position to Equipment	In your opinion how does <i>position relative to equipment</i> affect your productivity?
Refreshment Areas	In your opinion how does <i>refreshment area</i> affect your productivity?
Canteen	In your opinion how does <i>canteen/ café</i> affect your productivity?
Overall Office Layout	In your opinion how does the <i>overall office layout</i> affect your productivity?

Table 1 List of questionnaire items used for the analysis

There were 308 employees surveyed and 251 employees participated in the research. However, only 220 responses were admissible responses. The survey included managerial, technical and administration grades. The managerial and technical grades could be considered to be knowledge type workers with flexibility in how and where they work. In contrast, the administration roles could be considered to be more process workers with an expectation they will be at their desks most of the time (2008). The survey was undertaken in December 2013. The demographic data gathered on these employees is described in Table 2. There are more male respondents represented in the research data than there are female; and there are fewer respondents aged over 50 years, nevertheless there is a fairly even distribution of those below the age of 50 years across the two age groups.

Personal characteristics	Description	N	Percentage
Gender	Male	156	71%
	Female	61	28%
	Unknown	3	1%
Age	Under 34 years	91	42%
	35-50 years	101	46%
	Over 50 years	25	11%
	Unknown	3	1%

Table 2 Survey respondents' personal characteristics

All of the occupants were based in an office environment, but the design of the office layouts varied. Occupants were asked to specify the type of office layout that they occupied and the responses are described in Table 3. The office layouts have been classified using the well-established "industry standard" classifications adopted in Post Occupancy Evaluation (POE) across the built environment industry (see for example the Center for the Built Environment (CBE) at the University of California). This classifies the office layouts into five categories depending on the level of personal enclosure: 1) Enclosed private office; 2) Enclosed shared office; 3) Cubicles with high partitions (about five or more feet high); 4) Cubicles with low partitions (lower than five feet high); and 5) Open office with no partitions or limited partitions. Although the CBE classifications do not include descriptions, those used by Danielsson & Bodin (2008) have been added in Table 3 to give further clarification of the office layouts and are complemented with the general characteristics of the offices that were observed in the case study company by one of the authors. As can be seen the largest proportion of respondents are in an open plan (58%) office layout (including cubicles with high partitions, cubicles with low partitions and open plan with no partitions or limited partitions). Of all the office configurations Enclosed shared is the most popular office configuration (25.9%) that consists of a single room shared by 2- 5 people and the fewest are in a private office (16.4%). It is acknowledged that a limitation of the research is that physical dimension of the different office types was not collected.

Office layout	Description	N	Percentage	Characteristics	Characteristics (Danielsson & Bodin, 2008)
Enclosed private	Single person office	36	16.4%	-Single room -Most equipment and amenities are in the room	-Single room -Most equipment and amenities are in the room
Enclosed shared	2-5 person office	57	25.9%	-Office shared by 2-5 people	-Office shared by 2-3 people
Open-plan	Cubicle	44	20%	-Cubicle with high partitions	-Common workspace is shared by employees
	6-10 person office	50	22.7%	-Cubicles with low partitions	-workstations are often freely arranged in groups

	More than 11 person office	33	15%	-Open plan office with no partitions or limited partitions	-partitions are usually installed at the individual workstation to provide some privacy.
Total		220	100.0%		

Table 3 Survey respondents’ office layout occupation and general characteristics of different office layouts

**2.1 Data analysis**

Firstly, to assess perceived productivity, a mean score was calculated for each of the PPI variables. By assigning scores of 1-5 on the 5 answer options, the nominal data gathered is converted to interval data, after being checked for normal distribution, which allows for more comprehensive analysis. Using the 5 point scale, the mean for each question included in the PPI variable (Table 1) was calculated to give an overall score for the variable. With this analysis the higher the score shows that occupants found the variable to have a more positive effect on their productivity. Following this, the variables that occupants have rated as having the most negative impact on their productivity are considered i.e. those who selected the bottom two ratings (very negative and negative effect) on the five-point answer scale. This is classed as the Actual Percentage Unproductivity (APU)<sup>4</sup> and captures the areas that result in a perceived lack of productivity for the occupants. Analysing elements of the office environment with the lowest ratings will give an indication of potential complaints, and is an established metric used in thermal comfort studies (Fanger, 1972; Kim & de Dear, 2008). The combination of the mean productivity ratings and the APU can be used to quantitatively assess whether occupants in the different office layouts respond differently to the various PPI variables.

Secondly in order to understand the key elements of all of the PPI variables that impact upon occupants’ perceived productivity, factor analysis was undertaken using SPSS v22.0. This technique enables the exploration of latent variables (i.e. not directly measured) from multiple variables and can be used to either confirm a model of specific variables or explore relationships between variables. In this study, exploratory factor analysis will be undertaken to identify the principal components of the office environment impacting on perceived productivity (see Tabachnik and Fidell, 2001, for a detailed introduction to factor analysis). Varimax rotation was included in the principal component analysis as this allows for analysis across all the variables (not just ones that are specified) and it identifies factors that are most closely correlated which helps to produce a more interpretable result.

Lastly, after conducting factor analysis the resulting ‘office factors’ are used in a series of t-test analyses to examine for statistical significant differences in the productivity perceptions of the office occupants. These are considered using dummy variables for office layout, gender and age of the occupants. Dummy variables are artificial variables created to represent a nominal (naming) variable so it can be used in more advanced analysis. They tend to be created with two distinct categories. In this study, survey respondents were divided into those that occupied an open-plan space (with high partitions, low partitions and no partitions) and those that occupied an enclosed space (private or shared) as 1 for open

<sup>4</sup> Actual Percentage Unproductivity (APU) is a term developed for this paper.

and 0 for enclosed; the naturally occurring gender dummy variable (1 for Male and 0 for Female); and in terms of age, the 3 categories were transformed to 1 for Old (those in the 35-50 years and Over 50 years categories) and 0 for Young (those in the Under 34 years category).

### **3.0 Results**

#### **3.1 Impact on perceived productivity of office environment**

Figure 1 depicts the mean rating scores for each of the PPI items, rated on the five-point scale ranging from 'Very negative' (1) to 'Very positive' (5) given by the respondents according to their different office layouts.

The most positive impact on perceived productivity for the majority of office types were temperature, lighting, proximity to manager, social interaction, work interaction, position to colleagues and also position to equipment. Those elements having a negative impact on perceived productivity for the majority of office types were internal noise, informal meeting space, quiet areas, crowding, interruptions, refreshment area and canteen.

In terms of overall office layout, those in 'Enclosed private' offices believed their configuration had the most positive impact of all the office types and those in 'Open Plan with little or no partitions' believed the configuration had the most negative impact on their productivity.

The perceived productivity of those in 'Enclosed private' offices was noticeably higher than those in the other office layouts with regard to a number of elements of the office environment, namely storage (3.4) informal meeting points (3.0), privacy (3.5), quiet areas (3.1), position to equipment (3.7) and the canteen (2.9) but this was only significantly higher ( $p < 0.05$ ) for storage, privacy and position to equipment. The other significant differences were between those in 'Open Plan offices with low partitions' who were more negative about the impact of a number of elements on their perceived productivity, namely lighting (2.7), air quality (2.3) social interaction (2.9) and work interaction (3.1).

Another interesting result to note is those given by occupants of 'Enclosed shared' offices, who regard internal noise (2.3) to have the most negative impact on their productivity compared to those in the other office layouts and was also the case for crowding (2.4).

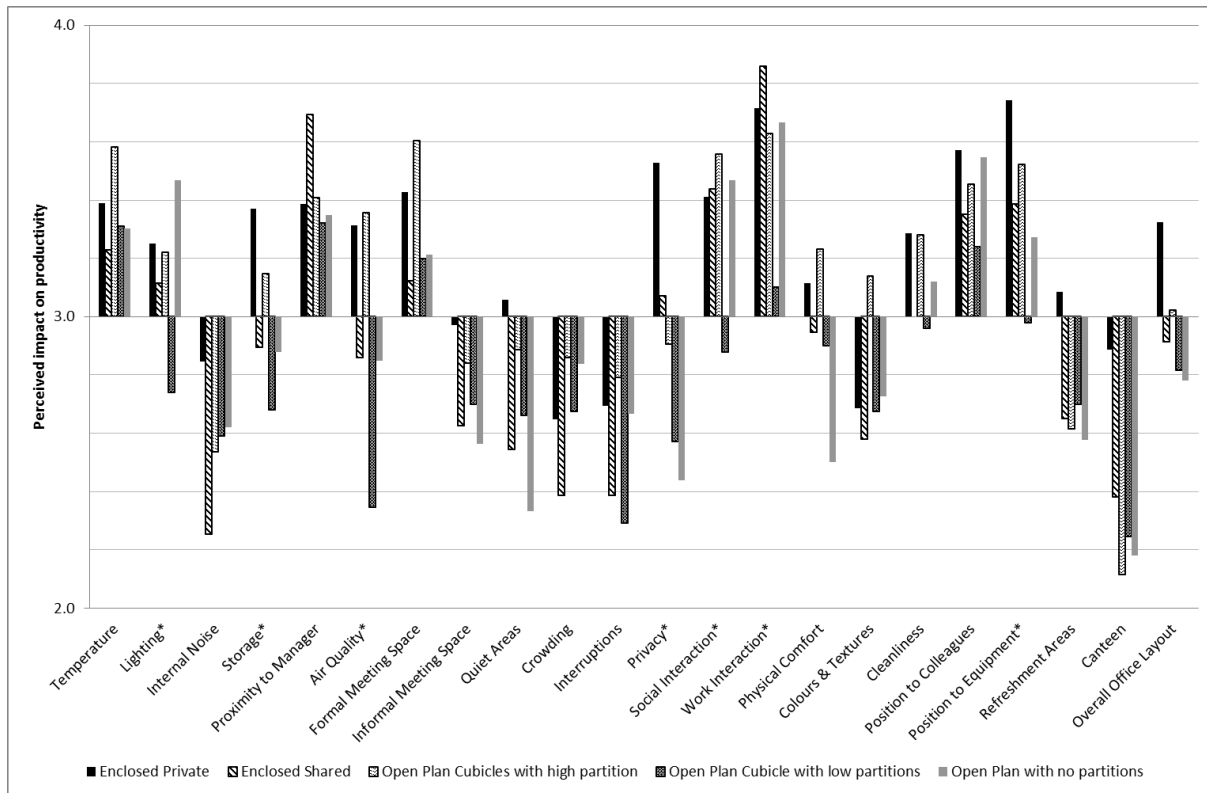


Figure 1 Mean perceived productivity impact rating (1 = very negative, through 3 = neutral to 5 = very positive) for PPI variables by office layout configurations. \* significant difference ( $p < .05$ )

The Actual Percentage Unproductivity (APU) with each PPI variable is shown in Figure 2. In this chart those rating the office space items as having the most negative impact on their productivity (1 = very negative and 2 = negative) have been separated out and classified according to the office layout that they occupy. The highest level of APU was scored for refreshment areas, air quality, quiet areas, crowding and interruptions and were common across many of the office configurations. Refreshment areas were a negative impact on the productivity of those in most (60%+) of the office layouts, suggesting that occupants of all office types regard the refreshment areas as a cause for distraction rather than sustenance. Consideration needs to be given to the location of refreshment areas so that they do not impact on people whilst they are working at their desk. Interestingly those in the 'Enclosed private' offices regarded them as less of a negative impact (28.6%) perhaps suggesting that they can demonstrate more restraint in using these areas due to the physical barrier. Interruptions were a source of unproductivity for occupants in all of the office configurations, but primarily for those in 'Open plan cubicle with low partitions' (60.4%) and 'Enclosed shared' (57.9%) layouts.

For those in enclosed offices, Crowding had a more negative impact on perceived productivity than those in open plan offices (52-56% APU for enclosed and 37-48% for open plan) as was also true for Internal Noise (38-47% APU for enclosed versus 34-42% for open plan). This suggests that the close proximity experienced in these office spaces is the cause of the reduction in perceived productivity.

Perceived unproductivity seemed to increase for those in open plan spaces in relation to Informal meetings spaces (35-44% enclosed versus 36 - 59% open plan) and privacy (30-40% enclosed versus 38-59% open plan). This implies that the accessibility of the space by a large mass is the source of distraction for those occupying the space. Those in 'Open Plan with low partitions' felt most strongly about the negative impact of air quality (61.2%) but did not appear to be a consistent problem across the other office configurations.

In terms of the impact of the overall office layout on perceived unproductivity, those in 'Enclosed private' considered their configuration to have the least negative impact. The ratings given by those in 'Enclosed shared' offices were at a similar level as those in 'Open Plan' office layouts.

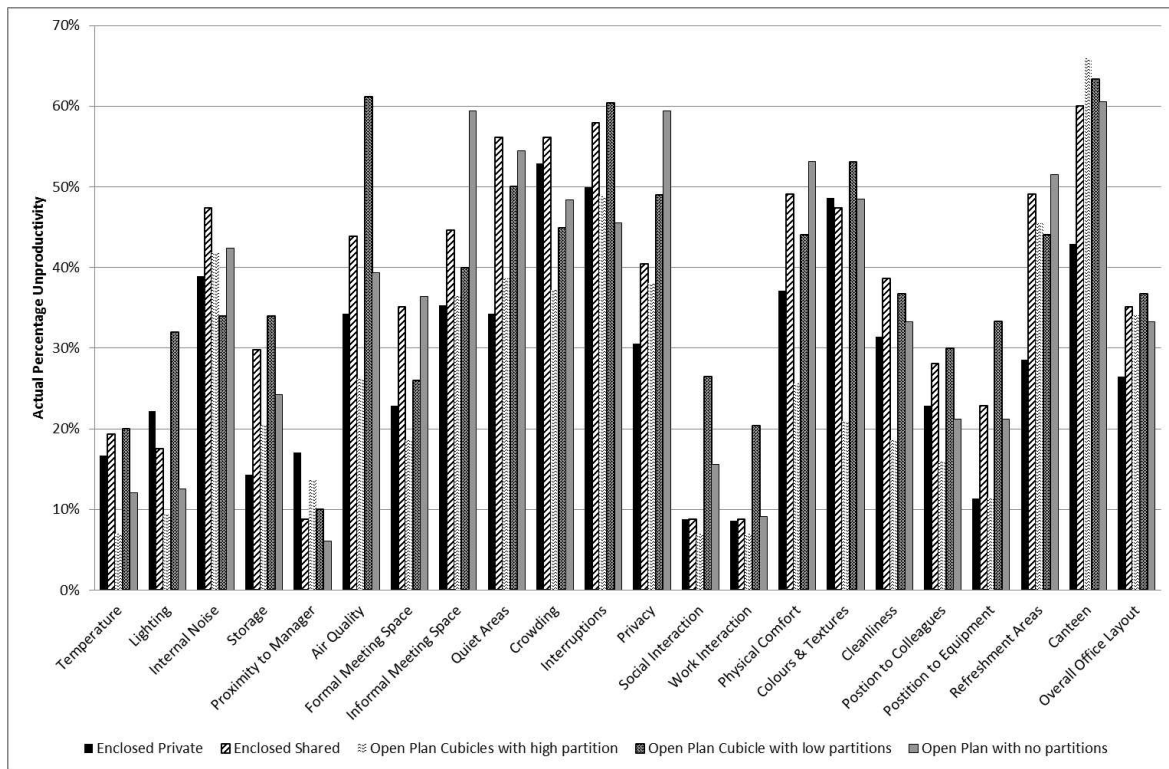


Figure 2 Actual Percentage Unproductivity for PPI variables by office layout configuration

### 3.2 Underlying office environmental factors

To give a better understanding of the relationships between the environmental factors of occupants' perceived productivity, factor analysis was applied to the 21 indicators. Factor analysis uses mathematical procedures for the simplification of interrelated measures to discover patterns in a set of variables (Child, 2006). Exploratory factor analysis was applied, as opposed to confirmatory factor analysis, since this stage of the analysis is simply trying to uncover complex patterns in the dataset. This procedure groups together variables that share a common variance and as such reduces dimensionality (Bartholomew, Knott and Moustaki, 2011) and the latent variables that emerge are in essence hypothetical constructs that are used to represent variables (Cattell, 1973). By adopting this approach



the key factors influencing perceived productivity will be identified, and those that are more trivial will be placed into more meaningful categories. Principal component analysis was performed to extract the maximum variance from the data with each component (Tabachnik & Fidell, 2007). Rotation was also undertaken to improve the interpretation of the factors, by attempting to load each variable on each factor (Rummel, 1970). This was operationalised through varimax rotation using SPSS v 22.0 to identify those factors that have a truly high loading on each factor, thus providing a more meaningful interpretation of the influences on perceived productivity. The results are shown in Table 4.

Using the Cohen (1988) criterion of factor loading (>.40) there are five factors. Inspection of the correlation matrix reveals many coefficients greater than 0.32 as recommended by Tabachnik and Fidell (2001). The sample size was adequate with a Kaiser-Meyer-Olkin value of .879 (Kaiser 1970, 1974) and the Bartlett's Test of Sphericity (Barlett, 1954) was statistically significant as required. The analysis revealed five components with initial eigenvalues greater than 1, explaining 34.5%, 8.2%, 7.3%, 6.0% and 5.9% of the variance respectively. Once this was rotated the 5 factors explained 16.6%, 12.8%, 12.4%, 10.6% and 9.6% of the variance respectively. The five components were confirmed by the Scree Test (Catell 1966).

	Factors				
	1	2	3	4	5
Air Quality	.761	.148	.136	.105	.088
Lighting	.709	.021	.258	.184	-.196
Cleanliness	.666	.288	.148	.101	.214
Colours & Textures	.622	.306	.174	.119	.142
Physical Comfort	.615	.401	.205	.011	.112
Temperature	.546	.001	.149	.074	.201
Formal Meeting Space	.037	.787	.131	.174	.079
Informal Meeting Space	.209	.707	.160	.089	.246
Quiet Areas	.361	.696	.067	.067	.133
Storage	.305	.560	.335	.282	.028
Work Interaction	.381	.051	.755	.039	.039
Social Interaction	.328	.010	.732	.030	.125
Proximity to Manager	.030	.329	.633	.023	.226
Position to Colleagues	.173	.348	.586	.254	-.008
Privacy	.388	.160	.459	.127	.228
Crowding	.073	.115	.056	.882	.039
Interruptions	.099	.123	.276	.830	.074
Internal Noise	.310	.192	-.077	.668	.216
Refreshment Areas	.198	.099	.136	.104	.853
Canteen	.183	.155	.071	.056	.842
Position to Equipment	-.041	.225	.287	.173	.393

Table 4 Principal Component Factor analysis of PPI variables

The Cronbach's alphas are satisfactory for the scale as shown in Table 5.

		Alpha
Factor 1	Comfort	0.833
Factor 2	Office Space	0.810
Factor 3	Interaction	0.791
Factor 4	Distraction	0.795
Factor 5	Social Interaction Points	0.707

Table 5 Internal reliability of factors using Cronbach alpha

Factor 1 consists of six items which has been labelled as Comfort as it reflects elements of the physical office environment that influence the ease with which people could work. The standard of air quality and temperature, generally controlled in these offices by air conditioning, as well as lighting affects one's physical ability to work. Standards of cleanliness and colours and textures, though related to the physical office environment, are subjective perceptions of the working environment however they influence the experience of comfort to work in an office. Factor 2 relates more to the design of the physical office space in terms of the location of areas for meetings, contemplation and storage, and consequently has been labelled Office Space. Factor 3 consists of five items that all relate to actual or the potential for interaction, whether this is formal or informal with superiors or peers, and so has been labelled Interaction. Fewer variables loaded on Factors 4 and 5, but the majority of the correlation coefficients are of a sufficiently high level (>0.40, Cohen, 1988) to be considered significant. Factor 4 relates to variables that impact on concentration levels in an office environment such as interruptions, noise and having a large volume of people in close proximity, and has consequently been labelled as Distraction. The variables with the highest loadings on Factor 5 relate to areas where social interaction are designed to take place and so has been labelled as Social Interaction Points.

### 3.3 Impact of office type, gender and age on PPI factors

To analyse the true extent to which the Office Factors influenced the perceived productivity of the occupants, a series of t-test analyses were undertaken. The one sample t-test was used to examine the mean difference between the mean ratings assigned by the office occupants to the office factors using the dummy variables created :

office type: open-plan space was coded as a 1 (those in open high partitions, low partitions and no partitions) and enclosed was coded as a 0 (those in enclosed private or enclosed shared);

gender; coded 1 for Male and 0 for Female;

and age; coded as 1 for Old (those in the 35-50 years and Over 50 years age categories) and 0 for Young (those in the Under 34 years category).

The results of this are shown in Tables 6 - 8 below:

	t-test	sig	mean diff	mean perceived productivity impact
Factor 1: Comfort	0.10	0.92	0.01	Enclosed = 3.04 Open = 3.03
Factor 2: Office Space	0.46	0.65	0.06	Closed = 2.96 Open = 2.90
Factor 3: Interaction	2.51	0.01*	0.28	Enclosed = 3.50 Open = 3.22
Factor 4: Distraction	-1.05	0.29	-0.13	Enclosed = 2.50 Open = 2.63
Factor 5: Social Interaction Points	2.18	0.03*	0.30	Enclosed = 2.98 Open = 2.68

Table 6 Independent sample t-test using Office Type Dummy Variable \* p <0.05

	t-test	sig	mean diff	mean perceived productivity impact
Factor 1: Comfort	0.35	0.72	0.05	Male = 3.03 Female = 3.08
Factor 2: Office Space	0.85	0.39	0.13	Male = 2.89 Female = 3.02
Factor 3: Interaction	2.05	0.04*	0.28	Male = 3.26 Female = 3.54
Factor 4: Distraction	-0.83	0.41	-0.12	Male = 2.61 Female = 2.49
Factor 5: Social Interaction Points	0.05	0.96	0.01	Male = 2.82 Female = 2.83

Table 7 Independent sample t-test using Gender Dummy Variable \* p <0.05

	t-test	sig	mean diff	mean perceived productivity impact
Factor 1: Comfort	-1.60	0.11	-0.19	Young = 2.92 Old = 3.11
Factor 2: Office Space	-1.59	0.11	-0.20	Young = 2.81 Old = 3.01
Factor 3: Interaction	0.03	0.97	0.00	Young = 3.35 Old = 3.34
Factor 4: Distraction	-1.59	0.11	-0.20	Young = 2.45 Old = 2.65
Factor 5: Social Interaction Points	-3.12	0.00*	-0.41	Young = 2.57 Old = 2.98

Table 8 Independent sample t-test using Age Dummy Variable \*  $p < 0.05$

The t-test analysis has identified a number of statistical differences in the perceived impact of the office environment according to the office occupant's gender, age and type of office environment. With regard to the type of office occupied, those in the enclosed office environment found that the Interaction factor had a significantly more positive impact on their perceived productivity than those in the Open office environment (enclosed = 3.50, open = 3.22,  $p < 0.05$ ). This was also the case for the Social Interaction factors, with the occupants of the Open office environment considering areas such as the canteen and position to equipment to have more of a negative impact on their perceived productivity (enclosed = 2.98, open = 2.68,  $p < 0.05$ ).

With regard to gender, female office occupants had a significantly more positive perception of the Interaction factor on their perceived productivity, such as proximity to managers and colleagues, compared to their male counterparts (female = 3.54, male = 3.26,  $p < 0.05$ ). And finally with regard to the age of the office occupant, the older occupants had a significantly more positive view of the Social Interaction factor on their perceived productivity than their younger counterparts (young = 2.57; old = 2.98,  $p < 0.05$ ).

## 4.0 Discussion

### 4.1 Impact of different office layouts on the perceived productivity of the office occupants.

The overview results of the research (Figures 1 and 2: mean productivity score = +3.3, APU = 55%) illustrate that, compared to other office layouts, enclosed private offices are perceived to be more productive than open-plan offices. These results are in general agreement with previous research based upon office satisfaction (Bodin Danielsson & Bodin, 2009; Kim & de Dear, 2013) and would suggest that the productivity penalties of open plan working outweigh the productivity benefits. An evaluation of the individual variables however illustrates a more complex picture with the enclosed private office not always being the office layout with the highest productivity score.

Compared to the other office layouts the variables where the enclosed private office had a positive impact on perceived productivity were privacy (mean productivity score = +3.5, APU = 30%) and position to equipment (mean productivity score = +3.7, APU = 11%). Although the relatively high privacy score could be a function of the type of work undertaken in enclosed private offices (Wajcman & Rose, 2011), as the office occupier is in total control of their physical environment and also how they undertake their work, thereby allowing for distraction-free working (Seddigh et al., 2014). Kim & de Dear (2013) proposed that enclosed private offices provide the occupant with visual privacy which would contrast with those in open-plan environments, where there could be visual distractions from others walking by. Those in the open plan office environments had a much lower rating for privacy (open plan mean productivity score = +2.6, APU = 49%) suggesting that the lack of privacy was detrimental to their perceived productivity. Nearly half of those in an open plan office rated this as being a source of unproductivity. With regard to the position to equipment result, enclosed private office space generally include individual printers rather than communal printers and so the distraction caused by the noise of this office equipment and the need to travel to collect work would be minimised.

Sound privacy, as measured by internal noise, was reported by all office types as having more of a negative impact on productivity than positive. This indicates that even in enclosed private offices issues exist with internal noise caused by equipment, telephones, conversations and people movement. An explanation for such a result could be the type of materials used to construct private offices not been sufficient quality to provide acoustic isolation (Kim & de Dear, 2013). The office type that reported the most negative impact on their productivity for internal noise was the enclosed shared office (mean productivity score = +2.3, APU = 47%). This group also reported the second highest negative score for crowding (mean productivity score = +2.4, APU = 56%) and interruptions (mean productivity score = +2.4, APU = 58%). The relatively high negative internal noise score could be caused by colleagues' conversations which the office occupier inadvertently tunes into due to the content of other colleagues' conversations (Marsh, Hughes & Jones, 2009). These conversations could be seen to have speech intelligibility and therefore can be deemed as a disruptive sound source (Hongisto et al., 2008). In contrast to the scores for internal noise, crowding and interruptions being detrimental to perceived productivity, the enclosed shared occupants reported one of the best scores for work interaction benefitting their perceived productivity (mean productivity score = 3.9, APU = 9%). This indicates that enclosed shared office environments facilitate work interaction with other colleagues which has the potential to increase collaboration and knowledge sharing (Heerwagen et al, 2004; Lansdale et al., 2011). This collegiate collaborative way of working could potentially offset the productivity penalties caused by internal noise, crowding and interruptions. Internal noise and privacy were also detrimental

to productivity for those in the open plan with no partitions (internal noise mean productivity score = 2.6, APU = 42%) and (privacy mean productivity score = 2.4, APU = 59%). These results indicate that occupants of open plan office environments, who produce similar work interaction scores to other office types, have to overcome the more negative aspects of increased noise and loss of privacy. It could therefore be argued that office occupants of open plan environment have to undertake more emotional work (Evans & Johnson, 2000; Jahncke et al., 2011) than their enclosed private office counterparts.

Productivity benefits of open plan working include increased opportunities for collaboration and knowledge sharing (Openshaw, 2013; Cummings & Oldham 1997; Dunbar 1995); and was measured in this research through work interactions, informal meeting space and position to colleagues. With the exception of open plan cubicles with low partitions, the other two types of open plan office configurations have similar positive work interaction scores as the ones for enclosed private and enclosed shared office layouts (mean productivity score between +3.6 - +3.9, APU between 7% - 9%). This similarity would suggest that the office configuration does not have a great influence on the efficiency of work interaction. There was a greater variation in the results for the informal meeting space however across the types of offices (mean productivity score between +2.6 - +3.0, APU between 35% - 59%), particularly for those in the open plan with no partitions where nearly two-thirds regarded this as being detrimental to their productivity. With no physical barrier between workers, regardless of its size, there is clearly an open invitation for informal interaction which is not considered to be productive, and so would suggest that some form of partition is valuable in open plan working not only for its physical qualities but also psychologically through its symbolism. Although both those occupying enclosed offices and open plan configurations gave a similar rating for their position to colleagues (mean productivity score between +3.2 - +3.6), there was a greater level of disruption from colleagues for those in enclosed shared offices and those in open plan with low partition offices (APU between 28 - 30%). The most conducive position of colleagues of all the office configurations was for those in the open plan with high partitions (APU = 16%).

#### **4.2 Underlying concepts that underpin the evaluation of the impact of office layout on office occupiers' perceived productivity.**

Principal component analysis allowed the 21 perceived productivity variables to be reduced to 5 underlying components. The five components created were comfort, office space, interaction, distraction and social interaction points, and can largely be validated by previous workplace research (Haynes 2008). The comfort component consisted of variables that related to the physical office environment such as temperature, lighting, air quality, cleanliness, colours and textures, and physical comfort. These tend to be common variables that are used in workplace satisfaction studies (Bodin Danielsson et al., 2015; Kim & de Dear, 2013) and workplace productivity studies (Leaman & Bordass, 1999). The office space component consisted of informal meeting space, quiet areas and storage and is largely defined by the range of spaces provided by the office environment (Bodin Danielsson et al., 2015; Sundstrom et al., 1982). The interaction component is largely defined by the variables work interaction, social interaction, proximity to manager, proximity to colleagues and privacy and captures the complexity of human interaction and social dynamics within the office environment as well as the potential loss of privacy (Nathan & Doyle, 2002). Another component that relates to the social dynamics of the office is the distraction component which consisted of crowding, interruptions and internal noise. These could be considered to be the variables that have the most negative impact on office occupants, specifically in open-plan environments (Kaarlela-Tuomaala et al.,

2009; Kim & de Dear, 2013). The final component is the social interaction point component which consisted of refreshments areas, canteen and position to equipment and contained the variables relating to areas where ad hoc conversations can occur in an office environment. The value of these 'actants' to organisational creativity is supported by a number of authors (Fayard & Weeks, 2007; Haynes, 2008).

#### **4.3 Differences between office occupiers' perceived productivity based on gender, age and office type.**

Previous research that has investigated the impact of indoor environmental quality (IEQ) on office occupants has identified gender differences and in certain instances significant differences (Kim, de Dear et al. 2013, Karjalainen 2007). In contrast, this research found no significant difference between male and female respondents with regards to office comfort. An explanation for this could be that since the offices were based in the Middle East were they are more likely to be fitted with air conditioning. Therefore, with air-conditioned office environments set at a constant level there is less opportunity for variation within the office environment. However, a statistical significant difference between genders was found for the Interaction component (female = 3.54, male = 3.26,  $p < 0.05$ ). Whilst both genders perceived Interaction as having an overall positive impact on their perceived productivity, the female respondents perceived it to be having more of a positive impact than the male respondents. The factors that contribute to the Interaction component are; work interaction, social interaction, proximity to manager, proximity to colleagues and privacy. All these factors relate to the social dynamics that can exist within an office environment, and can be perceived as being both supportive of productivity or as interruptions so having a negative effect on productivity. The results from this research indicate that female respondents are more likely to see interruptions as a positive experience and would suggest a greater openness to work and social interactions within the office environment (Mark, Gudith et al. 2008). However, included in the Interactions component is the privacy variable which indicates that a balance has to be struck between social and work interaction in the office environment and privacy to allow the office occupier to withdraw and concentrate on focussed work as necessary (Haynes, 2008).

A significant difference was found between the older and younger office occupiers with regards to their views on the Social Interaction Points component (young = 2.57; old = 2.98,  $p < 0.05$ ). This component consisted of refreshment areas, canteen and position of equipment. Whilst both age groups were slightly negative on this component it was the younger respondents that were the most negative. This result supports research undertaken by Rothe et al (2011) who identified significant difference between age groups with regards to workplace restaurant services. The results could indicate that the older respondents appreciate the opportunity to get away from their working environment and interact on a social level in the refreshment areas, canteen or around the actants (printer and photocopier - position of equipment). In addition, research undertaken by Rasila and Rothe (2012) establish that younger employees saw the same limitations and problems of open plan environment as the older employees but saw them as a fair trade-off against the benefits. Therefore, the younger employees may not feel the same need as the older employees to get away from their workstation.

The research results for office type indicate significant differences for the Interaction component (enclosed = 3.50, open = 3.22,  $p < 0.05$ ) and Social Interaction Points component (enclosed = 2.98, open = 2.68,  $p < 0.05$ ). These results are in line with previous research that has investigated occupant satisfaction with open plan and private enclosed office environments (Bodin Danielsson & Bodin, 2009; Bodin Danielsson et al., 2015; Kim & de Dear, 2013). Whilst both occupiers of enclosed and open office

environments perceived the Interaction component to be generally positive, it is the enclosed office occupiers that see interaction as having the most positive effect on their productivity. As discussed previously interactions can be perceived as being both positive and negative. The average interruption by colleagues per day is around 12 interruptions (Wajcman, Rose 2011) and once distracted from the task it could take an average of 25 minutes to return to that task (Mark, Gonzalez et al. 2005). In addition, background noise can also be seen as an interruption if it consists of meaningful speech as this causes a higher distraction than irrelevant speech (Marsh, Hughes et al. 2009). The benefits of an enclosed office environment mean that the occupiers have greater control over their working environment than occupiers of open plan environments (Kim, de Dear 2013). This effectively means that the levels of interruptions can be reduced which leads to longer periods of uninterrupted concentration on focused work.

Statistical analysis of the Social Interaction Points component identified a significant difference between occupiers of enclosed office environments and occupiers of open plan office environments (enclosed = 2.98, open = 2.68,  $p < 0.05$ ). This component consisted of refreshment areas, canteen and position of equipment. Whilst both open and enclosed office occupants perceived social interaction points to be slightly negative, it is the occupiers of enclosed office environments that perceived them as having a slightly more positive impact on their productivity. This could be interpreted as the occupiers of enclosed office environments appreciating the opportunity to move away from their designated workplace and having a physical and psychological break from their work activities. In addition, refreshment areas, canteens and position of equipment also allows opportunities for informal serendipitous interactions which would not normally occur within the enclosed office environments (Fayard, Weeks 2007).

## **5.0 Conclusions**

This research has shown that the configuration of the office has a clear impact on the perceived productivity of the occupier. Those in enclosed office spaces were more productive due to privacy and limited distractions, and those in open plan spaces were more productive because of their access to informal meeting spaces. The productivity of those in enclosed shared offices however suffered more due to crowding and interruptions, although work interactions and knowledge exchange were enhanced from this close proximity. Internal noise and proximity to colleagues had a similar impact on office occupiers regardless of the type of office, with a negative and positive perceived impact on productivity respectively. With such contrasting results, there is insufficient evidence to suggest that the productivity benefits of open plan office environments outweigh the productivity penalties.

Three key underlying concepts were identified to have the greatest influence on office occupiers' evaluation of their perceived productivity in relation to the office layout. Firstly, the physical layout of the office space was important to productivity and captured the provision of formal meeting space, quiet areas and storage, suggesting that a range of different spaces are key to perceived productivity rather than one large open plan environment. By having a range of different spaces office occupiers can choose the most appropriate space to best undertake that particular work task. Secondly, interaction was vital to perceived productivity, requiring the overall office layout to not only facilitate and enable interaction with managers and colleagues, but to also allow occupiers to withdraw from this interaction and undertake private and concentrated work. Office environments need to be sufficiently flexible to provide the balance of interaction and privacy that is required by its occupiers. The third influence in the



office space on perceived productivity was social interaction points, and emphasised the value that occupiers placed on 'downtime' to their productivity. The term "downtime" is used to mean the office occupier is able to physically move away from their desk and engage in either social interaction or just to have time to themselves away from their desk. Although areas such as the canteen and refreshment points were important, they were also a source of distraction, so their positioning requires careful consideration. It is proposed that 'downtime' has a key role to play both in terms of productivity and the health and wellbeing of office occupiers.

Some differences were identified in the research on the impact of the office environment on perceived productivity according to gender and age. Generally, female occupiers considered the office environment to have a more positive impact on their perceived productivity than male occupiers, which is in contrast to previous research in this area. The one exceptions being distraction where females perceived this to have a more negative impact on their productivity. This has implications for the design of office environments for these office workers. Older workers were more positive about the impact of the office environment on their perceived productivity than younger workers which contradicts previous research on age differences. Younger workers were previously found to view the positives of open plan offices to outweigh the negatives, but this has not been found to be the case in this research.

The differences identified in this research based on gender and age however, are only the beginning, given the variation in office configurations occupied by respondents. Further research is recommended on the perceptions of male and female office workers in both open plan environments and those in enclosed office environments, to ascertain the true impact of the office environment on their perceived productivity. This is also the case for those in different age groups, so that any correlation between older workers occupying private enclosed office space because of their age, career progression and status that may have been evident in this research, are thoroughly compared against those occupying open plan offices.

Further research is also recommended on understanding in more depth the influences of the office space on perceived productivity through more qualitative research methodologies. This can be to understand the value of having a range of physical spaces, the benefits of interactions, examples of coping mechanisms used for achieving privacy, managing internal noise and reducing distractions. This research approach would also be valuable to explore further the gender and age differences, particularly to understand the reasons for female workers' more negative perceptions of the office environment and the requirements of the new generation of workers.

Since this research has been undertaken on an organisation in the Middle East, there could be cultural influences on the results that have been uncovered. A further recommendation would therefore be to repeat the research with organisations in other countries to make comparisons and extend the reliability of the research further, in order to fully understand the impact of the office environment on occupiers' perceived productivity.

## References

- Allen, T. J., & Henn, G. (2006). *The organization and architecture of innovation: Managing the flow of technology*. Amsterdam: Butterworth-Heinemann, Amsterdam.
- Altmann, E. M., Trafton, J. G., & Hambrick, D. Z. (2014). Momentary interruptions can derail the train of thought. *Journal of Experimental Psychology*, *143*(1), 215-226. doi:10.1037/a0030986 [doi]
- Banbury, S. P., & Berry, D. C. (2005). Office noise and employee concentration: Identifying causes of disruption and potential improvements. *Ergonomics*, *48*(1), 25-37. doi:10.1080/00140130412331311390
- Bartholomew, D.J., Knotts, M. and Moustaki, I. (2011). *Latent variable models and factor analysis: A unified approach*. (3<sup>rd</sup> edn.). West Sussex, UK: John Wiley & Sons.
- Bartlett, M.S. (1954). A note on the multiplying factors for various chi-square approximations. *Journal of the Royal Statistical Society* 16 (Series B): 296-298.
- Bennett, J., Pitt, M., & Price, S. (2012). Understanding the impact of generational issues in the workplace. *Facilities*, *30*(7), 278-288. doi:10.1108/02632771211220086
- Block, L. K., & Stokes, G. S. (1989). Performance and satisfaction in private versus no private work settings. *Environment and Behavior*, *21*(3), 277-297. doi:10.1177/0013916589213003
- Bodin Danielsson, C., & Bodin, L. (2008). Office type in relation to health, well-being, and job satisfaction among employees. *Environment and Behavior*, *40*(5), 636-668. doi:10.1177/0013916507307459
- Bodin Danielsson, C., & Bodin, L. (2009). Difference in satisfaction with office environment among employees in different office types. *Journal of Architectural and Planning Research*, *26*(3), 241-257.
- Bodin Danielsson, C., Bodin, L., Wulff, C., & Theorell, T. (2015). The relation between office type and workplace conflict: A gender and noise perspective. *Journal of Environmental Psychology*, *42*(0), 161-171. doi:http://dx.doi.org/10.1016/j.jenvp.2015.04.004
- Boutellier, R., Ullman, F., Schreiber, J., Naef, R. (2008) Impact of office layout on communication in a science-driven business. *R&D Management*, *38*, 4, 372-391.
- Brager, G., & Baker, L. (2009). Occupant satisfaction in mixed-mode buildings. *Building Research and Information*, *37*(4), 369 - 380.
- Cattell, R.B. (1966). The Scree Test for the number of factors. *Multivariate Behavioural Research* 1: 140-161.
- Cattell, R.B. (1973). *Factor analysis*. Westport, CT: Greenwood Press.
- Child, D. (2006). *The essentials of factor analysis*. (3<sup>rd</sup> edn.). New York, NY: Continuum International Publishing Group.
- Clements-Croome, D (2006). *The Productive Workplace*. Taylor Francis. Cohen, J. (1988). *Statistical power analysis for the behavioural sciences*. London: Lawrence Erlbaum Associates.
- Cummings, A., Oldham, G.R. (1997). Enhancing creativity: managing work contexts for the high potential employee. *California Management Review*, *40*, 22 - 38.

- Danielsson, C.B. and Bodin, L. (2008) Office type in relation to health, well-being and job satisfaction among employees. *Environment and Behaviour*, 40 (5), pp. 636-668.
- Dobson, S., Breslin, D. Suckley, L., Barton, R. & Rodriguez, L. (2013) 'Small firm survival and innovation: an evolutionary approach, *International Journal of Entrepreneurship and Innovation*, Vol. 14, No. 2, pp. 91 - 102.
- Dobson, S., & Suckley, L. (2015). "A squash and a squeeze": Managing spatial relations in the office. *International Journal of Business Environment*, 7(2), 137. doi:10.1504/ijbe.2015.069011
- Dunbar, K. (1995). How scientists really reason: scientific reasoning in real-world laboratories. In Sternberg, R.J., Davidson, J. (eds) *Mechanisms of Insight*. MIT Press, Cambridge MA.
- Erlich, A., & Bichard, J. (2008). The welcoming workplace: Designing for ageing knowledge workers. *Journal of Corporate Real Estate*, 10(4), 273-285.
- Evans, G. W., & Johnson, D. (2000). Stress and open-office noise. *Journal of Applied Psychology*, 85(5), 779-783. doi:http://dx.doi.org.lcproxy.shu.ac.uk/10.1037/0021-9010.85.5.779
- Fanger, P.O. (1972) *Thermal comfort: Analysis and applications in environmental engineering*. New York: McGraw-Hill.
- Fayard, A., & Weeks, J. (2007). Photocopiers and water-coolers: The affordances of informal interaction. *Organization Studies*, 28(5), 605-634. doi:10.1177/0170840606068310
- Freedman, D.A. (2009). *Statistical Models: Theory and Practice*. Cambridge University Press.
- Frontczak, M., Schiavon, S., Goins, J., Arens, E., Zhang, H., & Wargocki, P. (2012). Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. *Indoor Air*, 22(2), 119-131. doi:10.1111/j.1600-0668.2011.00745.x
- Furnham, A., & Strbac, L. (2002). Music is as distracting as noise: The differential distraction of background music and noise on the cognitive test performance of introverts and extraverts. *Ergonomics*, 45(3), 203-217. doi:10.1080/00140130210121932
- Hair, J. F.; Anderson, R.; Tatham, R. L.; Black, W. C. (2006). *Multivariate Data Analysis*. Upper Saddle River, NJ.
- Haynes, B.P. (2007) The impact of the behavioural environment on office productivity. *Journal of Facilities Management*, 5, (3), 158-171.
- Haynes, B.P., 2009. Research design for the measurement of perceived office productivity. *Intelligent Buildings International*, 1(3), 169-183.
- Haynes, B. P. (2008). Impact of workplace connectivity on office productivity. *Journal of Corporate Real Estate*, 10(4), 286-302. doi:10.1108/14630010810925145
- Haynes, B.P (2008b) "The impact of office comfort on productivity", *Journal of Facilities Management*, vol. 6, no.1. 37-51. ISSN 1472-5967.

- Haynes, B. P. (2011). The impact of generational differences on the workplace. *Journal of Corporate Real Estate*, 13(2), 98-108. doi:10.1108/14630011111136812
- Hedge, A. (1982). The open-plan office: A systematic investigation of employee reactions to their work environment. *Environment and Behavior*, 14(5), 519-542. doi:10.1177/0013916582145002
- Heerwagen, J. (2000). Green buildings, organizational success and occupant productivity. *Building Research & Information*, 28(5-6), 353-367. doi:10.1080/096132100418500
- Heerwagen, J. H., Kampschroer, K., Powell, K. M., & Loftness, V. (2004). Collaborative knowledge work environments. *Building Research & Information*, 32(6), 510-528. doi:10.1080/09613210412331313025
- Hongisto, V. (2005). A model predicting the effect of speech of varying intelligibility on work performance. *Indoor Air*, 15(6), 458-468. doi:10.1111/j.1600-0668.2005.00391.x
- Hongisto, V., Haapakangas, A., & Haka, M. (2008). Task performance and speech intelligibility—a model to promote noise control actions in open offices. *9th International Congress on Noise as a Public Health Problem (ICBEN)*, Foxwoods, CT,
- Jahncke, H., Hygge, S., Halin, N., Green, A. M., & Dimberg, K. (2011). Open-plan office noise: Cognitive performance and restoration. *Journal of Environmental Psychology*, 31(4), 373-382. doi:http://dx.doi.org.lcproxy.shu.ac.uk/10.1016/j.jenvp.2011.07.002
- Joy, A., & Haynes, B. P. (2011). Office design for the multi-generational knowledge workforce. *Journal of Corporate Real Estate*, 13(4), 216-232. doi:10.1108/14630011111214428
- Kaarlela-Tuomaala, A., Helenius, R., Keskinen, E., & Hongisto, V. (2009). Effects of acoustic environment on work in private office rooms and open-plan offices – longitudinal study during relocation. *Ergonomics*, 52(11), 1423-1444. doi:10.1080/00140130903154579
- Kaiser, H. (1970). A second generation Little Jiffy. *Psychometrika* 35: 401-415.
- Kaiser, H. (1974). An index of factorial simplicity. *Psychometrika* 39: 31-36.
- Karjalainen, S. (2007). Gender differences in thermal comfort and use of thermostats in everyday thermal environments. *Building and Environment*, 42(4), 1594-1603.
- Kim, J. and de Dear, R. (2013) Workspace satisfaction: The privacy-communication trade-off in open-plan offices, *Journal of Environmental Psychology*, 36, pp. 18-26.
- Kim, J., & de Dear, R. (2013). Workspace satisfaction: The privacy-communication trade-off in open-plan offices. *Journal of Environmental Psychology*, 36(0), 18-26. doi:http://dx.doi.org/10.1016/j.jenvp.2013.06.007
- Lansdale, M., Parkin, J., Austin, S., & Baguley, T. (2011). Designing for interaction in research environments: A case study. *Journal of Environmental Psychology*, 31(4), 407-420. doi:http://dx.doi.org/10.1016/j.jenvp.2011.05.006
- Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford: Oxford University Press.

- Leaman, A., & Bordass, B. (1999). Productivity in buildings: The 'killer' variables. *Building Research & Information*, 27(1), 4-19. doi:10.1080/096132199369615
- Leather, P., Beale, D., & Sullivan, L. (2003). Noise, psychosocial stress and their interaction in the workplace. *Journal of Environmental Psychology*, 23(2), 213-222. doi:http://dx.doi.org/10.1016/S0272-4944(02)00082-8
- Lister, T., & DeMarco, T. (1987). *Peopeware: Productive projects and teams*. Dorset House, New York,
- Maher, A., & von Hippel, C. (2005). Individual differences in employee reactions to open-plan offices. *Journal of Environmental Psychology*, 25(2), 219-229. doi:http://dx.doi.org.lcproxy.shu.ac.uk/10.1016/j.jenvp.2005.05.002
- Mak, C. M., & Lui, Y. P. (2012). The effect of sound on office productivity. *Building Services Engineering Research & Technology*, 33(3), 339-345. doi:http://dx.doi.org.lcproxy.shu.ac.uk/10.1177/0143624411412253
- Mark, G., Gonzalez, V. M., & Harris, J. (2005). No task left behind?: Examining the nature of fragmented work. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 321-330.
- Mark, G., Gudith, D., & Klocke, U. (2008). The cost of interrupted work: More speed and stress. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 107-110.
- Marsh, J. E., Hughes, R. W., & Jones, D. M. (2009). Interference by process, not content, determines semantic auditory distraction. *Cognition*, 110(1), 23-38.
- Martinez, A., Dimitriadis, Y., Rubia, B., Gomez, E., de la Fuente, P. (2003) Combining qualitative evaluation and social network analysis for the study of classroom social interactions. *Computers and Education* 41, 353-368.
- McElroy, J. C., & Morrow, P. C. (2010). Employee reactions to office redesign: A naturally occurring quasi-field experiment in a multi-generational setting. *Human Relations*, 63(5), 609-636. doi:10.1177/0018726709342932
- Nathan, M., & Doyle, J. (2002). *The state of the office: The politics and geography of working space* Industrial Society.
- Openshaw, R. (2013) Places for Innovation: A way to measure space's effect on knowledge worker productivity. Workplace Week Convention, London, 8-12 November 2013.
- Oseland, N., (1999). *Environmental factors affecting office worker performance A review of evidence*. London (United Kingdom): Chartered Inst. of Building Services Engineers, Department of the Environment, Transport and the Regions,.
- Oseland, N (2004) Occupant Feedback Tools of the Office Productivity Network, Assessed 17/01/2017, <https://pdfs.semanticscholar.org/42dc/a90ef2fb820016aef738901bd14267e249cf.pdf>

- Oseland, N. and Burton, A., (2012). Quantifying the impact of environmental conditions on worker performance for inputting to a business case to justify enhanced workplace design features. *Journal of Building Survey, Appraisal & Valuation*, 1(2), 151-165.
- Parkin, J., Austin, S., Pinder, J., Bagueley, T., Allenby, S. (2011) Balancing collaboration and privacy in academic workspaces. *Facilities*, 29, 1/2, 31-49.
- Pejtersen, J., Allermann, L., Kristensen, T. S., & Poulsen, O. M. (2006). Indoor climate, psychosocial work environment and symptoms in open-plan offices. *Indoor Air*, 16(5), 392-401. doi:INA444 [pii]
- Penn, A., Desyllas, J., and 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., Bafna, S., Bajaj, R., Bromberg, J., Congdon, C., Rashid, M., Zimring, C. (2007). Designing space to support knowledge work. *Environment and Behavior*, 39(6), 815–840. doi:10.1177/0013916506297216
- Peterson, T. O., & Beard, J. W. (2004). Workspace technology's impact on individual privacy and team interaction. *Team Performance Management*, 10(7), 163-172. doi:10.1108/13527590410569887
- Rasila, H., & Rothe, P. (2012). A problem is a problem is a benefit? generation Y perceptions of open-plan offices. *Property Management*, 30(4), 362-375. doi:10.1108/02637471211249506
- Rianne Appel-Meulenbroek. (2010). Knowledge sharing through co-presence: Added value of facilities. *Facilities*, 28(3), 189-205. doi:10.1108/02632771011023140
- Rothe, P., Lindholm, A., Hyvönen, A., & Nenonen, S. (2012). Work environment preferences – does age make a difference? *Facilities*, 30(1), 78-95. doi:10.1108/02632771211194284
- Rummel, R.J. (1970). *Applied factor analysis*. Evanston, IL: Northwestern University Press.
- Samani, S. A. (2015). The impact of personal control over office workspace on environmental satisfaction and performance. *Journal of Social Sciences and Humanities*, 1(3), 163-175.
- Seddigh, A., Berntson, E., Bodin Danielsson, C., & Westerlund, H. (2014). Concentration requirements modify the effect of office type on indicators of health and performance. *Journal of Environmental Psychology*, 38(0), 167-174. doi:http://dx.doi.org.lcproxy.shu.ac.uk/10.1016/j.jenvp.2014.01.009
- Smith, J. (2008). Welcoming workplace: Designing office space for an ageing workforce in the 21st century knowledge economy. *Helen Hamlyn Centre, Royal College of Art, London*,
- Stenberg, B., & Wall, S. (1995). Why do women report 'sick building symptoms' more often than men? *Social Science & Medicine* (1982), 40(4), 491-502. doi:0277953694E0104Z [pii]
- Sullivan, J., Baird, G., & Donn, M. (2013). *Measuring productivity in the office workplace. Final report*. Wellington, New Zealand: Centre for Building Performance Research, Victoria University of Wellington.
- Sundstrom, E., Town, J. P., Brown, D. W., Forman, A., & Mcgee, C. (1982). Physical enclosure, type of job, and privacy in the office. *Environment and Behavior*, 14(5), 543-559. doi:10.1177/0013916582145003
- Tabachnik, B.G. and Fidell, L.S. (2001). *Using multivariate statistics* (4<sup>th</sup> edn.). New York: Harper Collins.

- Wineman, J.D. and Serrato, M. (1998) 'Facility design for high performance teams' in E, Sundstrom (Ed.) Supporting Work Team Effectiveness San Fransisco, CA: Jossey-Bass, pp 271-298
- Van Hoof, J. (2008). Forty years of fanger's model of thermal comfort: Comfort for all? *Indoor Air*, 18(3), 182-201. doi:10.1111/j.1600-0668.2007.00516.x
- Veitch, J. A., Charles, K. E., Farley, K. M. J., & Newsham, G. R. (2007). A model of satisfaction with open-plan office conditions: COPE field findings. *Journal of Environmental Psychology*, 27(3), 177-189. doi:http://dx.doi.org.lcproxy.shu.ac.uk/10.1016/j.jenvp.2007.04.002
- Wajcman, J., & Rose, E. (2011). Constant connectivity: Rethinking interruptions at work. *Organization Studies*, 32(7), 941-961. doi:10.1177/0170840611410829
- Wells, M. M. (2000). Office clutter or meaning personal displays: The role of personalization in employee and organizational well-being. *Journal of Environmental Psychology*, 20(3), 239-255. doi:http://dx.doi.org.lcproxy.shu.ac.uk/10.1006/jevp.1999.0166
- Wells, M. M., Thelen, L., & Ruark, J. (2007). Workspace personalization and organizational culture: Does your workspace reflect you or your company? *Environment and Behavior*, 39(5), 616-634. doi:10.1177/0013916506295602
- Witterseh, T., Wyon, D. P., & Clausen, G. (2004). The effects of moderate heat stress and open-plan office noise distraction on SBS symptoms and on the performance of office work. *Indoor Air*, 14, 30-40. doi:10.1111/j.1600-0668.2004.00305.x
- Wong, M., Gardiner, E., Lang, W., & Coulon, L. (2008). Generational differences in personality and motivation: Do they exist and what are the implications for the workplace? *Journal of Managerial Psychology*, 23(8), 878-890. doi:10.1108/02683940810904376
- Yan, X. (2009), *Linear Regression Analysis: Theory and Computing*, World Scientific, pp. 1–2
- Zagreus, L., Huizenga, C., Arens, E., & Lehrer, D. (2004). Listening to the occupants: A web-based indoor environmental quality survey. *Indoor Air*, 14 (Suppl. 8), 65 -74.
- Zweers, T., Preller, L., Brunekreef, B., & Boleij, J. S. M. (1992). Health and indoor climate complaints of 7043 office workers in 61 buildings in the netherlands. *Indoor Air*, 2(3), 127-136. doi:10.1111/j.1600-0668.1992.00001.x