# An Holistic Evaluation of the Workplace. Understanding the Impact of the Workplace Environment on Satisfaction, Perceived Productivity and Stimulation

A thesis submitted in partial fulfilment of the requirements of the University of Northumbria at Newcastle for the degree of Doctor of Philosophy

Research undertaken in the School of the Built Environment with the support of the School of Psychology and Sport Sciences

Jennifer Sarah Thomas

January 2010

**Abstract**

The central argument in this thesis is that the workplace environment has an impact upon users and that perceptions of the environment are related to overall satisfaction with the workplace, stimulation and perceived productivity. In addition, it is proposed that changing the environment can influence users' perceptions and stimulation levels. To test this argument a methodology was developed to allow the collection of both objective and subjective data relating to a range of aspects of the workplace environment. A questionnaire was developed to test users' attitudes towards aspects of the workplace environment including the internal climate, spatial layout, interior design and workplace features. These user perceptions were analysed in relation to corresponding objective measures of these workplace aspects. Data was collected in 16 workplaces and analysed to determine the relationship between user perceptions and objective measurements of the workplace and establish how these were related to overall satisfaction, stimulation and perceived productivity. The results revealed that users were satisfied with the more quantitative aspects of the workplace: internal climate and spatial layout, but were not satisfied with the qualitative aspects of the workplace: decoration, furniture, personal control and choice, window provision and break areas. All aspects of the workplace were significantly correlated with satisfaction with the workplace and stimulation. There was also an effect on perceived productivity. The findings of the workplace evaluations were tested to determine whether changing the environment in the afternoon could affect stimulation. The results revealed some evidence of a positive impact upon stimulation levels through variation of the workplace environment. Implications for the design of future workplaces and further research in light of the findings are discussed.

**Acknowledgements**

This research was undertaken for the purpose of gaining a more in-depth understanding of the impact of the built environment upon those who use and interact with it. This was done with the intention of benefitting future design. The research for this thesis was commenced during a Knowledge Transfer Partnership scheme with the University of Northumbria at Newcastle and Ryder Architecture.

I would like to express my appreciation for the help and support I was given to complete this research and thesis to:

Ryder Architecture for sponsoring me and giving me the opportunity to carry out this research.

Bob Giddings, Linda Little and David Knight, my supervisors from The University of Northumbria for their support, advice and guidance.

The organisations and staff involved for completing questionnaires and allowing me to collect data.

Shirley and Derek Thomas without whose patience and support I could not have completed this thesis.

Friends and family for their support throughout, notably Nick, Helen, Anna, Tasha and Zoe.

## Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work.

Name: Jennifer Sarah Thomas

Signature: 

Date: 10 January 2010

**Contents Page**

# Chapter 1 Introduction

## 1.1 The Workplace Environment

As the United Kingdom moves to an increasingly service based economy, there are more people in employment working in an office environment than ever before. Currently full time employees spend on average 42 hours per week at work and over 50% of the working population in the United Kingdom work in an office environment (Office of National Statistics, 2005). The amount of time that people spend in the workplace has provoked interest in the relationship between the environment and users. Duffy (1992), who has conducted a significant amount of research into the impact of the workplace environment with international business consultants DEGW, argues that "you cannot get good work out of a bad office" (p.6). However, he suggests that a strong and established evidence base that would allow for the informed development of workplace environments does not exist. Organisations and managers want to know whether the workplace environment has a positive impact upon employees and their work. The changing nature of workplace environments also indicates that those responsible for determining the design believe there to be a link between the workplace environment and users. To fully understand the impact of the workplace environment, a conclusive and comprehensive evidence base is necessary to inform design. The evidence base will allow decisions to be made based upon knowledge about the impact of the environment. The challenge for this thesis is to establish whether the impact of the workplace environment upon users can be measured. Secondly it is to demonstrate user perceptions of the environment and the impact of the workplace. Finally, it is to determine whether the workplace can be designed to have a positive effect upon users.

Before the workplace environment is discussed further, it is important to establish the definition of key terms and parameters of this thesis. The term workplace is used frequently throughout and refers to a specific type of environment. Workplace here is defined as an environment that people use for the primary reason of working on non-industrial tasks. Commonly, these environments are referred to as offices. However, the term offices does not adequately describe the type of environments referred to as workplaces within this thesis. The first reason for this is the ambiguity surrounding the term office. It can be used to refer to a space within a building such as 'the manager's office'. Equally is can be used to describe the entire space occupied by an organisation, for example, the offices of Company A. Thus, the term 'office' could be

confusing, particularly when discussing spatial layout where cellular offices are located within ‘an office’. Thus, the term workplace is used to refer to the working environment as a whole. The second reason for using the term workplace is that a number of functions often occur within an organisation’s facility that do not take place in what would be considered office spaces. However, they are still part of the working environment. This may be specialised spaces such as laboratories or an area used by people for purposes other than work, such as break out spaces or canteens. As these spaces are a part of the environment in which people work, the term workplace will be used as opposed to office to encompass the whole environment. It is important to note that whilst the term workplace includes environments in which some practical work takes place, in addition to administrative or service based functions, it does not include factory environments. In addition, environments which are workplaces but with a different primary function have been excluded. For example, hospital and school environments are not included in the evaluation as their primary functions are healthcare and education respectively. Whilst there is opportunity to learn from the impact of these other environments, it is not within the scope of this thesis to evaluate them. Two further key terms which require definition are quantitative and qualitative aspects of the workplace environment. For the purpose of this thesis these refer to elements of the design such as air temperature or window provision and the way in which they are measured. Quantitative aspects are those which can easily be measured objectively using a standardised scale. For example area is quantitative as it can be measured in m². Any aspect of the environment that can be measured on a standardised, interval scale such as this is referred to as quantitative. The term qualitative is used to refer to those aspects of the environment that cannot be measured on a standardised scale and are, to some extent, considered to be subjective. For example the view out of a window cannot be quantified using a standardised scale. Whilst it is difficult to measure these qualitative aspects of the environment, some level of differentiation based upon measureable elements can be made. Thus, whilst referred to as qualitative as a whole, it is possible to measure these aspects with some objectivity. Further definition of these terms is made within the thesis.

With regards to scope some parameters have been deliberately set. The first of these is information technology which is not considered in great detail within this thesis. The importance of the impact of information technology is recognised, but is considered to be part of the organisation rather than part of the environment within this thesis. This position is supported by the research of others (for example, Starbuck, 1983).

Information technology is given consideration only in relation to the impact that it has upon users' experience of the physical environment. The complexity of information technology provision and the impact upon users and the work of an organisation cannot be adequately evaluated within this thesis and requires a more in-depth and focused analysis. Thus, it is deliberately excluded. The impact of the workplace environment on health has also been excluded from this thesis as the focus is on satisfaction, stimulation and perceived productivity. A substantial amount of research has been conducted into the impact of buildings upon health and evidence demonstrates that a building should not have a negative impact upon health. For a good example of this work see Raw's research into Sick Building Syndrome (Raw, 1996). It is assumed in this thesis that a building should not have a negative impact upon health and therefore the focus is on creating a workplace environment which goes beyond this to have a positive impact. Thus, the focus is upon satisfaction and productivity, not health.

The final major parameter set for this thesis is that it is focused upon workplaces in the United Kingdom. Whilst research into the impact of workplaces in other countries, particularly the United States of America, has informed the current state of knowledge, only findings that enhance the understanding of the impact of workplaces in the United Kingdom have been incorporated. The reason for limiting the scope to the United Kingdom is that the context (cultural, economic, political and historical) is likely to affect the impact of the workplace environment and therefore the data gathered and analysed within this thesis may not easily be generalised to workplaces in other countries. Further investigation would be required to establish the implications of the findings internationally.

### 1.2 Background to the Thesis

The lack of robust, highly regarded and well established research evidence contributes to the assumption of some managers that the workplace environment has little impact upon users. Therefore they see no need to change the spatial layout of their workplace to suit the way in which their organisation works (Becker, 1981). Research by occupational psychologists into the impact of job characteristics upon users' satisfaction and productivity have demonstrated that the workplace environment or working conditions do have an impact upon users. However, when determining the significance of factors, workplace conditions are superseded by other aspects of the job such as variety, autonomy, identity, feedback, the degree of social support, and the

level of cognitive demand (Warr, 2002). A similar pattern is revealed in relation to models of motivation at work. Workplace conditions are listed as a contributing factor but other aspects are given greater importance within the models. Research by Herzberg, Mausner, Peterson and Capwell (1957) demonstrated from a meta-analysis of studies that the following aspects had an impact upon users in order of importance: security, interest, opportunity for advancement, appreciation, company and management, intrinsic aspects of job, wages, supervision, social aspects of job, working conditions, communication, hours, ease, benefits. The workplace environment, identified here as working conditions, is listed as being the tenth most important factor in a list of fourteen. This is supported by the research of other psychologists (for example; Vroom, 1964; Lofquist and Davis, 1969). With the evidence suggesting that other aspects of work affect satisfaction, motivation and productivity to a greater extent than the environment, it is understandable that managers may not believe the workplace to have a significant impact upon users. However, the real impact of the workplace environment may be greater than it appears in these models of satisfaction. The impact may have been misinterpreted due to a lack of a robust and readily available evidence base to demonstrate how the workplace environment affects users. There are a number of potential reasons for this evidence base not existing. These include the commercial nature of the research preventing results being published, the complexity of the workplace environment and the varied approaches of different disciplines. Much research into the impact of the workplace environment has been driven by the desire of an organisation to determine how their workplace environment, or one which they were involved in providing, affects users. The evidence from these studies has the potential to be biased as a result of the self-selection of the workplaces and the desire to keep aspects of both the methodologies and results confidential. Thus, the findings reported are not comprehensive and therefore do not provide a complete evidence base. A further barrier to the comprehensive evidence base is that there are limited aspects of the workplace considered. This complexity of the workplace environment has also prevented a robust evidence base being developed. The aspects of the workplace environment referred to as working conditions in the motivational models, for example Herzberg et al (1957 and Herzberg, 1966), are those relating to the internal climate such as air temperature, illuminance and noise rather than the workplace environment as a whole. There is potential for the workplace environment to have greater importance within the models of motivation and satisfaction if a more holistic representation of the workplace is taken, including other aspects of the environment. The third potential barrier to the development of a conclusive evidence base being developed is that research into the workplace environment has evolved

from at least three separate disciplines: built environment, psychology and organisational management and there is very little evidence of a multi-disciplinary approach. Instead, studies of the impact of the workplace environment upon occupants have been approached in a slightly different way by researchers from each discipline. With the different approaches, there has been little opportunity to draw together the positive elements of each approach and obtain conclusive evidence to demonstrate the impact of the workplace environment. Together these barriers have had a considerable effect upon the findings in relation to the impact of the environment. Thus, the evidence base is limited.

Whilst the research into the workplace environment has not provided a robust and frequently applied evidence base, there is evidence to demonstrate the benefits of understanding the impact of the workplace on users. A well cited and highly regarded publication by Eric Sundstrom (1986), a researcher with interests in environmental and organisational psychology, highlights the various ways in which the physical environment affects users. Sundstrom describes how the workplace environment has developed and how a wide range of aspects of the environment including the internal climate, spatial layout and decoration, affect users. His analysis of research into the physical workplace environment reveals that there are a number of studies demonstrating the positive impact of the workplace on users. Sundstrom suggests that research demonstrates a link between job satisfaction and satisfaction with the workplace (Sundstrom, 1986, p. 78). The evidence gathered and reported by Sundstrom provides strong support for the potential impact of the workplace environment upon users. Further support comes from an analysis of empirical research into the impact of the workplace environment. Findings from the research demonstrated increases in productivity or perceived productivity of between 5% and 15% as a result of the workplace environment (Lorsch and Abdou, 1994). With evidence to support an impact of the workplace environment upon users and their work, a full understanding of the workplace environment could be beneficial on a number of levels. Understanding the relationship between the environment and user satisfaction could enable a workplace to be developed which has a positive impact upon individuals who work for an organisation. The impact of the workplace environment upon user satisfaction could be more accurately incorporated within models of job satisfaction and motivation using a more robust evidence base. Beyond the individual, greater understanding of the workplace environment offers potential benefits to the performance of an organisation through increased productivity. Staff costs represent around 80% of the costs of an organisation, compared with less than

20% to build, fit-out and operate the workplace environment (Oseland, 2007). Thus, it makes financial sense for organisations to consider ways in which they can effectively spend that 20% on the environment to have a positive impact upon staff and off-set some of the costs (Walden, 2005). The overall benefit to an organisation is highlighted in an example developed by Lomonaco and Miller (1997). They demonstrated that by taking a workplace of 46,000m² (the average size of a workplace in the United States), a 3% increase in productivity through the effective design of the environment could lead to an increase in annual turnover of $2,925,000 (based on the overall average salary costs from a building this size which totals $97,500,000). The increase in turnover through increased productivity is an effective way of demonstrating the potential impact of the workplace environment, particularly to those concerned primarily with the performance of an organisation. The 3% increase used within this example is less than the 5% to 15% reported by Abdou and Lorsch suggesting that the financial implications for an organisation could be even greater if the workplace environment was designed to have a positive impact upon users.

### 1.3 The Need for an Evaluation of Workplace Environments

Currently there is insufficient conclusive evidence readily available to demonstrate best or even good practice in terms of workplace design. To inform and develop a stronger evidence base, further research and evaluations into the impact of the workplace environment are necessary. These evaluations need to be systematic and robust to ensure that the data gathered gives a true representation of the impact of the workplace environment. As architects do not always get the opportunity to occupy and use the buildings they design, the assumptions they make about the performance of buildings may be inaccurate. Mikellides (1980) suggests that architects base design decisions on authority (assertions of leaders in the field), tenacity (a belief that something is true as they've always done it) and intuition (what appears to be self-evident). They do not test these assumptions against the findings of research and evidence. The difference in ratings or perceptions of a building between architects and lay people has been reported by a number of researchers (for example Hershberger, 1969; Hubbard, 1996; Wilson, 1996). The findings of their work demonstrated that architects and lay people rate the built environment using different criteria, therefore they demonstrate preferences for different buildings or aspects of buildings. For example the aesthetics or appearance of the building are frequently rated differently by architects and lay people with the professional architects giving a lower rating to buildings classified as popular styles of architecture. The difference in ratings has been

attributed, by Hershberger amongst others, to the training and education of architects which has encouraged them to evaluate buildings differently to lay people. The result of different ratings of the built environment supports the need for systematic evaluations of buildings to determine the impact that they have on users. Relying solely upon the perceptions and experience of architects does not appear to provide an accurate understanding of how that building will affect those who use it. Furthermore, researchers have discovered that architects were unable to predict the ratings of buildings from a lay persons' perspective (Brown and Gifford, 2001). Not only do architects and lay people rate buildings using different criteria, architects appear overall to be unable to determine accurately how lay people, which will include workplace users, rate a building. Thus, to provide design teams with adequate understanding of the impact of the environment, systematic evaluations are required. Furthermore, the results and findings of the evaluations need to be published so that the information can be fed back into the design process and influence future workplace designs. Without the learning from evaluations being available and applied within the design industry, the findings from research will not influence building design.

### 1.4 An Overview of the Thesis

Based on an understanding of the importance of the work of Sundstrom and others, and the potential benefits derived from a greater understanding of the workplace, the purpose of this thesis was to create an effective model for evaluation and use this to analyse perceptions of the workplace environment and impact upon users. There was also an aspiration to test findings from the evaluations of workplace environments in a real world setting. The results from the evaluation and further analysis of the current state of knowledge informed and allowed the realisation of the testing phase of the thesis. The process began with an analysis of the current state of knowledge and establishment of the gaps in understanding. The historical development of the workplace was explored and key findings highlighted to demonstrate how workplace design has evolved since the first purpose built workplaces were created. Evaluating the development of the workplace provides an insight into why these environments were designed as they are and how this design was influenced by factors such as theories relating to the management of organisations. Analysis of critical research from social science, architectural and business management disciplines relating to the workplace environment led to an in-depth understanding of the current state of knowledge as a whole. Including research into both the whole workplace and individual aspects of the environment revealed the complexity of the subject of this thesis.

Collectively the research which provides the current state of knowledge highlighted that the workplace potentially had an impact upon users but the nature of this impact and relationships between the environment and users was not clear from the research completed by others to date. Once this gap in the knowledge was established, a methodology was created, informed by the research methods of leading researchers. Consequently, a mixed method approach to workplace evaluation was developed incorporating questionnaires, environmental monitoring, analysis of spatial layout plans and objective reporting. An holistic approach was taken with the workplace environment as a whole being evaluated, rather than a small number of individual aspects. To allow patterns to be established across workplaces, 18 organisations were approached to participate in the research for this thesis, 16 accepted and took part. Using this methodological approach user perceptions of the workplace environment in terms of internal climate, spatial layout, interior design and workplace features were established and analysed in relation to objective measures. User attitudes towards these aspects of the workplace were also empirically tested to determine whether they had an impact upon three dependent variables: satisfaction with the workplace, stimulation levels and perceived productivity.

The results were analysed and patterns in the data established. The testing phase of this thesis was developed using the findings which highlighted an interesting relationship between the workplace environment and stimulation. There were positive correlations between stimulation levels and the other dependent variables: satisfaction with the workplace and perceived productivity. Further support from the current state of knowledge confirmed the potential benefit of increasing stimulation levels in workplace users and the impact of the environment on stimulation levels. Thus, a methodology was developed whereby the conditions in the workplace environment were varied throughout the day in a controlled manner and the impact of these changes monitored. The results were analysed and conclusions drawn relating to the impact of the workplace environment. These were developed into understanding that could be fed back into the design process and have a positive impact upon future workplace environments. A multi-disciplinary, holistic approach to workplace evaluations, and the results of the research, provide the contribution to knowledge of this thesis. The contribution is furthered by the testing of findings from the evaluations of workplace environments to determine how the workplace can have a positive impact upon users.

## Chapter 2 The History of the Workplace Environment

### 2.1 Early Workplace Design

The workplace, as taken in the context of this thesis, has existed in some form for hundreds of years. With the need to record information came the requirement for a space in which this work could be carried out, thus the workplace began to develop. In the United Kingdom ruins of Roman forts from around 100 AD show small rooms purpose built around the perimeter of the great hall of a fort, which would have acted as offices for military personnel. Artefacts such as the Vindolanda tablets show stock inventories and letters relating to personnel matters, such as requests for leave, which are thought to have been processed within the offices of the fort (Vindolanda Tablets Online, 2003). These are some of the earliest examples of specifically designed workplaces in the United Kingdom. However, the workplace as a designated and separate space in which administrative work was carried out was not really developed until the 1500's. The earliest known building designed specifically as a workplace was the Uffizi in Florence (1560-1565) designed by architect Giogio Vasari as the administrative centre of the Florentine State (Klein, 1982). Although this building was specifically designed as a workplace, like most other workplaces developed shortly after this time, it was multifunctional and contained other elements such as a theatre and art collection. The majority of other workplaces from this time, and essentially up until the industrial revolution of the late 18$^{th}$ century, were actually one or two rooms within a building whose main purpose was something else. Offices were often contained within a house, with one floor being a workplace. For example, it was common up until the Victorian times for many administrative businesses such as banks to be run from the ground floor of the manager's house. Although these workplaces seem impractical now, they suited the work of the time which was essentially small businesses run by a manager assisted by a clerk and a 'boy' (Klein, 1982). However, the industrial revolution of the late 18$^{th}$ century changed the demands placed upon workplaces as factories developed, becoming larger. With the development of factories and industrial labour there was a requirement for far more administration of the work.

As the requirement for administration of factory work increased, dedicated spaces within the factories were developed where this work could be carried out. Fairly soon it became necessary for separate administrative workplaces to be created so that large numbers of administration staff could work together in one building. In addition, organisations whose business were solely administrative began to emerge. This was

due to the development of work in the service industry and large administrative organisations (Sundstrom, 1986). In particular, big insurance firms established themselves based upon the increased risk of managing and organising large scale factories (Duffy, 1980). For example, Sun Fire Insurance Company in London had a dedicated workplace for over 80 employees by 1860 (Steelcase, 1990). These organisations needed large buildings in which to house their staff so that all claims and paperwork could be processed efficiently. As a result the first examples of buildings which resemble our modern workplace were designed and built. As with the development of factories, the need for efficiency was an important factor in the design of the early workplaces. This was reflected not only in the design of the environments but also the rapid developments in technology to increase efficiency. Technological advances are demonstrated by desire to increase the speed of work and associated inventions such as the typewriter, first introduced in 1873, and the telephone, first used in 1876 (Zelinsky, 1998). Concrete evidence of the advances in technology demonstrate the speed at which new technologies were introduced. However, there is less evidence of such a fast development and evolution of workplace design. Whilst technology drove the changes to work, such as the development of typing skills and typists as a profession (Steelcase, 1990), other factors beyond task completion have influenced the design of the workplace. For example, the invention of passenger lifts in 1853 led to the development of taller buildings, and a preference to work on higher floors away from the noise and dirt of the ground floor levels and with better views and light (Sundstrom,1986). Prior to the introduction of passenger lifts the premium office space was at ground floor level as there were no stairs to climb. When reaching the higher floors no longer required such a degree of physical exertion, the seventh storey and above became more popular and was where senior management in organisations chose to be located. However, the availability of materials and limits of construction technology still restricted the height of buildings through the thickness of the base walls needed to support the upper floors.

It was only the introduction of iron girders and pillars, followed by structural steel from the 1880s, to support the weight of the building that enabled much deeper plan and taller buildings to be designed (Sundstrom, 1986). Modern buildings no longer relied upon internal walls and other structural elements for support which had previously dictated building shape and size. With the introduction of new technologies, the floor area of a building was no longer as restricted and designers could create large open spaces in which hundreds of people could work. The ability of designers to do this was further assisted by the increase in availability, and reasonable cost, of mechanical

systems to heat, light and ventilate deep plan buildings effectively. This meant that even people in the centre of large plan offices could have adequate light levels and provision of fresh air. Previously they had been reliant upon windows and insulation of the buildings. Organisations were keen to capitalise on these new materials and systems as they understood that it would cost them much less to build and maintain deep plan than shallow plan workplaces. In the shallow plan workplaces fewer people could be accommodated and the buildings were multiple storeys to accommodate the number of employees they had working for them. Building tall buildings with shallow floor plates was only achieved at a much greater cost. The development of the way in which workplaces were designed and built, however, cannot simply be attributed to new building materials. As more and more people were being employed to work in workplaces, managers began to realise that the environment itself could be having an impact upon their staff and affecting their productivity and efficiency levels. This is reflected in the comparisons that can be drawn between emerging management theory and the design of workplace environments.

### 2.2 Scientific Management Theory and the Workplace

As the focus of management theory changed, the design of the environments in which work happens has evolved. This is a trend which has been highlighted by Sundstrom (1986) who identified the early workplaces as being designed around management principles driven by process. He also suggests that the focus of managers on human relations and social interaction in the 1950s and 1960s was facilitated by the development of more open plan offices. As identified, the development of factories influenced the work taking place in what became office environments. Similarly, management theories were first applied to factories. However, and as the nature of work evolved they were applied to administrative work. Early management theories are referred to as the classic approach. The most prominent and frequently cited process driven theory is scientific management developed by Frederick Taylor (1911, also Anderson & Kyprianou, 1994; Turner & Myerson, 1998; Rosenfeld & Wilson, 1999; Mullins, 2005). Taylor outlined his original theory in 1911 which was focused upon the analysis and reform of work processes to achieve maximum efficiency and productivity. The argument, originally developed to influence manufacturing processes in factories, was that every task could be identified, isolated and then scientifically analysed to determine the most efficient way in which it could be performed. Once determined, the job to be carried out was split into component parts and each different task allocated to one individual who was instructed as to how they should best complete the task. The

production line arrangement in factories was developed based upon this principle. Almost invariably the work carried out was limited and repetitive with no room for the worker to exercise any individuality or autonomy over their work. The aim of such an approach was the identification of the most efficient way to do something, and having someone repeat it over and over again. This was perceived to be the most effective way of completing jobs. Rationalisation of work processes at Bethlehem Steel Corporation where Taylor worked from 1898 to 1900 had an impact upon output. However, his was an unpopular approach as demonstrated by riots relating to work processes which took place at the Watertown Arsenal in 1911, a factory designed upon the scientific management principles (Rose, 1988). Although actual productivity did increase, the working environment and conditions were so unpopular with the staff that it had to be discontinued (Rose, 1988). Despite this there has been an enduring impact of scientific management theory on aspects of workplace design, particularly where an organisation is process driven.

Figure. 1 – Inside the Larkin Building, New York

Perhaps, the most famous building designed around the principles later formalised in Taylor's scientific management theory is the Larkin Building in New York (Figure 1). Designed by Frank Lloyd Wright and completed in 1904 the workplace was owned by the Larkin brothers who ran a mail order company and needed a workplace in which large quantities of paperwork could be handled. The design of the workplace was very

much related to the scientific management principles in that the layout and arrangement of the desks allowed workers as little movement as necessary to complete their work. Ergonomically, employees were positioned, through furniture design and layout, in such a way that they could efficiently carry out their very specific task and nothing else. The open space of the workplace supported the processing of the paperwork but also provided good sightlines for effective supervision. In addition to the incorporation of balconies, the openness of the design allowed managers to supervise the employees work to ensure maximum efficiency was obtained. Fayol (1949, cited in Mullins 2005), a supporter of Taylor, suggests that supervision of workers is an essential element of process-focused scientific management theory. Hierarchy was another aspect of scientific management considered by Taylor to be integral for effective performance. Employees were expected to know their role and their place within the organisation to ensure the effective processing of tasks. All decisions were taken by senior management. The design of the Larkin building and workplaces like it provided adequately for this rigid hierarchy with the senior people occupying private offices that were luxuriously furnished, as opposed to the functional and restrictive environment in which lower status employees worked. The impact of scientific management on the design of buildings was widespread and has been enduring. Although not all workplaces were designed as close to the principles of scientific management as the Larkin building, elements of this management theory are still evident in workplaces today. Despite more modern organisational theorists suggesting a move away from the rigid hierarchies advocated by Taylor and his supporters, the senior managers of many organisations are still maintaining environments which support a hierarchical arrangement. The reflection of status within the environment is demonstrated by over half of senior managers surveyed in the 1990s having a private office within the workplace (Turner and Myerson, 1998). In addition some modern workplaces adhere to the principles of the layout and design of the Larkin building. Modern call centres are operated from workstations where the movement of employees is restricted by the headsets that they wear and the efficiency of the work that they do is dictated by the limited resources available to them at their station (Figure 2). It seems that where the limitations of scientific management in terms of organisational approach were recognised and prompted an advancement of management theory, the design of workplaces has not evolved as quickly.

Figure. 2 A Call Centre in the United Kingdom

### 2.3 Human Relations Approach and the Workplace

Research prompted management theorists to focus on organisational factors beyond improving process efficiency and take into account the workers themselves. The focus upon workers is the foundation of a people based approach that organisational theorists advocated, as support for Taylor diminished. Known as the human relations approach advocates focus almost wholly upon the employees rather than the processes of the work that they are carrying out. The principles of the human relations approach originate from the findings of the Hawthorne studies (Mayo, 1933; Roethlisberger & Dickson 1939; Roethlisberger & Dickson, 1949). These studies were a series of experiments conducted at the Western Electric Company between 1924 and 1932. The Hawthorne studies were designed to test the impact of changing illuminance levels in the workplace upon productivity. The experimental group had the levels of illuminance in their work area varied whilst the non-experimental group were told that they were part of the research yet no changes were actually made to their environment. The studies revealed that there was an increase in productivity in both the experimental condition and the non-experimental condition. Researchers suggested that the reason these results were obtained was due to the social response of workers to participating in research aimed at improving their working conditions. In addition, the organisation of working groups and job design were cited as being contributors to the positive impact upon productivity. These studies demonstrated the social influences in job satisfaction and productivity involved in work and led theorists to develop ideas about other variables which contribute to efficiency and effectiveness at work beyond the

mechanics of process. The Hawthorne studies highlighted several key drivers for human relations management theory. Factors based on relationships between people at work such as work groups and their formation, leadership and communication need to be understood to maximise effectiveness of workers. The Hawthorne studies demonstrated that there are certain limits to output which are not process related, such as motivation, and that job design and social relations are important to encourage employees to perform well (Mayo, 1933; Roethlisberger & Dickson 1939; Roethlisberger & Dickson, 1949). Management theories focusing upon the importance of people as individuals, as well as communication and social relationships, provided the basis for advances in office design which became popular in the 1960s.

One of the most radical examples of a workplace design following the recommendations made by the human relations theorists is that of Bürolandschaft created by the Quickborner team from Germany (Duffy, 1969; Klein, 1982). This team worked upon the principle that communication and social interaction were key to the success of an organisation and that the workplace should be designed to facilitate these actions. The space plans were created through analysis of the interactions between employees and between teams. The specific space requirements and equipment needs of each individual were examined and this informed the spatial layout. Figure 3 is an example layout of a Bürolandschaft workplace.

Figure. 3 Layout of a Bürolandschaft Workplace

The workplaces into which Bürolandschaft was implemented were large open plan spaces with no private or individual offices for managers or more senior people, everyone was treated equally and location in the workplace was based upon need rather than status. This reflected the move away from rigid hierarchical structures, a move supported by human relations management theory (Mayo, 1933; Rose, 1988). The way in which the workplaces were developed, through analysis of social relationships, produced floor plans that were apparently random in layout but were actually based upon careful analysis of the communication and interaction between individuals and teams (Duffy, 1992) According to human relations theory, people should be able to interact easily and develop relationships with those that they are working with which is reflected within the Bürolandschaft design. The furniture which had previously been used in workplaces was not fit for purpose and reduced the effectiveness of Bürolandschaft workplaces. To rectify this, furniture manufacturer Herman Miller introduced a range called the Action Office in 1968 (www.hermanmiller.com/products/action-office-system accessed December 2009). This furniture system was flexible and could accommodate the need to move people around the workplace with ease, an integral part of the human relations theory which encourages the formation of social relationships. The Bürolandschaft design was advocated by many designers from the 1960s onwards, with around one in three office workers being based in an open plan workplace by 1980 (Harris, 1980). However, the very open and unstructured design has proved relatively unpopular with organisations, and researchers have argued that the Bürolandschaft design actually reduced the effectiveness of communication (Brill et al, 1985).

As with scientific management theory, the influence of human relations theory on workplace design is still apparent. Aspects of workplace design did and still do follow some of the principles. Many workplaces designed since the 1960s are open plan with the majority of the workforce no longer working in cellular spaces. Furthermore, the needs of workers are a consideration influencing the design of workplaces. Workers are no longer merely provided with adequate space and equipment to carry out their jobs, a certain level of comfort and features designed to increase their feelings of well being are incorporated within the workplace. Ensuring that employee well being and satisfaction are considered is often referred to as neo-human relations. This facet of human relations work is based upon the principles of research into human needs and motivation, e.g.Maslow's hierarchy of needs (Maslow, 1970) and others (for further details see Warr, 2002). The focus on people within an organisation rather than processes is matched by evolving workplace design. Organisations and designers seek

to accommodate people's personal requirements within the workplace environment through provision of open plan environments to encourage social interaction, and the addition of new areas that support well being such as cafés and informal meeting areas. The organisational theory of human relations endures in the management of organisations and the design of their workplace, as reflected in the way that workplace design has evolved since the 1960s. However, management theorists recognised that focusing solely upon the human relations or the tasks being completed does not recognise the importance of interaction between people and process or external factors such as the economic climate (Lupton, 1971).

### 2.4 Contingency Theory and the Workplace

As the focus in the 1960s had been on human relations, there was a move in the 1970s to re-identify with process and introduce a greater emphasis on the need for an organisation to be flexible. The theory which has received most support is the contingency theory, which was promoted by management theorist Lupton (1971). The basis of the contingency theory is that there is no single, structured way of prescribing how an organisation should be managed. It is the situation in which an organisation is operating that dictates the most effective management response. This response should be based upon the current external and internal situation, the people involved and the tasks to be carried out. Flexibility is an essential basis for this theory due to the interaction of several factors including culture, the economy, the organisation and technical issues (Schein 1988). Flexibility was an important consideration in the development of the workplaces based upon the principles of the human relations theory. However, this only really extended to facilitating movement around the workplace as and when required. Flexibility within contingency theory goes beyond ease of movement and recognises the need to respond to any situation and the need to have the culture and facilities to support this. The influence of contingency theory on workplace design became apparent in workplaces from the 1980s with adaptability and flexibility being key design drivers for many organisations. The 'alternative office' or 'new ways of working' are the manifestation of contingency theory as they provide workplaces which meet the needs of workers through improved well being, in addition to supporting the processes of the organisation. Different spaces may range from quiet areas for work requiring high levels of concentration through to breakout zones for informal, collaborative work. The spaces are designed to be chosen by an employee depending upon their preference and the work they are expected to do.

The diversity and flexibility of work and the workplace environment was first classified as ‘alternative officing’ around the late 1980s and as thinking evolved DEGW, an international business consultancy with a specific interest in the workplace environment, began referring to ‘new ways of working’ in the 1990s (Zelinsky, 1998). These alternative ways of working reflect contingency theory by providing a workplace environment that has a diverse range of spaces and can be used in a number of different ways. However, there is no consistency in the combination of spaces provided. Within different organisations there are different types of working being adopted, from home working to fully flexible hours of work. The space requirements of each workplace vary to support and facilitate these ways of working. The range of so called alternative ways of working are detailed in Zelinsky (1998) who lists in excess of eighteen different descriptions of the ‘new’ and ‘alternative’ ways in which people can work. These definitions range from red carpet clubs, workplaces in which occupants have no permanent desk but reserve an appropriate workstation for a period of time, through to unitel, workplaces in which everything is uniform so people can be moved from one workstation to another almost instantly. Each of these ways of working is influenced by the way in which the workplace is used and the facilities provided within that space.

Research carried out by DEGW is an example of an empirical study in which eight workplaces were evaluated to provide evidence of the impact of new ways of working on workplace design. Laing, Duffy, Jaunzens and Willis (1998) developed four models which they argue are what all organisations comprise in different proportions. Depending upon the organisation they may have a significantly higher proportion of one type of space than another organisation. The four models can be applied to all workplace designs, not merely those based upon contingency theory principles. The models were developed on the basis of two continuums, interaction and autonomy. Interaction refers to social contact with others and autonomy refers to personal control over work processes and other job characteristics. Laing et al (1998) argued that the level of interaction or autonomy in an organisation, or part of an organisation, influenced the type of workplace environment that would best suit them and their work. When both interaction and autonomy were low the most supportive workplace environment would be a uniform and standardised space where everyone had access to the equipment that they needed to perform a task. A low requirement for interaction and little autonomy means that flexibility of the space and ease of communication will not benefit an individual’s work. This type of space is referred to as the Hive. As autonomy increases but the requirement for interaction remains low the

recommendation is that an enclosed workspace, labelled cell, will be most effective as there is opportunity to personalise the space but being separated from other people in the workplace reduces the ease of communication. With a high requirement for interaction but very little autonomy an environment needs to be designed to support those who work in teams but on tasks that require them to have little access to a range of spaces as their tasks are relatively pre-determined. These spaces are called Dens within the model. Finally, in jobs or workplaces where there is a requirement for high levels of interaction and high autonomy, a flexible and diverse environment where there is space to meet and interact as well as work in a number of different ways is recommended. These environments are referred to as Clubs. The four models and the corresponding levels of autonomy and interaction are illustrated in Figure 4.

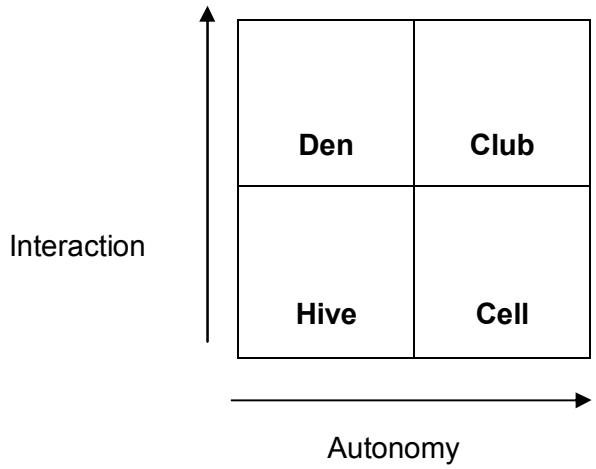



Figure. 4 Diagram Representing Relationship Between Interaction and Autonomy (Laing et al, 1998)

Analysis of the way in which the eight organisations worked and organised their workplace was conducted and from the findings the researchers made the following assertions. The spatial layout of hive organisations, in which workers have low levels of interaction and autonomy, is a large, high density open-plan workplace with simple workstations and minimal partitions. This is a similar model to the workplace organisation of the Larkin Building and others based upon the principles of scientific management theory. Workplaces that match the hive model are also often found to have a small number, around 10%, of individual private cellular offices. Workplaces comprised mainly of cellular space are usually occupied by those with individual concentrated work who have little interaction with others but high autonomy. This way of working, and workplace setting, is similar to the offices that existed before the

industrial revolution, as described previously. Den settings are associated with organisations made up of teams or groups who carry out highly interactive work but may not be particularly autonomous, an arrangement similar to that found in Bürolandschaft. The Bürolandschaft design has an open-plan spatial arrangement with dedicated group or team areas. The final model is the club where the workplace is made up of many different complex settings which are not occupied by any individual on a permanent basis. Workstations are booked on an as need basis and often result in a workplace with a 2:1 ratio of open plan to enclosed space. The development of a workplace based upon the model of the Club is apparent where organisations want to provide their employees with environments that support a range of ways of working without increasing their costs dramatically. By sharing the different working spaces within the workplace, a range of environments can be provided for employees. This was a principle adopted first by Andersen Consulting, San Francisco in the late 1980s whereby desks were allocated on a Just in Time or as need basis and each desk and area provided the worker with a different type of environment. Thus, people selected a workspace to meet their specific needs at that time (Becker & Steele, 1995). Chiat/Day have also developed their New York workplace based upon the Club model with employees having no fixed workstation, but a range of specialised work areas is provided that employees select depending upon their needs and preference. The Chiat/Day workplace has been featured in both industry and national press (for example, Anderton, 1998; McGuire, 2003) and a diagram of the floor plan and one bookable area can be seen in Figure 5. The workplace has several different areas from private cellular spaces, to meeting areas and open plan spaces all of which can be booked by employees to provide them with maximum flexibility to change their working environment to suit their needs and the situation.

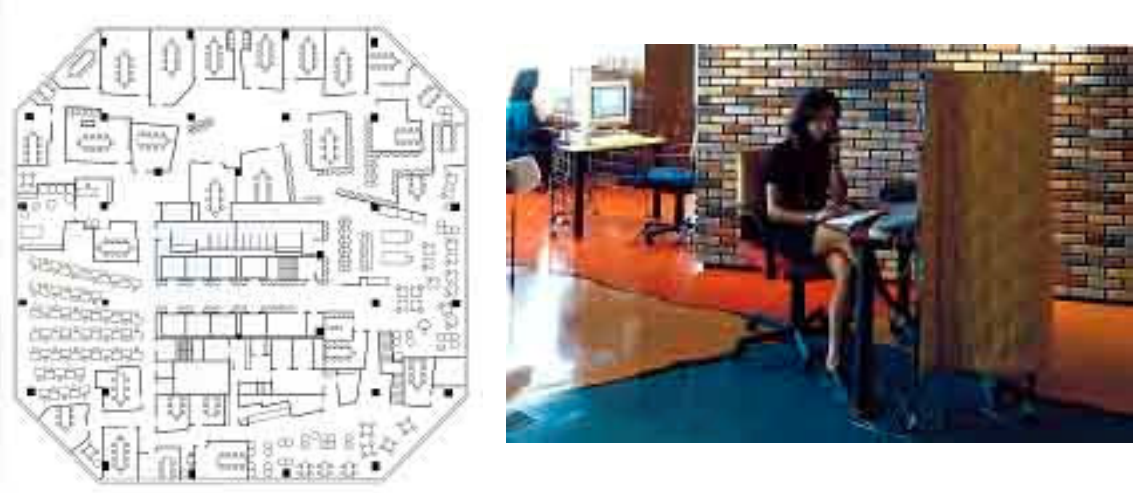


Figure 5 Plan of Chiat/Day workplace and example of bookable area in use

## 2.5 Summary and Conclusions

This analysis of the progression of management theory demonstrates links with the changing design of workplace environments. Management theory has advanced from its starting point of being very process focused, as detailed within scientific management theory. The Hawthorne studies influenced researchers who realised the importance of social relations in determining effectiveness at work. More recently, since the 1970s, contingency theory has gained popularity. Focusing upon task, social relations and the situation at the time, contingency theory suggests that flexibility is the key to organisational success. The shift in focus from process to human relations and then maximising flexibility is a pattern also observed in workplace design. Early, large scale workplaces, such as the Larkin Building, were based upon the principles of scientific management theory. At this point in time the management theory and workplace design appeared to correspond and learning about the impact of space and organisational management was a two way process. Researchers observed how the environment affected work, as demonstrated in the Hawthorne studies, and management theory influenced the way in which environments were designed. As management theory developed, workplace design did not progress as quickly. The focus on human relations influenced the design of workplaces such as Bürolandschaft, but this model of workplace design was developed approximately 15 years after the findings of the Hawthorne studies encouraged researchers to consider human relations. A similar pattern is observed with the introduction of contingency theory in the 1970s, but flexible workplace designs to support alternative ways of working only gaining popularity in the late 1980s. This demonstrates that the development of workplace design has not evolved at the same pace as management theory. This gap could present potential problems for an organisation who occupy a workplace environment that does not support the way that they work.

Although there is a delay in the implementation of management theory principles in workplace design, there are clear links between the two. This suggests that there is a perceived link between the work environment and the performance of individuals and an organisation. With workplace design only now developing so that it supports current management theory, the focus of the impact of the workplace environment has been on the physical provision rather than the environment created for an organisation to operate effectively. The empirical research of others to date has focused upon tangible aspects of the environment rather than the strategic aspects such as management theory. Until management theory and the workplace environment are synchronised the

pragmatic approach of studying individual, physical aspects of the environment is most beneficial. Understanding the impact of the physical environment upon those using the environment is important to provide evidence of how the workplace can best be designed to suit users' needs, whatever they might be in the context of management theory. Without this basic knowledge, it is impossible to understand the impact of the workplace environment. Analysing the history and development of the workplace provides a context for the design and evolution of future environments. It highlights why the workplace environment is important and how understanding the workplace environment can have an impact upon an organisation and the individual.

## Chapter 3 Spatial Layout of the Workplace

### 3.1 Introduction

Chapter 2 detailed how workplace design had followed the principles of changing management theory so that the environment supported the work of an organisation. The spatial layout of the workplace is an integral part of the design which most clearly reflects the changes in environments in line with management theory principles. The patterns of change in the spatial layout of workplaces demonstrates a move from the focus on process and task completion to human relations and the desire to improve social relations. As demonstrated in Chapter 2, current trends in spatial layout are to develop workplace environments that contain a diversity of spaces to offer maximum flexibility. The influence of management theory principles has affected spatial layout with environments designed to facilitate efficient completion of tasks and to support effective interaction between employees (Sundstrom, 1986). However, spatial layout has also been designed to suit specific needs of occupants such as changing technologies and employee well being. Advances in information technology have shaped the spatial layout through the need to accommodate equipment and different ways of working. These influences on workplace layout have led to the introduction of different workplace designs such as open plan. Simultaneously, a range of issues linked to the spatial arrangement of the workplace have been the subject of research to fulfil the desire to understand the impact of the workplace environment.

### 3.2 Space Standards for Workplace Environments

Historically, as witnessed in workplaces such as the Larkin Building, spatial layouts were designed to provide the optimum environment for task performance of the majority of employees. For senior employees, the space allocated to them was a reflection of their status rather than process driven (Rose, 1988). They were provided with individual offices that were luxuriously furnished to reflect their seniority within the organisation. The allocation of area and type of space based upon position is an enduring principle. Turner and Myerson (1998) found that over 50% of senior managers they surveyed still had their own private offices. This suggests that despite management theory moving towards a more flexible workplace where there is less ownership over space, cultural factors such as the hierarchy of staff still influences spatial layout. The significant impact of status upon space allocation is reflected in the space standards given in industry guidance such as the Architects Journal Metric

Handbook. This publication is used by industry professionals when designing the spatial layout of workplace environments as a benchmark for good practice. Previous editions of the Architects Journal Metric Handbook (Sliwa & Fairweather, 1969) detailed appropriate office types and spaces standards which reflected both status and actual space required to carry out tasks. Size of space was given as a footprint. This is the allocation of space within the workplace defined as belonging to one person. It is the area required for their equipment, furniture and access to their workstation. The recommendation for senior managers was that they should have an individual enclosed office of 37-42m² footprint whilst the standard for administration staff was open plan workstations with a 4.5-5.5m² footprint. There is a clear distinction between the provisions of space based upon the seniority of individuals. Whilst this may be in part process driven (there is an assumption in the guidance that senior managers will have more private meetings, etc) the status of individuals is still influential. More modern editions of the Metric Handbook (Adler, 1999) recommend a less structured approach to the allocation of space. However, the reality is that there are a number of workplaces in which status continues to influence spatial layout, as highlighted by Turner and Myerson (1998). Furthermore, the determination of space based upon status has been linked to satisfaction amongst employees. Konar et al (1982) found that a spatial layout which was considered to be appropriate to status meant that individuals were more satisfied with their work and perceived themselves to be more productive. This suggests that the importance of the spatial layout is based upon congruence. Within an organisation employees are satisfied when they perceive area allocation and space type to accurately reflect the status of individuals. Dissatisfaction results from what is perceived to be the unfair location of individuals within the workplace. This is linked to organisational research which frequently cites perception of fairness as being a significant indication of satisfaction and motivation at work (Warr, 2002). However, further research into the link between spatial layout and status indicates that it may also be a desire to identify with colleagues of the same status. In instances where individuals are allowed to dictate the spatial layout, status seems to be one of the most important criteria they use. Lott and Sommer (1991) found that when people were asked to seat a sample of people with whom they worked in a fictitious setting, they positioned themselves with people of a similar status within the organisation. They seated themselves further away from those who were considered to be of a higher or lower status. This suggests a desire to be equal to those they perceive to be of the same status as themselves within the organisation. Although this research indicates that status still informs spatial layout in some workplace environments, more modern

space standards are based upon principles of flatter hierarchical structures in organisations and effective collaborative working.

Evolution of the management of organisations based upon the principles of human relations theory has produced organisations in which there is a flatter hierarchy. That is, there is less distinction between people of different levels of seniority within an organisation. Eley and Marmot (1995) suggest that are usually three levels of employees within most organisations as opposed to the average fifteen distinct levels of seniority which existed when Taylorist principles were still the basis of organisations. The workplace environment, subsequent to human relations theory gaining popularity, was developed to not only improve communication but reflect a flattening of hierarchies within an organisation. Consequently, more modern space standards are given as areas per person in the workplace rather than being designated depending upon role. The standards are denoted as Net Lettable Area (NLA) and refers to space in the workplace that could effectively be used to complete work tasks. This includes circulation space, main floor areas and other space dedicated to break areas, etc. The space standards suggested in the revised format of the Metric Handbook (Adler, 1999) are given as an area for a type of workstation, which is determined by function not role, and area allocations are not distinguished in further detail. A space standard devised on a per person basis is specified within the British Council for Offices Guide (British Council for Offices, 2000), another industry publication from which space standards are frequently quoted and referred to. The British Council for Offices Guide recommends a minimum of 10m² NLA per person. Analysis of the actual provision of space within workplaces suggests that the majority of workplaces in the United Kingdom are meeting these space standards. The British Council for Offices found that good practice in space allocation was between 12m² and 17m² NLA per person. Marmot and Eley (2000) found a similar pattern with the average area found to be within the range of recommended best practice at 14m² to 16m² NLA per person. In terms of footprints, both the British Council for Offices and Marmot and Eley found that the average in open plan environments was roughly the same at 4-6m² and 7m² respectively. The average footprint for cellular spaces were between 13m² and 15m². Whilst the average cellular footprints are between 6m² and 11m² larger than the open plan footprint areas, this gap is considerably less than the previous standards recommended. In the Architects Journal Metric Handbook from 1969, the difference between open plan footprints, at 4.5-5.5m², to cellular offices for senior employees, at 37m-42m², was up to 37.5m². This is a considerable difference and highlights the impact upon spatial layout of organisations moving towards a less structured and rigid hierarchy as the

disparity in workspace allocation is greatly reduced. This is further supported by the allocation of office types based upon seniority no longer being specified within the guidance. The changing space standards indicate not only that organisations now have flatter hierarchical structure, but also that there is a reduction in area for many employees. This is a result of moving towards more open plan offices, influenced by human relations theory. With open plan workplaces becoming more prevalent, there has been an increased research interest in the impact that the different types of offices have upon employees' satisfaction and actual, or perceived, productivity.

### 3.3 Office Type

Open plan offices became more popular from the 1970s as the benefits of human relations theory to organisations was realised and the spatial layout of existing workplaces did not support interactive ways of working (Duffy, 1992; Duffy, 1997). However, the choice to move to an open plan layout cannot solely be attributed to fulfilling the aims of management theory. Two other factors played a major part. The first was the availability of more advanced building materials and building management technology allowing deeper floor plates with larger, open spaces to be created. The second factor that has encouraged organisations to develop open plan layouts are the potential financial benefits to an organisation. With fewer internal walls occupying floor space and the ability to share ancillary spaces such as circulation in an open plan workplace, a smaller area for the same number of people can be provided in open plan workplace than cellular offices. This offers the opportunity to increase density within the workplace so that more employees can be accommodated in the same area. Marmot and Eley (2000) argue that open plan workplaces cost less to install, maintain and re-plan per square metre than enclosed offices. Maintenance costs are further reduced by the ability to relocate people quickly and economically. Organisations no longer need to ensure that promotion within the organisation leads to an individual having workstation befitting of their new status and uniformity of provision means that less equipment and furniture has to be transported if an individual relocates. There are clearly financial benefits associated with moving from cellular to open plan workplaces. However, the benefits to the organisation in terms of improved communication and interaction, often cited as a benefit of open plan working as opposed to cellular spaces, have been studied and the findings are not conclusive. There is evidence to suggest that open plan environments do not benefit communication and interaction as argued by supporters of open environments and human relations theory such as Duffy (1992). Equally, researchers have raised concerns about the impact of an open plan

environment on occupants' satisfaction with aspects of the workplace and well being (for example, Pejtersen et al, 2006)

In some empirical studies, the move from a workplace comprised of enclosed offices to an open-plan workplace was found to have a positive impact upon occupants. Allen and Gerstberger (1973) studied a group of engineers moving from enclosed offices to an open-plan workplace, over a period of twelve months. The engineers rated their new workplace much more favourably than the old enclosed workplace and communication was perceived to significantly improve. However there was no change in productivity levels after the move. Similarly researchers found that building occupants perceived the level of sociability to increase (Brookes & Kaplan, 1972) and communication to become easier (Boutellier et al, 2008) when they moved in to an open-plan workplace from individual offices. Marans and Yan (1989) found that 64% of participants in their study working in an open-plan office were satisfied with their workspace and O'Neill (1994) found that the amount of enclosure around an occupants' workstation in terms of walls or partitions did not directly affect either satisfaction or performance in the workplace. Together these studies demonstrate that in some cases open-plan areas were perceived to have a positive impact upon communication and interaction. There were also positive or neutral relationships identified between open plan environments and satisfaction with the workplace. The findings from these studies support the assumption that open plan environments have a positive impact upon social relations and therefore have a positive impact upon satisfaction. However, research has also demonstrated that an open plan working environment can have a negative impact upon both satisfaction and perceived productivity (DeCroon et al, 2005).

Wineman (1986) argues that studies have shown occupants in open-plan suffer a lack of both visual and acoustic privacy which leads to dissatisfaction and a reduction in performance. Research into the impact of open-plan workplace environments has demonstrated that working in an open-plan workplace negatively affects occupants. Open-plan layouts were perceived to be distracting (Brookes & Kaplan, 1972; Hedge, 1982; Becker, Gield, Gaylin & Sayer, 1983; Block & Stokes, 1989; Marmot & Eley, 2000), to reduce visual and acoustic privacy (Becker et al, 1983; Marans and Spreckelmeyer, 1982; Sundstrom et al, 1982; Hedge, 1982; Brooks & Kaplan, 1972) to negatively affect team relations and to increase stress levels (Brennen, Chugh & Kline, 2002). Oldham and Brass (1979) assessed occupants' attitudes towards work before and after moving from enclosed offices to an open-plan workplace. They revealed that occupants' levels of satisfaction with work and their internal motivation levels declined

significantly after moving to the open-plan workplace. Attitudes had not changed when a further analysis was carried out six months later. These findings demonstrate that there is a greater body of research supporting the argument that open-plan workplaces have a negative impact upon occupants' perceptions of the working environment and satisfaction with their job compared with cellular offices. In addition researchers have found that perceived productivity decreases amongst occupants in open-plan workplaces (Brennan et al, 2002; Wineman, 1986; Brookes & Kaplan, 1972; Becker et al, 1983).

The research into office types highlights a significant amount of dissatisfaction with open plan environments in contrast to cellular offices. Danielsson and Bodin (2008) evaluated the impact of different types of workplace on satisfaction and found that the preferred office type was a small shared office rather than individual cellular offices and that the least preferred were open plan offices. The diverse and flexible environments highlighted in Chapter 2 and developed around the principles of contingency management theory may be perceived differently by occupants and have a different effect upon satisfaction. Thus, further research into different office types like that of Danielsson and Bodin would be useful. Worth noting is that whilst satisfaction levels were generally lower in open plan environments, the majority of researchers found little or no impact of these environments upon perceived or actual productivity. Considering that productivity was not positively correlated with increased enclosure of an individual's workstation, managers were provided with justification to move to open plan from cellular workplaces based upon the financial benefit that this provided. Unfortunately the lack of more contemporary research makes it difficult to conclude whether modern open plan layouts have an impact upon satisfaction and productivity. However, the effect that open plan environments have upon occupants' experiences of the workplace can be analysed to determine whether spatial layout indirectly affects satisfaction and productivity.

### 3.4 Privacy in the Workplace

Privacy is an aspect of occupants' experience of the workplace environment which can be affected by the spatial layout. Privacy is defined by researchers as the 'regulation of interaction between the self and others and/or environmental stimuli' (Kupritz, 1998, p341). Both visual privacy and acoustic privacy are considered to be important to employees in helping them work to the best of their ability (Wineman, 1986). As a result attention has been focused upon determining the best way of providing workers with

privacy through the spatial layout of the workplace. For example, Kupritz (1998) identified the eight design features which were perceived to have the greatest impact upon privacy in the workplace for a sample of engineers. The design features identified were: having minimal traffic routed through workers' area, being located away from the main traffic flow, having 1.5m partitions, having 2.1m partitions, having floor to ceiling solid walls, having a door, having a conference room and having a window with blinds in the cubicle. In further studies workers associated having a personal office with increased privacy (Kupritz, 2003), having low levels of spatial density (Kupritz, 2000) and having many partitions around the workstation (Sundstrom et al, 1982). These findings suggest that the spatial layout does offer opportunities to provide privacy for occupants. Providing barriers around the workstations in the form of partitions or walls and locating people away from circulation routes are all correlated with increased perceptions of privacy. Research into the impact of privacy upon satisfaction and productivity demonstrates the importance of providing privacy in the workplace. O'Neill (1994) analysed the impact of the workplace upon several job characteristics and then assessed the direct impact and indirect impact of the workplace upon satisfaction and perceived productivity. The results demonstrated that not only did respondents perceive the amount of privacy they had within the workplace to affect their satisfaction with work, they also perceived it to have a significant impact upon their productivity. DuVall-Early and Benedict (1992) also found a significant relationship between perceived level of privacy and satisfaction with work. Although these findings demonstrate that privacy is important for workers, some researchers suggest that the need for privacy is mediated by the complexity of the task. Thus, occupants who have to perform complex tasks are more dissatisfied and suffer more from a reduction in privacy (Sundstrom et al, 1982; Hedge, 1982). Other researchers however suggest that all workers like to have privacy regardless of the tasks that they are carrying out (Wineman, 1986). The need for privacy at work has been recognised and has led to the introduction of different spatial layouts and furniture solutions that are designed to increase privacy, such as the use of partitioning systems. The research demonstrates that partitioning increases positive attitudes towards privacy and increases satisfaction. However, adding partitions to the workplace begins to resemble a series of cellular offices again and could be perceived to have a negative impact upon the factors that open plan working was designed to facilitate such as collaboration and team working. Further research is required to understand the relationship between increased privacy and communication in the context of the spatial layout of the workplace environment.

### 3.5 Density in the Workplace

Spatial layout, and in particular the move from cellular to open plan offices has had an impact upon density levels within the workplace. This can have an impact upon privacy as people perceive that they can be seen and heard by a greater number of people at high density levels (Kupritz, 2000). In addition, there are issues associated with attitudes towards overcrowding. Desor (1972) suggested that feeling crowded is due to excessive social stimulation which is a direct result of the number of people within a given area. In terms of density, standards have been developed to guide designers and occupiers when determining how many people should be located within a workplace of a certain area. According to health and safety guidelines in the United Kingdom the average volume per person should be 11m³ to ensure that they have adequate space to be comfortable and safe (Marmot & Eley, 2000). Marmot and Eley (2000) also suggest that if people are within two or three metres of each other their desks should be at a 90º angle from each other to reduce the feeling of being crowded.

Being crowded has been found to have a negative impact upon satisfaction with work and performance. Research into what people disliked about their work environment revealed that workplaces in which there were many employees and where people were seated close to one another were considered to be dissatisfactory (Oldham & Fried, 1987; Oldham & Rotchford, 1983; Fried, 1990). Marans and Yan (1989) found that satisfaction of occupants of an open plan workplace was dependent upon the amount of floor space respondents perceived was their own. The more space people felt they had the more satisfied they were. In further support of this Oldham (1988) found that occupants' satisfaction with work increased when they were moved from a high-density, open-plan workspace to a low density workplace. In further support of the negative impact that high density workplaces have upon occupants, researchers have found that higher density levels can reduce productivity (Paulus, 1976; Oldham & Fried, 1987). Paulus (1976) conducted an experiment with 236 participants and discovered that increasing the group size, decreasing the room size, and decreasing interpersonal distance all independently led to a decrease in task performance. The research into the impact of high density workplace upon satisfaction and productivity, both perceived and actual, is very conclusive. High density workplaces are related to lower levels of satisfaction, decreased perception of privacy and lower levels of productivity.

### 3.6 Summary and Conclusions

The spatial layout of the workplace has been influenced by a number of factors, predominantly changing management theory. From individual cellular offices to open plan environments, and workplaces with a diversity of spaces the spatial layout has been an integral element of providing these different workplace environments. However, there have been other drivers of the design of spatial layouts including status of an individual within an organisation and the way in which the environment affects users' satisfaction and productivity. The recognition of the impact of the spatial layout led to the development and publication of space standards. These have evolved from recommendations in which status of an individual was given priority over the tasks they were performing. Rather than specifying office types and areas on the basis of someone's role, space standards now give an acceptable workplace area per person. Despite this, the status of individuals in many organisations still dictates space standards and evidence demonstrates that this may also be influenced by employees who have demonstrated higher levels of satisfaction when space allocation in the workplace is perceived to be fair. Spatial layout has also been influenced by the impact that it has upon factors affecting users' satisfaction and productivity levels. Open plan offices when analysed at the time they were becoming popular were correlated with high levels of dissatisfaction but no strong links were established between open plan workplaces and productivity. Additionally, an open plan layout has been found to be more cost effective to organisations which has influenced their popularity with managers. Linked with the increase in open plan workplaces is the impact upon privacy and density levels. Both a lack of privacy and high levels of density within the workplace have been correlated with low levels of satisfaction and reduced perceived or actual productivity.

Despite the amount of research into the spatial layout of the environment, the findings are not conclusive beyond the indirect impact of the layout on factors such as privacy and density. The first reason for this is a lack of recent, empirical research into the impact of modern workplace environments. With the introduction of open plan workplaces in the 1970s there was a considerable level of research interest, much of which demonstrated dissatisfaction with open plan versus cellular spatial layouts. However, at this point a number of people had moved from cellular spaces to open plan and in the process had to undergo a significant culture change and adapt the way in which they worked (Duffy, 1992; Duffy, 1997). As open plan has become more prevalent and organisations are used to working within these environments, the culture

change may have a less significant impact upon results. The diversity of spaces within workplaces may also have an impact upon attitudes towards the open plan environment. An element of choice in the environment allows people to decide where they want to work based upon personal preference and appropriate conditions for their tasks.

The somewhat inconclusive evidence relating to the impact of the spatial layout suggests that there are other aspects of the workplace environment which may have an impact upon users. Beyond the spatial layout, the workplace is a multi-faceted environment in which aspects such as the internal climate and design all exist together. To fully understand the impact of the spatial layout and the workplace, it is essential to understand the impact of these other factors.

## Chapter 4 Current State of Knowledge: Internal Climate of the Workplace

### 4.1 Introduction

The links between the workplace environment and satisfaction were detailed in Chapter 1. Research has shown that when referring to the workplace environment in most of these instances, the focus is often the internal climate rather than more qualitative aspects of the workplace. For example, Sundstrom (1986) suggested that the aspects of the workplace affecting workplace satisfaction were noise, lighting, temperature, air quality, colour, furniture and equipment, privacy and status. From this list four of the aspects are elements of the internal climate demonstrating the importance placed upon it by researchers. For the purpose of this thesis, the internal climate has been defined as the environmental conditions including air temperature, air movement, relative humidity, illuminance and noise. Analysis of the research demonstrated that these aspects of the workplace have received the most research attention compared with others and design guidance has been developed to reflect the findings. It is important to note that design guidance contains recommendations for workplace environments based upon creating a comfortable environment, they are not legal requirements. The separate aspects of the internal climate have predominantly been analysed individually as thermal factors, illuminance and noise.

### 4.2 Thermal Factors

Thermal factors comprise air temperature, relative humidity and air movement (McCoy, 2002). Air temperature, relative humidity and air movement interact so that an individual experiences thermal comfort as a combination of these factors. A leading organisation in the building services industry, the American Society of Heating, Refrigerating and Air-Conditioning Experts (ASHRAE) suggest the addition of a fourth element of the thermal environment, radiant temperature (ASHRAE, 2002). This is the temperature of surfaces which can have a significant impact upon the perception of air temperature. With the addition of radiant temperature, ASHRAE describe the impact of these factors upon an individual as thermal comfort, the perception of being satisfied with the thermal climate. This emphasises the psychological response to the thermal environment demonstrating the highly subjective nature of comfort. However, other researchers suggest that it is actually the physiological impact of thermal factors that has the greatest impact upon comfort (Johl, 1995). Whilst most researchers do not agree that only physical measures are necessary to determine thermal comfort as Johl

does, physiological responses such as shivering when cold and sweating in high temperatures do give an indication of the impact of the thermal environment upon an individual and that these physiological responses can be measured as an indication of thermal comfort (Rowe et al, 1995; Humphreys & Nicol, 1995; de Dear, 1998; ASHRAE, 2002; Fanger & Toftum, 2002; Nicol & Humphreys, 2002). A scale developed by ASHRAE (1966) is used by many researchers as an indication of psycho-physical comfort in relation to thermal factors. It is a seven point scale with labels of cold, cool, slightly cool, neutral, slightly warm, warm and hot. By selecting an item on this scale, ASHRAE suggest that individuals are classifying both their physiological and psychological, or comfort, response to the thermal climate. The use of this scale was subsequently endorsed by Fanger (1970) in the development of his widely cited Comfort Equation and Humphreys (1976) within the further developed model of thermal comfort, the Adaptability Model.

Fanger (1970) developed an equation to determine thermal comfort. The result is derived from analysing the four previously stated aspects of thermal comfort; air temperature, air movement, radiant temperature and relatively humidity in addition to two further factors; level of activity of an individual and clothing worn. The equation calculating thermal comfort is based upon this information and is known as the Predicted Mean Vote or PMV. The rating scale is taken directly from ASHRAE. There has been empirical support for Fanger's Comfort Equation with researchers demonstrating that a neutral rating on the PMV is equated with satisfaction with the thermal environment (Gagge et al, 1986; Doherty & Arens, 1988; Fanger & Toftum, 2002). For example, Fanger and Langkilde (1975) demonstrated 95% satisfaction with the thermal environment when it was deemed to meet requirements of the thermal comfort equation. However, there is inconsistency in the findings with research demonstrating that high satisfaction with the thermal comfort in workplaces is not always recorded when the equation is applied (for example, Croome et al, 1992). Criticisms of Fanger's model are that the model is too static and does not account for change in the thermal conditions across time (Oseland, 1995) thus rendering a single prediction inadequate. The reliance of the model on physiological variables rather than psychological interpretation (Jones, 2002), and human adaptability, such as changing behaviour to modify thermal comfort, not being considered are cited as further criticisms (Humphreys, 1995). Humphreys suggests that adaptability is an important factor as it can account for up to 50% variation in thermal comfort. It is this premise upon which he based his adaptability model of thermal comfort (Humphreys, 1976). Humphreys found that people make a number of adjustments to their environments

such as opening windows and dressing in a particular way to achieve thermal comfort. They do not just passively accept the thermal conditions. Thus, they are able to adapt to and work in conditions that would not be deemed comfortable using Fanger's equation. The premise of Humphreys' adaptability theory is that people are comfortable if the thermal conditions meet their expectations. Thus, thermal comfort in his model is based upon outdoor temperature (Humphreys, 1978). If the workplace environment is cooler when the weather outside is cold, and vice versa when the weather outside is hot, people will have higher levels of thermal comfort than when there is no relation between the external and internal temperatures. The adaptability model has received significant support from a number of researchers (for example, Humphreys & Nicol, 1995; Brager & de Dear, 1998; de Dear, 1998; Nicol & Humphreys, 2002; Toftum, Andersen & Jensen, 2009), although there has some been criticism of over-reliance upon external temperatures (Fanger & Toftum, 2002). Overall though, the theories of thermal comfort have been supported and have helped inform the design of workplace environments to ensure that they are comfortable for users. Predominantly this has been through informing the development of industry guidance for thermal comfort. As with the standards for spatial layout detailed in Chapter 3, standards for thermal factors were designed to ensure that the internal climate within the workplace was comfortable.

Within the industry, the ASHRAE Standard 55-66 is generally used as the benchmark for good performance in terms of creating a comfortable thermal environment. (ASHRAE, 1966). The ASHRAE standard recommends air temperature and relative humidity ranges for the environment for thermal comfort. These have been amended in subsequent years as building management systems have been developed which can control the internal climate more effectively and research evidence has informed understanding about thermal comfort. ASHRAE 55-96 (1996) suggests an air temperature range in the workplace environment of 22.5ºC and 26ºC in summer, and 20ºC and 23.5ºC in the winter. This reflects the work of Humphreys who advocates recognising differences in external temperature when determining thermal conditions for comfort. Other industry guidance is in accordance with these recommendations. The Chartered Institute of Building Services Engineers (CIBSE) Guide A recommends a range of 21ºC to 24ºC. The ASHRAE Fundamentals Handbook (2001) recommends a range for comfortable relative humidity levels of between 30% and 70%. Egan (1975) suggests that the maximum relative humidity should be 60% and that the target should be 50%. The mean radiant temperature is roughly the same range as the air temperature guidance with the additional recommendation that it should be no more

than ±3 ºC from the mean air temperature to prevent feelings of discomfort (ASHRAE, 2001; Egan,1975). Air movement speeds of between 0.05m/s and 0.25m/s are recommended to prevent stagnant air but not cause the feeling of draughts (ASHRAE, 1996; Egan, 1975). Whilst these standards were developed from an evidence base, this was predominantly research carried out in laboratory settings such as climate chambers and it has therefore been suggested that they are not applicable to real world settings (Cena et al, 1990; Croome et al, 1992; de Dear & Brager, 2002). Despite this there has been support for the industry standards (for example, Kostianinan et al, 2008 and Kuchen & Fisch, 2009). Schiller et al (1998) found that 80% of people sampled in the buildings they surveyed were comfortable when the air temperature was between 20.5ºC and 24.0ºC. However, there has been criticism of such prescriptive definition of standards without consideration of individual differences (for example, Tanabe & Kimura, 1994; Rowe et al, 1995; Fountain et al,1996; Heidari & Sharples, 2002 and Nakano et al, 2002), or the activities being performed (Fanger, 1970; Fanger & Langkilde, 1975; Humphreys, 1995; Fanger & Toftum, 2002). Zang et al (2007) demonstrated that workplace occupants were dissatisfied with the air movement speeds in their workplaces, even when the air movement speed was over speeds of 0.2m/s as specified within the design guidance. Haghighat and Donnini (1999) found that 15% of a sample of office workers reported that their thermal environments were unacceptable despite 80% of the buildings surveyed being within the range of thermal comfort specified by ASHRAE 55-96. Furthermore, 22% of the respondents who rated their thermal comfort as being acceptable were working in conditions that did not meet the ASHRAE standard. The research evidence suggests that the standards are not consistently effective predictors of thermal comfort. The evidence from research has been used to inform the ASHRAE standard 55-2004 (ASHRAE, 2004) which no longer specifies a particular temperature range but advocates the use of the Predicted Mean Vote model of Fanger with some consideration given to the adaptability model of Humphreys. This demonstrates the importance of understanding that the situation, individual differences and personal preference have an impact upon thermal comfort. Thus, whilst there may not have been support for prescriptive thermal comfort standards in terms of air temperature and relative humidity ranges, the standards are not automatically inaccurate or wrong. They are just limited through their lack of consideration of other factors which may affect thermal comfort beyond the physical measures of the internal climate. Although the standards were developed using research from laboratory studies, research into the impact of thermal factors within the workplace environment has revealed that there are some correlations between thermal comfort, the internal climate and overall satisfaction with the workplace.

There is evidence that job satisfaction is affected by users' attitudes towards their workplace environment (Sundstrom, 1986). Workplace conditions have also been referenced in models of motivation (for example, Maslow 1943). In both models of job satisfaction and motivation, a comfortable environment for users is cited as being a contributing factor, and within that thermal comfort is an important component. Therefore thermal comfort is perceived to have a positive impact upon users in terms of satisfaction. However, from the research into the impact of thermal conditions it has become apparent that specifying a limited temperature range, albeit one that has been validated in laboratory settings, does not necessarily produce thermal conditions that users perceive to be comfortable. Whilst the research into satisfaction and thermal comfort has not been able to demonstrate a clear, significant relationship, research has demonstrated some links between thermal conditions, comfort and perceived or actual productivity. Research into air temperature has revealed that lower temperatures than specified in the standards, or at the lower end of the range given, was correlated with higher levels of productivity. Nelson et al (1984) found that the best performance of a sedentary task was at an air temperature of 13ºC and that the fewest reports of fatigue were recorded in this condition. The air temperature at which participants were most satisfied in terms of thermal comfort was 23ºC, which is in line with the standards specified by ASHRAE. However, performance and reports of fatigue were higher in this condition and worse still at 30ºC. This finding is supported by results of research when the conditions were less extreme and within the range specified by the standards. Abdou and Lorsch (1994) found that performance on a task was worst at 27ºC, the air temperature perceived to be the most comfortable in their study. Performance was highest at 20ºC, which was a condition rated by participants as being uncomfortable. Wyon (1974) found that people were equally comfortable when the air temperature was 20ºC and 24ºC but that performance was higher in the 20ºC condition. These results suggest that performance and satisfaction in terms of comfort are not related and that a cool rather than warm air temperature has a positive impact upon productivity. However, the air temperatures within these studies were not extreme, even though Nelson et al tested the impact of air temperature below the standards specified by ASHRAE. Studies of the impact of less moderate air temperatures demonstrate that air temperatures as low as 6ºC have a considerable negative impact upon performance (Meese et al, 1984; Ellis, 1982) and higher air temperatures led to more reports of mental fatigue and reduced blood flow to the brain when completing tasks (Tanabe, Nishihara and Haneda, 2007). The impact of air temperature on productivity, particularly moderate rather than extreme temperatures, has not been consistently

replicated. There are a number of studies in which no correlation between moderate differences in air temperature and productivity have been reported (Pepler,1958; Chiles, 1968; Azer et al, 1972; Lorsch & Abdou, 1994; Hygge & Knez, 2001; Fang et al, 2004). Sutton and Rafaeli (1987) assessed the impact of a number of factors considered to be stressors within the workplace environments and found that moderate differences in air temperature did not affect the performance of tasks.

Taken together, research findings reveal that extreme thermal conditions have a clear impact upon productivity when they begin to affect people's level of comfort to the extent that they can no longer function. However, moderate differences in thermal conditions have a less consistent impact and may be influenced by a number of other factors such as expectations of a comfortable environments (Humphreys, 1976) or the activity being carried out (Fanger, 1970). The standards are important, therefore, to ensure that moderate thermal conditions are maintained. However, the range of the thermal comfort standards could be questioned due to the lack of consideration for adaptability and individual differences. The different influencing factors may lead to thermal conditions outside of the recommended ranges being perceived as comfortable. Thus, whilst the industry guidance has been criticised, this is not on the basis that the standards are wrong but that they are too restrictive. The evidence suggests that if thermal comfort factors are within the recommended range people will be satisfied. There is potential for the thermal factors to be outside of the recommended range with no impact upon satisfaction or productivity. However, research evidence suggests that there may be links between moderate air temperature changes and productivity with temperatures perceived to be cool in particular being correlated with increased performance levels.

### 4.3 Illuminance

Illuminance, for the purpose of this thesis, refers to the amount of light in the workplace. It is a combination of natural light and artificial light. The same definition of illuminance is used in each of the studies cited in this section unless otherwise stated. The reason for using overall level of light, rather than distinguishing between artificial and natural light, is that it is the experience of the individual and their perception of light that is important, rather than how this level of illuminance is achieved. Lighting in the workplace fulfils three criteria according to the Chartered Institute of Building Services Engineers (CIBSE): ensuring safety, facilitating the performance of visual tasks and aiding the creation of an appropriate visual environment (CIBSE, 1994 p.1). Whilst

recommendations exist, as for thermal factors, there is still discussion based upon the research findings about how the optimum environment can be provided in terms of illuminance. The standards have been developed to indicate ideal illuminance levels in the workplace. CIBSE (1994) recommend illuminance levels of between 300lux and 500lux in the workplace with 500lux being the ideal for general workstations in the average workplace. Below this range and it is argued that illuminance levels will affect users' visual perception and have a negative impact upon task performance. Considerably higher illuminance levels than the recommended range and users could suffer discomfort and glare which also affects performance. Historically, the illuminance levels recommended were considerably lower than modern standards. In 1936 the IES code (Boyce, 2003) recommended a level of 150 lux in general offices. In modern industry guidance, the recommended level is 500 lux in the United Kingdom (CIBSE, 1994). Loe et al, (1996) suggested that there is little justification for the existence of standards as the recommended illuminance levels have changed therefore they cannot have consistently been correct. However, what they may indicate is a recognition that higher levels of illuminance have a positive impact upon users and that the technology allows these levels to be achieved. The increase in recommended illuminance levels is supported by research findings which have demonstrated that increased illuminance is related to increased satisfaction with the light levels (Saunders, 1969 in Boyce, 2003). However, further research incorporating an analysis of illuminance on computer-based tasks has demonstrated that there is not a simple, direct relationship between illuminance and satisfaction. Newsham and Veitch (2001) analysed both paper-based and computer-based tasks to determine whether there was a significant relationship between levels of illuminance and satisfaction. Given the opportunity to adjust the illuminance levels in the experimental setting, the intersection with the linear regression line for the amount of change was 0% at 392 lux. That is, participants made least change to the illuminance levels when they were already set at 392 lux. The level was actually calculated at 458 lux when the results were adjusted to take into account changes made to eliminate glare. The results of this research demonstrated that there was not a continuous positive correlation between increased illuminance and satisfaction. Illuminance levels over 500 lux were adjusted to a lower lux level in Newsham and Veitch's study suggesting that there is a maximum acceptable level of illuminance. The finding that higher illuminances do not necessarily lead to higher levels of satisfaction is supported by the findings from other studies (Flynn, 1977; Katzev, 1992).

The research into illuminance levels above or below the range recommended within the standards highlights the importance of providing a specific level of illuminance within the workplace environment. However, the reliability of standards is somewhat challenged by the huge range in recommended lux levels across different countries. Boyce (2003) analysed the differing illuminance levels recommended throughout the world and found that they ranged from as low as 100lux in Denmark, Finland and Sweden to higher levels of 750-1000lux in some countries including Brazil and Japan. These different standards suggest that if there was a specific illuminance level that was best practice, then industry guidance should be more consistent. A further criticism of the standards listed in industry guidance is that they do not account for individual differences and assume that there is a specific level of illuminance that suits all users. Van Irland (1967) found a maximum of 80% of participants were satisfied with the illuminance levels in the workplace. At least 20% of participants were therefore not satisfied with the illuminance, even when it was within the range recommended by industry guidance. Researchers have suggested that there are different properties of light which have been linked to attitudes and perceptions of users. Users have individual preferences for the direction of light, i.e. whether the light shines on their desk directly or whether it is indirect and is directed towards the ceiling so that the light reflects off the ceiling onto the desk (van der Burgt & van Kemenade, 1992; Hedge, Sims & Becker, 1995; Boyce, 2003). Visual interest created by the lighting has also been found to have an effect upon user attitudes. Workplaces in which the illuminance is not uniform and different areas of the space are lit in different ways have been associated with high levels of satisfaction (Loe et al, 1996). However, other researchers have reported conflicting results with uniformity of light being rated as more comfortable and acceptable (Slater, Perry and Carter, 1993; Carter, Slater, Perry, Mansfield, Loe and Sandoval, 1994). These findings suggest that the impact of light on users is complex and is not linked solely to illuminance levels, direction of light or uniformity. In addition to the different aspects of light contributing to the impact upon users attitudes, there are complexities involved in how light affects people which need to be understood. Findings have demonstrated that there is a relationship between illuminance and mood. Analysis of mood has revealed that participants consistently rated themselves as being more positive when the illuminance levels were lower than the recommended range of 300 – 500 lux (Biner, 1991; McCloughan, Aspinall and Webb, 1996).Baron and Rea (1991) found that participants reported a much more positive mood in a low illuminance condition, where it was 150 lux, than the high illuminance condition where it was 1500 lux.

Beyond the impact of illuminance upon mood, researchers have attempted to discover a significant relationship between illuminance and productivity. Illuminance can affect productivity in two notable ways. The first is physiological as illuminance levels that prevent the details of a task being visible will have a negative impact upon performance (Boyce, 2003). For example, Weston (1945) discovered that the performance of individuals carrying out a simple task increased as illuminance levels increased. This was because the details of the task became clearer. However, the increase in performance followed a law of diminishing returns with improvements in performance through the relationship between the fineness of detail and illuminance. Tasks which require greater visual attention are performed better at high illuminance levels. Once the illuminance reaches the point at which an individual can see clearly, visual performance is no longer a limiting factor to performance. These findings have been replicated and are referenced in CIBSE Code for Interior Lighting (CIBSE, 1994). Researchers evaluating the impact of high levels of illuminance found that there was no difference in performance on tasks between a condition in which the illuminance was 3001 lux and 1001 lux (Nelson, Nilsson and Johnson, 1984). However, the lower lux level in this study was still considerably higher than the 500 lux recommended in the industry guidance, and based upon the previous suggestion that performance improvements follow a law of diminishing returns until they reach saturation point, this could explain the result. In studies when the lux levels in some conditions were below the 500 lux recommended by the industry standards, researchers have found little impact upon productivity and that high illuminance levels have actually been correlated with lower levels of performance (Katzev, 1992; Boyce, 2003). McCloughan et al (1996) evaluated participants' performance in conditions where illuminance ranged from 750 lux to 300 lux. The productivity of participants in the lower lux condition was not significantly different to performance of participants in the higher lux condition, even though it was below the 500 lux level recommended in design guidance. These studies highlight that, as with satisfaction, there does not seem to be a consistent direct link between illuminance and productivity. Whilst the pattern of results indicates that higher levels of illuminance are related to increased performance, the significance of this relationship is reduced when the illuminance levels rise above the level required to improve an individual's ability to clearly see what they are doing.

The research findings demonstrate that standards have been developed to provide a range of illuminance that is deemed to be significant to allow tasks to be seen clearly but not cause glare. Research has not conclusively supported the range specified within the standards as participants have reported being satisfied with illuminance

levels outside of the recommended range of 300 lux to 500 lux. The research demonstrating the impact of illuminance on mood has been more consistent with lower levels of illuminance being associated with mood. In some contrast, increased productivity has been recorded at higher levels of illuminance, albeit following a law of diminishing returns. The inconsistency of these findings highlights the complexity of the impact that light has upon users. As with thermal factors, there are other factors which may affect users' attitudes towards the illuminance levels in the workplace. These may relate directly to the provision of artificial light with researchers finding that perceived productivity was higher with indirect rather than direct lumineres (Hedge, Sims and Becker, 1995) but there were inconsistencies in the impact upon satisfaction with some research indicating that people had a preference for indirect lighting (Hedge et al, 1995) whilst others found participants had a preference for direct lighting (Leibig and Roll, 1983). Different tasks were being performed in the studies, the first was paper based and the second computer based, but these are two types of task likely to be undertaken in a real world workplace. Thus, the findings from both studies are valid and indicate that people have different requirements from light in their workplace depending upon the tasks that they are working on and personal preference. This is supported by van der Burgt and van Kemenade (1992) who argue that individual needs of users cannot be met as their preferences for dispersion of light vary so widely. A further issue is the source of light with research demonstrating that three quarters of people stated a preference for natural light as opposed to artificial light (Sundstrom, 1986). The impact of daylight on users is covered in more detail in Chapter 5. Taken together the results demonstrate that illuminance is an important consideration in terms of ensuring that people can clearly see the detail of their work. This is justification for the implementation of illuminance standards to ensure that users can see what they are doing as conditions are not too dull or too bright. However, the inconsistent results relating to satisfaction and productivity in conditions of illuminance which are adequate for good visibility suggest the influence of individual preferences. There may also be interaction effects of other aspects of the workplace environment influencing satisfaction with the workplace and illuminance such as personal control which is discussed later in this chapter.

### 4.4 Noise

Noise within the workplace has been the subject of considerable research as the acoustics of environments have been found to have an impact upon those who use them. McKeown (2008) suggests that noise cannot be determined by measuring

volume or pitch as it is based upon the amount of annoyance it causes for an individual, rather than the sound itself. Workplace users in one workplace may not perceive a level of sound to be an annoyance, whereas the same volume of sound in another workplace would be considered to be noise. However, researchers have identified that noise in the workplace, predominantly from others talking, is cited as being distracting by over 75% of workplace users (Sundstrom, 1986). As a result, guidance relating to acoustics within the workplace has been developed. The British Council for Offices (2005) suggest a background noise which does not exceed 45dB in an open plan office. It should be noted that the acceptable volume level is stated as a background noise and does not refer to an occupied workplace. Whilst this allows the environment to be easily tested to determine whether it falls within the specified range, as it does not have to be occupied for the evaluation to take place, it does not provide much information on potential noise levels in an occupied workplace. Banbury and Berry (2005) found that the majority of workplace users report the sound from telephones ringing and other people talking as being the major sources of noise annoyance. These sounds are not included within the design guidance specification of a maximum of 45dB as they are not background noise. Thus, the standards do not take into account all potential disruption. Sound from background sources such as mechanical ventilation systems and traffic outside the building are not rated as having the greatest impact upon noise and distractions of users. It would appear to be more prudent to measure the sound levels within an occupied workplace and generate the design guidance based upon these findings. Research to date suggests an average volume level in an occupied open plan workplace of 50dB (McKeown, 2008). Although over the maximum decibel level recommended in design guidance, these are occupied workplaces so there will be other sound generated by occupants and is therefore not necessarily distracting. In addition to a maximum sound level in the workplace, researchers suggest that some background noise is beneficial as opposed to silence (McKeown, 2008). A small amount of constant, background sound masks inconsistent, random sounds that may occur such as a door closing or other occupants' telephones ringing. The benefit of background noise is demonstrated by an analysis of workplace acoustics and the impact of moving from cellular spaces to an open plan environment. Brill et al (1985) found that clerical workers moving to an open plan environment from their cellular offices were more satisfied with the noise levels in the workplace. The findings were attributed to the background sound levels provided by others working in an open plan workplace. This masking sound actually led to fewer distractions as the noise, whilst greater in volume, was less distracting. Thus, there is an argument for maintaining and adhering to the recommendations made within the design guidance.

By providing an acceptable range of consistent, background sound it prevents inconsistent sounds becoming noise and causing distractions. However, the design guidance does not take into account the impact of a workplace being occupied and the sound generated by the activity of people which becomes noise. It is important to consider the noise in an occupied office as research has demonstrated that there is an impact of perceived noise within the workplace upon satisfaction and productivity.

Noise as opposed to sound is not a neutral term and implies a negative impact upon those who perceive it. Therefore, it is of little surprise that the empirical research has indicated that where workplace users have identified noise within the workplace, it has had a negative impact upon them. In terms of satisfaction, the research has demonstrated that noise is rated as being a stressor within the workplace environment and reducing levels of satisfaction. Brill et al (1985) analysed a number of studies and found that noise was significantly negatively correlated with environmental satisfaction. That is, when users perceived there to be increased noise levels in the workplace, their reported level of environmental satisfaction decreased. Dissatisfaction with the workplace environment in terms of spatial layout was also attributed to the presence of noise by Leaman and Bordass (2001). Their analysis of perceptions of the workplace environment demonstrated that users, from a number of case studies, were dissatisfied with very open, high density workplaces. A lack of partitions between desks and large numbers of people in a relatively small space were disliked by users. This dissatisfaction was attributed by the researchers to acoustics. The open plan, high density environments had higher sound levels and greater incidents of sound from sources considered to be the most distracting: other people talking and telephones. Thus, it led to reports of dissatisfaction.

As expected, the research to date has demonstrated that noise is negatively correlated with satisfaction. However, the evidence demonstrating a relationship between noise and productivity is not as conclusive. Empirical research has been fairly consistent in demonstrating a negative correlation between perceived productivity and noise. For example, Banbury and Berry (2005) reported that 99% of occupants they surveyed rated their concentration levels, and consequently their productivity levels, as being negatively affected by noise levels within the workplace. Other researchers have found a similar pattern. Kaarlela-Tuomaala et al (2009) found that noise was rated as having a negative impact upon satisfaction and perceived productivity. Users reported finding noise in the workplace distracting and leading to difficulties in concentration. However, research into the perceived impact of noise upon task performance and actual

performance revealed an interesting, and different, pattern of results. Kristiansen et al (2009) found that participants in their research perceived themselves as having to exert greater mental effort to complete a task when there was noise. However, analysis of their physiological response to the noise and task performance demonstrated that there was no impact of noise upon their stress levels or cerebral activity. Other researchers have demonstrated that even perceived productivity is not necessarily affected by noise. For example, Leea and Branab (2005) demonstrated that whilst workplace users rated themselves as being distracted by noise in the workplace, their perceived productivity levels were not significantly correlated either negatively or positively with the amount they were distracted. Despite these studies not revealing a significant relationship between noise levels and productivity, there is support from other empirical research to suggest that noise does affect the performance of tasks. A number of studies were conducted by Banbury and Berry (1998) to evaluate the relationship between noise in the workplace and productivity. The main finding from their research was that noise generated by others talking in the workplace, whether the speech was meaningful or irrelevant to the participants, had a negative impact on performance of tasks. Different tasks were selected, one that required participants to memorise prose and another that involved mental arithmetic, to determine whether there was any effect of task type. The results indicated that whilst noise from speech disrupted all tasks, noise that was not speech affected only the mental arithmetic task. These findings demonstrate that the source of the noise and the work being carried out may mediate the impact of noise on productivity. Further support for a negative impact of noise upon productivity has been demonstrated by a number of researchers (for example, Evans and Johnson, 2000; Witterseh, Wyon and Clausen, 2004; Smith-Jacksona and Klein, 2009). Taken together, the research findings demonstrate that the relationship between noise and productivity cannot easily be defined. This may be due to the interaction of noise with other aspects of the workplace environment. Research conducted in laboratory settings may not have accounted for these interaction effects, thus generating findings which do not accurately reflect the impact of noise in a real world workplace environment. For example, Witterseh et al (2004) demonstrated that noise had an effect upon concentration levels within their study. However, they also evaluated the impact of varying air temperature. When the environment was perceived to be warm, the impact of noise on concentration was reduced. Interaction with spatial layout has also been analysed. Newsham, Veitch and Charles (2008) found that participants were more dissatisfied with the acoustics within the workplace if they were located in close proximity to a window or had a smaller than average workstation.

The standards for acoustics in the workplace environment have been developed to inform the design based upon background sound. Whilst this has the potential to become noise and have a negative impact, noise tends to be attributed to the activity of those within the occupied workplace. The sound from telephones and conversations within the workplace are inconsistent and are cited as having the greatest impact upon concentration levels by workplace users. A level of background sound can mitigate against the impact of these noises if it masks them without becoming a distraction itself. An appropriate level of background sound is the premise for the standards. However, it is noise rather than sound which has been found to have a consistently negative impact upon satisfaction. It is also noise that has been negatively correlated with productivity in a number of studies, rather than background sound. Thus, it seems relevant that both sound and potential causes of noise are considered in the development of the workplace environment. In addition, aspects of the workplace, such as air temperature, should be considered in conjunction with sound levels to determine whether there are any interaction effects.

### 4.5 Personal Control of the Internal Climate

A key aspect to consider when evaluating the internal climate of the workplace is the amount of control that occupants feel they have over the environment. The impact of the thermal factors, illuminance and noise levels cannot be considered without determining how much influence occupants have over these aspects. For the purpose of this thesis, the definition of control is taken from Burger (1989, p246) who describes control as “the perceived ability to significantly alter events”. Control is defined as perceived because in the majority of studies, it was not the actual level of control that influenced the results, but the amount of control that participants believed themselves to have. In general, the research into perceived control of the workplace in the areas of management theory, built environment and psychology have focused upon the positive impact of choice and control in the workplace, with many studies supporting a positive relationship between the two (for example, Harris, 1980). On the other hand, there are several studies demonstrating the potential negative impact of control (for example, Veitch and Newsham, 2000). Researchers from these studies argue that there is no significant correlation between the level of perceived personal control and satisfaction or productivity. However, a much higher proportion of researchers and industry professionals support the argument that the perception of personal control has a positive impact upon workplace occupants. Although this is the case, modern workplaces generally offer occupants little to no personal control over their environment

(Bromley, Bordass, & Leaman, 1993). This is largely due to the development of building management systems that allow the building owners to control the environment of the whole workplace centrally. The levels set within workplaces are generally driven by the industry guidance and standards detailed earlier in this chapter. However, as discussed, these standards are fixed and therefore make the assumption that one size fits all and that an environment that fulfils the standards is comfortable for all building occupants. Researchers have argued that even if standards are met, upto 20% of occupants will not be satisfied with their environmental conditions (for example, Fountain et al, 1996). Further to this Fountain et al (1996) state that it is "unreasonable to expect all people to be satisfied within a centrally controlled environment" (1996, p180). Occupants cannot select the environmental conditions that best meet their requirements, thus a significant number of occupants will always be dissatisfied in a centrally controlled environment over which they have no control. People's needs in terms of their environment vary throughout the day and between individuals. The requirements of people in relation to the environment has been found to depend upon age, gender, personality, metabolism and hypersensitivity of the person in addition to the task being performed and the person's location (Lomonaco &Miller, 1997). As there are so many differences to be accounted for, it is unlikely that a workplace environment can be designed in which all building occupants are comfortable all the time. If individuals are given personal control, they can adjust the environment to meet their needs, thus increasing the number of people who are satisfied with their workplace.

Researchers have argued that one of the main barriers to offering occupants personal control is that the technology designed to manage environments is not innovative enough or user friendly (Karjalainen & Koistinen, 2007). If occupants are offered individual control over the environment, it is often through a unit added on to the main system post-construction which is not as effective as in-built individual workstation controls. A further consideration when developing a building is the creation of a comfortable environment for all users. There is a perception that giving all occupants individual control could have a negative impact as it will lead to conflict between people based upon their personal preferences (Carrilho de Graça, Linden & Harves, 2004). In the case of ventilation individual control is often offered in the form of opening windows. However, research has demonstrated that opening a window in a single location can affect both the work area of the person who has opened the window and the internal environment of other areas of the building (Carrilho de Graça, Linden & Harves, 2004). This could have a more negative effect than maintaining the industry standards as more than 20% of people could become dissatisfied with the environmental conditions.

Thus centrally controlled environments may be preferable to satisfy more people. Carrilho de Graça et al (2004) argue that individual control is effective if occupants are taught how to operate it. Being informed means people are aware of how their actions will affect the state of the building and the impact that it may have upon other occupants. This reliance upon occupants to make the right decisions when altering the internal environment may explain why most users are being excluded from the systems in order to make the management of the building easier (Bromley, Bordass, & Leaman, 1993). With managers considering the building users as a problem rather than a solution to the issues with the internal environment, the majority of workplaces are being designed to be centrally controlled. However, this seems to be a misconception as research carried out by the Usable Buildings Trust (Bordass et al, 1993) has shown that less local control leads to a higher number of complaints for the building manager to deal with.

Analysis of occupants' level of personal control, or a lack of it, has revealed that the majority of building users perceive themselves to have very little personal control and have a negative attitude towards their control of the environment (Bromley, Bordass, & Leaman,1993; Cohen, Field & Leaman, 2000; Szigeti & Davis, 2002). Researchers have suggested that workplace occupants perceive a lack of personal control to be a contributor to sick building syndrome symptoms (Raw, 1992). Evaluation of workplace occupants has confirmed that a significant proportion of workers would prefer to have more control over their environment (for example, Harris, 1980; Ne'eman, Sweitzer & Vine, 1984; Gossauer & Wagner, 2008). In a study of the physical environment, 60% of occupants from a selection of twelve workplaces reported having no control over their physical environment, only 1% had total control. 65% of occupants were dissatisfied with the level of control they had and wanted more (Haghighat & Donnini, 1997). This highlights how important personal control is in relation to satisfaction of workplace occupants and demonstrates that a majority of workers do not perceive themselves to have enough control over the environment. The findings of research into satisfaction with personal control over the environment specifically link in with more general organisational psychology research demonstrating the importance of autonomy at work. Studies have shown that workers are demanding more from their employers which includes flexibility of the way they work and a significant amount of control over their workplace environment (Becker, 1991). Researchers have developed a theory of situational control to explain the influence that people have over specific aspects of their environment (O'Driscoll & Cooper, 1996). Those with perceived control over the workplace environment will have situational control. The level of situational control

varies depending upon the individual involved and their perception of the environment, as well as the actual level of control they have. Having a high level of situational control, in this instance control of the physical environment, has been linked to stress reduction in the workplace (Glass and Singer, 1972; Murphy, 1988). Furthermore, Warr (1994) highlights nine factors that affect well-being in the workplace of which personal control is one of the key factors. These results suggest that there are benefits to providing users with personal control over their environment as it benefits them in terms of increased satisfaction with the workplace and well being. Very little research could be found to suggest that personal control over the workplace environment has a negative impact upon satisfaction. However, Burger (1989) argues that when given an increased level of control over a situation, people mentally calculate the anticipated advantages and disadvantages. He highlights that this may not occur at a very high level of awareness, and that people may not be conscious that this decision-making is occurring. The three negative aspects of control, Burger suggests, are that it can: i) lead to an uncomfortable level of concern for self-presentation ii) decrease the likelihood that the person will be able to achieve desired outcomes and iii) lead to an increase in predictability that draws the person's attention to the adverse aspects of the situation (Burger, 1989, p247). Self-presentation is the result of people's concerns about social evaluation. In relation to personal control within the workplace this is linked back to the issue of the actions of one adversely affecting the environment for others within the workplace. The level of people's concern with social evaluation varies, but those with high sensitivity are less likely to desire control over the environment. Often they feel it will reflect negatively upon them if they make the wrong decision. The possibility that a person will not achieve the desired outcomes relates to people's concern about the lack of experience they may have and the complexity of the situation. With reference to personal control within the workplace, occupants may feel that the control of the internal environment is managed more effectively by a building management system than it would be if they were given personal control, thus they prefer the environment to be centrally controlled. The probability of this occurring increases as the systems controlling the internal environment become more complex. Finally the increase in predictability can lead some people to desire a lower level of control over the situation, although Burger stresses that this is the most complex of the three negative effects of control and there is little direct evidence to support this theory. If this final negative aspect were to have an impact upon the desirability of control then it would most likely come in the form of preventing environmental stressors. Offering occupants of the workplace control over something such as a blast of cold air or a burst of noise, could have a negative impact due to the anticipation of the event and the

knowledge that they must prevent it. If occupants are not able to predict these events then they are less likely to focus attention upon them as they are not aware that the negative event is about to occur. Despite the arguments presented by Burger, there is still significant research supporting the positive relationship between personal control and satisfaction. Studies consistently demonstrating an empirical and statistically significant positive relationship between personal control and satisfaction demonstrate that perceived control of the internal climate is an integral element of user satisfaction with the workplace.

The positive relationship between personal control and satisfaction is reflected in the links drawn between personal control and productivity. Lomonaco and Miller (1997) found that using environmentally responsive workstations, which give the user personal control of the air temperature, lighting, air flow and background noise, increased productivity by 2.8%, although they report that other researchers have discovered even greater increases in productivity. Kroner et al (1992) found that giving occupants control over heating, cooling, humidity, ventilation, air velocity, air direction, lighting and sound-masking increased productivity by 15.7% on average. When the occupants had the control of the environment disabled at random intervals in Kroner et al's study, productivity was reduced by 12.8%. This suggests that the individual control had a significant impact upon satisfaction, and it was not the introduction of new workstations as the second experimental group were also affected. Oseland (1999) reported the findings of a study in which productivity increased by 9% when occupants were given personal control and Wyon (2000) discovered a 2.7% to 8.6% increase in group performance when they were given control over their environment. Sources of light that provided individual flexibility were rated more favourably by participants than those that could not be controlled (Boyce, 1979; Harris, 1980). Despite the majority of studies demonstrating a positive link between personal control and perceived productivity, researchers conducting a study in a laboratory setting could not demonstrate a positive relationship between personal control and productivity or other dependent variables such as mood. Participants in Veitch and Gifford's study (Veitch and Gifford, 1996) found that participants given a choice over the type of lighting arrangement in which to complete various tasks performed worse than those not given a choice. This was despite participants being aware of the fact that they had more personal control in this research condition. Concerned that the presence of an experimenter may have led participants to worry about a negative self-evaluation if they chose to exercise personal control, Veitch and Newsham (2000) repeated the experiment without the experimenter being present to witness adjustments being made to the internal climate. The results of

this study demonstrated that there was no difference between those who had control and those who did not on dependant variables satisfaction, mood, performance and health. The evidence to demonstrate the impact of personal control on productivity, perceived or real, is not wholly conclusive. However, as with the research into satisfaction and personal control, the majority of researchers have been able to demonstrate a positive correlation between personal control and productivity. Indeed, Veitch and Newsham (2000) themselves state that in a real world setting, over a longer period of time, personal control might have a positive effect. Therefore, according to management theory and studies evaluating the impact of personal control over the environment, it appears that offering occupants greater control increases satisfaction and productivity whilst also reducing stress levels.

One of the main issues is how best to increase personal control effectively. A barrier to the introduction of building management systems controlled by individuals is that managers believe it will cost more. Although the systems often cost more to install the increase in productivity and reduction in energy consumption that often follows can actually reduce the life cycle cost of the system. The benefits of obtaining value for money and being able to off-set additional construction costs were detailed in Chapter 1. Taken together the research findings to date, both field studies and laboratory experiments, have demonstrated that the majority of occupants want personal control over their workplace environment, and that providing this autonomy can lead to increased productivity. If linked with the potential cost savings this is a powerful argument. On the other hand, there is research to suggest that the relationship between personal control and satisfaction or productivity is not a simple positive correlation. There are other factors which may influence users' attitudes such as the impact that changes may have upon others in the workplace. A further consideration needs to be the environments in which an increased degree of personal control was considered to be a major issue. Of the studies conducted, several researchers concluded that users had a negative attitude towards personal control in workplaces in which the conditions were bad. That is, the internal environment did not meet the industry standards (Ne'eman, Sweitzer & Vine, 1984). Due to the negative impact that this environment was having upon occupants, it was concluded that they wanted personal control primarily to improve their working environment. In research carried out by the Probe team (Bromley, Bordass, & Leaman, 1993) findings indicated that increased satisfaction with personal control was correlated with responsiveness rather than an actual higher level of personal control. As the speed and efficiency with which faults with the building were rectified increased, so did the occupants' satisfaction with

the level of control they had over their environment. This was despite the level of user operated personal control not differing between workplaces.

Thus is seems that satisfying occupants' personal control needs is not as simple as merely supplying all occupants with individual control over their own environmental conditions. The system has to be simple enough for them to operate effectively and occupants must be informed so that they are able to alter their own environment without having a negative impact upon the environment of others. Solutions such as supplying a task light to offer greater control over illuminance however, appear to be ineffective as participants in at least one study expressed a dislike for an oversimplified solution to the issue of control (Harris, 1980). The introduction of effective personal control therefore requires an holistic approach evaluating the impact of introducing personal control and the most effective way in which to implement it.

### 4.6 Summary and Conclusions

The research demonstrates that there is an impact of the internal climate on users. However, consistent negative impacts upon satisfaction and productivity tend to only occur when there is an extreme condition, for example when the air temperature is either very hot or very cold. With more moderate variation from the ranges specified within the design guidance, there are less consistent results. Thermal factors, illuminance levels and noise levels just outside of the range recommended by industry standards do not have a consistent impact upon users across studies. Whilst there has been some criticism of the industry standards, overall the research indicates that there is a range of the internal climate factors which people find comfortable. This range may vary between individuals and situations but having a recommended range within industry standards is beneficial to prevent extreme conditions occurring which do affect users. The criticism of the industry standards and design guidance has been that it is too narrow, not that people are uncomfortable in these conditions or unable to perform their work. Thus, by providing environments which comply with the design guidance, users are likely to be satisfied. A positive impact of the environment upon users is influenced by personal control. As detailed previously, satisfaction with all aspects of the internal climate was found to increase when personal control increased. Thus, an internal climate that has a positive impact upon users appears to be achieved by providing an environment which is able to operate within the comfort range and is easily adjusted by occupants.

## Chapter 5 Current State of Knowledge: Design Features of the Workplace

### 5.1 Introduction

The previous chapters demonstrate that aspects of the environment that are easy to quantify objectively have received research attention. The spatial layout, in particular the impact of open plan layouts, and the internal climate have both been analysed to establish links between these and user perceptions and attitudes. However, the workplace environment is more complex than spatial layout and internal climate with aspects such as window provision, decoration, and furniture provision all potentially contributing to users' attitudes and the impact of the workplace environment. These aspects are less easy to quantify using a standardised scale such as distance in metres or temperature in degrees centigrade. Features of the workplace environment such as the view out of the window can be judged as being pleasant or unpleasant but this is a fairly subjective response and cannot be measured on an interval scale. The lack of research into the impact of less quantifiable aspects of the workplace is not due to researchers believing them to have no impact upon users. Leaman and Bordass (1998) carried out over 20 studies of workplace environments to establish the impact that the internal climate, space and personal control had upon occupant satisfaction. By their own admission, the less quantifiable aspects of the environments were not evaluated using their methodology. They argue that a lack of standardised, interval measurement scales prevents useful objective measures being taken and therefore the data could not be analysed quantitatively. However, Crouch and Nimran (1989) suggest that it is essential for researchers and those developing workplace environments to consider all aspects of the environment, including those that cannot easily be quantified. They listed aspects of the environment that were identified by managers, as facilitators or inhibitors of positive aspects of an organisation and the work of users. The aspects of the environment that were perceived to have a positive or negative impact were: features that affected social interaction, ambient conditions, communication and privacy. The features that affect the four areas cited by managers are those that are both quantifiable in measurement, for example spatial layout, and those that are not as easily quantifiable, for example furniture provision that can offer privacy. Preiser (Preiser et al 1988; Preiser, 2001), an advocate of the importance of evaluating and understanding the impact of the environment, supports the measurement of all aspects of the environment, including those that are not measured using a standard scale. The importance of evaluating all aspects of the workplace, including those which are not easily measured, is clear. A difficulty in quantifying an

aspect of the workplace objectively on a standardised scale does not prevent it from having a significant impact upon users. For the purpose of this thesis, the aspects of the environment classified as less easily quantifiable are decoration, window provision, break areas, furniture provision and control or choice. These will be collectively referred to as interior design and features of the workplace for ease of discussion. Despite workplace evaluations largely focusing on internal climate and spatial layout, some research has been conducted into the impact of design features on users' attitudes and productivity.

### 5.2 Decoration of the Workplace

Decoration refers here to the colour scheme used and other features introduced into the environment to contribute to the aesthetics of the workplace. The aspect of decoration which has received the most research attention is the colour scheme. In terms of attitudes towards colour, discussion has tended to focus upon preferences for certain colours (Vernon, 1965; Wright, 1998) which are thought to be in part influenced by cultural references and past experiences. However, research into attitudes towards colour have generally identified colours with longer wavelengths such as red and orange are perceived as being warm colours, and those with shorter wavelengths, i.e. blues and greens, perceived as being cool colours. This is due in part to cultural references with red and blue often used to denote hot and cold respectively (Vernon, 1965; Coren et al, 1999). There are three ways in which colour can be measured objectively which have been used in research into the impact of colour in the built environment. These are hue which is the shade of the colour, brightness and saturation, which runs on a scale from nearly white to the purest representation of the colour. Whilst these provide an objective measurement of colour, hue, brightness and saturation of colour do not reveal how the different colours are perceived by individuals or their psychological impact. As a result of a lack of research, designers often choose fashionable colours (Birren et al, 1982) or those that match the preference of the office manager or equivalent who is making the decisions (Wright, 1998). Research that has been conducted into the impact of colour scheme in the workplace environment has tended to be focused upon the relationship between hue, brightness and stimulation. Küller, Mikellides and Janssens (2009) found brain activity, indicating increased levels of arousal, was recorded in a mixed colour and red room as opposed to a gray room. Küller et al (2006) found that colourful rooms also had a positive impact upon mood compared with neutral colours such as cream or white. However, the majority of participants in their study actually worked in environments with few different colours.

The results of the research into the impact of colour demonstrate a similar pattern of results with warm, bright colours such as red being rated as more stimulating than cool, pale colours (Birren et al, 1982; Kelvin, 1999; Stone and English, 1998). Some researchers argue that stimulation as a dependent variable is positive as the environment may contribute to alertness levels which researchers suggest is a positive influence, particularly when the task places a low demand on attentional load (Stone, 2003) and when users complete tasks that require them to be alert at all times (Kelvin, 1999). Thus, a stimulating colour scheme within the workplace could have a positive impact upon productivity if higher levels of stimulation would benefit the performance of users' tasks. To this end, when an organisation wishes to increase the stimulation levels of particular users, a bright colour scheme is recommended. Equally, if the colour scheme can be used to stimulate people there is a danger of creating cognitive overload. Thus, some researchers have advocated that the colour scheme in a workplace should be paler and subtle shades used to provide an environment in which users can concentrate (Birren et al, 1982). Wright (1998) also suggests that the personality of individuals in the workplace should be taken into account when selecting the colour scheme. This is obviously difficult to achieve in workplaces with a number of occupants as their different personalities and the nature of work being carried out by individuals will vary.

Findings from empirical studies of the impact of the decoration of the workplace are limited in terms of published research. Laboratory studies of the impact of colour or task performance have revealed that preference for a colour is not necessarily correlated with improved performance. For example, Kwallek and Lewis (1990) analysed participants' performance on a proofreading task in different coloured rooms. The rooms in which the experiment was conducted were identical but for the colour of the walls. The three different conditions were red, white and green walls. Participants carrying out the task made fewest errors in the red room and the highest number of errors in the white room. When asked for their preferences of colour scheme, the white room was given the highest rating by participants and the red room was given the lowest preference rating. This is in contrast to the findings of Brill et al (1985) who found that people expressed a preference for workplace environments in which there were a number of colours rather than one or two neutral colours. Research has also demonstrated that the demands that the task places on attention levels affects the extent to which colour scheme has an impact upon participants' performance. For example, Stone and English (1998) found little difference between performance in a red room compared with a blue room unless the attentional demands of the task were

low. Participants completing a task that did not require them to concentrate produced significantly more errors in the red room than the blue room. The main effect of this study was the interaction between colour and task demand. In this case the differentiator was the participants' perception of the difficulty of the task. The amount of focused concentration required to complete the task was perceived to be highest in the blue environment, despite there being fewest errors made in this condition. Stone (2003), in a similar study, demonstrated that the low demand task was performed worse in the blue room across an extended period of time than in the red environment. The task requiring the highest level of concentration was performed worst in the red environment. These results suggest that low concentration tasks were performed better in a red environment compared with performance on tasks requiring high levels of attention which were performed better in a blue room. Mehta and Zhu (2009) found that the type of task as well as the level of concentration required determined the effect of colour scheme. In their study participants performed a task requiring detailed attention better in a red room but performed better on a creative task in a blue room. These studies indicate that the colour of the environment may affect performance through influencing levels of stimulation and users attitudes. Participants' performance in rooms where they were stimulated by bright colours was negatively affected on tasks which required a high level of concentration. However, their performance in bright coloured rooms was improved on easier tasks such as proofreading. Participants expressed a preference for rooms which were less bright or a more neutral colour such as white as they perceived the bright rooms to be over-stimulating. However, the specific colours and levels of brightness did not have a consistent effect upon performance, thus it is difficult to draw any firm conclusions about the direct impact of colour upon performance. Ainsworth, Simpson and Cassell (1993) suggested that there was no impact of colour across short periods of time. As the majority of the studies into the impact of colour schemes have been laboratory studies, this may account for the inconsistency in results. In addition, the impact of the colour scheme in a real workplace may be influenced by other factors that are part of the aesthetics and decoration of the workplace that could affect users' attitudes and performance.

Plants on the workplace have been linked to increased user satisfaction with the number of plants in the workplace being positively correlated with satisfaction and perceived productivity (Larsen et al, 1998; Fjeld, 1998; Shibata & Suzuki, 2004; Bringslimark, Hartig & Patel, 2007; Dravigne et al, 2008). However, the published, empirical research into the impact of plants in the workplace is limited and therefore no firm conclusions about the impact of plants can be drawn. For example, there are no

indications in the research about the optimum number or type of plants. Further research is required to reach strong conclusions about the impact of plants in the workplace. A further aspect of decoration is the display of artwork or images. Again, there are few empirical studies reported confirming the impact of artwork on workplace occupants. However, the research to date has provided an indication of the impact of artwork, particularly when considered in conjunction with the colour scheme. For example, Stone (2003) found that a picture of a nature scene incorporated within a workplace setting had a positive impact upon task performance when the room was red in colour. However, the same image in a room coloured blue had a negative impact upon performance of a task. Stone argues that the results are due to the impact of the environment upon stimulation levels of participants. She suggests that the picture in the red environment reduces the amount of stimulation provided by the red walls, making it easier for the participants to focus upon the task. However, in the blue condition the colour of the walls is not distracting so the presence of the picture actually increases stimulation and itself becomes a distraction, affecting task performance. In an earlier study, Stone and English (1998) found that a poster in the workplace has little impact upon productivity, but that the presence of an image did affect perceptions of task demand. Those tasks which required higher levels of focused attention were perceived as being less demanding in the conditions where the poster was present. Again, limited evidence has prevented clear patterns being established through analysis of the results of a number of studies. There is an indication that the decoration, as defined for the purpose of this research, has an impact upon users in the workplace. However, the nature of this impact and replicability across all workplaces is not clear due to the need for further empirical research.

### 5.3 Break Areas

Break areas are a feature of many modern workplaces with the British Council for Offices recommending that breakout areas are included in all workplaces to enhance quality of life for occupants (BCO, 2003) and support for the benefits of being able to take a break at work (Kroemer & Kroemer, 2001). Research into the impact of focusing upon task performance supports the need to include breakout areas in workplaces as work requiring high levels of concentration cannot be sustained. Early psychological investigation by James (1890) led to him concluding that involuntary focused attention, that which has to be actively applied, can only be sustained for a finite period of time. To reduce fatigue, attention needs to be re-directed towards something that does not require one to focus attention in the same way that was required for completion of the

work. The ability to take a break from work can have a positive impact upon users by allowing them to restore their attention levels (Kaplan and Kaplan, 1989). Researchers have explored the relationship between different types of environment and their ability to have a positive influence on people's ability to restore their concentration levels and re-focus their attention on work after taking a break (for example, Kaplan and Kaplan, 1989). Kaplan and Kaplan suggest that a restorative environment is one that enables a person to escape from a stressor, such as work. Their research has also led them to conclude that a restorative environment should contain certain characteristics to enable a person to gain maximum restorative benefit. The first characteristic is 'fascination'. That is, a degree of unknown which will lead a person to consider the environment without having to actively direct focused attention to these thoughts. The second characteristic suggested is 'scope', the existence of many aspects and opportunities within the environment for people that are restorative. The third characteristic is 'compatibility' or the ability of the environment to allow someone or provide them with the means to achieve their aims. Fourth, the environment must facilitate a person's sense of being able to escape the stressor and separate themselves in some way. Finally, a 'restorative' environment must be perceived to have limits beyond that which can immediately be seen. That is to say, there is more to be found beyond a person's immediate surroundings. With all these elements present, an environment becomes restorative and has the potential to allow a person to escape from the stressor or task requiring concentration. Kaplan and Kaplan argue that the most effective restorative environment that fulfils all these characteristics is a natural environment. This is supported by other researchers who have found that task performance is improved when there were views or access to a natural environment (for example, Hartig et al, 1991; Tennessen & Cimprich, 1995; Staats et al, 2003). An analysis of the impact of different types of environments was conducted by Herzog et al (1997). They found that settings which they classified as sports/entertainment such as watching television or playing sport were more effective at restoring attention levels than being in an urban environment. However, natural settings still had the greatest restorative effect. A further study by Herzog et al (2003) provided additional support for Kaplan and Kaplan's definition of the characteristics that make up a restorative environment. The findings of the research were that the greatest predictors of restorative environments from the five characteristics are being away from the stressor and compatibility with their needs. The findings from this research, whilst not specifically related to workplace environments, provide useful information as the results indicate the impact that the environment can have upon attention levels. Understanding how the environment can be designed to facilitate the feeling of getting away from work and with adequate facilities will provide a

basis for designing effective break areas. Currently there is very limited empirical evidence of the impact of break areas on users in workplaces, in particular on their satisfaction or perceived productivity levels. However, the research into focused attention, the benefits of restoring concentration levels by taking a break and the types of environments which have been found to be restorative indicate that the inclusion of a break area in the workplace could have a positive impact upon users.

### 5.4 Window Provision in the Workplace

Traditionally windows performed the essential functions of providing natural light to enable workers to see what they were doing and natural ventilation. With the introduction of artificial light and mechanical ventilation systems, the provision of windows is no longer a necessity to allow people to complete their work. Despite the non-essential function of windows, they are still considered important features to be included in the workplace environment. In the United Kingdom window provision in the workplace is a statutory requirement and minimum daylight factors are specified in design guidance such as the British Council for Offices Guide (BCO, 2005). The daylight factor is calculated by dividing the lux levels recorded outside the workplace by the lux levels inside the workplace and multiplying by 100. The minimum daylight factor specified within workplaces is 0.5% with an average daylight factor recommended as being 2-5%. A daylight factor of less than the recommended range will lead to users perceiving the workplace as having no natural light. A level of daylight significantly higher than the average can lead to problems with glare, particularly close to the source of natural light. The provision of daylight is associated with comfort within the BCO Guide rather than a requirement to provide illuminance or ventilation. Although there are similar requirements to provide windows in workplaces in most European countries (CIBSE, 1999), workers in the United States and Japan are increasingly occupying windowless offices either underground or in buildings with deep floorplates incorporating internal offices (for example, Finnegan & Solomon, 1981; Stone and Irvine, 1994; Stone, 1998; Boyce, 2003). Even though windowless offices exist, research has demonstrated that people are more satisfied with workplaces where windows are incorporated (for example, Sundstrom et al, 1982). There are two benefits provided by windows in the workplace. The first is allowing daylight into the workplace which has been linked with satisfaction (Stone & Irvine, 1994; Stone, 1998; CIBSE, 1999; Boyce, 2003). This is due to the daylight contributing to illuminance levels so that people can see the details of their work tasks. However, it is also due to the quality of daylight which varies throughout the day in terms of illuminance levels and movement

around the environment and distinguishes it from artificial light. For example, Hopkinson and Kay (1972) suggest that daylight leads to variations in intensity of light, patterns of light and the colour of light vary throughout the day in a way that artificial is not yet capable of. Colours in the workplace are also thought to appear in their truest form under daylight rather than artificial light (CIBSE, 1999). Research has demonstrated that workplace users have a preference for daylight. For example, Heerwagen and Heerwagen (1986) found that participants in a questionnaire-based study perceived the illuminance produced by natural light to be more comfortable, to improve the appearance of their office and to improve the appearance of colours in their office. However, this preference for daylight may be due to the poor quality of artificial light in many workplaces (Boyce, 2003). When artificial light is adequate, daylight may no longer have as significant a link with user satisfaction. Further empirical research is required to provide conclusive information about the relationship between daylight and satisfaction.

Further to the provision of daylight, windows offer a second major benefit which is a view to the outside. As indicated in the research into restorative environments, natural scenes were found to have a positive effect. Thus, a view through a window could benefit users' ability to concentrate and their performance at work and research has tended to support this argument. For example, Biner, Butler and Winsted (1991) found that incorporating internal windows decreased the dissatisfaction reported in windowless offices. These findings demonstrate that it is more than just the provision of daylight which leads to the incorporation of windows having a positive impact upon users. The view through a window offers momentary distraction from work (Sundstrom, 1989; CIBSE, 1999; Boyce, 2003). Hopkinson and Kay (19720 describe this as a 'visual rest centre' (p.71) as it enables users to rest and take a break from directed, focused attention. The benefits of this were discussed in the previous section on break areas. In concurrence with the research into the most restorative environments, users demonstrated a preference for natural views out of the window as they were perceived to be more cheerful (Heerwagen and Heerwagen, 1986) and more desirable (Butler & Steuerwald, 1991). The results of these studies suggest that people prefer a natural view from their windows as it offers the most effective facilitator of a rest from their work and reduces mental fatigue. Some researchers have argued that the benefit of a view out of the window is a result of the stimulation it provides rather than giving people the opportunity to take a break. A review of research by Collins (1976) revealed that there was a positive impact of a view through a window in small rooms where monotonous tasks were being performed and both movement and social interaction

were limited. Thus, the benefit of window provision in the workplace is derived from the daylight provided and the view out of the window. Both these aspects have been linked with window size and satisfaction, an aspect of window provision which has been the subject of empirical research.

Although the research into daylight and view would support the inclusion of large windows to maximise daylight and access to views, the provision has to be balanced with the need to prevent glare and solar heat gain which is linked with dissatisfaction amongst occupants (Boyce, 2003). The research of Ne'eman and Hopkinson (1970) was designed to determine the minimum acceptable window size for occupants of a workplace building. Participants were asked to assess the size of windows in terms of preference within a scale model of a workplace environment. They were given the opportunity to adjust the size of the window in the model to the minimum size they deemed to be acceptable for satisfaction. The findings demonstrated that it was not the amount of internal or external light that determined how wide participants made the window, but the view. The width of the window was adjusted so that participants would be able to see all elements of the view clearly. This was affected by the location of participants in relation to the window as those located further away in the model adjusted the windows to a minimum area that was wider than that set by those located closer to the window. The importance of view in determining satisfaction with window size has been supported by the work of other researchers (Keighly, 1973a; Ludlow, 1976; Newsham et al, 2009) although the percentage of the external wall space that they found windows should occupy varied. Keighly (1973b) found that if the window occupied less than 15% of the external wall in a workplace, the majority of users were dissatisfied. To obtain a satisfactory rating of the window provision the researchers found windows had to occupy at least 30% of the wall. Ludlow (1976) suggested that the percentage of the external wall that was occupied by windows had to be between 50% and 80% to satisfy users. The results from both studies indicate that users prefer fairly large windows in the workplace with the minimum amount suggested as 30% of the external wall. The most satisfactory shape of windows in the workplace has also been the subject of research. Keighly (1973a) found that people expressed a preference for windows orientated horizontally whilst Markus (1967) argued that people are more satisfied with windows orientated vertically. Ludlow (1976) reasons that it is not the orientation of the window, but how effectively it frames the view to the outside. Thus, it is the nature of the view that influences user preferences for both window size and orientation. Butler and Steuerwald (1991) suggest a further dimension which influences satisfaction with window size which is the size of the room. They found that

the smaller the room, the greater the percentage of the wall windows had to occupy to be rated as satisfactory. Their research also revealed that larger windows were preferred when the view out of the window was judged to be satisfactory. Further support for these research findings comes from Butler and Biner (1989) who suggested that setting and space within the workplace dictated preferred window size. The research demonstrates that users' satisfaction with window provision is linked with the provision of daylight and the view. The relationship between window provision and productivity has also been evaluated by researchers.

Stone and Irvine (1994) asked participants to complete three different tasks that were monotonous, required directed concentration or were creative. These tasks were completed in two conditions, a room with a window and a windowless room. Whilst there was a strong preference for the room with a window expressed by participants, their performance on all three of the tasks did not differ significantly between conditions. These findings are supported by other researchers (Heerwagen and Heerwagen, 1986; Stone,1998). In a second experiment, Stone and Irvine positioned participants in the room with a window, giving them either a direct view out or locating them to the side of the room where they had no direct view out of the window. Those with a direct view out of the window expressed greater satisfaction than those with an indirect view and performed better on both the monotonous and creative tasks. This supports the earlier argument that a view out of the window is a source of stimulation for building occupants, especially as the task requiring directed attention and high levels of concentration was not performed better in the condition where participants had a direct view out of the window. Whilst there is limited empirical evidence beyond that reported to demonstrate a link between window provision and productivity, there is evidence to suggest that windows can have an impact upon mood. Finnegan and Soloman (1981) found a link between window provision and increased satisfaction at work, increased interest in their job and increased satisfaction with working conditions. Support for this finding comes from research in which psychological well-being and positive emotions have been linked with window provision by workplace occupants (Leather et al, 1998). The link between window provision and mood is significant in relation to research into a medical condition known as seasonal affective disorder. Around 5% of people in the United States have been diagnosed with seasonal affective disorder but up to 20% demonstrate some symptoms in mild form. The symptoms, including sleep deprivation and reduced cognitive functioning, have led researchers to suggest that seasonal affective disorder can have a negative impact upon performance and is related to daylight (Boyce, 2003). Although extreme, the potential impact of

windows to relieve symptoms of a disorder that affects such a high proportion of workers means that window provision is clearly something which designers would be wise to consider. The effective provision of windows could benefit satisfaction levels and have a positive impact on mood. There may also be a direct or indirect impact upon productivity.

### 5.5 Workplace Furniture

The furniture provision is an integral part of the fit out and design of the workplace. As workplace design has evolved to reflect changing management theory, furniture provision, in addition to spatial layout, has allowed designers to create different styles of workplace. Within the early workplaces designed to reflect Taylor's scientific management theory (Taylor, 1911), the furniture played an integral part in influencing behaviour in two ways. The first was to provide the most efficient conditions in which tasks could be completed. Employees carrying out the processing of information in the Larkin Building were seated in chairs that limited movements to those which enabled them to carry out their specified tasks (Sundstrom, 1986). Comfort was not a consideration in the design. Taylor also advocated the need for supervision of employees and the presence of a strong hierarchy within the organisation. The furniture was used to allow ease of supervision with open desks and minimal partitions so that managers had good sightlines around the workplace. Status was demonstrated not only by the cellular offices allocated to senior managers, but also their furniture provision. Comfortable armchairs and large desks were provided to senior managers to denote their status within the organisation (Sundstrom, 1986). As workplace design evolved to reflect human relations theory (where the focus was communication, social interaction and the people within the organisation) furniture provision changed. The furniture within more open plan workplaces needed to be flexible and easily adaptable so that the layout could be changed as and when required. The new furniture requirements led to the development of furniture systems such as Herman Miller's 'action office', a modular system which could easily be reconfigured as required (www.hermanmiller.com/products/action-office-system accessed December 2009). In addition to supporting different ways of working, a further consideration was the impact of furniture design upon users' safety, comfort and well being. This is reflected in the interest in furniture design within workplaces from the field of ergonomics, defined by the International Ergonomics Association (http://www.iea.cc/) as 'the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to

design in order to optimize human well-being and overall system performance'. Ergonomics in relation to furniture design has led to the development of design guidance. The purpose of ergonomics in relation to furniture design is to provide furniture that is comfortable and does not cause physical discomfort or damage to those using it. However, researchers suggest that understanding the impact of furniture on users could have an even more significant effect. Dul argues that "*the value of ergonomics is beyond health and safety. With ergonomically designed work environments a company can reach a competitive advantage*." (Dul, 2009, p.16). As a result of the research into the impact of the furniture on users and their work, standards have been developed and reported in industry guidance. For example the British Council for Offices (2003) advise that the chair height and arm rest should be adjustable, the desk height should be adjustable, position of the keyboard and other equipment should be adjustable and people should be able to change posture at their desk to reduce strain on the body. Research has supported the need for adjustable furniture to ensure that the well being and satisfaction of users is met. Kroemer and Kroemer (2001) argued that having a back rest on the chair and adjustable height and tilt were essential and this has been supported by others (for example, McKeown, 2008). They also argued that being able to move around at the workstation was essential. Without a universally neutral position which places no strain on any aspect of the body, and people needing to move around to maintain a level of comfort, the workstation needs to support a number of different positions. Brill, Margulis, Konar and BOSTI (1985) found from an analysis of a number of studies that comfort at the workstation was significantly correlated with job satisfaction, particularly for those who were sitting for longer periods of time and were office bound during the working day such as clerical workers. A lack of significant correlation between comfort and job satisfaction of managers and professionals in the research was attributed to them spending a much lower percentage of their time actually sitting at their desk.

In addition to the impact of the desk and chair design, furniture provision plays a significant role in determining the use of information technology equipment. McKeown (2008) argues that whilst adjustability of the desk or chair is important, the shape of the desk only has an impact upon users through access to equipment. If the computer screen or laptop that are being used are not able to be placed directly in front of the person at the desk, and space available for paper adjacent to the screen, this will have a negative impact. In addition, the provision of storage, both personal and shared, can have an impact upon users. However, there appears to be little empirical research into the provision of storage and satisfaction with the workplace environment or

productivity. Ergonomists suggest that ease of access in terms of not having to twist into a position that places strain on the body is an important consideration for personal storage (Kroemer and Kroemer, 2001). Furthermore they suggest that having an excess of files, etc stored on the desk has a negative impact if it reduces the space people have available to carry out their work. The research into furniture provision has provided information to enable design guidance to be created for the design of workplace chairs and desks (for example British Council for Offices, 2003). This is based upon fairly conclusive ergonomic research which demonstrates the importance of being able to adjust the seating position. However, beyond the ergonomics of sitting at a desk, there appears to be a lack of empirical research into the impact of furniture design and how this interacts with other aspects of the workplace such as noise levels.

### 5.6 Summary and Conclusions

Analysis of the research into the qualitative, less easily quantified aspects of the workplace environment has demonstrated that there is limited evidence. There is more empirical research into the impact of aspects of the internal climate and spatial layout where the objective measures can be easily quantified on an established measurement scale. A search of the literature revealed that aspects of the workplace environment, such as the inclusion of plants, have been the subject of very few empirical research projects. Therefore, there is not conclusive evidence to demonstrate the impact of decoration, window provision and furniture on users. However, researchers have recognised the potential of these factors, in addition to the quantifiable aspects, to have an impact upon users. Initial findings from the studies that have been carried out indicate that qualitative aspects of the workplace environment are related to satisfaction and actual or perceived productivity.

# Chapter 6 Current State of Knowledge: Holistic Evaluations of the Workplace

## 6.1 Introduction

The importance of the workplace environment has been detailed in Chapter 4 where the work of Sundstrom (1986) and others (for example Duffy, 1992; Duffy, 1997) has highlighted the potential impact of the design upon individuals and organisations. There are significant benefits to organisations in ensuring that the workplace environment has a positive impact upon the work, behaviour, attitude and affect of their employees. By understanding how the workplace impacts upon users the information can be fed back into the design process so that lessons are learnt about the relationship between people and their environment. In addition, individuals can benefit from greater understanding about the workplace environment and the impact that it has upon them through increased levels of satisfaction and comfort at work as well as potential increases in perceived productivity (Duffy, 1992). However, despite the importance of the workplace environment and the desire to understand how it can be used as an asset rather than an overhead for organisations, the research into the overall impact of the workplace environment has been found to be limited. This is a view supported by a number of other researchers (for example, Preiser, 1988; Preiser, 1999; Oseland, 2007). As revealed in Chapter 3 to Chapter 5 there are studies which demonstrate that individual aspects of the workplace have an impact upon a range of variables from privacy to satisfaction and perceived productivity. Although there is a clear indication from these studies that the environment does have an impact upon users, the impact of the workplace as a whole, in a real world setting, cannot be determined. A more holistic approach to studying the impact of the environment upon users is required.

## 6.2 Historical Development of Workplace Evaluations

The realisation that a more robust and systematic approach to understanding workplace environments was first introduced in the 1960s according to Preiser (1988). He suggests that people began to suspect the problems experienced in hospitals and prisons around this time were in part caused by the design of the environment. To establish empirical evidence to demonstrate that the environment had an impact, a methodology was developed. The aim was to test the impact of the built environment upon users or occupants and determine how they perceived the environment. This methodological framework became known as post-occupancy evaluation. Further details about the history of post-occupancy evaluations can be found in Preiser (1988).

As the methodology developed, the approach became more standardised and other building types were the subject of evaluation, including workplaces. The approach was to conduct an evaluation in a completed and occupied real world setting and determine how people using that environment perceived it. For example they would be asked to rate the temperature, acoustics, illuminance, aesthetics, etc in terms of how they perceived it (i.e. too hot or too cold, too loud or too quiet, too dull or too bright, attractive or unattractive, etc). Users were also asked to rate how satisfied they were with each aspect of the environment and the environment overall. Marans and Spreckelmeyer (1981) state that "few attempts have been made to gather the necessary data in an orderly manner or to analyze them in such a way that the results can have both immediate and long-term applicability." (Marans & Sprekelmeyer, 1981. p.2). They conducted an analysis of an individual workplace environment to demonstrate effectiveness of applying the principles of a systematic evaluation and applicability. Although the methodology was robust, measuring a number of aspects both objectively and from a user perspective, it was an individual case study and ability to generalise the data would require further evidence to support the results. However, the findings highlighted the potential impact of the workplace and the benefit of understanding how the environment affects users. The increased awareness of the need to understand the impact of the workplace is demonstrated by organisations that have been founded to further knowledge. The Environmental Design Research Association (EDRA) was founded in the United States in 1968 with the aim of advancing and disseminating behaviour and design research toward improving understanding of the relationships between people and their environments (www.edra.org). In the United Kingdom the British Council for Offices was established in 1990 with an aspiration to research, develop and communicate best practice in all aspects of the office sector (www.bco.org.uk). It delivers this by providing a forum for the discussion and debate of relevant issues. More recently in 2007 a group called Building and Social Sciences was created to provide a forum for discussion about the impact of workplace environments from a social sciences perspective, much in the same way as EDRA. More specifically, in 2009 the Workplace Consulting Organisation (www.workplaceconsulting.org) was established to raise the profile of workplace consulting and improve the understanding of workplace consulting within the property and design industry, client organisations and the research community. The establishment of these networks and groups generated significant interest in their work from both academic and commercial organisations. In addition to these organisations being established, there have been a number of post-occupancy evaluation methodologies developed and tested in a large number of workplaces. These

methodologies have been shown to be robust and reliable, successfully measuring the aspects of the workplace environment identified by the researchers.

Traditionally, post-occupancy evaluations or feedback on the impact of the built environment were perceived to be the responsibility of the architect. The Plan of Work developed by the Royal Institute of British Architects (RIBA) sets out the stages of a job for an architect from briefing of the clients and design team through to completion. In the first publication of the Plan of Work (RIBA, 1965) Stage M: Feedback was included in the schedule. This was included in response to a report that called for 'the study of buildings in use' (RIBA, 1962, p.187). Architects were advised to gather an understanding of the impact that their design had and feed this back into the design process. However, this stage was removed from the Plan of Work in subsequent editions of the Architect's Handbook (e.g. RIBA, 1973). The reasons suggested for this are not that feedback and post-occupancy evaluation was no longer valued, but that architects were not given a fee for this work therefore it was rarely undertaken (Cooper, 2001). By continuing to incorporate Stage M: Feedback in the Plan of Work, it was perceived that clients would assume that this was part of an architect's ordinary scope of works when in actual fact very few evaluations were being carried out. By the 1990s researchers into building services engineering had established an interest in the impact of the workplace environment (Cohen et al, 2001). Building Services Journal reported the results of several post-occupancy evaluations (for example, Leaman & Bordass, 2001) and Cooper (2001) suggests that there was an understanding developed within the profession of the benefits that could be derived from understanding the impact of the workplace environment upon users. As a result post-occupancy evaluations became very focused upon building services, energy consumption and the operation of the building (Preiser et al, 2001). At the same time there was a research interest developed by social scientists. Their research tended to focus upon user perceptions and attitudes towards the workplace rather than objective measures (for example Brill et al, 1984; Oseland, 1999). Whilst the research of social scientists has explored a wide range of aspects of the environment from the air temperature to the colour scheme, many of the studies are laboratory based. The different research focuses of the separate disciplines have all made significant contributions to the holistic evaluation of the workplace environment (Oseland, 2007). Post-occupancy evaluation methodology has evolved with input from an architectural perspective, building services engineers and social scientists with an interest in the impact of the workplace environment (Cooper, 2001) and there are significant studies from each of these

disciplines which have made a contribution to the development of post-occupancy evaluation and the current state of knowledge.

### 6.3 Architectural Perspective of Post-Occupancy Evaluation

A long term advocate of post-occupancy evaluations, Wolfgang Preiser has authored a number of publications detailing the importance, benefits and implementation of post-occupancy evaluations (for example Preiser, 1988; Nasar & Preiser, 1999; Preiser et al, 2001; Preiser & Vischer, 2005). Preiser, from an architectural background, suggests that 'post-occupancy evaluation provides insight into the consequences of past design decisions and the resulting building performance' (Preiser et al, 1988. p. 3). Preiser et al suggest three elements of building performance that can be analysed. The first is technical which includes health and safety such as acoustics and illuminance levels. The second is functional which relates to the ability of users to operate effectively within that environment, for example, ergonomics, storage, etc. The third and final element is behavioural and refers to the psychological aspects of the performance of the workplace environment such as satisfaction and well being. Preiser et al also recommend that both easily quantifiable aspects of the environment, such as air temperature, and less easily quantifiable aspects of the environment for example aesthetics, are measured. Although they acknowledge the difficulty in evaluating the more qualitative aspects of the environment, they argue that objective measures of the qualitative aspects would be welcomed. Whilst the methodology of Preiser et al demonstrates positives in terms of advocating the measurement of a number of factors, both quantitative and qualitative and the collection of both objective and perceptual data, there are some limitations to their evaluations. The questionnaire incorporates aesthetic appeal as a qualitative measure of the environment but does not explore this concept in detail such as colour scheme, plants, etc. In addition, there are no measures of other qualitative aspects of the environment identified within the previous chapters of this thesis such as break area provision, furniture, etc. The aspects of the environment which are easier to measure objectively, i.e. space, light, temperature and acoustics, constitute a greater proportion of the evaluation. Thus, despite the recognition of the importance of qualitative elements, the methodology still focuses to a greater extent upon quantitative factors. An explanation for this may be the applicability of the methodology. Preiser et al designed their methodology to be suitable to measure the impact of any built environment, not specifically workplace environments. To obtain comparable data aspects applicable to just one type of environment, such as workplaces, would not yield useful data as many aspects measured would not exist in

other environments. For example, the inclusion of plants in the workplace was demonstrated to have some impact upon users in Chapter 5. However, plants are not incorporated into residential buildings in the same way that a specifically residential provision of bedrooms is not incorporated in most workplace environments. Thus, a methodology that is suitable for evaluating any type of built environment may not contain fine enough detail to establish the true, holistic impact of the workplace environment. A further limitation that results from the aim to provide a methodology applicable to all built environments is that there is no standard dependent variable against which the success of the environment can be measured. Although Preiser et al advocate establishing what the criteria for use of the building is as a measure of success, this will differ from building to building. In a school the criteria for measuring success may be increasing attainment levels of students whilst in the workplace it might be increasing productivity levels at work. As a standard measure of success cannot, and has not, been developed by Preiser et al, the impact of the building on users, beyond their perceptions of aspects of the environment, cannot be compared and benchmarked across studies. The measurement of success is based upon criteria of what the environment is intended to support such as behaviours, attitudes, etc but a universal measure is not possible other than general satisfaction with the environment. Preiser et al suggest that for architects the systematic evaluation of environments is beneficial in the development of benchmarks and design guidance. More quantifiable aspects of the environment can much more readily be developed into benchmarks and design guidance as there are standardised scales of measurement from which an acceptable range can be selected. In addition, objective measures and related user perceptions can easily be analysed to determine whether they are correlated. For example, satisfaction with illuminance levels can be determined and the relationship between perceptions of the light levels and actual illuminance levels can be analysed. This can lead to the development of design guidance based upon how satisfied users are with a certain level of illuminance, providing there is a correlation between objective measures and perceptions of the light levels. Satisfaction with the environment and the development of benchmarks are the primary concerns of architects when evaluating workplace environments. The understanding they gain from post-occupancy evaluations, if effectively fed back into the design process, can promote future learning. Thus, architects and designers can continually improve the quality of buildings they design through the feedback loop and avoid issues of liability when aspects of an environment have a negative impact upon users (Preiser et al, 1988). The design of the post-occupancy evaluation methodology from Preiser's perspective as an architect fulfils the criteria of an effective evaluation to demonstrate satisfaction with the design.

However, researchers from other disciplines give post-occupancy a different focus as they develop a methodology to provide them with greater understanding of the elements of the built environment which they can influence.

### 6.4 Building Services Perspective of Post-Occupancy Evaluation

From a building services perspective, the Usable Building Trust (www.usablebuildings.co.uk accessed December 2009) has made a significant contribution to post-occupancy evaluation research. Members of the Usable Buildings Trust and periodicals such as Building Services Journal and Building Research and Information have promoted post-occupancy evaluation and a methodology called Probe (Post-Occupancy Review of Buildings and their Engineering). The methodology was developed with the Department of the Environment to provide feedback on the performance of buildings, primarily to inform future design (Cohen et al, 2001). They used methods which had been tested to ensure that they were robust and reliable tools. Therefore, two of the main components of Probe were an occupant survey developed by Building Use Studies (BUS) and the Energy Assessment and Reporting Method (EARM). Both of these tools were evolved and developed for Probe following pilot studies and testing (Cohen et al, 1999). The occupant survey essentially measured satisfaction with the environment in terms of internal conditions, control and management. The EARM was adapted to become specific to offices (Office Assessment Method or EARM OAM). Since the publication of the Probe studies, EARM OAM has been developed and incorporated into CIBSE Technical Memorandum 22, which is the accepted industry standard for measuring energy use (CIBSE, 2006). In addition to these two tools, the Probe methodology incorporated a pre-visit questionnaire to allow contextual information and data records to be collected from the building manager. Objective measurements of the environment were also taken by the researchers to establish the internal climate and conditions that were being provided for users. The Probe studies were conducted between the years of 1995 and 2002 with the results of 20 Probe studies being published and both the findings and methodology have received a great deal of support (Markus, 2001; Preiser, 2001; Szigeti & Davis, 2002). This support is primarily due to the robustness and consistency of the standardised methodology that was used. Comparable data has been collected using these tools and analysed together to allow the development of benchmarks against which other buildings can be compared and understanding of good practice developed. The Probe studies have also received support for being more thorough than other evaluations, covering a wide range on aspects of the environment

and gathering data relating to user satisfaction, energy use and the internal climate (Markus, 2001; Szigeti & Davis, 2002).

The research of the Probe team revealed that users still perceive their workplace environment, or aspects of their environment, negatively and this is linked with lower levels of user satisfaction and comfort ratings (Leaman et al, 1997; Leaman & Bordass, 1998; Cohen et al, 2000; Cohen, Field & Leaman, 2000; Leaman & Bordass, 2001). Implications with regards to the impact that these attitudes towards the environment might have on user productivity were also highlighted. The results of their research have specifically highlighted that noise and thermal comfort overall had a negative impact upon building users and that these problems are persistent. A lack of personal control over the environment was also cited as a major issue for building occupants (Bromley, Bordass & Leaman, 1993). The team found that even in the buildings that received the best overall rating of satisfaction with the environment, around 65% of users on average were dissatisfied with at least one aspect of the internal climate (Leaman and Bordass, 2001). The aspects of the environment rated negatively that were cited most frequently and by the highest number of participants, were: deep floor plates, open plan work areas, large workgroups within organisations, mixed activities being carried out in a space, higher densities of occupancy, long working hours, people remaining in the same location for the whole working day, long hours spent working at computers, the presence of complex technology which users found difficult to use, irrelevant noise and an inefficient facilities management team with slow response rates (Leaman and Bordass, 2001). The aim of highlighting these findings was to encourage designers to learn from previous projects and implement this knowledge into the development of future designs. This is intended to be part of a continuous feedback loop. The Probe studies have made an important contribution to the current state of knowledge through demonstrating the importance of developing a standardised methodology and highlighting aspects of the workplace with which users are still dissatisfied. From their research there is a greater understanding of how the internal climate is perceived and how this relates to user satisfaction. However, the studies are still limited by the number of variables that were evaluated thus preventing them from being truly holistic. The Probe team themselves recognise that aspects not easily quantified such as colour scheme and the impact of the environment such as privacy are not evaluated using the Probe methodology (Cohen, 2001). Leaman and Bordass (2001) argue that the complexity of the built environment requires that some limitation be placed upon evaluations to ensure that it is manageable. However, they recognise the importance of other aspects of the environment outside the focus of the Probe

studies. These more qualitative aspects have been considered by social scientists in post-occupancy evaluation methodologies which they have developed.

### 6.5 Social Sciences Perspective of Post-Occupancy Evaluation

One of the first published post-occupancy evaluations from a social science perspective in which numerous workplaces were evaluated is that of Brill et al (1984). Brill et al evaluated around 70 workplaces using a standardised methodology centred around a questionnaire with supporting evidence from objective measurements of the internal climate and environment. The social science approach included aspects of the environment that are qualitative in addition to the quantifiable aspects measured by the building services engineers. The range of aspects found to be related to job satisfaction, starting with the most significant were: enclosure, layout, furniture, noise, flexibility, participation, comfort, communication, light, temperature, air quality and occupancy. These results demonstrate the importance of considering all aspects of the workplace, including those that were not easily quantifiable. Spatial layout was found to have the strongest relationship with job satisfaction followed by a number of other qualitative factors including furniture and personal control or choice. The internal climate factors, although related to job satisfaction, were not as significant predictors as the qualitative factors. The impact of Brill et al's research is considerable with their findings being widely cited. However, the research was conducted in 1983 and may not be as applicable currently with changes in the design of workplace environments as described in Chapter 2. Furthermore, the research was conducted with organisations in workplaces located in the United States. A review of the evidence has not revealed a similar study on such a large scale that has been undertaken in the United Kingdom. However, there have been a number of post-occupancy evaluation methodologies developed from a social science perspective, predominantly business management, and implemented within the United Kingdom. Oseland (2007) developed a guide to post-occupancy evaluation highlighting methods in use at the time of writing. The report was developed on behalf of industry body the British Council for Offices by an expert panel. The panel consisted of experts from the industry including engineers, architects and social scientists. Each member of the panel was involved in post-occupancy evaluation and shared their methodologies with the group. The rigor of methodologies could therefore be examined and similarities and differences between them established. There were over 20 methodologies described within the report, all of which were in use by various firms within the construction industry at the time of publication. Analysis of the specific approach of each of the evaluations and the lessons learnt

revealed considerable similarities between the approaches. The major similarity was the methodology with all case studies presented involving questionnaires. There were very few methodologies which used objective measures and Oseland suggests that monitoring of the environmental conditions, or internal climate, was only conducted when serious issues were revealed from analysis of the questionnaire data. An objective measure favoured by organisations including international consultancy and architecture firm DEGW and consultants Alexi Marmot Associates is analysis of space use through utilisation studies. These demonstrate the occupation of space across a period of time and the activities taking place. Questionnaires are still used by these researchers and the objective data compared with attitudes established from users responses. Overall, the guide indicates that social scientists, whilst evaluating a wide range of aspects of the workplace environment, tend to focus upon user attitudes rather than objective measures of the actual conditions. Further details of the post-occupancy evaluation methods can be found in Oseland (2007).

Whilst the focus of the publication was the demonstration of post-occupancy methodology, there were a number of case studies included which revealed the aspects of the environment with which users were satisfied and dissatisfied. Overall, the case studies revealed that aspects including furniture provision, light, communication and window provision were satisfactory in the workplaces surveyed. Aspects with which dissatisfaction was recorded include privacy, storage and noise levels. The main finding however, was that there were aspects that were rated as being both satisfactory and dissatisfactory depending upon which environment was evaluated. These factors included internal climate and decoration. The finding that different environments produced different attitudes indicates that the workplace does have an impact. If there was no impact of the workplace, there would be no variation in attitudes of users in different environments. In addition, these results demonstrate that a number of variables should be considered beyond the internal climate. Thermal comfort, illuminance and noise were not the only aspects of the environment related to satisfaction and perceived productivity in the case studies. An analysis of the different methods of post-occupancy evaluation by Oseland et al indicated that whilst internal climate conditions and spatial layout were the aspects of the workplace included most frequently in post-occupancy evaluations, less easily quantifiable aspects were also included by the majority of researchers. These included furniture provision, storage and personal control which were included in over half of the evaluation methodologies. Other qualitative factors were included in over a quarter of the evaluations and included aesthetics, decoration, breakout space and equipment. The findings from the case

studies demonstrating a link between a range of aspects of the environment and attitudes of users highlight the need for holistic evaluations. The results of the case studies indicate that more qualitative aspects of the environment can have a positive impact upon users. However, despite a number of studies revealing similar patterns of satisfaction and dissatisfaction, two caveats should be applied. The first is that the methodologies differed significantly, therefore the data was not directly comparable statistically. Without further in-depth analyses of the methodologies and data, assumptions cannot be made and the results cannot be reliably reported together. A complex statistical analysis of the data would be required to reach these conclusions, which is beyond the scope of this research. Therefore, any patterns of responses found within the results are merely indicative when taken as a whole. One of the major difficulties of analysing the different methodologies is that details of the tools are not publicised in detail as they were in the Probe Studies. Questionnaires are rarely published in full due to the requirement of organisations conducting their post-occupancy evaluations to retain intellectual property over their methodology. This, in part, leads to the second caveat of the post-occupancy methods of social scientists. The majority of the methodologies have been developed for commercial purposes. Consequently the tools are not made publically available for analysis and the robustness and reliability of the methods cannot be established. A further consequence of the commercial focus of post-occupancy evaluations is the range of building sampled. The workplaces evaluated are not selected at random but chosen for a reason. In some cases the building occupiers may wish to know how their building is performing and therefore fund a post-occupancy evaluation which suggests that they have an interest in the environment which is likely to have influenced the brief and development of the workplace. In other instances the post-occupancy evaluation has been commissioned by the design team to demonstrate how the environment they have designed is performing (Oseland, 2007). Again, this leads to a potential bias in the selection of workplaces as a design team is more likely to have an interest in the performance of a building if their aspiration is to create an environment that functions well. The commercial nature of post-occupancy evaluations has been recognised by Markus (2001) who highlights the lack of academic research in the field of post-occupancy evaluation. Without an in-depth analysis of the methodology, the robustness of the methods in terms of having validity and reliability is not known. The results alone are not enough to demonstrate that the post-occupancy evaluation methods such as sampling of participants and survey design are sufficiently rigorous to provide accurate and adequate data. Further analysis and development of post-occupancy, based upon previous research and practice could be beneficial.

### 6.6 Summary and Conclusions

The nature of post-occupancy evaluation has developed from the 1960s through to the present and current practice. In the 1960s architects were encouraged to feed back understanding of their buildings into the design process and this shaped the methodology with the focus very much upon the design of the building itself. However, as building services engineers began to take greater responsibility for post-occupancy evaluation in the 1980s and 1990s, the focus of the evaluations was the internal climate and energy performance. The change to a much narrower focus than the evaluations of designers was accompanied by a much more in-depth and thorough analysis of aspects of the workplace. Thus, what was lost in holistic terms with regards to the range of factors evaluated, the aspects of the environment that were the subject of the evaluation were analysed in great detail. Researchers such as the Probe Team took physical measures of the environment and utilised questionnaires to analyse how users perceived their environment and the effect that the environment had upon their comfort levels and satisfaction with the workplace. The number of aspects of the workplace that were measured was reduced, and much more focused with less quantifiable aspects of the environment largely omitted. Whilst more consistent results were obtained in relation to the impact of the internal climate of the workplace environment, a truly holistic understanding could not be developed through the findings of the Probe studies. The approach of social scientists was more holistic in the nature of the range of aspects of the environment that they studied. More qualitative aspects of the environment were introduced into the post-occupancy evaluation models with decoration, window provision, etc being considered and other indirect impacts of the environment such as privacy and a sense of personal control over the environment. The aspects incorporated in the analysis allowed for a more holistic evaluation of the workplace. However, incorporating the aspects of the workplace that are less easy to quantify happened at the same time as reducing the measurements of objective measures. The majority of post-occupancy evaluations carried out and reported by social scientists have only incorporated measures of satisfaction and perceptions of the environment. There are very few studies in which both objective and subjective measures are taken. This more in-depth approach is usually adopted if considerable dissatisfaction is identified when analysing users' attitudes (Oseland, 2007). Thus, although a significant amount has been learnt about attitudes towards the workplace environment as a whole, there is no objective data with which comparisons can be drawn. Equally, the commercial nature of the majority of these studies has influenced

the design of the methodology, the selection of the sample of workplaces and the reporting of the results. Thus, the academic nature of the research is limited as the methods and results are not published for interrogation of their rigor.

Taken together the post-occupancy evaluations, intended as holistic analyses of environments including workplaces, reveal that there are key elements of the methodology which need to be incorporated to produce useful results. Although between them, the important qualities of the methodological framework are demonstrated, there is no single approach that satisfies all of the key elements. From the research into the impact of the workplace environment in these studies and those described in previous chapters, the following key elements of an effective holistic evaluation of the workplace environment have been identified. Firstly the methodology for the evaluation needs to be standardised as it was for the majority of the more holistic evaluations analysed in this chapter. A standardised methodology allows patterns of data both within a building and across buildings to be analysed together. From this, patterns in the data can be established and benchmarks developed. This makes the results more applicable to other workplaces as they are not as greatly affected by the context of a specific workplace and individual organisation. The second key element of an holistic evaluation identified from the methods used in existing research is that both objective measures and associated user perceptions are measured. This provides an understanding of how the actual workplace environment is perceived by users and their attitudes towards it. Without one or the other, any changes to the environment in an attempt to improve the workplace for users may not have an impact as both the real environment and how it is experienced need to be understood. The third key element is that a wide range of aspects of the workplace environment are measured, both those that are easy to quantify such as internal climate factors and the less easily quantifiable aspects such as aesthetics. Research, including post-occupancy evaluations, has indicated that there is a relationship between all aspects of the workplace environment and user attitudes. Thus, the whole workplace needs to be considered rather than focusing on limited aspects to provide an holistic understanding. The fourth key element is that the sample has to be unbiased with reference to both the workplace selected for evaluation and the individual participants in the post-occupancy research. The workplaces considered in post-occupancy evaluations should not be selected for commercial reasons if the aim is to develop patterns of results that can be generalised and applied to all workplaces. Similarly, the sample of respondents needs to be unbiased with random selection of the sample advocated and respondent bias controlled for where possible. A sample

that is representative and unbiased will allow patterns to be established that are not just applicable to workplaces and individuals selected for specific reasons which would affect the results. The fifth and final key element of an effective post-occupancy evaluation established from previous research is that dependent measures of the impact of the workplace environment are clearly understood and established. Determining the relationship between attitudes towards individual aspects of the workplace and the impact upon users is necessary to gain a full understanding. Without measuring satisfaction with the workplace as a whole, overall satisfaction and perceived or actual productivity the impact of the workplace on users and their work cannot be established. In addition there are potentially other impacts of the environment upon users that should be considered such as motivation and stimulation. These five key elements, identified through analysis of the positive contribution of existing workplace evaluations, need to be brought together effectively in a single approach to produce a truly holistic evaluation of the workplace environment.

## Chapter 7 Aims and Objectives of Workplace Evaluation Phase

### 7.1 Introduction

The historical development of the workplace environment highlights how the design and layout has evolved to support emerging management theory. As organisations adapt the way in which they function and are managed, the design and layout of the workplace has changed. The chronology of the change demonstrates that it was management theory being put into practice which preceded the change in workplace design. Workplaces were developed to facilitate the different way that organisations now operate. However, despite these significant changes to the workplace environment, a review of the literature and previous research indicates that there have been few systematic and robust evaluations of the impact of the workplace environment upon both organisational performance and user satisfaction. A review of the existing research detailed within the current state of knowledge reveals that there are four areas where there is significant scope for a further contribution to knowledge. These are: the need to analyse aspects of the workplace together rather than in isolation, the analysis of both objective and subjective measures, evaluating aspects that are not easily quantifiable and carrying out workplace evaluations that are not commercially motivated.

### 7.2 Gaps in the Current State of Knowledge

The current state of knowledge reveals that the design of workplace environments has been influenced by management theory as it has evolved from being designed to facilitate process to supporting interactions and communications between workers. Since the introduction of adaptability theory in the 1980s management theorists have advocated adaptability and flexibility which, as was detailed earlier in the current state of knowledge, is beginning to influence the design of workplaces. Researchers hold conflicting views of the extent to which the workplace environment has an impact upon users. Research into overall job satisfaction and motivation has included the workplace environment or working conditions as one of the contributing factors with varying degrees of influence (Maslow, 1943). Evidence also suggests that managers and workplace users perceive the environment to have an impact upon their satisfaction and productivity at work (for example, Warr, 2002). Researchers recognising the potential impact of the workplace environment (for example, Sundstrom,1986) have analysed available evidence to determine the impact of workplace design. Their

evidence supports the existence of an impact of the environment on users and how design can affect perceptions, attitudes and behaviours.

Many of the studies in the current state of knowledge focus upon just one or two aspects of the workplace environment. This does not provide a full understanding of the user's experience of the environment as whole, with different aspects affecting them simultaneously. All the aspects that constitute the workplace may have an individual impact upon users, but it is likely that there are interaction effects when everything is experienced together as it is in a real world workplace setting. All aspects may have a different effect when experienced together than they do when analysed separately. For example, the illuminance levels may be affected by colour scheme in the workplace and the spatial layout. This may also have an impact upon user satisfaction with the workplace as a whole. Analysing each aspect of the workplace individually, and assuming that a users' experience of the environment is simply the result of the sum of isolated experiences, may be inaccurate. Thus, the workplace as a whole in a real world setting should be analysed to give a more accurate understanding of the impact of the workplace environment.

Secondly, many evaluations focus upon either objective measurements of the workplace environment or analyses of users' perceptions and satisfaction. Few studies were identified that focused upon both quantitative data collected from the environment and an in-depth analysis of user satisfaction and perceptions. For example, the most widely applied objective evaluations of the workplace environment focus upon the internal climate including air temperature, acoustics, illuminance, relative humidity and air movement, and spatial layout. The Design Quality Matrices (DQM) (Cook, 2007 ) and Probe studies (Leaman and Bordass, 1998) focus upon measures of the environment and by the researcher's own admission have only a small element of their research methodology devised to establish an overview of the impact of the environment upon users. They consider nothing beyond satisfaction, and it is satisfaction with specific aspects of the environment such as air temperature rather than the workplace as a whole. Factors such as perceived productivity, stimulation and motivation, and how these are related to the environment, are not included within their studies.

In contrast, the studies which have focused more upon user satisfaction contain few objective measures of the environment to compare with the perceptual data collected. The British Council for Offices Guide to Post-Occupancy Evaluation (2007) details 21

post-occupancy evaluation methodologies and states that measures of perceptual data were obtained using questionnaires. The majority of case studies within the guide focused upon perceived productivity as a dependent variable and analyse this in relation to user perceptions of the workplace rather than objective measures. However, by not measuring aspects of the environment both objectively and subjectively one cannot fully understand the impact of the workplace upon users. Furthermore, analysis purely of user perceptions does not provide enough information for changes to the environment to be made which have a positive impact. For example, low levels of satisfaction with the air temperature and data demonstrating that users perceive the environment to be too cold may lead to a decision to raise the air temperature. However, objective measures would reveal that the cause is a large difference between the temperature of a surface such as a large window and the internal air temperature. A significant difference between these two temperatures has been found to create a perception in users that the workplace is too hot or too cold. However, raising the internal air temperature would actually exacerbate the users' perception that the environment was too cold because the difference between the air temperature and the surface temperature would increase. Conversely, taking purely objective measurements does not necessarily demonstrate how users perceive the environment. For example objective measures of the illuminance levels may indicate that the levels of light at users' desks is lower than the 300 lux recommended within the design guidance (CIBSE, 1994). However, if users are satisfied with the illuminance levels and it is of an adequate level to allow them to complete their work, increasing the lux level is unlikely to lead to greater satisfaction with the workplace. It is clear that making effective improvements to the workplace to affect user satisfaction requires an understanding of people's perceptions and the actual conditions within the workplace, otherwise there is no basis on which to demonstrate that changes can have a positive impact.

The third area where there is a gap in the current state of knowledge is that the focus has been upon the easily quantifiable aspects of the workplace environment. As clearly identified within the literature review of the current state of knowledge, both the internal climate and aspects of the spatial layout, such as density, have been the focus of a number of different studies carried out by researchers from a range of different disciplines. The internal climate and spatial layout have been evaluated from an architectural, engineering, ergonomic, psychological and business management perspective. However, there are many other aspects of the workplace which are less easily quantifiable but that research has demonstrated do have an impact upon users

to varying degrees. Much of this research comes from psychological discipline and focuses upon the impact of specific aspects such as a view from the window or colour scheme. The results of these studies are not conclusive but the findings indicate that less quantifiable aspects of the workplace, perceived to be more subjective, are related to user satisfaction and could have an impact upon productivity. More robust research is required to demonstrate conclusive evidence of the impact of subjective aspects of the workplace upon satisfaction and productivity. However, the research findings to date do support the need to include these aspects in evaluations to give an holistic evaluation of the workplace environment.

The fourth area where there is a gap in the current state of knowledge is the systematic evaluation of workplaces that were not selected for commercial reasons. The drivers of post-occupancy evaluations from the commercial sector have had an impact upon methodology, sampling and the reporting of results. However, without these commercial drivers there is less chance that a post-occupancy evaluation will be carried out. There is no legislation or policy in place that encourages either the design team or end users to initiate a post-occupancy evaluation. In the original job stages developed by the Royal Institute for British Architects (RIBA) there was a Stage M: Feedback included (Hughes, 2003). This suggested that once completed and occupied an architect should evaluate the extent to which their project was successful. This shaped early post-occupancy evaluations such as the methodology used by Preiser (1988). However, in more recent editions of the Architect's Handbook (RIBA, 2007) Stage M: Feedback has been omitted from the RIBA Plan of Work. Thus, the responsibility of obtaining feedback about the performance of buildings has been removed from architects. Building and facilities managers, and those who develop building management systems to manage the internal climate, have more recently taken a research interest in post-occupancy evaluations. As the management of the internal climate has become more automated, research into the impact of the environment upon users and the ability of an organisation and its employees to function effectively has been the subject of research. This has expanded as the performance of buildings has been scrutinised to inform the development of environments that are comfortable for users. This has furthered the development of organisations such as the Usable Buildings Trust. However, it has influenced the focus of the research which is now on factors that comprise the internal climate and the performance of the building in relation to user satisfaction. The research which considers the impact of the more subjective aspects of the workplace environment has tended to come from a psychological perspective and is for the most part focused upon individual aspects

such as colour scheme or the inclusion of plants rather than the workplace as a whole. In addition, much of the research from the psychology discipline are laboratory studies rather than evaluations of real world workplaces. With all these different approaches and commercial influences it is difficult to analyse and reconcile the findings. Recently the driver for post-occupancy evaluations has been business performance with analyses demonstrating that 80-82% of an organisation's expenditure is in staff costs and 18-20% is construction and building management costs (Walden, 2005; Oseland, 2007). Thus, organisations want to establish whether there is a positive relationship between the environment and productivity. If the relationship exists, there is the potential to design the workplace environment to benefit the organisation through increased productivity of employees. The recent publication of the British Council for Offices Guide to Post-Occupancy Evaluation (Oseland et al, 2007) and the development of groups such as Buildings and Social Sciences (BASS) founded 2007 and Workplace Consulting founded 2009 in the United Kingdom demonstrate an interest in recognising the building as an asset that may impact upon the performance of an organisation. Whilst this interest has led to the development of more holistic methodologies as detailed in the current state of knowledge, such as the Office Productivity Index (Oseland,1995), with aspects other than the internal climate being considered as well as the impact upon users and productivity, there are some issues created by the commercial drivers of this work.

The first is a sampling of organisations and workplaces. The workplaces evaluated tend to have been selected by the design team who want to demonstrate the positive impact of the building that they have designed, or the organisations that occupy or own the workplace to demonstrate how it has a positive impact upon the way that they work. This self-selection of workplaces gives a very strong respondent bias towards buildings perceived to have a positive impact. The second issue with commercially driven post-occupancy evaluations is the unavailability of methodology details and results for academic testing and rigorous independent analysis. Those who own the intellectual property of the post-occupancy evaluations retain exclusive use and knowledge of their methodologies and results. Many organisations involved are only prepared to allow the publication of results that reflect favourably upon them and their workplace. In the review of evidence for the current state of knowledge there were very few full methodologies or details of data published. Without this information available it is not possible to determine how effective these post-occupancy evaluations are and the robustness of the findings. A further issue with the existing research is that many findings reported are from individual case studies. Whilst useful to indicate the impact

of an individual workplace upon users, the results cannot easily be generalised to other workplaces. There are a number of other influences upon the results such as organisational factors, geography, nature of the work and type of individuals working in that environment that will affect levels of satisfaction and perceived productivity beyond the workplace environment. Thus, an individual case study provides little more than greater understanding and learning for one organisation in that workplace. The impact of the workplace upon users requires more systematic evaluation across a number of different workplaces so that patterns can be established which are affected to a lesser degree by other variables.

### 7.3 Aims and Objectives

The first aim of this thesis was to investigate the impact of the workplace through a holistic evaluation process and, in doing so, demonstrate the development of an effective approach to measuring the impact of the environment on users. An analysis of the current state of knowledge revealed that there were a number of gaps. The design of the workplace has changed significantly throughout history to reflect changing management theory. Whilst the workplace environment may have been designed to facilitate the different ways of working advocated by management theories, the impact of different aspects of the environment on users has not been conclusively established or sufficiently researched (Cooper, 2001; Sundstrom, 1986; Duffy, 1997). Therefore, few strong conclusions have been drawn about the impact of the workplace environment upon users. There are many studies, from a range of disciplines, demonstrating that individual aspects of the workplace have an impact upon users. These range from the air temperature (for example, Abdou & Lorsch, 1994) through to plants in the workplace (for example, Larsen et al, 1998). Whilst there are some holistic studies of the workplace environment, in particular the post-occupancy evaluations detailed earlier in the current state of knowledge, they do not appear to provide conclusive evidence of the impact of the workplace environment upon users. This is for three main reasons. The first is that some evaluations are case studies and are analyses of a single or very few workplaces (for example, Marans & Spreckelmeyer, 1981). As a result, the findings are not necessarily generically applicable to other workplaces as the results are dependent upon context. The second reason is that some evaluations are focused on a limited range of aspects of the workplace such as internal climate (Cohen et al, 2001). Thirdly, the measures taken are either objective measures or user attitudes, rather than both types of data. This means that the relationship between the physical workplace environment and users' perceptions has

not been fully understood. For an holistic evaluation and the gathering of data that clearly demonstrates the impact of the workplace on users, the learning from previously tested methods was used to develop an effective methodology. This approach was used to evaluate workplace environments and highlight the impact of the environment on users. To achieve these overall aims, the objectives of phase one were:

- To develop an approach that allows holistic evaluations of the workplace environment to be conducted. Both objective measures and user perceptions will be measured in relation to a wide range of aspects of the workplace.

- To use the approach to conduct an evaluation of the workplace environment in 18 workplaces to identify patterns and trends relating to the impact of the workplace.

- To analyse data and provide an understanding of perceptions of the workplace and the corresponding objective measurements of the environment

- To understand the relationship between the environment and satisfaction with the workplace, perceived stimulation levels and perceived productivity

## Chapter 8 Methodology of Workplace Evaluation Phase

### 8.1 Review of Existing Methodologies

With the disciplines ranging from building services engineers (Cohen et al, 2001) to social scientists (Oseland, 2007) evaluating the workplace environment, a number of methodologies have been developed and tested. Researchers from each discipline had a specific focus when analysing the impact of the workplace and therefore took different approaches. For example, many of the building services engineers were interested in the environmental performance of the building (Preiser, 1988) as this was the aspect of the design over which they had most control. Thus, any knowledge gained from the research would be useful and could be fed back into their design processes to positively influence building management systems in future designs. Social scientists have an interest in the building users and the psychological and physiological impact of the workplace environment which influenced the methodology choice. The type of methodology used was also affected by their information being gathered. For conditions that naturally occurred in the real world and could not easily be replicated in a laboratory setting, research was conducted in an actual workplace environment (for example Marmot & Eley, 2000; Turner & Myerson, 1998). The majority of studies of spatial layout reviewed within Chapter 3 were conducted in real world settings as it was difficult to re-create a typical layout of a large workplace in a laboratory. In contrast, there are aspects of the workplace environment that have been isolated and evaluated in a laboratory setting such as colour of the workplace (for example Stone, 2003) or personal control (for example Veitch and Newsham, 2000). These aspects of the environment can be more clearly defined and applied to smaller scale spaces making them more suitable for laboratory studies. There are some aspects of the environment that have been evaluated in both real world and laboratory settings. For example, Heerwagen and Heerwagen (1986) evaluated the impact of natural light on occupants' perceptions of their workplace environment with regards to comfort, appearance and colour. It was necessary to collect data from real world workplaces using a survey to gain an understanding of how natural light affected the appearance of an existing environment. A laboratory setting would not have enabled researchers to understand how the access to daylight affects perceptions of users' actual workplace and attitudes to their work. However, in Ne'eman and Hopkinson (1970)'s study a laboratory setting of daylight was more appropriate as they were manipulating the size of windows to determine the impact of window size on occupants' perceptions. In a real world setting they would not have been as easily able to vary to

size of windows to evaluate the impact upon users. Thus, the choice of setting, whether real world or laboratory, is influenced by the information required and focus of the research.

The holistic evaluations of the workplace detailed in Chapter 6 highlight the importance of measuring a range of variables simultaneously to gain an understanding of how the workplace as a whole impacts upon users. To allow measurement of a number of aspects of the workplace environment, real world settings have been exclusively used (Brill et al, 1984; Preiser, 1988; Cohen et al, 2001; Oseland, 2007). This is due to the nature of the research requiring that a number of variables are evaluated simultaneously. To recreate a workplace environment in a laboratory setting where all of these aspects could be measured would be difficult. In addition, the majority of researchers were interested in the workplace as an integral part of an existing organisation and their work (for example, Brill et al, 1985). Researchers have argued that real world research is essential to demonstrate the true impact of the workplace as a dynamic and interactive environment. However, there are benefits of laboratory settings that are not easy to replicate in real world settings.

Whilst researchers of holistic evaluations have argued for the use of actual workplace settings in research, there are some limitations of real world research. Understanding these limitations and the potential benefits of laboratory settings has informed the development of the methodology for this research. Where possible the benefits of laboratory research have been incorporated into the methodology to reduce the limitations of real world research. The first advantage of laboratory studies is that the researcher can control the environment and the conditions being analysed. Extraneous variables can be minimised, with the specific factor being analysed as the sole focus of the study. Smith (1998) refers to this as a closed system analysis whereby the impact of variables not being studied is minimised. This ensures that the results obtained are not affected by issues that are not being specifically measured within the research. Potential effects on the results, such as organisational culture or even the individual tasks that people perform as part of their regular job, are all designed out of laboratory research by creating an artificial situation with standardised tasks and no external influences. However, there are significant limitations imposed by controlling the environment rather than using a real world setting. By removing or controlling extraneous variables in a laboratory setting the situation no longer resembles the real world and therefore the results cannot always be directly applied to real world settings. The intricacies of real world environments need to be studied using methods which

reveal these complexities (Parker, Wall and Cordery, 2001). Research carried out within a controlled setting is not always able to provide this sort of complexity. Thus, using a real world setting for the research improves the reliability of generalising the results. At the same time, the researcher is aware that when developing a methodology and testing the impact of the workplace environment, care should be given to understand the context and be aware of extraneous variables which may affect the results.

The second advantage of laboratory studies is that they can be easier to set up than conducting the research in a real world setting where gaining permission and access is difficult (Robson, 2002). One of the main issues cited by the Probe research team was the difficulty in gaining full and unlimited access to the buildings they evaluated with fewer than 50% of the organisations from whom they established initial consent actually taking part in the process (Leaman and Bordass, 2001). Oseland (2007) make several recommendations for ensuring participation in a post-occupancy evaluation but many contributors to this work experienced difficulties in terms of gaining permission and access to the workplaces in question. In addition, there were commercial reasons, outlined in Chapter 6, which affected the choice of workplaces in many studies of the workplace environment. As a result real world research into the impact of the workplace is potentially affected by bias. The environments evaluated were not selected at random and were often those that were already perceived to be having a positive impact. Thus, when carrying out real world research it is essential to be aware of the impact of a self-selected sample of workplaces and the difficulty in arranging research with the full co-operation of the occupying organisation.

The third important advantage of laboratory studies is that it is easier to establish cause and effect. It is possible to control the setting and what takes place there, thus the impact of changes can be recorded. A specific variable can be manipulated, and the direct or indirect effect of this measured. As all other factors are controlled for by the experimenter, a change to the conditions set within the laboratory can more easily be established as causing variation in the dependent variables. With real world research there is less opportunity to establish cause and effect. The strength of relationships revealed can be established statistically but this does not provide evidence of cause and effect. Whilst some assumptions might be made based on common sense and the findings of previous experimental work, the true cause and effect cannot be reported conclusively. For this, some controlled variation of the environment is required so that the specific impact of these changes can be measured. Whilst it is important to

establish cause and effect, the benefits of real world research counteract this to some extent. The complexity of real world environments means that it is difficult to recreate them in laboratory settings. It is much easier to carry out the research into individual or a small number of isolated aspects of the workplace environment in a laboratory setting. However, to determine which aspects of the workplace should be isolated so that cause and effect can be established, an understanding of the correlations between factors should inform the laboratory studies. The research to date has been divided with those studies in laboratory settings being able to draw some conclusion about the causal relationship between the impact of the workplace environment (for example, Stone and English, 1998) and those that have been conducted in real world settings and have demonstrated clear relationships between the workplace environment and dependent variables; satisfaction and perceived or actual productivity (for example, Oldham & Bass, 1979). Although causal effects cannot be established, the more holistic evaluations, where a number of aspects of the workplace are considered, are conducted using real world environments rather than laboratories (Preiser, 1988; Leaman & Bordass, 2001; Oseland, 2007). As a result they have revealed the complexities associated with determining the relationship between the environment and the satisfaction and productivity, or perceived productivity. This complexity could not easily be replicated in a laboratory setting. For this thesis the benefits of laboratory settings in allowing cause and effect to be established have been taken into consideration. To obtain an holistic understanding of the workplace environment and all its complexities, real world settings should be utilised for this research. Once the relationships between aspects of the workplace and the dependent variables have been demonstrated, a foundation is provided for the testing of the cause and effect based upon these significant correlations.

By recognising the benefits of laboratory settings in contrast to real world workplace settings, the methodology was developed to reduce the impact of limitations on the research. The ability of researchers to isolate distinct variables to be tested in laboratory settings and reduce the impact of extraneous variables is a benefit as it allows clear conclusions to be drawn. However, it is also a limitation as controlling the environment reduces the impact of naturally occurring complexities and extraneous variables which do affect people in the workplace. Additionally, the complexities affect users' perceptions of the workplace environment. Thus, by isolating variables for analysis, important context is lost. Understanding and analysing how the workplace as a whole is experienced by users is essential. Without this, the research may produce results that are unreliable and not easily generalised to real workplace settings. The

culture of the organisation and other factors such as location, type of individuals who work there, etc (Warr, 2002) are likely to affect users' perceptions of the workplace. The findings from an individual case study may be very dependent upon the particular situation of that organisation in that workplace. The context and extraneous variables must be factored into the analysis so that the results can be generalised. Therefore, the findings from individual case studies are not easily applied to other workplace environments which may operate in a very different context. To increase applicability of the findings, a series of real world workplaces should be studied. Applying a standardised methodology in a number of workplaces allows patterns to be established. When the perceptions of the workplace are shared across a number of environments, regardless of the type of work taking place and the culture of the organisation occupying that space, conclusions can be drawn that are more widely applicable. If similarities in user perceptions are identified between workplaces it suggests that it is the environment rather than context or culture of the organisation that is significantly related to satisfaction and perceived productivity. If it was the nature of the organisation affecting the perception of the environment, it is unlikely that there would be clear patterns in the data between workplaces. The patterns in the data provide an understanding of user perceptions of workplace environments. With a standardised methodology and patterns in the data between workplaces, benchmarks can be developed with which perceptions of workplace environments can be compared. These benchmarks can become the foundation for testing the cause and effect relationship between the environment and users.

### 8.2 The Tools for Evaluation

The importance of using real world workplace environments in which to carry out holistic evaluations has been established. However, previous studies analysed in Chapter 3 to Chapter 6 reveal that there are a range of different methods utilised in real world settings including questionnaires, observation studies, objective measures and workshops (Oseland, 2007). There are benefits and limitations of all the possible methods and these were considered in the context of an holistic evaluation of the workplace environment and previous studies to ensure that a methodology with high validity and reliability was developed. High validity means that the tools being used accurately gather the data required. For example a questionnaire is designed with the right questions to elicit the attitudes and perceptions sought. A reliable methodology is one that can be replicated and the same responses continuously obtained when the

conditions are consistent. The methods considered for this research were questionnaires and objective measurements including expert observations.

### 8.2.1 Questionnaires

Questionnaires are a popular choice of methodology and have been used in both holistic studies of the workplace and by researchers analysing the impact of specific aspects of the environment. There are a number of questionnaires that have been tried and tested by researchers such as the Building Use Survey (Leaman et al, 1997) and have demonstrated that they are an effective tool for gathering useful data. The advantages of questionnaires are that they can be standardised, are adaptable, generate large amounts of data, are relatively simple to administer and allow for anonymity (Robson, 2002).

Standardisation is achieved by distributing the same questionnaire to all respondents across all workplaces being tested. Providing the questionnaire has been tested and has both high validity and reliability, the data collected from the questionnaire is comparable. It allows attitudes to be quantified for analysis and patterns to be established. The holistic studies detailed in Chapter 6 utilised standardised questionnaires, therefore the data gathered could be compared by the researchers. The results produced had inter-rated reliability, that is the respondents understood the questions as there was no ambiguity in terms of the wording of the items in the survey. Thus, respondents were answering the same question and the data reflected differences in attitudes rather than different interpretations of the questions. However, despite some tested and standardised questionnaires being freely available such as the Building Use Survey, which can be obtained from the Usable Buildings Trust, a number of different questionnaires have been developed by researchers which are all bespoke and not readily available. This has benefits and limitations. The main limitation is that the results cannot be statistically analysed together. The data gathered using non-standardised and different questionnaires cannot easily be compared to identify the impact of the workplace environment across studies. The key messages and a qualitative analysis can be carried out to highlight the main issues in workplace environments but not direct, empirical comparisons. The benefit of different questionnaires being developed is that they can be adapted to ensure that the questions are designed to elicit information which is the focus of a specific study. For example the questions in the Building Use Survey (Leaman et al, 1997) were focused upon user perceptions of the internal climate. However, the questions in Laing et al

(1998) were designed to elicit attitudes about the spatial layout as this was the focus of their research. By adapting the questions within the questionnaire, and then using this with all respondents in all workplaces evaluated, there is standardisation within the study. Thus, patterns in the results can be identified and reported as the data is comparable.

The second major benefit of questionnaires identified is that large amounts of data can be gathered. This is due to the large sample size that can be taken. In addition, researchers have the ability to incorporate numerous items into questionnaires. Attitudes of users on a range and number of issues can be obtained quickly, particularly if the responses are on a scale. Using a scale can minimise the amount of time that participants have to spend completing the questionnaire, thus increasing the likelihood of a high response rate and allowing numerous items to be incorporated. The ability to gather a large amount of data is particularly true if the questionnaires are self-administered. If a researcher is not required to assist every respondent there is less demand on resources and more questionnaires can be distributed. Self-administration also has the advantage of allowing participants to retain anonymity, which is more likely to lead to them giving honest answers. Without anonymity there is a risk of a social desirability effect occurring (Robson, 2002; Sapsford, 2007). This is when respondents answer questions in the way that they feel is socially acceptable or the way that they think the interviewer or researcher wants them to respond. By offering respondents the opportunity to remain anonymous they have the opportunity to answer truthfully with concerns minimised in relation to the impact of the answers they give.

Whilst questionnaires offer benefits, there are some disadvantages to using this method. The first limitation is that respondents' level of understanding or the information available to them limits their responses. Participants can only answer a question to the extent that their knowledge allows them to. For example, participants asked about their preferred colour scheme within the workplace can only respond with the knowledge and experience of the colour scheme in their existing workplace or other buildings in which they have worked. They have no terms of reference other than what they have previously experienced. However, the experience they have had is a factor in their attitude towards the workplace and is therefore part of the complexity of studying the workplace environment. It is actually an important consideration despite being a potential limitation. A second disadvantage of questionnaires is that a low response rate may be achieved with a low proportion of those issued the questionnaire actually completing them. This is particularly true of self-administered questionnaires

due to the self-motivation that may be required to complete and return them. With every non-response the sample becomes less random as non-responses are usually representative of a particular type of person. Vice versa those who respond to questionnaires regularly are likely to have particular characteristics. Therefore a low response rate will not be representative of the population from which the sample has been drawn (Sapsford, 2007). A third important limitation to recognise is the potential for ambiguity and misunderstanding of the questions. Again, this is particularly problematic with self-administered questionnaires as there is no researcher or interviewer present to clarify questions. Therefore the questionnaire needs to be tested and researched thoroughly to ensure that ambiguity is minimised or eliminated. A pilot study is a useful way of testing the questionnaire and methodology. If there is ambiguity the responses may have low validity as they are not assessing what the researcher intended the questionnaire to measure. Despite these disadvantages of questionnaires, it is an effective way of gathering data on user attitudes to the workplace environment. Limitations can be recognised and then dealt with appropriately. A pilot study, encouragement to complete the questionnaire and return it, and understanding that the limitation of respondents experience influences their perception of the workplace will all help to mitigate against the disadvantages of questionnaires.

### 8.2.2 Objective Measurements

A questionnaire methodology has been used frequently in previous research and appears to offer an effective tool to gather data on the attitudes of users. However, the responses are user attitudes and do not provide data on the actual workplace conditions. Preiser et al (2001) and others (for example, Brill et al, 1985; Mallory-Hull, van de Voordt and van Dortmont, 2005) argue that both objective and subjective measures of the environment must be obtained to provide an holistic understanding of the workplace. Users' perceptions may be affected by a factor other than the actual environmental conditions. Without objective measures of the actual environment, inferences about the cause of users' perceptions cannot be drawn. There are also limitations of just taking objective measures as users' attitudes may not be significantly correlated with the conditions in the actual workplace environment. Users' perceptions may be influenced by interaction effects of aspects of the workplace environment or other complexities such as organisational culture. Thus, both objective and subjective measures should be measured within an holistic evaluation.

To gather the objective data, a range of methods can be used depending upon the information required. Previous workplace evaluation methodologies have included expert walkthroughs (Cook, 2007), the use of monitoring equipment (Brill et al, 1984) and analysis of accurate spatial layout plans (Laing et al, 1998). As with questionnaires, each of the methods for collecting objective data has benefits and limitations. Expert walkthroughs rely heavily upon the knowledge and skills of the researcher recording data. There is a possibility of inconsistency between workplaces and between researchers which can affect the results. To mitigate against researcher subjectivity, frameworks for expert walkthroughs have been developed by researchers. For example, the Design Quality Matrices expert walkthrough methodology (Cook, 2007) consists of six overarching matrices within which are contained further matrices of objective measures used to elicit an objective response from the researcher. The matrices are designed to minimise subjective responses and endeavour to elicit objective, comparable data. The use of monitoring equipment is a well-established practice within the discipline of building services and accepted methods of taking a number of spot measurements to obtain an average recording. Obtaining an average score prevents erroneous data from influencing the results. Providing accurate and calibrated equipment is used to gather data and the researcher has been trained to operate the monitoring devices, the data collected will be reliable. However, there are limitations of using monitoring equipment to gather objective data. The main limitation is that monitoring equipment only exists to measure specific aspects of the workplace environment, such as internal climate. There is no equipment available to measure privacy levels or the quality of a view out of the window. Thus, the monitoring equipment can only be used to gather data on a few specific aspects of the workplace environment. The final method identified in a number of workplace evaluations (for example Laing et al, 1998) is the analysis of spatial layout plans and drawings. As with the use of monitoring equipment, there are only a finite number of measures that can be taken. Distances, density levels in terms of area per person and the area of workplace features such as the windows and furniture can be measured using this methodology. These measures are well accepted and straightforward to implement. However they are limited in terms of what can be measured effectively in an holistic evaluation of the workplace. All objective measures used have demonstrated high levels of reliability and validity in previous studies but are inadequate on their own to provide a complete and accurate understanding of the whole workplace. Using a range of tools to gather objective data, in conjunction with subjective data, offers a methodology which allows an holistic evaluation to be carried out. This is supported by Robson (2002) who recommends a mixed method approach to real world research.

### 8.2.3 Mixed Methods Approach

As detailed in Chapter 6, there are a number of methodologies that have been developed to evaluate the workplace environment. Many of the methods are tried and tested and demonstrate high validity and reliability. In addition, researchers have tended to use a mixed method approach to gathering data. The methodology from the Probe studies (1995-2002) incorporated interviews, questionnaires and physical monitoring of the environment. Oseland (1999) followed a similar pattern using interviews, a questionnaire and physical monitoring as well as focus groups to gather qualitative data. Laing et al (1998) used observational reports, marked-up spatial layout plans, questionnaires and surveys of the environment. The researchers from each of these three key studies were aiming to be holistic in their approach to evaluating the workplace environment. Importantly, their methodology was also founded on collecting data from real world workplace settings. The aim of the 20 Probe studies was to establish energy use and occupant comfort in relation to the internal climate of a workplace. Using a mixture of methods reduced the negative impact on the results associated with simply collecting either objective or perceptual data and allowed relationships between the environment and user attitudes to be analysed. Oseland (1999) developed the Office Productivity Index (OPI) using similar methods to those from the Probe studies. The Building Use Survey was the foundation of the questionnaire for both the OPI and Probe. However, there were more items included within the OPI relating to qualitative factors: furniture, equipment, decoration and personal control. Although these qualitative factors were included within the research no objective measurements were obtained to allow comparisons to be drawn between the actual environment and occupant perceptions of the workplace. To develop the OPI Oseland (1999) completed 10 evaluations of workplaces so that patterns between workplaces could be established. Laing et al (1998) also used a questionnaire as the foundation of their research. However, they also objectively recorded and analysed spatial layout plans and methods of working, aspects of the workplace environment that were traditionally considered qualitative. These three studies have benefited from their more holistic approach to evaluating the impact of the workplace environment. By analysing both objective data and occupant perceptions, understanding about the relationship between them could be established and the research became more holistic. A further benefit of these mixed methodologies accounts for the complexity within the real world. The mixed methods allow effective evaluation of aspects of the

environment that are both quantitative such as the air temperature and those that are more qualitative such as occupant perceptions of the colour scheme.

### 8.3 Proposed Methodology for Workplace Evaluations

Researchers aiming to evaluate workplace environments as a whole have developed methodologies that are both reliable and allow data to be collected that has a high validity. However, there is scope for these methods to be developed further to allow a more holistic evaluation to be conducted. The majority of methodologies are limited by the number of variables measured or the focus on certain aspects of the environment such as the internal climate. Others are limited by a lack of both objective and perceptual measures. Finally, in those evaluations in which both objective and perceptual data are collected in relation to a wide range of variables, there tend to be few workplaces included in the research. To address these limitations but benefit from the development of tools to date, the methodology for this research study was designed to further the work of previous researchers.

Within an holistic evaluation of the workplace all common aspects of the environment must be measured and a variety of methods used to obtain the data to reflect the complexity of real world situations. As identified within the current state of knowledge, a significantly higher proportion of the research has been focused upon the internal climate such as air temperature and illuminance, variables that are easy to measure quantitatively to allow comparisons to be drawn between conditions within a workplace and occupant perceptions. There is a small body of research demonstrating that qualitative aspects of the environment also have an impact upon occupant satisfaction and productivity. These qualitative factors are not regularly incorporated in evaluations of workplaces due to the difficulty of measuring them objectively and quantifying them. In addition, the analyses of a number of variables have revealed key interaction effects such as the relationship between aspects classed as thermal factors: air temperature, air movement and relative humidity. Thus, it is apparent that an holistic evaluation of the workplace incorporating both quantitative and qualitative factors that can be measured objectively is vital.

Although an holistic evaluation could potentially incorporate every possible aspect of the workplace environment, it was necessary to control the factors that were measured. Measuring every aspect of each workplace would have been extremely complicated and this would have affected the quality of the data. The occupant questionnaire would

have been unwieldy as it would require occupants to dedicate too much time to entering their responses. This would have been likely to reduce the response rate. Including all aspects of every workplace environment would also have made it very difficult to establish patterns between workplaces due to a lack of commonality. Something found within one workplace, such as an internet café, may not have existed within another workplace. Extensive evaluations of the impact of this facility could not be conducted and patterns established if an internet café was not something common to all workplaces in the research. Therefore the factors analysed were limited to those present in the majority of workplaces. In addition to evaluating aspects that are common to all workplaces, a theoretical framework was developed to ensure that the results were meaningful and useful. Robson (2002) suggests that without a theoretical framework data collected is merely descriptive. Therefore, aspects of the workplace included within this holistic evaluation were those that were identified as having some research history demonstrating a link between them, and satisfaction or perceived productivity. Research detailed in Chapter 3 to Chapter 6 demonstrated a link between several aspects of the workplace environment and satisfaction or productivity. Analysis of the existing studies and workplace design led to the identification of the following key factors: respondent characteristics, spatial layout, decoration, density, window provision, furniture provision, break areas, temperature, illuminance, noise, air movement, humidity, personal control and choice. These factors are found in the majority, if not all workplaces as identified in the British Council for Offices guidance on workplace fit-outs (British Council for Offices, 2003).

The methods for the collection of data were established following a review of the existing research and consideration of the advantages and disadvantages of each method. As highlighted there are three studies that have been critically analysed that have, to date, demonstrated an holistic approach to workplace evaluation. The methodology of each of these studies, in addition to the methodologies utilised within other workplace evaluations were evaluated to establish the most appropriate methodology for this study. The results of the Probe studies and case studies from Oseland (1999) and Laing et al (1998) using their established methodologies have demonstrated that their results were consistent and the data indicated that the variables being measured represented the aspects of the workplace that the researchers were aiming to evaluate. Therefore the methodologies of these studies were used as a foundation for phase one of this thesis. Including elements of well established methodologies helped to ensure that the data collected and evaluated was appropriate and useful. So that items within a questionnaire are appropriate it is

important to ensure that where possible they have been statistically evaluated in relation to existing survey items (Yates, 2004). This approach was taken to develop the methodology for this thesis. From the foundation of previous research, the methodology for this study was designed to comprise the following tools: interview with senior member of staff and building manager or equivalent, occupant questionnaire, environmental monitoring, marked-up spatial layout plans, observational reports and digital photographs. These methods will be used in conjunction with one another to allow all the required data to be collected for analysis.

An important consideration was the measurement of productivity or perceived productivity. Despite the importance of obtaining objective measures to establish how the design of the workplace environment correlates with productivity, it is extremely difficult to effectively gather this data in real world workplaces. Most occupations have multiple outputs and these differ significantly between individuals both within an organisation and between organisations. Thus, their actual productivity could not be measured or expressed in this sense. Establishing a common method of determining actual productivity was extremely difficult and deemed not possible within this study. Therefore, perceived productivity was measured. Perceived productivity as a measure has been used by other researchers evaluating the impact of the workplace environment. Within the Probe studies (Cohen et al, 2001) and OPI (Oseland 1999), perceived productivity rather than actual productivity was measured. This was justified by the research teams as perceived productivity measurement has been used as a measure of effectiveness for more than 15 years. Perceived productivity data has been found to be significantly correlated with actual productivity levels when analysed (Oseland, 1999). It should be noted however, that whilst a correlational relationship exists people actually tend to over estimate their levels of productivity. Despite this, perceived productivity is still a valid measure for this research and researchers have suggested that self-assessment of productivity is the most effective measure of productivity in research carried out across organisations where the work practices differ (Haynes, 2009). When occupants perceive themselves to be more productive, there is a significant correlation with their actual levels of productivity (Lorsch & Abdou, 1994). Thus, even if respondents' actual productivity is not as high as their perceived productivity, an increase in perceived productivity is related to an increase in actual productivity. By analysing the variance in perceived productivity, there is opportunity to use this as a dependent variable. Oseland (1999) supports the use of perceived productivity for workplace evaluations. Whilst he advises against using perceived productivity measures as absolute values, he argues that it is effective for the purpose

of comparison between respondents. Therefore, using a measure of perceived productivity had validity in this study. The work carried out by individuals and across all of the workplaces varied. Respondents ranged from people analysing chemical compounds to those working in a call centre. Therefore, a common objective measure of productivity was difficult to establish.

## 8.4 Methodology

### 8.4.1 Design

This was a correlational study in which the independent variables were aspects of the environment grouped under the following headings: internal climate, spatial layout, interior design and workplace features. The dependent or indicator variables were overall satisfaction with the workplace, perceived stimulation provided by the workplace and perceived productivity. Extraneous variables such as culture of the organisation were controlled for by having a large and diverse sample of organisations.

### 8.4.2 Participants

**Participating Organisations**

Eligible workplaces were identified using the criteria that they had were designed by British Architectural firm Ryder Architecture (or RyderHKS as it was formerly known) and that they had been completed and occupied for at least one year and less than eight years. Eighteen organisations in separate workplaces were identified as being eligible and all were approached to take part in the research. Of these 18 organisations, 16 agreed to take part. A diverse range of organisations were included within the sample.

The reason for selecting only workplaces designed by Ryder Architecture was to ensure consistency of design approach. Through extensive work with designers at Ryder Architecture it was possible to gain a thorough understanding of the way they developed design briefs with clients and how they delivered a project. Interviews with project leaders from Ryder Architecture revealed a similar approach was followed on each workplace project, which involved consulting with the client and working with them to develop a brief that met their needs rather than imposing a solution upon them. As a result, each of the workplaces sampled was significantly different but was also designed to meet the aspirations of a client.

Sampling workplaces that were occupied for at least a year ensured that occupants had had enough time to settle into the building and determine the way in which they wanted to use the environment. Researchers have recommended that a post-occupancy evaluation of any description should not be undertaken less than one year after occupation as the true impact of the environment will be masked by other factors such as a sense of being somewhere new and different (Oseland, 2007). By only sampling buildings that were under eight years old, all the workplaces were relatively modern. This was to eliminate factors such as draughts and other problems caused by aging buildings which may have affected the results. All the buildings were purpose-built workplace environments, therefore the intention was to provide an environment that had a positive impact upon work practices. Workplaces in older buildings designed for an alternative purpose may be affected by a number of issues relating to being fit for purpose which is outside the scope of this research. This study compared workplaces that differed only in design.

There was a wide range of different organisations in the sample. The following sectors were represented: legal and financial, chemical/manufacturers, construction, service/call centres, not-for-profit organisations, government offices and administration. The majority of these workplaces were traditional workplace environments with office furniture like standard desks and chairs. Some had additional accommodation such as factory space for large scale manufacture or storage. These spaces were not evaluated as they did not fit the definition of workplace used within this thesis. The work taking place was not administrative and was neither computer nor paper based. The requirements of the users of the environments were very different, thus their responses could not readily be compared with the rest of the data. However, two of the workplaces within the study contained a proportion of laboratory spaces in addition to traditional workplace accommodation. Both the traditional spaces and laboratory spaces were included within the evaluation. The laboratory spaces were not highly specialised and many of them were used for desk based paper or computer work. Thus, the function performed within them was similar to that in traditional workplaces when practical scientific work was not being carried out. In addition, the majority of users of these workplaces had access to and used traditional style workplace environments. Therefore these workplaces were included within the sample as they were deemed to be eligible.

Two organisations of the 18 approached declined to take part in the research. The sixteen remaining organisations agreed to take part, thus giving an overall acceptance rate of 89%. This was a very high response rate compared with that of other evaluation studies such as Probe who had around a 50% refusal rate. The reasons cited by the two organisations who did not feel able to take part in the research were ongoing staff changes that would affect the results and concerns about the commercially sensitive nature of their work. Those sixteen organisations who agreed to take part were proactive in ensuring that the research ran smoothly. The organisations occupying each workplace were vary varied and the patterns established could be more easily generalised to all workplaces as extraneous variables such as organisational culture were accounted for by the size and variety within the sample. Patterns could not be attributed to individual differences between organisations. To provide an overview of the different organisations involved Table 1 contains details of each organisation. Only basic details can be provided to maintain the confidentiality guaranteed to the organisations who took part.

| Workplace | Number of Users | Nature of Business | Description |
|---|---|---|---|
| A | 55 | Development of social housing (administration, legal, finance) | Open plan with some cellular offices (less than 10%) for directors |
| B | 27 | Property investment and development | Open plan, some cellular (less than 25%) for directors |
| C | 461 | Manage and accommodate charitable organisations | Small, enclosed offices with between 1 and 20 users (separated by charity) |
| D | 116 | Manufacturers and developers of chemicals | Open plan offices and some laboratory space |
| E | 130 | Insurance | Small enclosed offices with some small scale open-plan space for administrative staff |
| F | 180 | Public transport provider head office | Mix of open plan and cellular (less than 50%) |
| G | 81 | Print broker and stationary distribution | Open plan, some cellular (less than 10%) for directors |
| H | 69 | Examinations and training administration | Open plan, some cellular (less than 5%) for directors |
| I | 11 | Financial services | Open plan |
| J | 100 (approx) | Chemical research and manufacture | Hot desk open plan, cellular (less than 10%) offices for directors and laboratory space for the majority of staff |
| K | 180 | Accountancy | Open plan |
| L | 56 | Planning agency | Open plan, some cellular (less than 5%) for directors |
| M | 750<br>(350 at a time) | Customer service centre (telephone based) | Open plan with some cubicles (formed with moveable internal partition panels) |
| N | 1,500 | Call centre and training centre | Open plan with some small offices (less than 10%) |
| O | 850 | Insurance | Open plan, some cellular (less than 15%) for directors |
| P | 10,000 | Administrative offices | Open plan, some cellular and small enclosed offices (less than 10%) |

Table 1 Details of the participating organisations

**Participants – Users**

A random sample of users was taken from each workplace and approached to take part in the research. Within each workplace 30 people were asked to take part, or all occupants if fewer than 30 people worked there. A return rate of 88% was obtained which equates to 390 participants. With a high response rate and number of datasets a low margin of error could be achieved as an adequate proportion of the population was sampled. Thirty users of each workplace were sampled to increase the probability that a minimum of 20 questionnaires were completed and returned. Twenty is the minimum number of cases recommended within a single condition in empirical research (Robson, 2002). The sample size was analysed to determine whether the data collected would be reliable. This ensures that the data collected was adequate to enable conclusions to be drawn, even though there were some people within the sample who did not respond to all the items or did not return a completed questionnaire.

The sample was randomly selected using staff lists from each organisation which ensured that all employees had an equal chance of being selected. Any workplace user could have been selected, regardless of where their workstation was within the workplace, what their position was within the organisation, or how long they had been working for the company. The random selection of users yielded a sample of both males and females from all levels of the organisations, spread geographically throughout the workplace. Of the users surveyed 40% were male and 46% were female (14% did not disclose) demonstrating a fairly even split. In terms of occupation, there were larger numbers of administration and professional staff surveyed than managers and directors. However, this is a reflection of the larger numbers of staff than managers in most organisations.

### 8.4.3 Materials and Apparatus

**Pre-visit Questionnaire and Interview Format**

Before the workplace evaluation was conducted, information was gathered from a senior member of staff at the participating organisations and/or the building facilities manager. This was to provide a basic understanding of the building as a whole and the organisations who occupied the environment. To gather this information a pre-visit questionnaire was developed. Having set questions allowed consistent information to be gathered. A copy of the questionnaire can be found in Appendix A.

The items within the pre-visit questionnaire were designed to gather information about the building, such as how the internal climate was controlled, and information about the occupying organisation such as the number of employees in the workplace. In addition to providing an overview of the workplace and organisation working there, the pre-visit questionnaire provided some objective measures of the workplace environment. For example, the amount of choice that users had in the design of their workplace was established by gathering information from a senior member of staff or the facilities management team heavily involved in the project to develop the new workplace. Where possible, the items within the questionnaire were designed to be open-ended so that a full response could be obtained from the building occupiers. However, the items within the pre-visit questionnaire were also used as the basic structure for the interview conducted with senior staff and/or facilities managers at the outset of the workplace evaluation. This was to ensure that adequate information was obtained to inform the evaluation and allow comparisons to be drawn between workplaces.

**Occupant Questionnaires**

A paper-based questionnaire was developed specifically for this research using other reliable and rigorously tested occupant surveys as guidance. Published surveys from the Probe Studies (Cohen et al, 2001) and OPI (Oseland, 1999) were used to establish questionnaire items. Using questions that were found to be reliable and valid measures, demonstrated by the results obtained by the researchers involved, provided a sound foundation to the occupant questionnaire. Quantitative factors such as air temperature and illuminance were measured successfully in the Probe studies. The items from the BUS questionnaire used to measure perceptions of the internal climate were adapted for this study as they were found to be reliable (Leaman, Bordass, Cohen, Standeven, 1999). However, the Probe studies did not focus upon the qualitative aspects of the environment including the fit out and features of the workplace. Therefore additional measures were developed and incorporated in the questionnaire. Questions were designed following good practice in survey design (Sapsford, 2007). All items created were developed to ensure that they were measuring the factors being researched. This provided data that was useful and applicable. The questions were designed to minimise ambiguity and the wording was tested with a focus group to ensure that the meaning of each question was clear and that accurate responses would obtained. The information required to respond to all questions was also evaluated to ensure that respondents had the knowledge to be able to answer every question.

As identified, the aspects of the workplace evaluated within this study, and therefore incorporated in the questionnaire were those that exist in the majority of workplaces and are reported in the current state of knowledge as having some link between them and the impact of the workplace environment upon users. To provide clarity for respondents the items were grouped into categories under headings in the questionnaire. These headings were: your job, layout, decoration. density, windows, furniture, break areas, temperature, light, noise, air, and personal control. The number of items under each heading ranged from four to eight. Information relating to respondents' characteristics including sex and age were included in the questionnaire in addition to information on their job characteristics. This was to ensure that these factors were not related to variation in the results. The items relating to respondents' jobs were taken from questionnaires designed to analyse job characteristics (Warr, 2002) that have been tested and their reliability and validity established.

Each response required a pre-set response to be selected from a list. The pre-set choice of responses to each question were carefully constructed so that they were mutually exclusive i.e. that a respondent was only able to select one point on a scale, or multiple choice list, unless offered the opportunity to select more than one response. This reduced confusion and also forced respondents to make a choice if answering the question. Data relating to individual characteristics was obtained using a series of multiple choice questions about the respondents. The remainder of the questionnaire focused upon the workplace environment and responses were on a scale of 1 to 7. Researchers have argued that this is the most effective scale as fewer categories do not allow respondents enough discrimination between points on the scale, and more than 7 categories can exceed respondents' ability to discriminate between points on the scale (Hancock & Klockars, 1991; Symonds, 1924).

In addition to the aspects of the workplace environment evaluated, three indicator variables were identified and measured within the questionnaire. These were titled overall satisfaction, overall impact and overall performance. Respondents were asked to rate how satisfied they were with the workplace environment overall by four items. Similarly, four items within the questionnaire were used to determine when users felt most stimulated at work and the relationship between stimulation and the environment. Perceived productivity was measured using items designed to obtain a relative measures of perceived productivity. That is, respondents were asked to rate how productive they were on their most recent full day at work in relation to their normal performance. Phrasing the items relating to perceived productivity in this way was

designed to elicit responses that were not the result of respondent bias, in particular social-desirability bias, or an over-estimating how productive respondents were. As an additional measure of productivity, occupants were asked to reveal how many days they had been absent from work in the previous six months. Absence from work through illness is another factor that can be applied to occupants in all workplaces and is an accepted measure of productivity where more accurate ways of measuring performance are not available (Warr, 2002) providing further data for correlational analysis.

A copy of the occupant questionnaire can be found in Appendix B.

**Objective Measurements**

Physical measures of the environment were taken using five separate pieces of environmental monitoring equipment. A digital thermometer/hygrometer was used to measure the air temperature and level of relative humidity in degrees centigrade and percentage respectively. The temperature of surfaces adjacent to the user were measured using an infrared thermometer in degrees centigrade. The sound levels in the workplaces were measured using a sound level meter set to record average decibel (dB) levels in a ten minute time period. The air movement was measured using an anemometer which recorded air speeds in m/s. Finally the illuminance levels were recorded using a handheld light meter which recorded the illuminance levels in lux.

Objective measurements of the spatial layout were taken using floorplans of the workplace. These layouts were marked-up during the evaluation of the workplace, i.e. changes to the layout were noted and additional information added. The additional information added was the location of plants and the location of artwork. The location of respondents in the workplace was also recorded on the spatial layout plans using a code which corresponded with the questionnaires.

Other objective measures which could not be measured with monitoring equipment or on the spatial layout plans was recorded in an observational report to provide as much objectivity as possible. A blank copy of the report can be found in Appendix C. The aspects of the workplace within the observational report were the design of the chair, design of the desk, personal equipment provided, storage provision, the partitions within the space, amount of daylight, the number of plants that could be seen from an individual's workstation and the colour of the walls seen from the individual's workstation.

### 8.4.4 Procedure

Once the eligible workplaces were identified, they were all contacted to determine whether they would be prepared to take part in the research. An initial meeting was arranged with each of the sixteen organisations who agreed to take part. At this meeting the process of the evaluation was described and agreement to go ahead with the data collection obtained from the organisations in question. An important part of this agreement was the assurance of confidentiality provided by the researcher. The organisations were assured that the name of their company would not be revealed in the research or any associated publications. This allowed them to retain anonymity and would encourage participants to answer questions truthfully. In addition, an assurance of confidentiality was offered to all occupants in the sample. Their specific responses were not revealed in the results reported, or to the management of their organisations. The confidentiality allowed them more freedom to answer honestly without concern about repercussions in relation to their responses.

To conclude the meeting a nominated representative who would act as the main contact from the organisation was established and a copy of the pre-visit questionnaire given to them. It was explained that the pre-visit questionnaire was designed to establish an overview of the organisation taking part and the workplace environment. This included obtaining details about the building management systems, the process followed when designing the workplace and the impact that the environment was having from their perspective. The organisations were left with a paper copy of the pre-visit questionnaire. They were asked to complete this in advance of the next meeting and to send it to the researcher in advance if possible. However, they were made aware that the interview at the next meeting would be based upon the pre-visit questionnaire and that they could use this interview to detail and elaborate upon their responses. A date for the data collection from sampled building users was agreed approximately two weeks from the initial meeting.

A period of three days for data collection within the workplace was agreed. In these three days questionnaires were distributed and collected and objective measures taken. In addition, an interview with the senior manager and/or facilities manager was held on the first day of the data collection period. In this interview the organisations were prompted to give further information to their responses to the pre-visit

questionnaire. At the end of the interview the sample was randomly selected from staff lists which the organisation was asked to provide.

Once the sample of users within the workplace had been identified paper questionnaires were distributed. Paper questionnaires were developed to ensure a higher response rate than would be expected from electronic questionnaires. Even though a larger number of people could easily be sampled using electronic questionnaires, a lower response rate would lead to a risk of respondent bias. The questionnaires were handed out to people in the sample by the researcher so that the purpose of the research could be explained and the confidentiality of their responses guaranteed. The purpose of the research was also incorporated on the front of the questionnaire which can be found in Appendix B. Respondents were informed that they did not have to answer any questions they felt uncomfortable responding to, or were not able to answer. When occupants feel uncomfortable answering questions they are less likely to respond to the questionnaire and take part in the study. This is a common problem with self-completed questionnaires where respondents are often found to have concerns about anonymity and implications relating to the responses they are giving (Yates, 2004). This can lead to social desirability bias or an un-returned questionnaire (Robson, 2002; Sapsford, 2007). A partially completed questionnaire is more valuable than a questionnaire that is not returned at all as there are still some responses that can be used within the analysis. To maximise the data collected and ensure that the sample was as representative as possible it was considered prudent to allow respondents to not respond to questions if they felt uncomfortable answering them. Respondents were informed that they could return the questionnaires to the nominated person from their organisation, the researcher or to a designated location and that they could chose the way that was easiest and preferred by them. A code was allocated to each respondent which was recorded on the spatial layout plan at their location in the workplace and on the front of their questionnaire. This code was a letter from A to P designated to their workplace and a number between 1 and 30 allocated in the order that the questionnaires were distributed.

For the following two days objective measures were collected in the workplace. Physical measures of the workplace were taken using environmental monitoring equipment. Hand held devices were used to measure the internal climate at the workstation of each of the respondents in both the morning and afternoon. The factors measured were; air temperature, relative humidity, radiant temperature, illuminance, air movement and sound. Measurements were taken at occupants' desks to allow

comparisons to be drawn between the responses that they gave to the items within the questionnaire and the actual conditions at their workstation. Most measures (except sound level which was taken as an average over 10 minutes) were taken at four random spots at the respondents workstation. It was important to measure the internal climate at their desks rather than take a general measurement of the whole environment as conditions could vary significantly across the workplace. Taking measurements in both the morning and afternoon allowed researchers to determine whether conditions at occupants' workstations remained consistent throughout the day.

Objective measurements relating to the spatial layout of the workplace were collected using a spatial layout plan. The plans were marked-up with additional information; the location of respondents within the workplace, the location of plants, the location of artwork and any changes that were made to the arrangement of the workplace since the layout plans were produced. The qualitative factors measured that could not be marked on the spatial layout plans, such as the colour of the walls or the amount of personal storage of each respondent, were recorded in a standardised observational report. As all the data was recorded by the same researcher, there is consistency in the responses making them more reliable and comparative as objective measures. Qualitative factors were quantified, where possible, for objectivity. This was to allow comparisons to be drawn between occupant perceptions and the physical workplace. For example the objective measure of colour scheme was the number of different colours used in the decoration of the workplace that a respondent could see from their desk.

At the end of the three day data collection a short de-briefing session was held with the nominated individual from each organisation. They were thanked for taking part and giving their time to help with the successful completion of the data collection. They were also offered the opportunity to see the results in the form of a short report for their own workplace. It was agreed that this report, if desired, would be sent within two weeks of the data collection being completed. The data, both objective and attitudinal from the questionnaires was entered into Excel and SPSS for analysis.

### 8.4.5 Pilot Study

To test the validity and reliability of the methodology before the research commenced in the participating workplaces, a pilot study was conducted in the workplace of Ryder

Architecture. A random sample of 15 occupants was selected from a staff list and asked to complete the research questionnaire. They were also asked to answer a few feedback questions to determine how long it had taken them to complete the questionnaire, whether there were any questions they did not understand and whether there were any questions they could not, or did not want to, answer. In addition to the questionnaire, objective measurements of the environment were collected using the methodology developed for this thesis.

The feedback on the questionnaire was positive with only two items being found to cause respondents any difficulty in terms of comprehension. As a result the items identified were amended. The first related to the number of people they worked with and this was clarified with the size of team in terms of numbers of people being specified. An item relating to stimulation was also re-worded to clarify the meaning of atmosphere in the workplace. There was no indication from the feedback that there was an aspect of the workplace environment that had not been incorporated in the questionnaire and all respondents were able to complete the questionnaire in under 30 minutes. Half an hour was deemed to be an acceptable length of time for them to remain engaged in the research. This was based upon recommendations made by the focus group initially consulted about the research and respondents in the pilot study. The objective measures were taken successfully and useful data gathered.

### 8.5 Summary and Conclusions

A review of different research methods revealed those that were most appropriate for an holistic evaluation of the workplace environment. The benefits and limitations of laboratory studies and real world research were considered. In addition, the advantages and disadvantages of specific tools including questionnaires and objective measures were analysed. Existing research, particularly those studies taking a more holistic approach to evaluating the workplace environment were reviewed to identify the research methods they had adopted. The success of the various methods utilised within the research in terms of validity and reliability was established. All of this understanding provided the foundation for the development of the research methodology for phase one of this thesis. The methodology comprised an interview with senior management, an occupant questionnaire, environmental monitoring, marked-up spatial layout plans, and observational reports. Sixteen organisations took part in the research and 390 datasets were collected from a random sample of participants in each workplace.

## Chapter 9 Results of Workplace Evaluations

### 9.1 Introduction

All user perceptions and objective measurements were analysed to determine satisfaction with each aspect of the workplace. In addition, the relationship between perception and objective measurements of the environment were analysed. The data was grouped into four categories for ease of evaluation and graphical representation. The four categories nominated were based upon the evidence from the current state of knowledge and were: internal climate, spatial layout, interior design and workplace features.. Once categorised the data was analysed to determine user perceptions of the workplace environment. The mean ratings for all users, across all workplaces were calculated and plotted on graphs for analysis. By evaluating the satisfaction of all users and workplaces together, patterns in user satisfaction were established that would not necessarily have been possible with individual case studies where many other factors would have affected the results. The standard deviations from the means were analysed to determine whether users' levels of satisfaction with each factor were similar across all participants from all workplaces. The differences between workplaces were also analysed with data for each individual workplace being plotted on radar plots for comparison. These graphs can be found in Appendix D.

Some items from the questionnaires were grouped at this stage as they were deemed to be measuring the same or a similar construct. The factors which are a result of a combination of items are: air temperature, relative humidity, noise, illuminance, choice and personal control. To ensure that these factors were reliably clustered, the significance of the relationship between the variables was calculated using Cronbach's Alpha. This allowed the reliability of the categories that were created to be determined. In addition to revealing whether variables can reliably be grouped, Cronbach's Alpha also reveals how significant the reliability score would be if a variable were removed. The Alpha Scores in this instance revealed that the items from the questionnaire highlighted could be reliably grouped. The measures of air temperature in the morning and afternoon, summer and winter combined had a coefficient alpha of .811. The measure of illuminance in the morning, afternoon, summer and winter produced a coefficient alpha of .915. The sound levels in the morning, afternoon, summer and winter produced a coefficient alpha of .965. The relative humidity in the morning, afternoon, summer and winter produced a coefficient alpha of .954. The air movement in the morning, afternoon, summer and winter produced a coefficient alpha of .919. The

personal control individuals had over the air temperature, illuminance, sound levels and ventilation produced a coefficient alpha of .804. The amount of choice users had in the spatial layout, decoration and furniture provision produced a coefficient alpha of .804. Each variable was tested to ensure that the scale was not more reliable if one or more of the items were deleted and for all variables this was the case. Therefore with the high coefficient alphas and the results suggesting that none of the items should be deleted from any of the factors.

Following an analysis of the individual items from the questionnaires and comparisons with the objective measures, a factor analysis of all the aspects of the workplace measured was conducted. This allowed constructs to be established that were made up of items that could be reliably grouped for analysis. This calculation was based upon the amount of variance between items and whether this was significant enough to conclude that they were measuring the same thing. The factor analysis revealed that there were 16 components measured by the questionnaires. These new components were used for further analysis in relation to the indicator variables of overall satisfaction, stimulation and perceived productivity detailed in the following chapter, Chapter 10.

### 9.2 The Internal Climate

The perceptual data from the questionnaire responses was analysed to determine the mean rating of each aspect of the internal climate across all workplaces. The average rating obtained was plotted on a radar graph. The mean rating relates to the seven point Likert Scale used within the questionnaire. The data was recoded where necessary so that seven was the highest level of satisfaction and one the lowest. Therefore any mean rating of the workplace environment above four on the scale represents a positive user rating on the scale. The mean score of users from all the workplaces is denoted on the graph by the red line. The Likert Scale is represented by the grey lines with seven at the extremity of the graph and zero at the centre. The blue line denotes the minimum level of satisfaction which is four on the Likert Scale. The more satisfied users were with an aspect of the internal climate, the closer the red line is to the outside of the graph and the maximum rating of seven. The perceptual data for the internal climate is highlighted on the radar plot in Figure 6.

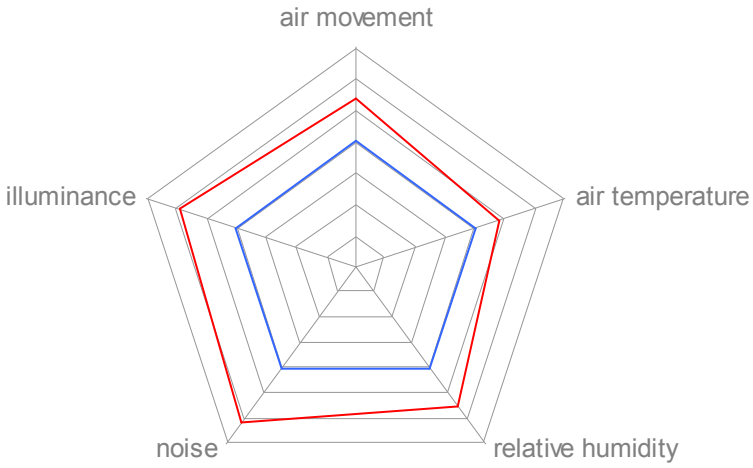



Figure 6. Graph to Demonstrate User Perceptions of the Internal Climate

This graph demonstrates that users' perceptions of the internal climate were very positive. The air temperature, relative humidity, noise levels, illuminance and air movement were all rated as being very satisfactory and users felt that the internal climate was comfortable. To determine whether the perceptions of users were similar between individuals and across workplaces the standard deviations from the mean rating of satisfaction were calculated. These are reported in Table 2.

| | **Minimum** | **Maximum** | **Mean** | **Standard Deviation** |
|---|---|---|---|---|
| Air movement | 1 | 7 | 5.36 | 1.94 |
| Air temperature | 1 | 7 | 4.82 | 1.80 |
| Relative humidity | 1 | 7 | 5.53 | 1.88 |
| Sound | 1 | 7 | 6.16 | 1.41 |
| Illuminance | 1 | 7 | 5.93 | 1.58 |

Table 2 Descriptive Statistics for User Perceptions of the Internal Climate

The table reveals that overall users were equally satisfied with the internal climate and there were no considerable differences between individual respondents and between workplaces. The radar plots of the individual workplaces can be found in Appendix D. These highlight a similar pattern of results across workplaces. Together, the radar plots and standard deviations reveal that the internal climate was liked by the majority of

users across all workplaces. The air temperature was perceived as neither too hot nor too cold, the air movement and humidity levels were rated as good being neither too draughty nor too still and not too damp nor too dry. The sound levels were rated as being good, not too loud nor too quiet. Finally, the illuminance levels were perceived to be very satisfactory as the workplace was not too bright or too dull. To determine whether these user perceptions were related to the actual internal climate conditions, the subjective measures were compared with objective measures taken in the workplaces.

Table 3 highlights the mean rating of each aspect of the internal climate given by the users. This rating is compared with the corresponding objective measure detailed in column two. For the internal climate the objective measure for comparison with the subjective responses was the difference between the measurement taken and the mid-point in the range recommended within the design guidance. This is because the factors that comprise internal climate are all bi-polar (e.g. too cold or too hot) however they fall on a single scale (e.g. ˚C). This means that without identifying a point at which users are assumed to be comfortable, as indicated within the design guidance, the correlational analysis would only indicate whether people were more satisfied when they were too hot or too cold. The differences of the objective measures from the mid-point of the design guidance range are detailed in column two. The results of a statistical test used to determine whether there is a significant relationship between the subjective and objective measure is reported in the final column.

| **subjective measure** | **objective measure** | **objective average** | **correlation** |
|---|---|---|---|
| Air temperature | air temperature am (difference from 22.5˚C) | 22.67˚C | not significant |
| Air temperature | air temperature pm (difference from 22.5˚C) | 23.16˚C | not significant |
| Illuminance | illuminance am (difference from 550 lux) | 552.60 lux | not significant |
| Illuminance | illiminance pm (difference from 550 lux) | 565.02 lux | not significant |
| Sound | sound level am (difference from 50dB) | 58.59 dB | not significant |
| Sound | sound level pm (difference from 50dB) | 58.53 dB | not significant |
| Relative humidity | relative humidity am (difference from 45%) | 38.31 % | r=0.117,df=340,p<0.05 |
| Relative humidity | relative humidity pm (difference from 45%) | 37.59 % | r=0.107,df=341,p<0.05 |
| Air movement | air movement am (difference from 0.15m/s) | 0.02 m/s | not significant |
| Air movement | air movement pm (difference from 0.15m/s) | 0.02m/s | not significant |

Table 3 Correlations Between Objective and Subjective Measures of Internal Climate

The table reveals that the mean, objective measures of the air temperature, relative humidity and illuminance fell within the range recommended by the design guidance which was detailed in Chapter 4. The mean air temperature across all workplaces was 22.67˚C in the morning and 23.16˚C in the afternoon which is within the design guidance range of 21 to 24˚C. The mean illuminance level was 553.60 lux in the morning and 565.02 lux in the afternoon which is within the recommended range of 300 to 800 lux. The mean relative humidity was 38.31 % in the morning and 37.59 % in the afternoon which is within the range of 30 to 60 % recommended within the design guidance.

There were two aspects of the internal climate of the workplace environment which, when measured objectively were found to be outside of the recommendations in design guidance; sound levels and air movement speeds. The mean sound level recorded was significantly higher than that recommended within the design guidance at 58.59 dB in the morning and 58.53 dB in the afternoon. The recommended maximum level of noise is 45dB. However, it must be noted that the recommended range for comfort with regards to sound refers to background sound within an unoccupied workplace. There is no official design guidance to indicate what constitutes comfortable sound levels within an occupied office. However, conclusions from the research evaluated as part of the current state of knowledge revealed that the average dB level was 50dB in an open plan office. The mean level of sound recorded within this research was 58.5dB which is above the average sound level. 50dB was taken as the mid-point from which the actual ratings deviated for the comparison with the subjective responses as it was felt to be more representative than the unoccupied workplace recommendation.

At 0.02 m/s in both the morning and afternoon air movement was well below the recommended range of 0.05m/s to 0.25m/s. The air movement speeds recorded in each of the workplaces ranged significantly from 0.00m/s through to 0.4m/s. Ventilation, and therefore the majority of air movement, in over half of the workplaces was provided by swirl vents. These lead to very localised air movement as air is pushed along a pipe system and the pressure forces air up through vents in the floor. Higher air movement speeds were recorded adjacent to these vents. However, much lower speeds were recorded at a distance of 0.4m away or more. As the majority of these swirl vents were located away from the workstations along circulation routes, it may be that users perceived the air movement speeds to be higher as it fluctuated when they moved around the workplace. All the measurements of the internal climate,

aside from air movement and noise, fell within the range recommended by design guidance and research. The high levels of user satisfaction with the internal climate therefore support the recommended ranges of the design guidance. However, air movement speeds were significantly lower than the design guidance range and users were still satisfied. To determine what the relationship was between the measurements of the internal climate and the user perceptions, the objective and subjective data were compared. The final column in Table 3 highlights where there were significant correlations between the subjective and objective data.

The results reveal that there is no significant correlation between the air temperature, air movement, sound levels and illuminance and user perceptions of these factors. Actual variation in these aspects of the internal climate were not reflected in changes of user satisfaction. This could be interpreted as the actual internal climate having little impact upon user perceptions. However, there is a possible explanation for the lack of significant correlations which relates to the moderate nature of the environments tested. The ranges of the objective measures of the internal climate were relatively low with only moderate differences recorded. A change of 1˚C in air temperature or 1dB in sound levels, for example, is unlikely to be detected by the majority of respondents and therefore their perception of the environment may not vary. McKeown (2008) suggested that a change of at least 5dB was required before users were able to detect a difference in sound levels in a workplace setting. If more extreme conditions were recorded the number of significant correlations between the objective and subjective measures may have increased as highlighted by the findings from earlier research. The lack of impact of moderate variance in actual conditions is supported by the current state of knowledge where design guidance was challenged for being too prescriptive with people being comfortable in conditions outside of the design guidance range.

There was a significant, positive correlation between relative humidity and user perceptions. As the humidity levels moved further away from the mid-point of the range recommended within the design guidance, satisfaction levels decreased. There is no evidence to indicate that users should be more susceptible to changes in relative humidity levels than changes in air temperature or air movement. In addition the standard deviations from the mean for the objective measures of relative humidity were not particularly high therefore there were not extremes of relative humidity within the workplaces. One possible explanation is that users can be more sensitive to changes in relative humidity if they wear contact lenses which tend to dry out in lower relative humidity conditions. This was raised by several respondents in different workplaces

during the research. However, no empirical data was collected to support this explanation and it would require further testing.

Overall, in terms of user attitudes, there were fairly consistent results between workplaces. Standard deviation data revealed that the results did not differ significantly across the workplaces and both the individual workplace graphs and objective measures of the workplace support the assertion that the internal climate was similar in all workplaces. To highlight where there were some differences in user perceptions and how this was reflected in the actual internal climate conditions, two workplaces have been identified as differing most clearly from the mean; Workplace I and Workplace P.

In Workplace I users rated themselves as being more satisfied with all aspects of the internal climate in relation to the mean overall ratings. Users of Workplace I were very satisfied with all aspects of the internal climate and this was true for all respondents from Workplace I. Objective measures of the environment demonstrated that they did in some cases differ from the mean. Air temperature was lower than the mean in both the morning and afternoon. The mean air temperatures from all workplaces were 22.67ºC in the morning and 23.16 ºC in the afternoon, the mean air temperature in Workplace I was 20.88ºC in the morning and 21.14 ºC in the afternoon. Relative humidity was also lower in Workplace I than the sample of workplaces. It was 25.4% in the morning and 24.5% in the afternoon in Workplace I. The mean measures from all workplaces were 38.3% in the morning and 37.6% in the afternoon. The air movement in Workplace I was the same as the air movement in all workplaces to 2 decimal places at 0.02m/s in both the morning and afternoon. The other internal climate factors differed from the mean with illuminance levels in Workplace I being higher than the average at a mean level of 712.7lux in the morning and 609.7lux in the afternoon. The mean from all workplaces was 552.6lux in the morning and 565.0lux in the afternoon. Lastly, noise levels differed from the mean. Despite the small number of occupants in Workplace I, background sound levels were higher than the overall mean in both the morning and afternoon. Background sound levels in Workplace I were 62.8dB in the morning and 61.6dB in the afternoon. In comparison the sound level across all workplaces was an average of 58.6dB in the morning and 58.5dB in the afternoon. These comparisons of the objective measures from Workplace I with the overall mean measures from all workplaces indicate that there were some differences but that Workplace I did not deviate greatly from the overall mean. Thus, there must be other factors influencing satisfaction. One possible explanation is satisfaction of the personal preference of the users of this workplace. There were only 11 users in Workplace I and

they were therefore able to exert a greater degree of influence on the internal climate conditions. This may explain their higher levels of satisfaction.

Conversely in Workplace P, users overall rated themselves as being less satisfied than the average across the workplace with all aspects of the internal climate, particularly air movement. Analysis of the standard deviations from the mean of responses in Workplace P revealed that there was greater difference in the attitudes of users compared to users from all workplaces in relation to illuminance (Workplace P was a standard deviation from the mean of 2.2 points, the overall standard deviation was 1.5 points on the Likert Scale), air movement (Workplace P was a standard deviation of 2.3 points compared with 1.9 from all workplaces) and relative humidity (Workplace P was a standard deviation of 2.3 points compared with 1.9 from all workplaces combined). These results suggest that different people in Workplace P had differing attitudes towards aspects of the internal climate which may have been related to the variation in conditions around the environment. Further investigation of the objective measurements reveals that there were no real differences between the objective measures of Workplace P and the overall measures for air temperature (less than 1 ºC in both the morning and afternoon), and air movement (less than 0.01m/s difference in both morning and afternoon). However, the users of Workplace P were less satisfied than the overall average with the air movement and air temperature suggesting that there were other factors which influenced user satisfaction beyond the actual internal climate conditions. There was a difference between relative humidity which was lower in Workplace P than the average, particularly in the afternoon, and sound levels which were higher than the overall mean in Workplace P. However, users were only slightly less satisfied with the relative humidity levels and sound levels in Workplace P than users overall. There was user dissatisfaction with the illuminance levels and the objective measures reveal that the illuminance levels in Workplace P were lower than the overall mean level. They were 550.6lux in the morning in Workplace P in comparison with the overall mean of 552.6lux in the morning. The difference was greater in the afternoon with the mean illuminance level in Workplace P being 488.6lux compared with a mean of 565.0lux from all workplaces. These results demonstrate that the differences between the actual workplaces and user perceptions are not consistent but there are reasons for these findings, such as personal preference. This is supported by the analysis of standard deviations of user perceptions whereby the standard deviations from users' attitudes towards illuminance, air movement and air temperature were much greater in Workplace P than all workplaces combined. This

suggests that there may have been differences in the conditions around the workplace which affected users' perceptions.

Whilst collecting data it became apparent that there were isolated issues associated with the internal climate that users were aware of in Workplace P and this affected their attitudes and responses to the questionnaires. For example, air movement overall in Workplace P was rated as satisfactory but individual users were dissatisfied when they were located near to an external door in the atrium or adjacent to swirl vents at the end of a floor in which other vents were purposely blocked forcing all the air to one end of the system.

There were few significant correlations between the objective measures of the internal climate and users' attitudes. The insight gained from analysis of the data has been supplemented by a more general understanding of the workplaces from the immersion of the researcher into these environments. There is a clearer appreciation of the reasons for users' attitudes and the differences between workplaces as a result of the methodology developed. Mean objective measures from all workplaces revealed fairly comfortable conditions in relation to the design guidance recommendations. However, higher levels of satisfaction can, in part, be explained by workplaces with fewer users being adapted to suit personal preferences as there were less people to influence the decision differently. Negative ratings of the workplace environment tended to be reported in workplaces where there was an isolated issue or source of dissatisfaction such as localised air movement from the proximity to external doors.

### 9.3 The Spatial Layout

As with the internal climate, both objective and subjective data was collected and analysed. Patterns across all workplaces were established to determine the impact of the spatial layout on workplace users' satisfaction. The mean user rating of the spatial layout from all workplaces was calculated and plotted on a radar plot (Figure 7). As before the red line denotes the mean user rating. The seven point Likert Scale is represented by the grey lines with seven, the highest level of satisfaction, being the extremity of the graph and zero at the centre. The closer the red line falls to the edge of the graph, the more satisfied users were with that aspect of the spatial layout. The blue line denotes four on the Likert Scale which is the minimum level of satisfaction. Anything below this blue line indicates that users were dissatisfied with this factor.

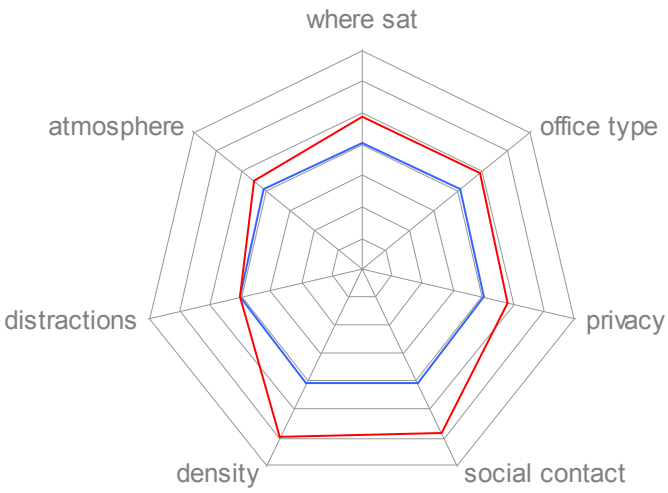



Figure 7 Graph to Demonstrate User Perceptions of Spatial Layout

The graph demonstrates that users were satisfied with all aspects of the spatial layout. This is demonstrated by the red line falling between the blue line and the outside of the graph. Overall, user satisfaction with the spatial layout is lower than satisfaction with the internal climate. The red line is much closer to the blue line used to denote minimum satisfaction. In particular, the mean rating for the number of distractions in the workplace is 4.04 on the seven point scale which is only just on the positive side of the satisfaction scale. These lower levels of satisfaction in comparison with the internal climate indicate one of two possibilities. The first is that the majority of users all experienced lower levels of satisfaction with the spatial layout than they did for the internal climate. The alternative explanation is that the levels of satisfaction between respondents and workplaces varied to a greater extent and this influenced the results. There may for example have been people in one or two of the workplaces who were very dissatisfied with the number of distractions and this reduced the overall mean level of satisfaction. To determine whether the majority of workplace users were equally as satisfied with the spatial layout or whether there were significant differences between individuals and workplaces, standard deviations from the mean were calculated. These are reported in Table 4 along with the maximum and minimum ratings given.

| | Minimum | Maximum | Mean | Standard deviation |
|---|---|---|---|---|
| where sat | 1 | 7 | 4.84 | 1.55 |
| office type | 1 | 7 | 4.84 | 1.59 |
| privacy | 1 | 7 | 4.80 | 2.05 |
| social contact | 1 | 7 | 5.76 | 1.65 |
| density | 1 | 7 | 5.89 | 1.84 |
| distractions | 1 | 7 | 4.04 | 1.73 |
| atmosphere | 1 | 7 | 4.48 | 1.52 |

Table 4 Descriptive Statistics for User Perceptions of the Spatial Layout

The table highlights that there was a good spread of data with ratings of the workplace environment ranging from the minimum score of one right through to the maximum score of seven. This demonstrates that user perceptions of the spatial layout ranged from very satisfied to very dissatisfied. The majority of the standard deviations are below two points on the seven point scale. Only the standard deviation for privacy is slightly above two points at 2.05. The relatively low standard deviations indicate that large numbers of the sample were equally satisfied with the spatial layout. The mean scores were not the result of widely varying user perceptions. Most users were satisfied with where they were sitting in the workplace, the type of office they worked in, the amount of social contact they had, the density of the workplace, the number of distractions they experienced and the atmosphere within the workplace. A standard deviation from the mean of more than two points for privacy suggests that the user perceptions were slightly more dispersed. There were a significant number of users who were very satisfied with the amount of privacy that they had. However, there were also a number of respondents who were dissatisfied with the level of privacy and this reduced the mean satisfaction rating. Evaluation of radar plots for individual workplaces revealed that the pattern of results across workplaces was fairly similar. Therefore any standard deviations from the mean are a result of individual differences between users as oppose to variance in the ratings of satisfaction of the different workplaces.

To determine whether the user perceptions of the spatial layout were related to the actual conditions within the workplace environments, the subjective user perceptions were correlated with the objective measures. The objective data collected and the results of the correlation are reported in Table 5.

| subjective measure | objective measure | objective average | correlation |
|---|---|---|---|
| where sat | distance from shell (m) | 6.2m | not significant |
| where sat | floor in building (storey) | ground | not significant |
| office type | office type eg open plan (type) | open plan | not significant |

Table 5 Correlations Between Objective and Subjective Measures of Spatial Layout

The table reveals that there were no significant correlations between the objective measures and the subjective measures in relation to where users were located within the workplace and the type of office they occupied. Users were not more or less satisfied with where they were sitting when their distance from the external wall and the floor of the building on which they were located varied. This suggests that there are other factors affecting satisfaction with location in the workplace than those measured. These may be factors that are related to other aspects of job satisfaction as a whole such as relationships with colleagues or location in relation to supervisor. As these other factors could not be controlled in the field setting it was not possible to determine whether the storey of the building or the distance a respondent was located from the external wall would have an impact if all other factors were equal. In addition, it should be noted that as with the internal climate, the conditions of the spatial layout were fairly moderate and there were no extremes. The workplaces surveyed were not particularly tall with the highest building being five storeys. A building of say 90 storeys may have produced different results as users may have had a more positive or negative perception of where they were located within the workplace. In addition, the floorplates of the buildings were relatively shallow with users sat a maximum of 38m from an external wall. As with the height of the building, a wider floor plate may have led to a more significant relationship with user satisfaction.

In addition to the standard deviations, the graphs in Appendix D demonstrate that there was not a great difference in user satisfaction with the spatial layout, with the exception of privacy, between workplaces. Indeed the descriptions of each of the workplaces and the objective measures of the workplaces indicate that the actual spatial layout in most workplaces participating did not really differ with 75% being a mixture of open plan and cellular spaces. To highlight where there were some differences between users' perceptions of the spatial layout, two of the workplaces which varied most notably from the mean score in relation to the spatial layout have been considered to determine the potential reasons for these results.

Workplace L produced the highest level of satisfaction with the spatial layout across all aspects measured, except density. The workplace was completely open plan with the only enclosed spaces being the managing directors office and some bookable meeting rooms. However, due to the nature of the workplace, a refurbished industrial building with a mezzanine floor, there were natural dividers in the space such as columns and half height walls. These dividers provided a degree of privacy and were able to minimise disruptions from noise. In addition, the desks were laid out in clusters and faced inwards so that users were grouped together with others with whom they worked. Density was rated negatively but this was accounted for by the office manager in the interview where she reported that they had more people working in the office than the space was intended to accommodate and that they were in the process of moving one team to an adjacent, vacant space to reduce the density levels.

In Workplace P there was greatest dissatisfaction with some aspects of the spatial layout; where sat, type of office and privacy. The attitudes of users were not different to the mean for all other aspects of the spatial layout. Although classified as open plan, the same as Workplace L, the design of the two workplaces was very different which may explain the difference in levels of user satisfaction. The layouts of the two workplaces are demonstrated in Figure 8 and 9.

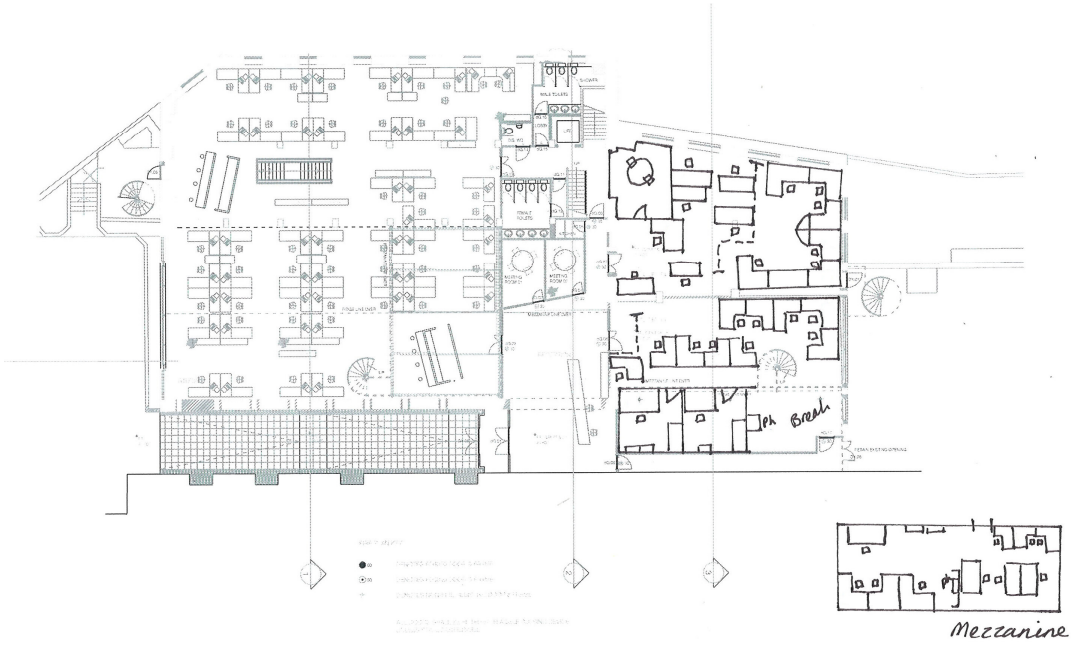



Figure 8 Spatial Layout of Workplace L

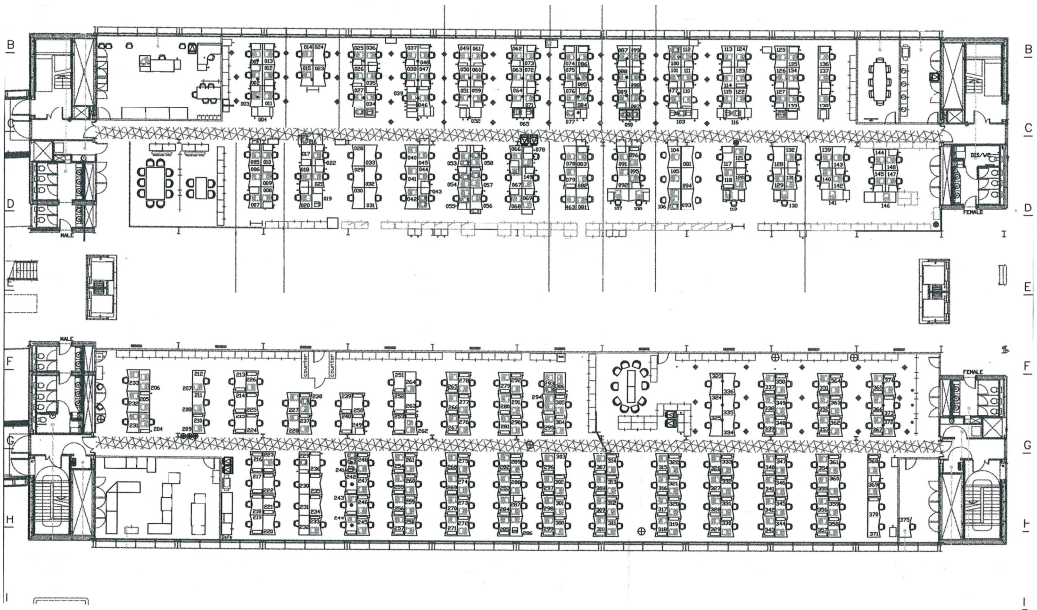


Figure 9 Spatial Layout of Workplace P

As is indicated, Workplace P was a very large, rectilinear floorplate opening out onto a large multi-storey atrium. There was little distinction within the floorplates either side of the atrium and no clear zoning in terms of spatial layout within the open plan spaces. Thus, there were a lot of people working simultaneously in one area and nothing to separate them, reduce distractions from other users and reduce sound transfer around the space. The design of this workplace epitomises some of the large open plan spaces detailed within the current state of knowledge (for example Brookes and Kaplan, 1972; Marmot and Eley, 2000; Wineman, 1986) and similar problems with privacy and distractions were discovered.

Although there were no significant correlations between user attitudes and objective measures, taking the questionnaire data and having spent time in the workplaces whilst they were in operation, an understanding has been gained of the relationship between the actual layout and user attitudes. It was clear that the relationship between the type of office (e.g. open plan, cellular, etc) was not simple with one type of office being preferred over another. An open plan office may have been considered satisfactory if it contained elements which offered benefits such as increased privacy. Differences in size, design and the zoning of a space all appeared to make a difference to satisfaction levels. Space itself and layout did not appear to make as great a difference as the design of the workplace in terms of spatial layout. Historical status related preferences for higher floors in a building, as highlighted in the current state of knowledge (Sundstrom, 1986) were not revealed in the research for this thesis. Visiting the

workplaces and seeing them in operation provided a greater understanding of the relationship between attitudes and layout. For example, users overall were not satisfied with where they were located. This was not found to be significantly correlated with the distance they were located from the exterior wall of the building or the floor within the building, but with the impact of the overall spatial layout of the workplace.

### 9.4 The Interior Design

User perceptions of the interior design of the workplace were measured to establish patterns of responses across workplaces. These were then analysed in relation to the objective measures of the interior design. The mean rating of satisfaction given to each aspect of the interior design was calculated across all workplaces and plotted on a radar graph (Figure 10). As before, the red line indicates the users' mean level of satisfaction, the blue line indicates a minimum level of satisfaction and represents four on the seven point scale. The Likert Scale from the questionnaire is represented by the grey lines with seven, the maximum rating of satisfaction, being at the extremity of the graph and the centre being zero. If the red line falls beyond the blue line it has been rated positively by users and the closer it is to the outside of the graph the more satisfied people were with that aspect of the interior design.

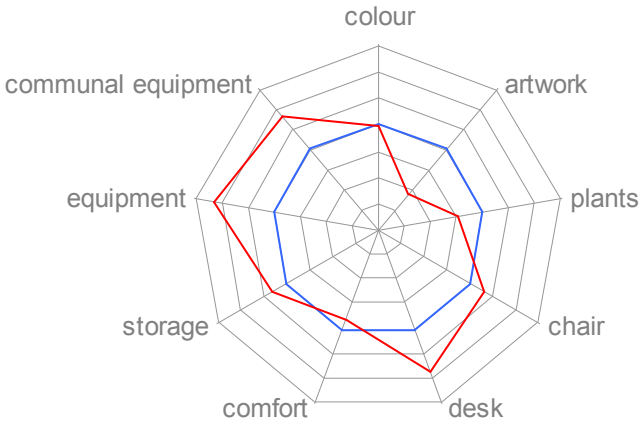



Figure 10 Graph to Demonstrate User Satisfaction with the Interior Design

The radar plot highlights that users were very satisfied with some aspects of the interior design: their chair, the desk, the amount of personal storage they had, their equipment and the communal equipment. Users rated their chair as being comfortable and the

desk a good size for the work they were doing. They liked the amount of personal storage and equipment that they had at the desks and rated the communal equipment as being a very satisfactory distance from their desks. However, the mean rating for colour scheme, artwork, plants and comfort were below the minimum level of satisfaction and were therefore considered by users to be dissatisfactory. Many users felt that the colour scheme was unattractive and that the number of artwork pieces and the provision of plants in the workplace was inadequate and unattractive. Users also reported feeling uncomfortable after sitting for long periods of time, despite the fact that they rated their chair and desk as being satisfactory. To further understand user perceptions of the interior design the standard deviations from the mean were calculated to see how much user perception differed between individuals and workplaces. The minimum, maximum and mean ratings are detailed in Table 6 along with the standard deviations from the mean.

| | **Mean** | **Minimum** | **Maximum** | **Standard Deviation** |
|---|---|---|---|---|
| Colour | 3.92 | 1 | 7 | 1.49 |
| Artwork | 1.75 | 0 | 7 | 2.33 |
| Plants | 3.05 | 0 | 7 | 2.39 |
| Chair | 4.58 | 1 | 7 | 1.61 |
| Desk | 5.70 | 1 | 7 | 1.87 |
| Comfort | 3.63 | 1 | 7 | 1.59 |
| Storage | 4.59 | 1 | 7 | 2.35 |
| Equipment | 6.27 | 1 | 7 | 1.45 |
| Communal equipment | 5.55 | 1 | 7 | 2.12 |

Table 6 Descriptive Statistics for User Perceptions of the Interior Design

The data recorded in the table highlights that the users' ratings of the interior design ranged from very satisfied to very dissatisfied, with the maximum and minimum levels of user satisfaction being one and seven on the seven point Likert Scale of satisfaction. This provided a good spread of results. The standard deviations range from 1.45 on the seven point scale to 2.39. This suggests that some of the user perceptions are more varied than others. The user ratings of the colour scheme, chair, desk, comfort and equipment provided deviate less than two points from the mean. This suggests that the majority of users perceive these aspects of the interior design to be equally satisfactory. This is less true of the aspects of the interior design which had standard

deviations that were greater than two points on the scale. Satisfaction with the provision of artwork and plants, personal storage and communal equipment vary considerably from the mean rating. This indicates that there are either individual differences with regards to satisfaction or there are notable differences between the workplaces. The different designs of the workplaces within the research could have affected users' perception of the interior design. To determine whether this was the case, the mean satisfaction ratings with the interior design were plotted for each workplace separately. These radar plots can be found in Appendix D. The pattern of results is different between the workplaces for some factors, particularly colour scheme, artwork, plants, comfort, the distance of communal equipment and personal storage. This indicates that there are differences in perceptions between the workplaces. To determine whether this variance is a result of differences in the actual workplaces, the relationship between the objective and subjective measures of the interior design were analysed. A correlational analysis was conducted and the results presented in Table 7.

| **subjective measure** | **objective measure** | **objective average** | **correlation** |
|---|---|---|---|
| Colour scheme | colours seen from desk (number) | 2.5 colours | r=0.181,df=292,p<0.01 |
| Artwork | artwork seen from desk (number) | 0.1 pieces | r=0.227,df=273,p<0.001 |
| Plants | plants seen from desk | 0.7 plants | r=0.287,df=294,p<0.001 |
| Chair | arms. tilt & height adjustable chair (y/n) | yes | r=0.215,df=270,p<0.001 |
| Desk | size of desk (m²) | 2.0 m² | r=0.143,df=283,p<0.05 |
| Personal storage | amount of personal storage (number of | 1 pedestal unit | r=0.226,df=268,p<0.001 |
| Communal equipment | distance of communal equipment (m) | 11.7m | not significant |

Table 7 Correlations Between Objective and Subjective Measures of Interior Design

The table demonstrates that there were correlations between the objective measurements of the interior design and the related subjective ratings. The number of colours that each user could see from their workstation was significantly related to how satisfied they were with the colour scheme in the workplace. The more colours they could see the more satisfied they were. The low standard deviation of user satisfaction from the mean suggests that most people were dissatisfied with the colour scheme in their workplace and this is related to a limited number of colours being seen from their workstation. The average number of colours that could be seen was 2.5, one of which

was usually white or cream. The objective measurements of the amount of artwork displayed and users' satisfaction with the artwork is significantly, positively correlated. This strong relationship indicates that the less artwork there is in the workplace, the less satisfied users were. There was very little artwork displayed in the workplaces, 0.1 pieces on average, which is related to the low level of satisfaction with the artwork. A similar relationship was found with the number of plants in the workplace and user satisfaction. The more plants there were the more satisfied users rated themselves and the more attractive the plants in the workplace. The average number of plants in the workplace overall was only 0.7 and is correlated with a low level of user satisfaction. There were also significant correlations discovered between the furniture provision and user perceptions of their furniture and equipment. Users were more satisfied with their chair when it was fully adjustable and had arms. The users were also more satisfied with their desk the bigger it was and were more satisfied with their storage provision the greater the amount of personal storage with which they were provided. However, there was no significant correlation between the distance users were located from the communal equipment and the actual distance recorded. Users located further away from the communal equipment were not less satisfied with the distance they had to travel than those located closer. There may be other factors affecting satisfaction with the communal equipment such as quality of the equipment or the number of times per day that users had to travel to and from the communal equipment.

Analysis of the standard deviations revealed that there was greater variance between workplaces in terms of satisfaction with the interior design than there was for internal climate and spatial layout. When considered with the conclusions drawn from the current state of knowledge it is apparent that there was little design guidance relating to these aspects as they were not deemed to be easy to measure quantifiably (Crouch & Nimran, 1989). Visits to the workplaces and objective measures taken revealed that those evaluated all differed considerably in terms of interior design. Significant correlations between the user perceptions and associated objective measures demonstrated that there was a link between interior design and user satisfaction with these aspects of the workplace. To highlight this further, examples of the workplaces where they differed most from the mean level of satisfaction have been identified for further consideration. The differences are displayed graphically in Appendix D.

As with the internal climate, Workplace I was rated by users as being more satisfactory in terms of interior design , aside from size of desk which did not differ from the mean. In terms of objective measures and the workplace interior observed during the data

collection visits there were no apparent notable differences from the other workplaces evaluated. The reason for Workplace I being rated so highly in terms of satisfaction was likely again to be due to the number of users in the workplace, which was only eleven, the smallest workplace within the sample. Thus, there were fewer employees with personal preferences to satisfy and they were able to have an input into decisions about the interior design of the workplace. In addition to Workplace I, users of Workplace B were more satisfied than the mean with a number of aspects of the interior design; namely colour scheme, artwork and plants. Users in Workplace B were more satisfied with these aspects of the interior design and visits to the workplace revealed that there were differences apparent between the interior design of Workplace B and the majority of other workplaces evaluated. The workplace was designed with a bright and varied colour scheme as can be seen from the photograph of Workplace B in Figure 11.

Figure 11 Interior Design of Workplace B

The organisation had also incorporated artwork and plants in the workplace environment that could be seen by users from their desks. These differences were reflected in the interior design of the workplace environment and user satisfaction.

Further support from individual workplaces comes from Workplace J. Users of Workplace J were less satisfied than the average user with the interior design of their workplace. Again, visits to the workplace and objective measures indicate why users may not have been satisfied. As an environment with a large proportion of laboratory space, the decoration was minimal and neutral, pale colours used throughout the workplace. Whilst this was necessary in laboratory areas to support the work being carried out, the administration areas were also decorated with the same colour scheme. Users in both the questionnaire responses and in conversation during the visit to the workplace expressed their dissatisfaction with the lack of colour, artwork and plants in the workplace. These results offer further support for the conclusions reached through evaluation of the current state of knowledge suggesting that more colourful environments with interesting decoration and comfortable furniture are more satisfactory (for example Küller et al, 2006; Küller et al, 2009 (colour); Stone & English, 1998; Stone, 2003 (interest in the decoration) and Dul, 2009 (furniture provision)).

### 9.5 The Workplace Features

The final category of workplace characteristics are features which include the window provision, choice in the design of the workplace, personal control over the internal climate and break area provision. The subjective measures of each of these features of the workplace were analysed and compared with objective measures. The mean level of satisfaction with each feature of the workplace was plotted on a radar plot (Figure 12).

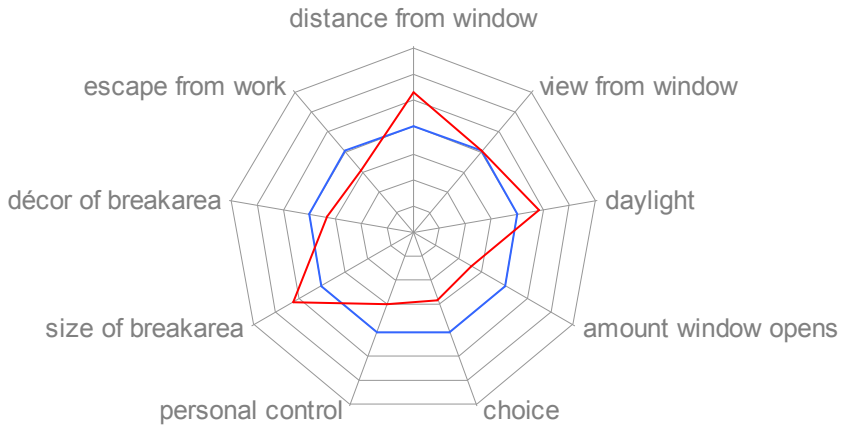



Figure 12 Graph to Demonstrate User Satisfaction with the Workplace Features

As with the previous radar plots, the red line denotes the mean level of user satisfaction and the blue line indicates the minimum level of satisfaction. Anything between the blue line and the extremity of the graph indicates a positive response as it is between four and seven on a scale of satisfaction, where one is very dissatisfactory and seven is very satisfactory. Anything below the blue line is considered to be dissatisfactory. The radar plot in Figure 12 indicates that users overall were satisfied with the distance they were located from a window, the amount of daylight in the workplace and the size of the break areas. All other features of the workplace were rated as dissatisfactory. This included the view from the window, the amount the windows open, the choice users had in the workplace design, the amount of control users had over the internal climate, the decoration of the break areas and the ability to get away from work in the break areas. Users perceived the view from the window to be unattractive and would like more windows in the workplace to open. The users felt that overall they had little choice in the design of the workplace and that they had little control over the internal climate. They were dissatisfied with this perceived lack of control or input. Finally, whilst users felt that break areas were of a satisfactory size they did not like the decoration of the break areas or feel that this was a place they could go to escape from work. To determine whether these ratings of satisfaction were the product of extreme attitudes or whether these were the views shared by the majority of users, the standard deviations were calculated. These are presented in Table 8.

| | Minimum | Maximum | Mean | Standard deviation |
|---|---|---|---|---|
| Distance from window | 1 | 7 | 5.24 | 2.31 |
| View from window | 1 | 7 | 3.99 | 1.73 |
| Daylight | 1 | 7 | 4.82 | 2.35 |
| Amount window opens | 1 | 7 | 2.55 | 1.89 |
| Choice | 1 | 7 | 2.72 | 1.39 |
| Personal control | 1 | 7 | 2.88 | 1.17 |
| Size of break area | 1 | 7 | 5.18 | 2.27 |
| Decor of break area | 1 | 7 | 3.30 | 1.30 |
| Escape from work | 1 | 7 | 3.03 | 1.57 |

Table 8 Descriptive Statistics for User Perceptions of the Workplace Features

This table highlights that around half of the responses did not differ considerably from the mean. The standard deviations for view, opening windows, choice, personal control, the decor of the break area and the ability to escape from work in the break area were all below two points on the seven point scale. This indicates that there were no large individual differences between users or differences between the workplaces. Users expressed a similar level of satisfaction with each of these features of the workplace. However, the standard deviations from the mean for the distance users were located from the window, the amount of daylight and the size of the break areas were all above two points. This indicates that there were individual differences or differences in perception between workplaces that were influencing the results. The radar plots for the individual workplaces reveal that there were differences in the patterns of results suggesting that differences in the environment were related to differences in satisfaction. These radar plots can be found in Appendix D. To determine whether the actual environment was related to user perceptions, the subjective questionnaire responses were analysed in relation to the corresponding objective measurements to determine whether there were any significant correlations. The results of the analysis of objective data and correlations between the objective and subjective data are reported in Table 9.

| Subjective Measure | Objective Measure | Objective Average | Correlation |
|---|---|---|---|
| Distance from window | distance from window (m) | 12.2 m | r=0.49, df=288, p<0.001 |
| View from window | view from window (urban to natural) | adjacent building | r=0.22, df=282,p<0.001 |
| Daylight | daylight (amount at desk) | some (still required artificial light) | r=0.40, df=261, p<0.001 |
| Amount window opens | opening windows | some but not all | r=0.44, df=233, p<0.001 |
| Control of temperature | control of temperature (ratio of control to | 1:25 | r=0.19, df=270, p<0.01 |
| Control of light | control of light (ratio of control to users) | 1:7 | r=0.19, df=268,p<0.01 |
| Control of noise | control of noise (door Y/N) | no door therefore no control | not significant |
| Control of ventilation | control of ventilation (ratio of control to | 1:15 | r=0.23, df=280, p<0.001 |
| Choice in layout | choice in layout (amount given) | none | r=0.24, df=278,p<0.001 |
| Choice in decor | choice in decor (amount given) | none | not significant |
| Choice in furniture | choice in furniture (amount given) | none | r=0.19, df=286, p<0.01 |
| Size of break area | size of break area (m²) | 212.6 m² | not significant |
| Colour of break area | colours in break area (number) | 1.9 colours | r=0.21, df=278, p<0.001 |
| Location of break area | Break area (type of space) | separate space | not significant |

Table 9 Correlations Between Objective and Subjective Measures of Interior Design

The table demonstrates that most objective measures of the workplace features were significantly correlated with the user perceptions. The highly significant, negative relationship between user satisfaction and the actual distance they were located from the window indicates that when users were further away from the window they were less satisfied. The results also demonstrate that a more natural view from the window, more daylight reaching their workstation and the more that they could open the windows were all positively correlated with greater user satisfaction with the window provision. The amount of choice users had in the interior design of their workplace and their satisfaction with their level of choice are related to the layout and furniture. The more choice users had in the way that the workplace was laid out and the furniture they had, the more satisfied they were with the amount of choice that they were given. There were also significant, positive correlations between the amount of personal control users had and their satisfaction levels. The more control users were given over the temperature, light and ventilation, the higher were satisfaction levels.

There were less significant relationships recorded for break areas with only satisfaction with decoration being significantly related to the objective measure. As with the workplace as a whole, satisfaction was greater when more colours were used to decorate the break area. The relationship between the objective measures of the choice that users had in the decoration of the workplace and user perceptions is not significant. This may be because users did not feel that they could influence the decoration of their workplace and therefore had no expectations of being offered any choice. Similarly there was no relationship between the control of noise and user satisfaction. This may be because the control of noise was through the opening or closing of a door. Those in open plan, which constituted the majority of respondents, did not have the ability to control noise in this way. Those who were able to control noise by closing the door may have been affected by the other connotations of closing the door such as the impact upon privacy and social interaction. Closing the door is not simply a method for controlling noise.

There is also a lack of a significant relationship between the break out space and user perceptions. The size of the break areas was not related to user satisfaction with the break areas. Larger spaces were not related to an increase in satisfaction. The relationship between the location of the break area and the perception of users that they could get away from work was not significant. Break areas that were enclosed and in a separate room to the main work area were not perceived to provide a better escape from work than those that were within the workplace. This suggests that the relationship between the break area and ability to escape from work is more complex than the degree to which the break area is physically separated from the main work area.

Analysis of the standard deviations for the workplace features, as with the interior design, revealed greater differences in responses. The graphs of results from individual workplaces compared with the mean response, as can be seen in Appendix XX, indicated that these differences were between workplaces. The pattern of responses in all workplaces does not follow the mean score. To highlight the differences between workplace environments the individual workplaces can again be compared with one another.

As with the internal climate and interior design, Workplace I was rated as considerably more satisfactory than the mean on a number of measures. Size of the break area and decor were rated highly as they suited the preferences of users. Aspects of the

workplace features over which the organisation had little control, because they were in a centrally managed building, did not differ notably from the mean and view out of the window was rated as less satisfactory than the mean. As expected, choice was rated as being much more satisfactory than the mean as users had a considerable amount of choice in the design of the workplace. This was confirmed by the senior management representative in the interview who reported that all staff were asked for their opinions when decisions were made about the design of the workplace. However, it should be noted that an organisation of 11 people, the opportunity to provide people with this much choice and act upon their decisions is much greater than in an organisation of a larger number. Another workplace in which users were more satisfied than the mean score with a number of factors was Workplace O. Users were satisfied with the distance that they were located from a window and daylight levels. With the majority of users being located less than 5m from a window in Workplace O compared with the average distance from the window across all workplaces of 12m, this may explain why users were more satisfied, despite the windows being sealed shut. Users were also satisfied with the break area and decor. The break area was a restaurant facility with access for all staff and distinctly separate from the rest of the workplace, with what appeared to be a sociable atmosphere. Use of the break area was high with senior management confirming that it was very popular with users. Notably the amount of control and choice users felt that they had over the workplace was rated as being more satisfactory than the average score by users of Workplace O. The interview with the senior management representative revealed that users had departmental control over the internal climate via the building management system and zoned light switches. In terms of choice the users were able to have an input in the selection of furniture, etc when the workplace was designed through nominated departmental representatives.

There were also workplaces in which users were dissatisfied with aspects of the workplace features. For example in Workplace M, which was a call centre, users were less satisfied with the amount of choice they had in the workplace design. This may be a result of the relatively high turnover of staff as revealed in the interview with the senior management representative. Many of them were not working for the organisation when the workplace was redeveloped. Users were also less satisfied than the mean with the window provision. On average users in Workplace M perceived themselves to be located too far from a window, having a poor view out of the window, having a lack of daylight and not having access to enough opening windows. The workplace environment itself was experienced on data collection visits. Along with objective measures it became apparent that the building was relatively deep plan with

windows that were fairly small and enclosed offices and meeting rooms around the perimeter which had access to direct natural light. Much of the natural light in the main workplace was borrowed light, that is it reached the space via an internal window. Workplace M can be seen in Figure 13.

Figure 13 Design of Workplace M

Similarly in Workplace N users were more dissatisfied with the window provision than the mean score. Again the building was relatively deep plan and the workplace perimeter on three sides was surrounded by enclosed offices, meeting rooms, break areas and training rooms as can be seen in the image of Workplace N (Figure 14).

Figure 14 Design of Workplace M

However, in Workplace N there was higher satisfaction with the break area provision than the mean recorded. Visits to the workplace and discussions with the building manager revealed that there were a variety of different break areas and that they were designed and developed on the basis of feedback from users. For example users said that they would like to be able to access the internet during their breaks from work. As a result the organisation turned one of the break areas into an internet cafe. These findings are supported by the significant correlations between user perceptions and objective measures of the workplace features. It is also supported by the findings from the current state of knowledge which suggested that break areas, window provision and choice have a positive impact upon satisfaction (for example BCO, 2003 (break areas); Sundstrom et al, 1982 (window provision) and Becker, 1991 (choice)).

### 9.6 Impact of Gender and Job Characteristics

The data was analysed to determine whether there was any effect of gender upon the perceptions of workplace users. Overall, the results demonstrated that whilst there were differences between the perceptions of males and females, very few of the differences recorded were significant. The data revealed that females were less satisfied with all aspects of the internal climate compared with males. The differences between perceptions of illuminance and sound were not significant. However, there were significant differences between the male and female perceptions of air movement ($t=2.99$, $df = 287$, $p<0.01$), air temperature ($t=3.88$, $df=292$, $p<0.01$) and relative humidity ($t=4.47$, $df=287$, $p<0.001$). The effect of gender on perceptions of the spatial layout revealed that there was no impact of gender on the results. Both males and female perceptions of the spatial layout follow a very similar pattern. There were also no significant differences between genders in the perceptions of the interior design. The effect of gender on perceptions of workplace features was mixed. There was no

significant difference between the perceptions of the break areas, provision of windows and the amount of personal control that they had over the internal climate. However, there was a significant difference in male and female perceptions of the amount of choice users had in the design of their environment ($t=3.09$, $df=295$, $p<0.01$). Analysis of this finding in relation to the objective measurements reveals a lower proportion of females than males were given a choice in the design of their workplace. Based upon the significant correlation between the actual amount of choice given and user satisfaction with choice, it demonstrates that females are being given less choice in the design of the workplace than males and are more dissatisfied.

The data was analysed to determine whether the job that occupants did had an effect upon their level of satisfaction with the workplace environment. With regards to the internal climate an occupant's job only had an effect upon the perception of temperature ($f = 1.84$, $df = 11,274$, $p<0.05$). Perceptions of all other aspects of the internal climate did not differ significantly between occupants with different jobs. The mean level of satisfaction with all aspects of the internal climate was highest amongst directors and lowest amongst administration staff. There were no significant differences between occupant perceptions of the spatial layout based upon occupants' jobs. In terms of interior design there was a significant effect of occupants' jobs upon satisfaction. Occupants with different jobs varied significantly in the extent to which they perceived the colour scheme to be attractive ($f = 4.42$, $df = 11,275$, $p<0.001$). There was an effect of occupants' job upon differences in perceptions of the artwork ($f = 2.15$, $df = 11,274$, $p<0.05$) and plant provision ($f = 3.32$, $df = 11,277$, $p<0.001$). With regards to furniture provision there was an effect of occupants' jobs in relation to the comfort of workplace chairs ($f = 2.24$, $df = 11,277$, $p<0.05$), their level of comfort after sitting for long periods ($f = 2.56$, $df = 11,278$, $p<0.01$) and the equipment provided at occupants desks ($f = 2.83$, $df = 11,272$, $p<0.01$). There were no significant differences between participants' occupations and size of desk, personal storage space and the distance they were located from the communal equipment. With regards to features of the workplace, there was an effect of occupants' jobs on satisfaction with the view out of a window ($f = 2.59$, $df = 10,264$, $p<0.01$), choice ($f = 6.73$, $df = 11,277$, $p<0.001$), personal control ($f = 4.41$, $df = 11,275$, $p<0.001$), the decoration of the break area ($f = 2.10$, $df = 11,260$, $p<0.05$) and the ability to escape from work in the break areas ($f = 1.83$, $df = 11,259$, $p<0.05$).

When assessing the effect of occupants' jobs upon satisfaction with the workplace as a whole, there was no significant relationship. Occupants' jobs and overall satisfaction

with the workplace were not significantly correlated. Satisfaction with the workplace was in no way dependent upon the job that the occupant had. Even less significantly related was perceived productivity and occupants' jobs. There was no effect of occupants' jobs on perceived productivity. Although the results did not reveal an effect of occupants' jobs on satisfaction with the workplace as a whole, there were significant relationships found between occupants' jobs and some specific aspects of the workplace. These tended to be the more qualitative aspects with differences in perception of the interior design of the workplace and features of the workplace being those most significantly affected by occupants' jobs. This further highlights the importance of developing research into the impact of qualitative aspects of the workplace.

Further to evaluating the results in relation to occupants' jobs, the data was analysed to determine whether the percentage of time occupants spent at their desk affected their perception of each aspect of the workplace environment. Very few significant correlations were found between the percentage of the working day occupants spend at their desk and their satisfaction with individual aspects of the environment. The only aspects that were significantly correlated to percentage of time spent at the desk were colour scheme ($f = 3.5$, $df = 4,282$, $p<0.01$), plants ($f = 2.59$, $df = 4,284$, $p<0.05$), personal storage space ($f = 2.65$, $df = 4,284$, $p<0.05$), the amount of equipment at the desk ($f = 2.89$, $df = 4,282$, $p<0.05$), choice ($f = 3.27$, $df = 4,285$, $p<0.05$), air movement ($f = 3.17$, $df = 4,278$, $p<0.05$) and temperature ($f = 2.56$, $df = 4,282$, $p<0.05$) although none of them are highly significant correlations. The percentage of time occupants spent at their desks was not significantly correlated with overall satisfaction with the workplace, or perceived productivity. Therefore it cannot be concluded that the percentage of time spent at one's desk is a product of or predictor of satisfaction with the workplace.

Although there were some significant relationships between job characteristics and satisfaction with certain aspects of the environment, there was no overall significant effect of job characteristics on satisfaction with the workplace overall. On average all occupants, regardless of job or gender, perceive the workplace in the same way. Neither gender nor job characteristics can be used to predict how satisfied occupants will be with the environment.

### 9.7 Summary and Conclusions

The findings from the evaluations of the workplace revealed that participants were satisfied with the internal climate and spatial layout but were less satisfied with the interior fit out and features of the workplace. Analysis of the individual workplaces indicated that overall levels of satisfaction with the internal climate and spatial layout did not differ significantly between workplaces. However, there were few correlations between the subjective and objective data. This may be due to the conditions in all the workplaces being fairly similar and adhering to design guidance specifications. With only moderate differences there was little variation which would be perceived by users and little difference between the workplaces which is reflected in the level of satisfaction expressed by participants. The perceptions of many aspects of the internal fit out and features of the workplace varied between workplaces suggesting that there were differences between them. This was supported by a greater number of objective measures and corresponding user perceptions being significantly correlated.

There was some impact of gender on the results, particularly in relation to the internal climate with females being less satisfied than males. This difference was significant in relation to the thermal factors: air temperature, air movement and humidity. The only other significant effect of gender was on the perception of the amount of choice that users had in the design of their workplace environment. Females were less satisfied with the amount of choice that they were given and this correlates with a lower level of actual choice recorded. Whilst job characteristics had some impact upon the results, there was no consistent overall impact of job characteristics.

## Chapter 10 Results and Discussion of Workplace Evaluation Phase

### 10.1 Results Demonstrating the Impact upon Users

The previous chapter highlights perceptions of the workplace environment and how these correlate with objective measures. To determine how the workplace environment, and how it was perceived, was related to the impact upon users, three variables were identified and measured. These indicators of the impact upon users were; overall satisfaction with the workplace, the amount of stimulation provided by the workplace environment and perceived productivity. These variables were each comprised of a number of items from the questionnaires which were grouped under the headings relating to the dependent variables; overall satisfaction, overall impact and overall performance. Coefficient alphas were calculated for each of the three indicators to determine whether the individual items could be reliably grouped as they were under the headings in the questionnaire (see Appendix B). The variable overall satisfaction produced a coefficient alpha of .926. All four items were retained as the coefficient alpha was reduced if any of the items were removed. Further consideration confirmed that all items appeared to be measuring the same construct and should therefore be retained. The variable overall stimulation produced a coefficient alpha of .456. Upon further analysis one of the items was dropped which was the time of day at which a user considered themselves to be most alert. This was not measuring the same construct of stimulation as it was a time of day measure as opposed to a level of alertness. With this item removed the remaining three items produced a coefficient alpha of .710. The final variable of overall performance produced a coefficient alpha of .715. All four items were again retained as they all made a contribution to the overall performance construct and the coefficient alpha score was reduced if they were removed.

Before perceptions of each aspect of the workplace were analysed in relation overall satisfaction, simulation and perceived productivity, these three variables were analysed as overall indicators, and to determine whether there was a significant relationship between them. Overall satisfaction of the workplace was calculated and the majority of users rated themselves as being satisfied with the workplace. The mean score on the 1 to 7 Likert Scale of satisfaction was 5 and therefore on the positive side of the neutral mid-point of the scale. Thus, on average respondents perceived their workplaces to be satisfactory. However, they did not rate the environment positively in terms of

stimulation with the mean score on the 1 to 7 point Likert Scale being 4, which is neutral. Therefore users did not perceive their environments to be stimulating. Both overall satisfaction and stimulation were analysed in relation to perceived productivity to determine whether there was a positive correlation between these indicator variables. Analysis of occupant satisfaction with the workplace and perceived productivity revealed that there was a significant correlation between these two variables ($r = 0.312$, $df = 297$, $p<0.001$). As satisfaction with the workplace increased, perceived productivity levels increased. A significant relationship was also revealed between how stimulated users perceived themselves to be and perceived productivity ($r = 0.292$, $df = 297$, $p<0.001$). Whilst conclusions of a causal nature cannot be drawn from correlational analyses, these findings suggest that overall satisfaction and stimulation are linked to perceived productivity which could have implications for design. There is potential to explore the causal links between these variables and establish how perceived productivity could be increased through changes to the environment both directly and indirectly through these other indicator variables.

### 10.2 Establishing Reliability and Validity

.As stated the groupings of items from the questionnaires under the four headings of internal climate, spatial layout, interior design and workplace features was to allow ease of analysis of descriptive statistics for example means and standard deviations. To determine whether these groupings of items were reliable for more in-depth statistical analysis using a regression model, a Principle Components Analysis was run with individual items from the questionnaire being entered. This was to allow variables or components to be identified for further analysis. These new variables could then be used within the regression analysis to more reliably predict the most significant predictors of the three indicator variables; overall satisfaction with the workplace, stimulation and perceived productivity. On the basis of the scree plot analysis and factor interpretability, 16 main factors were extracted and they accounted for 69.0% of the total variance. Each had an eigenvalue index of greater than 1.0. The rotated factor matrix is reported in Table 10.

| | Sound | Humidity | Light | Personal Control of Climate | Air movement | Aesthetic | Satisfaction with control | Temperature | Control of aesthetic | Spatial layout | Break area | Windows | Social interaction | Sitting at work | Relaxing environment | Equipment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **layout1** | | | | | | | | | | .767 | | | | | | |
| **layout2** | | | | | | | | | | .771 | | | | | | |
| **layout3** | | | | | | | | | | .501 | | | | | | |
| **layout4** | | | | | | | | | | | | | .411 | | | |
| **layout5a** | | | | | | | | | | .471 | | | | .362 | | |
| **layout5b** | | | | | | | | | | | | | | | .500 | |
| **layout6a** | | | | | | | | | .799 | | | | | | | |
| **layout6b** | | | | | | | .553 | | .398 | | | | | | | |
| **decor1** | | | | | | .712 | | | | | | | | | | |
| **decor2** | | | | | | .618 | | | .402 | | | | | | | |
| **decor3** | | | | | | .626 | | | | | | | | | | |
| **decor4** | | | | | | .665 | | | | | | | | | | |
| **decor5a** | | | | | | .702 | | | | | | | | | | |
| **decor5b** | | | | | | | | | | | | | | | .771 | |
| **decor6a** | | | | | | | | | .806 | | | | | | | |
| **decor6b** | | | | | | .462 | .567 | | | | | | | | | |
| **density1** | | | | | | | | | | | | | .787 | | | |
| **density2** | | | | | | | | | | | | | .794 | | | |
| **density3** | | | | | | | | | | | | | | | | |
| **density4** | | | | | | | | | | | | | | | | |
| **window1** | | | | | | | | | | | | .773 | | | | |
| **window2** | | | | | | | | | | | | .457 | | | | |
| **window3** | | | .368 | | | | | | | | | .718 | | | | |
| **window4** | | | | .525 | | | | | | | | | | | | |
| **furnish1** | | | | | | | | | | | | | | .791 | | |
| **furnish2** | | | | | | | | | | | | | .361 | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **furnish3** | | | | | | | | | | | | | | .658 | | |
| **furnish4** | | | | | | | | | | | | | | | | |
| **furnish5** | | | | | | | | | | | | | | | | .636 |
| **furnish6** | | | | | | | | | | | | | | | | .478 |
| **furnish7** | | | | | | | | | .729 | | | | | | | |
| **furnish8** | | | | | | | .447 | | | | | | | .402 | | |
| **break1** | | | | | | | | | | | .739 | | | | | |
| **break2** | | | | | | | | | | | .700 | | | | | |
| **break3** | | | | | | | | | | | .749 | | | | | |
| **break4** | | | | | | | | | | | | | | | | |
| **temperature1** | | | | | | | .371 | .536 | | | | | | | | |
| **temperature2** | | | | | | | | .718 | | | | | | | | |
| **temperature3** | | | | | | | | .745 | | | | | | | | |
| **temperature4** | | | | | | | | .763 | | | | | | | | |
| **light1** | | | .832 | | | | | | | | | | | | | |
| **light2** | | | .815 | | | | | | | | | | | | | |
| **light3** | | | .902 | | | | | | | | | | | | | |
| **light4** | | | .870 | | | | | | | | | | | | | |
| **noise1** | .924 | | | | | | | | | | | | | | | |
| **noise2** | .910 | | | | | | | | | | | | | | | |
| **noise3** | .925 | | | | | | | | | | | | | | | |
| **noise4** | .940 | | | | | | | | | | | | | | | |
| **air1a** | | .780 | | | | | | | | | | | | | | |
| **air1b** | | | | | .668 | | | | | | | | | | | |
| **air2a** | | .884 | | | | | | | | | | | | | | |
| **air2b** | | | | | .802 | | | | | | | | | | | |
| **air3a** | | .870 | | | | | | | | | | | | | | |
| **air3b** | | | | | .818 | | | | | | | | | | | |
| **air4a** | | .906 | | | | | | | | | | | | | | |
| **air4b** | | | | | .798 | | | | | | | | | | | |
| **personalcontrol1a** | | | | .729 | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **personalcontrol1b** | | | | .422 | | | .502 | .423 | | | | | | | | |
| **personalcontrol2a** | | | | .713 | | | | | | | | | | | | |
| **personalcontrol2b** | | | | .378 | | | .517 | | | | | | | | | |
| **personalcontrol3a** | | | | .665 | | | | | | | | | | | | |
| **personalcontrol3b** | | | | | | | .605 | | | | | | | | | |
| **personalcontrol4a** | | | | .784 | | | | | | | | | | | | |
| **personalcontrol4b** | | | | .405 | | | .531 | | | | | | | | | |

Table 10 Rotated Factor Matrix (coefficients lower than .3 have been omitted)

The first five factors extracted were all previously classified as aspects of the internal climate. The first factor was sound and contained the same questionnaire items as were grouped for the radar plots which were: sound in the morning and afternoon and sound in the summer and winter. This accounted for 6.1% of the total variance. The coefficient alpha of .965 revealed that these items could be reliably grouped. The second factor extracted was humidity and included humidity levels in the morning and afternoon and humidity in the summer and winter. This accounted for 6.0% of the total variance. The coefficient alpha was .954. The third factor extracted was light which included the items from the questionnaire measuring light levels in the morning and afternoon and summer and winter. In addition it included the item about the amount of daylight from windows in the workplace. This accounted for 5.8% of the total variance. The coefficient alpha for these items was .850 and although it would have increased to .911 with the daylight item removed it was deemed to be a useful addition to the factor and the coefficient alpha of .850 was still high. The fourth factor extracted was personal control of the users over the internal climate which included opening windows, amount and satisfaction with control of the air temperature, amount and satisfaction with control over the light levels, amount of control over the noise levels and amount and satisfaction with control over the ventilation. This accounted for 5.4% of the total variance. The coefficient alpha was .831 demonstrating that these items could be reliably grouped. The fifth factor extracted was air movement and this included air movement in the morning and afternoon and air movement in the summer and winter, and this accounted for 5.0% of the total variance. The coefficient alpha was .919.

The sixth factor extracted was labelled aesthetic and contained more of the qualitative measures. The questionnaire items included in this factor were the colour scheme, artwork, plants, appearance of the decoration and impact of the decoration on attention levels. This accounted for 4.9% of the total variance and the coefficient alpha was .764.

The seventh factor extracted was satisfaction with control, rather than amount of control, and included satisfaction with control over the spatial layout, choice in the workplace decoration, choice in the furniture provision, control over the temperature, control over the light levels, control over the noise levels and control over the ventilation. This accounted for 4.6% of the total variance. The coefficient alpha was .832 and these items could therefore be reliably grouped.

The eighth factor extracted was temperature and this included the questionnaire items measuring temperature in the morning and afternoon and summer and winter. It also

included how satisfied users were with the amount of personal control they had over the air temperature levels. This accounted for 4.6% of the total variance. The coefficient alpha was .828 therefore the items could be reliably grouped.

The ninth factor extracted was control over the space and included aspects not covered in control of the internal climate. The factor control over the space included amount and satisfaction with choice in the spatial layout, the amount of choice in the decoration of the workplace, the amount of choice in the furniture provided in the workplace and the artwork. The users' attitude towards artwork being included in this factor may be because users perceive the inclusion of artwork as being something they would be involved in if it were incorporated within the workplace. This accounted for 4.3% of the total variance and the coefficient alpha calculated was .736.

The tenth factor extracted was spatial layout and included where users were sat in the workplace, their satisfaction with the type of office they worked in (open plan, cellular, etc), the amount of privacy they had and whether the spatial layout made this a stimulating environment in which to work and this accounted for 3.7% of the total variance. The coefficient alpha was .681.

The eleventh factor extracted was the break area and this included the size of the break area, the decoration of the break area and the ability for this space to help people feel that they were "getting away from work". This accounted for 3.6% of the total variance. The coefficient alpha calculated was .644 demonstrating that these items could be reliably grouped.

The twelfth factor extracted was windows and included the distance users were sat from a window, the view they had from the window and the amount of daylight let in by the windows. This accounted for 3.4% of the total variance and the coefficient alpha was .669. Whether or not the windows opened was not included in this factor but instead appears in factors relating to control in the workplace. Athough the coefficient alpha calculations revealed that with the item measuring the view from the window removed the coefficient alpha would increase to .761, consideration and reference back to the current state of knowledge supported the need to include the view from the window as it is an important aspect of window provision. As the coefficient alpha with the view out of the window was .669 and therefore quite high, the item was retained within this factor.

The thirteenth factor extracted was social interaction and included satisfaction with the amount of social contact users had in the workplace, the number of people in the workplace, the number of desks in the workplace and the size of the desk. Although the desk is not immediately linked with social interaction it was felt that in many workplaces the size of the desk and the way they were clustered together had an impact upon social interaction. This explains the inclusion of this variable in the social interaction factor. This accounted for 3.4% of the total variance. The coefficient alpha was .595 and therefore these items could be reliably grouped as they were measuring the same construct.

The fourteenth factor extracted was sitting at work and refers to comfort and how people feel whilst they are sat in their workplace. The items included in this factor were how stimulated people felt by the spatial layout of the workplace, the comfort of the chairs, how comfortable people felt after sitting for long periods and how satisfied people were with the amount of choice they had in the furniture provision. This accounted for 3.3% of the total variance and the coefficient alpha was .710.

The fifteenth factor extracted was the extent to which the workplace is a relaxing environment and the items included were whether the spatial layout was relaxing or distracting and whether the decoration made the workplace distracting or relaxing. This accounted for 2.5% of the total variance and the coefficient alpha was .528.

The sixteenth and final factor extracted and identified through the rotated factor matrix was equipment in the workplace and included questionnaire items relating to the equipment people had at their desk and the provision of communal equipment in the workplace and this accounted for 2.4% of the total variance. The coefficient alpha was .293 and, although this is a low score, this factor made up of these items was retained as they were not extracted in any other factor therefore it was important to include them for further analysis.

### 10.3 Predicting Overall Satisfaction and Stimulation

With the groupings established through the principle components analysis and the reliability of the factors tested they were used as a model of predicting overall satisfaction with the workplace. Initially all the variables were entered simultaneously into a regression analysis to determine the extent to which the model as a whole was able to predict overall satisfaction with the workplace. The results revealed that the

adjusted R square = .519 therefore the model is able to predict 51.9% of the variance in overall satisfaction with the workplace, $F(16,334) = 24.617$, $p<0.001$. This model is a good predictor with a significant proportion of the variance in satisfaction with the workplace being accounted for by the aspects measured in this thesis. As almost all aspects of the workplace were correlated with overall satisfaction, it reveals that there is a significant relationship between the environment and satisfaction (see Appendix G). The results of this analysis demonstrate that when users perceived each aspect of the workplace to be satisfactory they were more likely to be satisfied with the workplace overall. To determine which aspects of the workplace environment were the greatest predictors of overall satisfaction with the workplace they were entered into a stepwise regression analysis. The adjusted R square =.515 therefore the model overall predicted 51.5% of the variance in overall satisfaction with the workplace, $F(1.342) = 7.330$, $p<0.01$. This is not much less than the model containing all variables as reported above. The significant predictors of overall satisfaction are highlighted in the summary Table 11. A more detailed table of the results of the stepwise regression can be found in Appendix G.

| **Predictor Variable** | **Beta** | ***p*** |
|---|---|---|
| Satisfied with Control | .615 | <0.001 |
| Spatial Layout | .335 | <0.001 |
| Sitting at Work | .197 | <0.001 |
| Humidity | .108 | <0.01 |
| Equipment | -.098 | <0.05 |
| Social Interaction | .103 | <0.05 |
| Break Area | .087 | <0.05 |
| Relaxing Environment | -.115 | <0.01 |

(sound, light, control of climate, air movement, aesthetic, temperature, control of space, and windows were not significant predictors of overall satisfaction on their own in this model)

*Table 11 Stepwise Regression of the Predictors of Overall Satisfaction with the Workplace*

The stepwise regression demonstrates that a significant amount of variance in overall satisfaction is predicted by aspects which were qualified as both quantitative and qualitative within this thesis. The quantitative factors which were significant predictors are spatial layout and humidity. However, the more qualitative factors of satisfaction

with the degree of personal control, experience of sitting at the workstation, equipment provision, social interaction, break area provision and the degree to which the environment is perceived to be relaxing are also significant predictors. This further supports the argument that an effective evaluation of the workplace needs to be holistic

The mean level of satisfaction with the workplace overall, with the mean taken from all sixteen workplaces, was 5 on the seven point Likert Scale. This result suggests that there is potential to improve perceptions of the workplace environment. The significance of this model in predicting satisfaction provides a good foundation for further investigation. The variance in satisfaction not accounted for by the variables in this model will be affected by other aspects of the environment that could be specific to an individual workplace, and not selected for measurement within this thesis. Those aspects of the environment which were not significant predictors of satisfaction in the stepwise regression analysis should not be dismissed. Some of these aspects were significantly correlated with overall satisfaction suggesting that there is a relationship between these aspects of the workplace and satisfaction. These correlations can be seen in Appendix G. The interaction effect of aspects of the workplace environment will also have had an impact. For example, whilst control of the environment was not able to predict a significant amount of variance alone, it is likely to have been linked to satisfaction with control.

The model, containing all aspects of the workplace environment, was also tested to determine the degree to which users attitudes towards each aspect of the workplace predicted how stimulating the workplace environment was perceived to be. With all variables entered simultaneously, the adjusted R square = .431 therefore the model was able to predict 43.1% of the variance in stimulation, $F(16,333) = 17.56$, $p<0.001$. This demonstrates that the model is a good predictor of the level of stimulation provided by a workplace environment. As with satisfaction, all aspects of the environment were correlated with stimulation suggesting that the workplace could play a significant role in determining variance in stimulation levels (see Appendix G). To determine which factors were the most significant predictors of stimulation by the workplace environment they were entered into a stepwise regression analysis. The adjusted R square =.423 therefore the model overall was able to predict 42.3% of the variance in stimulation levels, $F(1,343) = 5.474$, $p<0.05$. A summary of the most significant predictors of stimulation are highlighted in Table 12 A more detailed table of the results of the stepwise regression analysis can be found in Appendix G

| Predictor Variable | Beta | *p* |
|---|---|---|
| Spatial Layout | .252 | <0.001 |
| Air Movement | .158 | <0.001 |
| Personal Control (Climate) | .225 | <0.001 |
| Sitting at Work | .135 | <0.01 |
| Control of Space | .123 | <0.05 |
| Break Area | .101 | <0.01 |

(sound, humidity, light, aesthetic, satisfaction with control, temperature, windows, social interaction, relaxing environment and equipment were not significant predictors of stimulation on their own in this model)

Table *12 Stepwise Regression of the Predictors of Stimulation by the Workplace Environment*

As with overall satisfaction the table again demonstrates that both qualitative and quantitative aspects of the environment were significantly correlated with stimulation levels, further supporting the need for an holistic evaluation of the environment. The quantitative aspects of the environment which were significant predictors were spatial layout and air movement. The qualitative aspects of personal control of the environment, experience of sitting at the workstation, control of the space and break area provision were also significant predictors of stimulation. As with the model of overall satisfaction, the variables which were not significant predictors of stimulation in the workplace should not be disregarded. Many of these factors were significantly correlated with levels of stimulation reported suggesting that there is some relationship. Although they were not able to predict stimulation when measured independently they appear to play a role, possibly through interaction effects, in stimulation in the workplace.

A comparison of the most significant predictors of satisfaction and stimulation demonstrates that there are some similarities. The factors spatial layout, experience of sitting at the workstation and break area provision were significant predictors of both overall satisfaction with the workplace and stimulation. As both overall satisfaction and stimulation were significantly correlated with perceived productivity there are strong indications of the potential impact that the workplace environment could have for an organisation and their employees. The results demonstrating the ability of aspects of the workplace environment to predict how stimulated users feel at work demonstrates

the importance of considering the impact of the environment beyond the usual measures of satisfaction and perceived productivity.

Finally, a regression analysis was carried out to determine the impact that all the aspects measured had upon perceived productivity. The results revealed that the adjusted R square =.037 therefore the model was able to predict 3.7% of variance in perceived productivity, $F(16,333) = 1.829$, $p<0.05$. Although not a large amount of variance in perceived productivity was predicted by the model, it was still a significant result. This demonstrates that there is a relationship between perceived productivity and the environment. The low percentage is unsurprising if all other influences on perceived productivity at work are considered. For example autonomy, skill use, variety, supervision, interpersonal contact, etc (Warr, 2002). The significant correlation of perceived productivity with overall satisfaction and stimulation levels indicates that the workplace environment may have both an indirect and direct impact upon perceived productivity. Whilst some individual aspects of the workplace may not directly affect perceived productivity, as would be expected for something so complex, ensuring that users are satisfied with the environment overall and stimulated could benefit users and organisations through the relationship with increased perceived productivity. A further analysis was conducted to determine whether the factors extracted from the rotated components matrix were able to predict another measure of productivity taken during the evaluation research. This measure was number of days absent from work. The analysis revealed that there was no significant correlation between number of days absent from work through illness in the preceding six months, $F(16,324) = 1.00$, n.s. and the model of workplace environments.

### 10.4 Discussion of Findings from Evaluation Studies

The analysis of user perceptions of the workplace environment demonstrate which aspects of workplace design users were satisfied with and which aspects of workplace design are considered dissatisfactory by users. Gathering data across a number of workplaces with a large sample of individuals has allowed patterns to be established. These patterns indicate that there are varying degrees of satisfaction with the workplace environment.

All aspects of the internal climate i.e. air temperature, illuminance, noise, relative humidity and air movement were rated as being very satisfactory by users. The low standard deviations from the mean indicate that this level of satisfaction was shared by

most respondents and across all workplaces. There was no significant impact of individual differences and different workplaces. There were no significant correlations between the objective and subjective measures for all aspects other than relative humidity. The objective measures themselves generally fell within the recommended range of the design guidance and therefore there were no extreme conditions which may have affected the correlations as differences in conditions were not detected by users. The results from the evaluation of user perceptions of the internal climate and the significant correlation with overall satisfaction allow some conclusions to be drawn which can inform future design. Users were satisfied with the thermal aspects of the environment in all workplaces. The objective measures revealed that the average air temperature was between 22.7ºC and 23.2ºC, the average relative humidity level was between 37.6%and 38.3%, and the average air movement speed was 0.02m/s. As the measures of user perceptions and actual thermal conditions did not differ significantly from one workplace to the next, the results indicate that workplace users are satisfied with these thermal conditions. The illuminance levels in all workplaces were perceived to be satisfactory and the actual illuminance levels were recorded as between 553lux and 565lux which is well within the design guidance. Finally, the sound levels were found to be satisfactory in all workplaces and although the average measure of 59dB is above that suggested by the design guidance and reported by McKeown (2008), it is below the threshold indicated in research as being the point of disruption. As the measures of user perceptions and the actual internal climate within the workplaces did not differ significantly from one workplace to the next, the results indicate that workplace users are satisfied with these conditions in the workplace. This finding supports the ranges specified within the standards, as the achievement of the recommendations in design guidance are correlated with high levels of satisfaction. Whilst no causal relationship has been established, the results indicate that workplace environments in which the internal climate is similar to those recorded in this study are likely to be satisfactory for users.

All aspects of the spatial layout: where sat, office type, privacy, social contact, density, distractions and atmosphere, were perceived to be satisfactory in the workplaces evaluated. The low standard deviations from the mean for all aspects aside from privacy indicates that the level of satisfaction did not differ greatly between individuals and across workplaces. The greater deviation from the mean for perceptions of privacy indicate that there were some respondents who were dissatisfied with the level of privacy that they had in the workplace. A similar pattern of results across all the workplaces implies that this was due to individual preferences rather than the design of

a specific workplace. There were no significant correlations between the objective measures of the workplace and user perceptions. This suggests that other factors affected users' perceptions than spatial measures of the layout. The satisfaction with all aspects of the spatial layout and the lack of significant correlations between the objective measures and user perceptions does not allow inferences about the workplace layout that is most satisfactory. However, the results still provide useful evidence to inform future design. In the current state of knowledge a number of aspects of the spatial layout were identified as having a negative impact upon employee satisfaction. Notably open plan as opposed to cellular spaces were linked by many researchers to decreased levels of satisfaction (Brill et al, 1984). However, the findings from this thesis indicate that a particular type of spatial layout is not perceived negatively. There is no correlation between office type, or level of enclosure, and satisfaction. Users were satisfied with all spatial layouts from large open plan spaces to individual cellular offices. They also perceived the atmosphere in the workplaces to be positive, the number of distractions to be low enough to be satisfactory, the amount of privacy overall to be satisfactory and their location within the workplace to be satisfactory. These findings were not dependent upon the actual spatial layout, therefore there must be other factors affecting the results. As the spatial layout was significantly correlated with overall satisfaction and stimulation it is clearly important that users are satisfied with these aspects of the workplace. However, it is not possible to identify a particular design based on specific spatial measures or classifications that will satisfy workplace users. What can be concluded is that no individual spatial layout type was identified as having a negative impact upon users.

With regards to interior design, users were satisfied with their chair, the size of their desk, the amount of personal storage they had and the distance they were located from the communal equipment. They were not satisfied with the colour scheme, provision of artwork and plants or their comfort levels after sitting for long periods of time. The standard deviations revealed that attitudes towards the colour scheme, chair, desk, comfort and personal equipment did not differ significantly between individuals or workplaces. However, user perceptions of the artwork, plants, storage and communal equipment did differ significantly between individuals and workplaces. The significant correlations between objective and subjective measures of all aspects of the interior design, except the distance of communal equipment, highlight that actual measures and user perceptions are related. Based on these findings, some recommendations in terms of future design can be drawn, especially in light of the significant correlation between the objective and subjective measures. Users were satisfied with their chair

and size of the desk in their workplaces and there was a significant positive correlation between the objective and subjective measures. This indicates that the ability to adjust the chair and have arms is perceived positively by users. The larger the surface area of the desk in this study, the more satisfied users were. Due to the majority of the furniture analysed within this study being a form of standard office furniture, the majority of desks were between 1.5m² and 2.5m². Therefore it is not possible to establish whether continuing to increase the desk size would be related to a continuing increase in satisfaction. However, as the majority of users were satisfied with their desk size, the standard furniture provision appears to be adequate. Satisfaction with the amount of personal storage and the amount of storage actually provided was significantly, positively correlated and users were satisfied with the amount of personal storage that they had. From this it can be concluded that for the majority of workplace users a single pedestal unit is adequate storage. Satisfaction may continue to increase with the introduction of more storage space but without further investigation it is not clear whether the results would follow a law of diminishing returns. Users were not satisfied with the colour scheme in the majority of workplaces and this was correlated with the number of colours they could see from their desks. The results suggest that users are more satisfied with workplaces in which a number of different colours are used. As the average number of colours was only 2.5 and for most participants this included a neutral colour (white or cream) it is not clear from these findings whether there is a limit to the number of colours used in the workplace environment before satisfaction levels begin to decrease. Similarly the positive correlations between plants and artwork provided and user satisfaction indicate that the more plants and artwork included within the workplace, the more satisfied users will be. As there were very few plants incorporated in the workplaces measured, and even fewer examples of artwork being displayed, it is not possible to determine whether satisfaction levels would begin to decrease if many more plants and pieces of artwork were introduced to the workplace environment. A lack of significant correlation between the distance between users and the communal equipment and users' satisfaction suggests that there are other factors affecting satisfaction. As with personal equipment it is likely to be the quality of the technology and information technology provision which is outside of the scope of this thesis and was therefore not analysed.

In relation to the features of the workplace, users were satisfied with the distance they were located from the window and the amount of daylight in their workplaces. However, they were dissatisfied with the view from the windows and the amount they could open windows in the workplace. The standard deviations from the mean reveal that the

ratings for the distance of users from the window and daylight varied from the mean to a greater extent than those for user satisfaction with the view and the amount windows opened. All aspects of the window provision measured were significantly correlated with user satisfaction. Personal control and choice in the design were perceived to be dissatisfactory. The standard deviations were relatively low revealing that the amount of choice and personal control people had over their workplace was perceived to be unsatisfactory across all workplaces and between individuals. The significant correlation between satisfaction and the actual amount of personal control and choice reveals that when people had greater control they were also more satisfied. Finally, the users were satisfied with the size of their break areas but were not satisfied with the way they were decorated or the ability to make them feel as though they were getting away from work. There was a significant correlation between the colour scheme and users' perception of the break area decoration. There was no significant correlation between the location and size of the break area and user perceptions. These findings provide some understanding that can be used to inform future design. With regards to window provision users were satisfied with the distance they were from a window and the amount of daylight at their desks. The more daylight reaching their workstation and the closer they were to a window, the more satisfied users were. This applied even when illuminance levels exceeded the recommendations from design guidance due to high levels of daylight and when users were sitting adjacent to a window in the workplace. Results varied considerably from the mean level of satisfaction suggesting that those not located near to a window and with little daylight were dissatisfied. Dissatisfaction with the view was correlated with the objective measures suggesting that users preferred more natural and less urban views. Dissatisfaction with the amount that windows could open was correlated with a lack of opening windows indicating that users were more satisfied when they could open the windows in their workplace. The significant positive correlations between personal control and choice and user perceptions indicate that users had very little control of the workplace environment and design, and they were dissatisfied with this. Finally, the sizes of the break areas analysed were perceived to be satisfactory, although there was no correlation with user perceptions which suggests it is some other aspect of break area design that affects satisfaction. The number of colours used and satisfaction with the colour scheme were correlated and as with the workplace colour scheme the results indicate that more colours were related to increased levels of satisfaction. However, most users were still dissatisfied with the break area as a place to allow them to get away from work indicating that other aspects of the break area provision need to be considered to determine what constitutes a good break area.

### 10.5 Contribution to Knowledge of the Evaluation Phase

The evaluation of the current state of knowledge revealed that workplace design has developed as management theory has evolved. Process driven scientific management theory led to the development of workplace environments which facilitated the movements required to complete a task (Sundstrom, 1986). However, as management theory changed to become more person-focused so the environment changed to support this (for example Duffy, 1969; Klein, 1982). More recent management theories have focused upon the ability of organisations to adapt and researchers are noting a shift towards workplace environments which support this way of working (for example Becker & Steele, 1995). However, despite these influences upon workplace design there has been a lack of research into the impact of the workplace environment as a whole. Establishing the current state of knowledge revealed that there were aspects of the environment which had received a considerable amount of research and that they were those that were more easily quantifiable such as spatial layout in terms of office type and area per person (for example Laing et al, 1998; Adler, 1999; Marmot & Eley, 2000; British Council for Offices, 2000) and internal climate (for example CIBSE, 1994; ASHRAE, 2001; BCO, 2005). This has led to the development of design guidance to provide designers with recommendations for the creation of environments which are comfortable and facilitate the work of users. However, less quantifiable aspects of the workplace environment were revealed to have received considerably less research interest as they were not as easily quantified (Crouch & Nimran, 1989; Leaman & Bordass 1998). Thus, there was no accepted best practice for aspects of the environment such as decoration, window provision and break area provision. As a result there was no design guidance and less of an understanding of how these aspects of the environment had an impact upon users.

In addition to the level of understanding of the impact of the workplace environment upon users, the evaluation of the current state of knowledge revealed that whilst evaluations of workplace environments had been conducted, largely under the umbrella of post-occupancy evaluations, there were no published examples of truly holistic evaluations of the workplace environment. The most notable methodologies included Probe (for an overview see Cohen et al, 2001) and those incorporated within the British Council for Offices Guide to Post-Occupancy Evaluation (Oseland et al, 2007). However, these methodologies were not holistic as they did not fulfil the criteria of all considering both objective and subjective measures of the workplace environment

and/or were focused upon specific aspects of the workplace environment rather than the workplace environment as a whole.

Thus, four gaps in the current state of knowledge were identified which this research and thesis were developed to address. The first is a lack of systematic analyses of real world workplace environments as opposed to analysis of the impact of one or two aspects of the environment in a laboratory setting. The second gap identified was the lack of research evaluating both objective measures of the environment and related user attitudes simultaneously to determine the similarities or differences between them. The third gap in the current state of knowledge identified was a lack of consideration of qualitative aspects of the workplace environment with the focus to date having been upon factors which were easy to quantify and thus measure. The fourth and final gap in the current state of knowledge identified for this research was the lack of unbiased research into the impact of workplace environments. Many post-occupancy evaluations originated from the desire to demonstrate the positive impact of a specific environment, often one that was perceived to be performing well. In addition, the results of many workplace evaluations have not been published as a result of commercial confidentiality or sensitivity. Thus, there was a need for a systematic evaluation of a number of workplaces designed to demonstrate the impact of the whole environment upon users.

Considering the gaps identified in the current state of knowledge following analysis, the contributions to knowledge of this research and thesis can be demonstrated. These come primarily from the development of an holistic methodology to measure the impact of the workplace environment and a greater understanding of the impact of the workplace environment upon users.

The analysis of existing research in the current state of knowledge revealed a gap in academic knowledge relating to the impact of workplace environments and how this could be effectively evaluated. Thus, the development of a truly holistic evaluation of the workplace environment using a systematic and robust methodology used within a real-world setting provides a contribution to knowledge. The current state of knowledge supports the theory that aspects of the workplace environment are linked to user satisfaction and productivity (Sundstrom 1986). The internal climate has received much research attention and the studies analysed within the current state of knowledge reveal that these factors do have some impact upon users. However, there are other factors which also appear to have an impact, although the research findings are not as

well established. It is important that all aspects of the environment are studied simultaneously, including those which are deemed to be more subjective. The current state of knowledge revealed that a number of factors have been researched and have some correlation with users' perceptions and satisfaction with the workplace. These ranged from the easily quantifiable measures with standardised scales including air temperature, illuminance, noise, air movement, relative humidity, gross internal floor areas and density, through to aspects of the workplace that are not easy to quantify with a standardised measurement scale including window provision, furniture provision, break areas, decor, personal control and layout of the workplace. As identified, the majority of studies focused upon the measures that are easy to quantify or individual aspects of the workplace in isolation.

The research for this thesis took into account both the easily quantifiable aspects and those that were not quantifiable. All these aspects were analysed simultaneously to provide a more accurate understanding of the workplace environment. How users perceive the environment in the real world as opposed to a laboratory setting was demonstrated with any potential interaction effects taken into account. In addition to evaluating multiple aspects of the workplace, the research was holistic as it included measurements of the workplace environment that were both objective and subjective. To ensure that changes were effective both the real conditions within the environment and users' perceptions of the workplace had to be established. Understanding the relationships between these measures allows effective recommendations to be made with regards to the environment and demonstrated the relationship between reality and users' perceptions of the workplace. In addition to the holistic nature of the research the sampling methodology and number of workplaces researched furthered the contribution to knowledge. The workplaces analysed were not self selected and therefore the sample did not just contain workplaces perceived to have had a positive impact. Both positive and negative results have been reported in terms of impact upon users. Significantly, sixteen workplaces took part in the research. This allowed patterns in the data across all workplaces to be observed and analysed. With individual case studies it would have been difficult to separate the main environmental factors impacting upon users of the workplace from extraneous variables such as organisational factors. Thus, the development of a methodology which provides an holistic evaluation, demonstrating the impact of the workplace environment upon users is a contribution to the current state of knowledge. It is a systematic evaluation which demonstrates patterns of the impact upon users across workplaces, providing results that are more reliably generalised across other workplace environments.

Further contribution to knowledge from the evaluation phase of the research comes from the results of the data collection and analyses undertaken in the 16 workplaces. Details of the results are discussed earlier in this chapter but the overall contribution of the findings is an understanding of the impact of the workplace as a whole and identification of the more qualitative aspects of the environment as those with which users tend to be least satisfied. All aspects of the environment were found to be significantly, positively correlated with overall satisfaction and the model containing all aspects of the workplace environment measured was able to predict 3.7% of variance in perceived productivity. Thus, all aspects of the environment are important and can have an impact upon workplace users. The internal climate and spatial layout which have received more research attention and are supported by design guidance were found to be satisfactory in all workplaces. However, the more qualitative aspects of the environment, classified as interior design and features of the workplace, were not perceived to be satisfactory by users. As these aspects have received less research attention, standards and good practice have not been established. By understanding from this research, and the work of others, what users are satisfied with in relation to qualitative factors, further evidence can be gathered and good practice established as it has been for the qualitative aspects of the environment.

## Chapter 11 Aims and Objectives of the Testing Phase

### 11.1 Expansion of the Current State of Knowledge

The evaluation phase of this thesis was able to make a contribution to knowledge in the form of the development of a methodology and demonstrating how users perceive the workplace environment. In addition, the results of the evaluations highlighted the potential need to test some of the findings. There are two reasons for furthering the investigation to test the findings of the evaluation phase. The first reason is that the results from the evaluations have indicated significant relationships and demonstrated the strongest predictors of satisfaction with the workplace, stimulation and perceived productivity. However, the data collected was from existing workplaces and the environment was tested without any variables being changed to determine the impact that this had upon users. Thus, only correlational relationships can be established in the evaluation phase. To understand the causal relationship between the workplace environment and the indicator variables, a testing phase has been introduced, based on the results of the evaluation phase. The second reason that a testing phase was introduced was to analyse the relationship between the environment and stimulation levels. Whilst satisfaction with the workplace was rated positively by users, most of them rated themselves as not being stimulated. The ability of all aspects of the workplace to predict stimulation levels indicates that there is potential for changes to the environment to affect stimulation. Thus, a methodology based upon this evaluation phase of the research and further investigation of the current state of knowledge has been developed.

The relationship between arousal and performance was detailed within the Yerkes-Dodson principle (1908). The graph in Figure 15 demonstrates the relationship that they identified between performance of a task and the level of arousal of an individual.

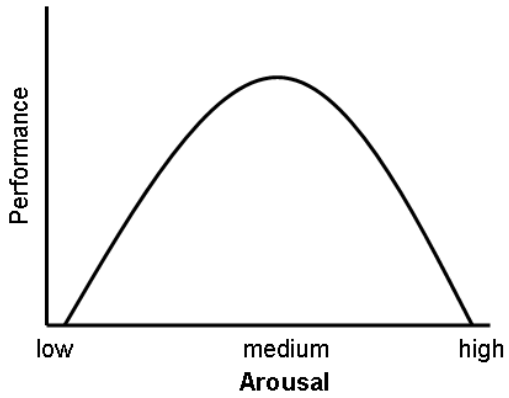



Figure 15 The Yerkes-Dodson Principle (Yerkes & Dodson, 1908)

An optimal level of arousal was identified that would facilitate the highest level of performance of a specific task. This model took account of the variation between tasks stating that the optimum level of arousal differs, with those that required high levels of concentration being facilitated by a lower level of arousal. Therefore an individual would need to be more stimulated to perform a simple task optimally than they would a more difficult task. At either end of the spectrum are states of low arousal and high arousal, which are correlated with poorer performance on a task. If an individual is not stimulated they are less likely to pay attention to details of the task and performance will suffer. When arousal levels are high an individual will not be able to focus as they are easily distracted or preoccupied. Subsequent empirical testing of this model has demonstrated that there is a relationship between arousal levels and performance (Anderson, 1994; Coles, 1974). However, evaluation of the physiological and psychological state of arousal has revealed that the Yerkes-Dodson model is over simplistic as it assumes that arousal is a single construct that affects performance in a consistent way whether it refers to an individual being anxious or excited (Mendl, 1999).

Analysis of the different types of arousal and the effect that these have upon performance support the multi-dimensional nature of arousal but acknowledge that there is still value in the Yerkes-Dodson model if it is accepted that it is a particular type of arousal that is being represented (Deffenbacher, 1994; Mendl, 1999). Dickman (2002) argues that there are two forms of arousal, which he labels wakefulness and vigour. Wakefulness is the level of arousal on a scale from extreme sleepiness to extreme alertness. Vigour on the other hand is a continuous scale from extreme physical fatigue to extreme readiness to take part in physical activity. The inverted u-

shaped curve of the Yerkes-Dodson model was recorded when the performance data was compared with the vigour component of arousal as identified by Dickman. These results support the relationship between arousal and performance within the Yerkes-Dodson model but distinguish the type of arousal as being specifically that of being ready to partake in activity as opposed to wakefulness. If the level of arousal is to be manipulated to improve task performance it is important that the correct form of arousal is affected.

This established effect of arousal upon performance demonstrates the importance of considering the level of stimulation of workplace occupants. If occupants are not stimulated at work or are over stimulated they are likely to be performing at a lower than optimum level. Within the first phase of research respondents from all workplaces were asked to indicate within the questionnaire when they felt most stimulated at work. The frequencies of replies to each time period are plotted in Figure 16.

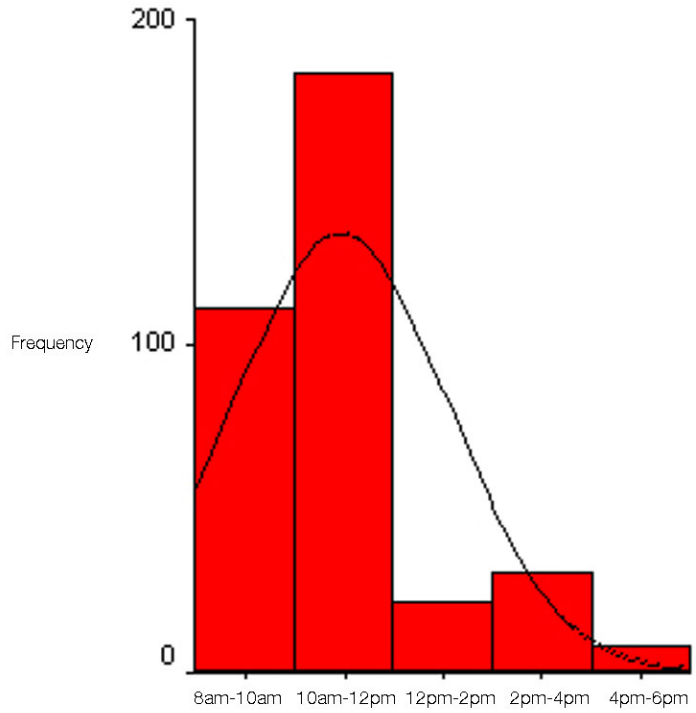



Figure 16 Frequency of Respondents Most Alert at Different Times of the Day

The results reveal that most respondents perceived themselves to be most stimulated between 10am and 12pm. There were significantly fewer people who perceived themselves to be stimulated in the afternoon than in the morning. There is a significant difference in the number of people who felt most stimulated at this time and the number

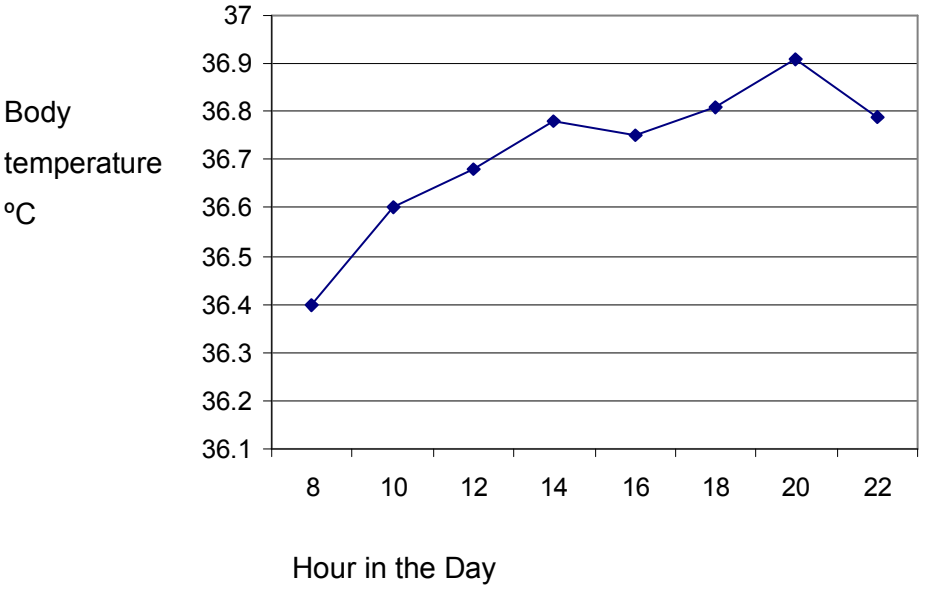
of people who felt most stimulated between 12pm and 2pm. This is traditionally the time during the standard working day when people eat their lunch. From this data it appears that this period of time in the working day is having an effect upon level of stimulation, which could also be affecting the performance of individuals within the workplace if they are not stimulated enough to perform tasks at the optimum level.

In order to determine whether the perceived lower levels of stimulation in the afternoon are a result of physiological changes, analysis of the research into circadian rhythms and the relationship between indicators of arousal and performance is necessary. Studies have revealed that as body temperature increases, indicating a rise in stimulation levels, performance improves (Colquhoun, 1971; Gupta, 1990). Body temperature follows a curve across a 24 hour period and peaks, on average, at 2000 hours. Obviously this peak varies according to individual differences and circumstances, although a similar pattern has been found in both introverts and extroverts (Wilson, 1989) and across different age groups (West et al, 2002). Evaluation of performance of cognitive tasks in relation to temperature has supported this data with performance peaking for many participants at 1900 hours and the worst performance being recorded at 0900 hours (Gupta, 1990).

However a different perception that performance of cognitive tasks declines in the afternoon has led to the development of a range of theories. Thorndike (1900) and Hollingworth (1914) proposed that mental fatigue builds throughout the day at work, thus people feel less alert in the afternoon due to mental exertion. Potter and Keeling (2005) found performance of a cognitive task worst at 1530 hours compared with results obtained at 0930, 1230 hours and 1830 hours. The best performance was obtained at 0930 hours. The relationship between these results and stimulation levels was analysed by increasing arousal through exercise. Activating the sympathetic nervous system, which controls the level of arousal, increased performance on the tasks, testing both working memory and long term memory at all times of the day except 1230 hours, supporting the argument that stimulation is linked to productivity.

There is an apparent conflict between those results demonstrating a steady increase in productivity throughout the day inline with fluctuations in body temperature, and those supporting the theory that productivity and stimulation decrease in the afternoon. The reason for this difference in the research findings may be due to differences in actual and perceived alertness. Folkard (1983) plotted the data from a series of studies to

reveal the differences between body temperature throughout the day and perceived level of alertness (Figure 17).



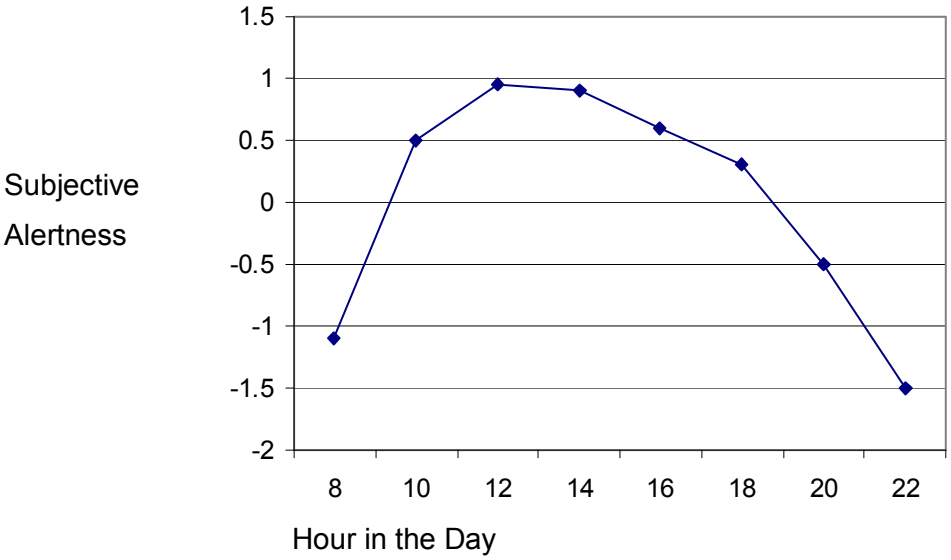




Figure 17 Objective and Subjective Measures of Alertness (Folkard, 1983)

The difference between these graphs demonstrates that subjective arousal is not correlated with physiological measures of stimulation. It appears that the significant relationship exists between perceived arousal and performance as opposed to actual levels of arousal determined by physiological measures and performance. West et al (2002) found that there was no significant difference in the daily fluctuation of body temperature of both old adult and young adult participants but their perceived level of

stimulation differed significantly. Older adults perceived their stimulation levels to peak in the morning whilst young adults rated themselves as being most stimulated in the early evening. It was this change in perceived stimulation that was found to be significantly correlated with measurements of efficiency of working memory. Hull et al (2003) found that participants performed best when their perceived levels of stimulation and motivation were at their highest. There was no effect of circadian rhythms and number of hours awake which have previously been found to correlate well with actual stimulation levels.

Whilst the graph of subjective alertness proposed by Folkard (1983) reflects the findings of the first phase of this research with perceived stimulation being lower in the afternoon than the morning it does not support the significant drop in perceived stimulation that occurs between the morning and the lunchtime period of 12pm-2pm. The post-lunch dip in levels of stimulation has been empirically studied to determine whether stimulation and performance of tasks is significantly lower than it is at any other time of the day. A decrease in performance on a variety of tasks has been recorded after lunch has been eaten (Christie & McBreaty, 1979; Colquhoun et al, 1969; Colquhoun, 1981; Folkard, 1983; Hildebrandt et al, 1974; Marks & Folkard, 1984; Smith & Miles, 1986). In a series of studies of the impact of shift patterns, time of day and meal consumption Colquhoun et al (1969) discovered that performance on vigilance tasks decreased after participants had eaten lunch. This was the only point of the day at which they found performance decreased as opposed to increased as the day progressed. The pattern of performance increasing from the morning through the afternoon and into the evening mirrors that of body temperature, an indicator of arousal levels (Folkard, 1983), which increases throughout the day. There was no significant relationship between the pattern of increasing body temperature and the level of performance throughout the day within Colquhoun et al's study. However, they argued that without the post-lunch dip in attention there would have been a statistically significant correlation. The reduction in performance on the task after lunch was of a magnitude and sustained for a period of time long enough to affect the correlation between body temperature and performance. This finding clearly highlights the importance of considering this reduction in performance after lunch in the early afternoon. A significant reduction in performance on a task requiring high levels of attention will have considerable implications for organisations wishing to improve the productivity of their workforce and individuals wanting to work more effectively. Although a significant correlation between eating lunch and a relative reduction in performance has been demonstrated in research, analyses of the cause of this

phenomenon are not conclusive. It is not clear whether the effect is a result of eating lunch or whether it is other factors such as physiological changes that follow a specific circadian cycle.

Analysis of whether it is the actual consumption of food or the association of midday with food has produced fairly conclusive results. A decrease in performance has been recorded around midday even when no food was consumed (Hildebrandt et al, 1974). This suggests that the cause of the drop in performance is intrinsic i.e. a physiological response not prompted by external influence and is not affected by aspects of the environment. However, the interpretation of this data from a behaviouralist point of view is that the control group, who did not consume lunch, were conditioned to expect food at that time of day and therefore produced the appropriate physiological response which affected their performance (Follenius et al, 1982). There is greater support for the theory that it is the actual consumption of the meal that affects performance rather than physiological changes and that the decrease in performance after lunch is due to extrinsic factors. Participants not given lunch during an experiment around midday performed worse in the early afternoon than participants who were given lunch (Craig et al, 1981; Follenius, 1982; Smith and Miles, 1986). Further support for the extrinsic effect upon task performance comes from an analysis of the impact of different types of food upon performance. Spring et al (1983) demonstrated that carbohydrate rich meals had a greater detrimental effect upon performance than protein rich meals. This has been linked to the impact that carbohydrate rich meals have upon levels of alertness in comparison to protein rich meals. Participants reported feelings of sleepiness and calmness to a greater extent after the consumption of the carbohydrate rich meal than they did the protein rich meal. If the type of meal has a significant impact upon performance it suggests that the consumption of a meal itself it the cause of a change in performance.

Although this evidence supports the extrinsic influences of lunch time upon performance, research into the relationship between time of day, consumption of food and performance has revealed an intrinsic influence. Overall, evidence suggests that the consumption of a meal at any time of day has an impact upon task performance (Smith & Miles, 1986a; Smith & Miles, 1986b; Spring et al, 1983). However, the majority of studies have revealed a greater effect of a meal being consumed at midday than in the morning or the evening (Colquhoun et al, 1969; Craig et al, 1981; Follenius et al, 1982). This supports the considerable influence of intrinsic factors upon the decrease in performance of a task in addition to extrinsic factors. The time of day has a

significant impact upon the accuracy and speed of participants which is not dependent upon a meal being consumed. However, the clear effect of food upon performance leads to the conclusion that there are both intrinsic and extrinsic factors related to a significant decrease in performance of a task in the early afternoon. The cause of this effect upon performance is potentially linked to arousal levels in the early afternoon. Whilst body temperature and other physiological indicators of arousal rise throughout the day, changes in hormone levels have been found to change in response to food, or the anticipation of food. These hormones have also been found to be significantly related, either positively or negatively, with arousal. Changes in insulin levels (Christie & McBreaty, 1979), plasma cortisol levels (Follenius et al, 1982) and serotonin levels (Spring et al, 1983) have been recorded in the period of time following the consumption of food around midday. The changes in levels of these hormones and neurotransmitters are associated with a reduction in arousal levels. Further support for the relationship between lower levels of arousal and a decrease in performance in the early afternoon is that providing a stimulus increases levels of arousal which has a positive effect upon the performance of tasks. Caffeine (Anderson, 1994) and noise (Smith & Miles, 1986) have been found to improve performance on tasks which was conversely decreased in control groups where no stimulus was provided. Noise was found to have a negative impact upon performance at other times of the day when levels of arousal were perceived to be higher.

When evaluated together the research to date indicates a clear potential and need to adapt the workplace environment to ensure that it has a positive impact upon those who work there. Whilst the relationship between arousal and performance is clearly complex it can be summarised by the Yerkes-Dodson principle whereby the optimum level of a beneficial form of arousal facilitates high levels of performance on a task. Too little stimulation is related to low levels of performance for an individual. Within the workplace environment stimulation is therefore a key consideration. As revealed in the first phase of the research perceived stimulation is significantly related to all aspects of the workplace environment that were measured. Although a causal relationship was not established, the current state of knowledge supports a link between particular environmental conditions and perceived levels of stimulation. Temperature (Abdou & Lorsch, 1994), noise (Smith & Miles, 1986) and colour (Kwalleck & Lewis, 1990) have all been found to be related to perceived levels of arousal. This research evaluated together supports the theory that the environment could be designed to affect stimulation levels. However, there is little evidence of a cause and effect relationship between perceived stimulation and aspects of the workplace environment in a real

world setting. Therefore it is not possible to conclude that changing specific aspects of a workplace environment will have an impact upon levels of stimulation without further analysis.

A further factor that requires consideration is optimum level of arousal. If the Yerkes-Dodson principle is applied, creating an environment that is over stimulating will be as detrimental to performance as an environment that is under stimulating. Therefore a stimulating environment must be created in the correct location within the workplace and at the time of day that is most beneficial to occupants in terms of having an impact upon performance through the creation of optimal levels of arousal. A clear link has been established between a reduction in performance on tasks requiring sustained attention and arousal levels after lunch. This perceived decrease in alertness levels is identified both within the first phase of this research and the previous research of others. The current state of knowledge also reveals a significant decrease in attention levels in the early afternoon. This evidence reveals that arousal in the early afternoon is generally below that required to facilitate performance on tasks with high cognitive load. If performance is to be maximised then people need to be stimulated more after lunch than they do in the morning. Using this knowledge and understanding that designing or manipulating the environment in a particular way can increase stimulation offers an opportunity for further research. Using data from the first phase of this thesis and the current state of knowledge, the best predictors of stimulation can be identified and the way in which these impact upon levels of alertness. Once this is established these aspects of the environment can be manipulated in the afternoon to increase the level of stimulation provided by the workplace and to increase the arousal level of occupants. This should lead to an increase in performance of tasks requiring sustained attention in the early afternoon and negate the negative effects of the lunch break.

### 11.2 Aims and Objectives of the Testing Phase

Following the completion of the first phase of the investigation, a second stage of research was established, informed by the findings of the workplace evaluations. The aim was to determine whether the workplace environment had an impact upon the stimulation levels of workplace users. Analysis of existing research revealed that the majority of previous evaluations of the workplace environment focused upon satisfaction with the environment, job satisfaction or perceived and actual productivity (Oseland, 2007). However, research from the first phase of investigation, revealed a statistically significant correlation between stimulation and perceived productivity. This

is supported by the current state of knowledge detailed earlier in this chapter, in particular the Yerkes-Dodson Principle (1908) which suggests an optimum level of arousal for task performance. In parallel, research into levels of perceived stimulation throughout the day clearly demonstrated a reduction in stimulation levels after midday. Taken together, the research revealed a potential need to provide additional stimulation to workers in the afternoon. The findings from the first phase of the research demonstrated that the environment could play a role in providing stimulation. Positive attitudes towards aspects of the workplace were significantly correlated with increased levels of perceived stimulation. Thus, there appeared to be scope for testing whether the environment could be designed in such a way to affect perceived stimulation levels. Previous research into models of motivation such as Herzberg's 2-factor model (Herzberg et al, 1957; Herzberg, 1966) suggest that working conditions are hygiene factors, that is they can only have a negative impact upon motivation. The aim of this study was to demonstrate that when used to increase stimulation levels in the afternoon, the workplace environment could also be a motivating factor and have a positive impact. Thus, the objectives of the second phase of the research were:

- To test the attitudes of users towards varying environmental conditions in the workplace between the morning and afternoon.

- To demonstrate whether there was an impact upon, or relationship between, changes to the environment, user perceptions and perceived stimulation.

## Chapter 12 Methodology of the Testing Phase

### 12.1 Introduction

The contribution to knowledge from the holistic evaluation can be extended by testing whether stimulation levels are affected by variations in the environment. Analysis of the data from the main phase of the research revealed that all aspects of the workplace were positively correlated with stimulation. However, the data collected in the main phase of the research only allows for correlations to be established, no causal relationships can be inferred. To determine whether variation in aspects of the environment affect how stimulated users are, testing in real workplace environments is necessary. The findings of the data analysis from the first phase of the research have informed the development of this research.

### 12.2 Methodology

#### 12.2.1 Design

The testing phase was a within subjects design carried out in two workplaces. Measurements taken of the workplace before the experimental changes were the control conditions.

The independent variables were changes made to the workplace environment in the afternoon and were air temperature, air movement, colour scheme, artwork, break area provision and personal control. All variables measured in the first phase of the research were significantly correlated with stimulation therefore those variables which also met the other experimental criteria were selected. The other criteria was that the aspects of the workplace chosen as variables could be varied on a daily basis as the ability to influence stimulation in the afternoon and not the morning was an integral part of the research.

The dependent variable was stimulation levels created by the workplace. Extraneous variables were controlled for by keeping all other aspects of the workplace constant during the experiment.

### 12.2.2 Participants

Participating Organisations:

It was not possible to collect all the necessary data from one workplace, therefore two workplaces were selected. These will be referred to as Workplace X and Workplace Y to ensure that confidentiality is maintained. These workplaces were selected due to the opportunity to manipulate those aspects that were predictors of stimulation as identified. Workplace X was a design practice working in a fully open plan environment across 3 floors. One floor was selected on which the experiment was carried out. There were 19 users located on this floor. Workplace Y was a financial services organisation working in a fully open plan environment with 30 users located in the workplace. Data was collected on the amount of time respondents spent at their desks, the type of job that they had, the amount of concentration that their work required, their three main tasks at work and the length of time they had been with the organisation. The data relating to the impact of the environment upon stimulation was tested against the job characteristics data to ensure that they were not having a significant impact upon the results. There was no significant impact recorded therefore the changes in stimulation levels are not likely to be a result of the differences between the workplaces and users of these environments.

Participants:

All users in Workplace Y and the ground floor of Workplace X were invited to take part in the research and given questionnaires to complete. The users fulfilled a range of roles within the two organisations from director to administration staff. As a within subjects model, comparing the change in stimulation from before the experiment commenced with the experimental conditions, all participants experienced all conditions within their own workplace. Thus, all participants in Workplace X experienced the air temperature, air movement, artwork and colour scheme conditions. All participants in Workplace Y were in the break area and personal control conditions.

From the participants who responded to the questionnaires, five from each workplace were randomly selected to be informally interviewed about the responses obtained. Those who took part and all the individual responses given to both the questionnaires and interview questions were kept confidential.

### 12.3 Materials and Apparatus

To create different conditions in each workplace equipment was installed and changes were made to the environment at noon.

The first condition was air temperature and this required the thermostat, which was linked to the building management system to be changed by 2ºC. The thermostat was tested to ensure that it was capable of bringing about this change. To do this the air temperature was measured in the morning and afternoon using a digital thermometer/hygrometer.

The second condition was air movement and the equipment required to achieve an increase in air movement in the afternoon was the installation of two tower fans in the space. These were located so that the air movement would reach as many users in the space as possible at their desks without causing any individual discomfort. The fans were set to rotate during the experiment. To ensure that the air movement was increased, an anemometer was used to measure the air movement speeds in both the morning and afternoon.

The third condition was artwork. To provide artwork in the space in the afternoons only an image was projected on to the main internal wall using a laptop and projector. The wall selected could be seen by all workplace users from their workstations. The images selected for projection were chosen as a result of the understanding gained from the current state of knowledge. Previously researchers had tested the impact of artwork or images and used scenes of nature (Stone & English, 1998; Stone, 2003). Thus, images were selected which were of natural scenes. A different scene each day was selected to provide variety. An example of one of the images projected can be seen in Figure 18. All images were of a similar variety.

Figure 18 An example of a nature scene projected on the wall in the artwork condition of the testing phase

The fourth condition was colour scheme and this was created using lights with coloured filters. These lights were positioned so that they shone on the main internal wall and washed the previously white wall with colour. As bright colours were highlighted as being stimulating in the current state of knowledge (for example, Küller et al, 2006; Küller et al, 2009; Mehta & Zu, 2009; Stone, 2003) two bright colours, red and green, were selected for the filters on the lights.

The fifth condition was the break area provision. Just before the experimental phase commenced a new break area was added to Workplace Y. For the duration of the experiment users were only given access to the break area in the afternoons. The break area design was very different to the rest of the workplace and the area was separated from the main workplace. The design was developed to make it feel like a place people could go to get away from work. The design of the break area can be seen in Figure 19.

Figure 19 Break Area design in Workplace Y

The sixth and final condition was personal control. In Workplace Y there were controls for the air temperature and illuminance levels installed on a grid to create smaller zones of control via the building management system. Users were given access to these controls in the afternoon so that they had greater personal control of the internal climate.

### 12.4 Procedure

During the testing phase the six aspects of the workplace identified were varied and respondents surveyed to determine whether this manipulation of the environment had a positive impact upon stimulation levels. As discovered within the first phase of the research, stimulation levels on average are lowest in the afternoon between 12pm and 2pm and continue to remain at a lower level throughout the afternoon. According to the Yerkes-Dodson principle it would be beneficial to increase occupants' level of stimulation in the afternoon due to the positive impact this can have upon productivity. Therefore each of the six variables was maintained in the morning so that they were the same as prior to the testing phase. This provided a baseline from which the variable could be manipulated in the afternoon to create a more stimulating environment. At 12pm the afternoon conditions were introduced. For twelve weeks

each aspect of the environment was taken in turn and manipulated every day from 12pm onwards for a period of two weeks.

Before the testing phase began, users were asked to complete two surveys. The first was the workplace satisfaction survey used within the holistic evaluation which allows the data from Workplaces X and Y to be compared with and benchmarked against that from the other workplaces. Environmental monitoring, observational reports and space plan mark-ups were also completed to allow for the comparison of this objective data as well as the subjective responses from the questionnaire. In addition to benchmarking, collecting data using the satisfaction survey provided a comprehensive baseline from which changes to the environment could be analysed. The second survey that participants were asked to complete focused upon stimulation levels and how this related to each aspect of the workplace environment. This can be found in Appendix E. Respondents were asked to rate how stimulating they found the spatial layout, decoration, furniture provision, window provision, break areas and internal climate on a scale of 1 to 7. As this is a relatively new area of research, little is known about what impact the environment has upon stimulation. Therefore respondents were given the opportunity to write in their own comments in relation to each aspect of the environment. This ensured that their responses were not constrained by the scale provided. In addition items were included within the questionnaire to determine overall stimulation levels, the specific tasks that individuals carried out at work and the amount of time that respondents spent at their desks. This information was analysed to determine whether job characteristics had an impact upon stimulation.

During the testing phase respondents were asked to complete a shorter version of the stimulation questionnaire, a copy of which can be found in Appendix F. The questions that were included were those referring to overall stimulation. Asking participants to complete a shorter questionnaire encouraged them to respond as it was not as time consuming and therefore did not require them to dedicate as much of their working day to taking part in the research. Occupants were asked to complete the questionnaire twice weekly for the duration of the testing period. This ensured reliability as the responses given were more rigorous and not subject to factors specific to a certain day or the mood of respondents.

### 12.2.1 Air Temperature

Analysis of the data from the holistic evaluation revealed that there was a positive relationship between air temperature and stimulation. Increases in air temperature were correlated with increased levels of stimulation. However, it is important to note that the air temperatures recorded within this research were not extreme and ranged from 19ºC to 27 ºC which is only 1 ºC outside of the recommended range within the design guidance. Research into more extreme air temperatures revealed that very hot or very cold environments are not stimulating as they begin to physically prevent people from performing their work. Therefore the air temperature was increased in the afternoon by 2ºC as this is a significant change whilst not creating an extreme internal climate. The air temperature was set using a local thermostat and was set at 22 ºC, the mid-point of the range within the design guidance, in the morning. At 12pm the thermostat was adjusted to 24 ºC. The air temperature was measured using a thermometer to ensure that there was an increase in temperature of 2 ºC.

### 12.2.2 Air Movement

The holistic evaluation demonstrated that an increase in air movement was correlated with increased stimulation levels. Therefore the air movement was increased in the afternoon from 12pm onwards. Tower fans were introduced to the workplace to increase the air movement speeds. The highest setting on the fans was used and the fans rotated so that the air movement speed was increased throughout the whole workplace. The air movement was measured using an anemometer to ensure that there was a significant increase in air movement speed. In the morning, when the fans were turned off, the average air movement speed was recorded at 0.01m/s. In the afternoon this was increased to an average of 0.07m/s.

### 12.2.3 Colour

The use of colour in the workplace, other than neutral whites and creams, was correlated with increased stimulation in the first phase of the research. Analysis of the current state of knowledge and data from the holistic evaluation suggest that red and green are the most stimulating colours. Therefore LED lights were used in the afternoon to wash the main wall within the workplace with colour, alternating between red and green on a daily basis. These LED lights were only switched on at 12pm and remained on for the rest of the afternoon.

### 12.2.4 Artwork

Having artwork on the wall was correlated with increased stimulation in the first phase of the research. Therefore images were projected onto a blank wall in the workplace from 12pm onwards. The images selected were of natural landscapes as research has shown these to be most restorative in terms of attention and therefore stimulating. Different images were projected daily to prevent respondents from becoming bored.

### 12.2.5 Break Areas

A break area in which people feel they can get away from work and is distinct from the main workplace was found to be highly correlated with stimulation in the first phase of the research. Within Workplace Y a break area was incorporated which was surrounded by full height partitions and therefore separated from the rest of the workplace. In addition the style of the fit out within the break area was very different to that of the rest of the workplace, further identifying and separating the break area from the work area. This provided a greater sense of being able to get away from work. The users were only given access to the break area in the afternoon for the first two weeks after completion.

### 12.2.6 Personal Control

Higher levels of personal control over the environment were correlated with increased stimulation in the main phase of the research. Therefore greater personal control over the air temperature and ventilation was offered to users after 12pm within the testing phase. Local controls were provided within the workplace for users to alter in the afternoon if they so wished. In the morning the internal climate was controlled remotely by a building management system.

Upon completion of the testing phase respondents were asked to complete a full version of the stimulation questionnaire so that the results from before and after the variation of the environmental aspects could be compared. The data from all the questionnaires and objective monitoring was statistically analysed to determine whether there were any significant relationships. Once the data from the questionnaires had been gathered and the results analysed five respondents from each workplace were randomly selected to take part in an informal one on one interview with the researcher. All participants accepted. The interviews were loosely structured around the data collected from the questionnaires and participants were asked three main

questions. The first was whether they had noticed any changes being made to the environment, the second was whether they liked the changes and the third was whether they felt the environment had become more stimulating as a result. Interviews were allowed to flow naturally and each one took approximately thirty minutes.

## Chapter 13 Results of the Testing Phase

### 13.1 Introduction

The data collected from the questionnaires was analysed to determine whether changing the workplace environment at midday had an impact upon stimulation levels. Respondents were asked to rate how stimulated they felt in both the morning and afternoon. The differences between the reported stimulation levels were calculated. This was to determine whether changing the environment had an impact upon the decrease in stimulation after midday as highlighted in the current state of knowledge and by the results of the first phase of the research. The data is presented as the percentage difference in stimulation levels between the morning and afternoon in comparison to the baseline measurement. The baseline measurement was taken before changes were made to the workplaces. Where stimulation levels in the afternoon did not decrease as much as the baseline measurement, a positive result is recorded. Where the decrease in stimulation levels between morning and afternoon was greater than the baseline a negative percentage change was recorded. The results are presented in Table 13.

| Factor | Decrease from AM to PM |
|---|---|
| Baseline | 0 % |
| Colour | +6.14 % |
| Artwork | + 5.43 % |
| Air movement | + 5.43 % |
| Air temperature | -2.43 % |
| Break area | - 7.1 % |
| Personal control | - 7.24 % |

Table 13 Change in Stimulation Levels between Morning and Afternoon

The table demonstrates that changing the environment during the testing phase is related to a decrease in the difference in stimulation levels between the morning and afternoon in the colour scheme, artwork and air movement conditions. These findings support the hypothesis that introducing colour into the workplace, projecting artwork on the wall and increasing air movement in the afternoon has a positive impact upon perceived levels of stimulation. However, the decrease in stimulation from the morning

to the afternoon was greater than the baseline measurement when the air temperature was increased, a break area was provided and the level of personal control over the internal climate was increased. This suggests that these changes to the environment had a negative impact upon stimulation levels in the afternoon compared with the workplace when no changes were made. To gain a greater understanding of the results and evaluate why changing some aspects of the workplace appeared to have a positive impact upon stimulation levels in the afternoon whilst other changes were correlated with a negative impact respondents were invited to attend an informal interview. Within these interviews the reasons for the responses obtained from the questionnaire data were analysed in greater detail. The findings of both the quantitative and qualitative research were evaluated together to determine the impact of changing the workplace environment upon stimulation levels.

### 13.2 The Impact of Colour Scheme

Analysis of the data from the questionnaire revealed that respondents' levels of stimulation were positively affected when the colour scheme of the workplace was changed in the afternoon. From the questionnaire data it appears that the colour scheme was associated with the smallest reduction in stimulation levels from the morning to the afternoon. These results were supported by the informal interviews when all participants stated that they had noticed the changing colour scheme from the projected lights and were aware of it changing on a daily basis, in the afternoon. All participants reported liking the changes to the colour scheme which demonstrates increased satisfaction levels. In terms of stimulation, those respondents who felt that the changes had a positive impact upon stimulation levels all cited colour scheme as one of the most significant factors. This supports the findings of the questionnaire data analysis. Together these qualitative and quantitative findings suggest that changing the colour scheme in the workplace by washing a previously neutral wall in coloured light is associated with a smaller decrease in stimulation levels from the morning to the afternoon.

### 13.3 The Impact of Artwork

Analysis of the questionnaire data revealed that a smaller reduction in stimulation levels in the afternoon occurred when artwork was projected on the wall than the baseline measurement. The interviews with respondents revealed that they perceived the addition of artwork in the afternoon to increase satisfaction and on the whole have

a positive impact upon stimulation levels. As with the changes to the colour scheme, the projection of artwork on the walls was noticed by all participants. They were aware of the artwork and that it was only displayed in the afternoons. All respondents interviewed stated that they liked the nature scenes that were selected and the variety of a different scene being displayed each day. Respondents also reported that the artwork provided a talking point within the workplace and encouraged positive social interaction. This led to respondents reporting high levels of satisfaction with the provision of artwork during the testing phase and there were requests for the continuation of the projection of images once the research was completed. In addition to high levels of satisfaction, respondents who perceived that the environment increased stimulation levels during the testing phase cited artwork as having the greatest impact. Thus, as with colour scheme, the qualitative data supports the quantitative data from the questionnaires. When artwork was projected on the wall respondents were more satisfied with the workplace and there was a positive impact upon stimulation levels.

### 13.4 The Impact of Air Movement

The increase in air movement was related to a positive impact upon perceived stimulation levels in the afternoon. Compared with the baseline measurement, before any changes were made, there was a reduction in the difference between stimulation levels in the morning and the afternoon when the air movement was increased. This is supported by the findings from the informal interviews, although to a lesser extent than the colour scheme and artwork conditions. The participants stated that they noticed a change in the air movement within the workplace, although the presence of the tower fan units was the reason given for this observation. In addition, the participants did not perceive the air movement to increase from the morning to the afternoon. This suggests that it was the equipment installed as opposed to a change in the environmental conditions which affected participants' perception of the changes to the workplace.

Respondents reported being satisfied with the air movement during the testing phase but this level of satisfaction did not differ from their satisfaction levels before the testing phase commenced. Participants did not perceive the changes to the air movement to have any impact, either positive or negative, upon their satisfaction. With regards to stimulation, some respondents suggested that the localised impact of the tower fans when they were moving around the workplace may have had an impact upon their

stimulation levels. Overall, they did not perceive there to be a link between the changes to the air movement speeds and their stimulation levels, particularly when compared with the impact of changing the colour scheme and artwork. The findings of the quantitative data suggest that there is a link between changing the air movement and stimulation but the qualitative findings did not produce as strong a result. There may be some impact of air movement speed upon stimulation levels but this does not appear to be as overtly evident to participants as other changes that were analysed.

### 13.5 The Impact of Air Temperature

Analysis of the data collected during the testing phase when the air temperature was increased indicates that there was a negative impact upon stimulation levels in the afternoon. Questionnaire respondents reported a greater decrease in stimulation levels from the morning to the afternoon when the air temperature was increased by 2ºC. The findings of the questionnaire data alone indicates that increasing the air temperature had a negative impact upon stimulation levels. However, further analysis of the results in the informal interviews provided qualitative data which helps to explain these findings. As with the other aspects of the environment evaluated during the testing phase, respondents were asked whether they had perceived there to be any change in the air temperature. None of the respondents in the informal interviews reported noting any change to the air temperature and did not perceive there to be any noticeable difference in air temperature between the morning and afternoon. These findings suggest that the change to the air temperature was not significant enough to have had an impact upon participants as they did not perceive the air temperature to have increased. The change made was an increase of 2ºC which meant that the air temperature at 23.5ºC was still within the comfort zone range specified within the design guidance. Pervious research and the findings of the holistic evaluations of the workplace from the first phase of the research have identified that overall people are satisfied with the air temperature when it is within the design guidance comfort zone and were not dissatisfied with moderate variations in air temperature. Furthermore, the holistic evaluations of the workplace revealed that there was no significant correlation between variation in the actual air temperature of the workplace and occupant perceptions. The moderate range of air temperatures recorded (the majority were well within the range specified within the design guidance) did not have any apparent impact upon occupant satisfaction. Respondents rated themselves as being satisfied with the air temperature overall and the standard deviations from the mean indicate that the majority of participants were equally satisfied across all workplaces. In the

discussions, respondents offered further support for this argument with all of those interviewed stating that they were satisfied with the air temperature both before and during the testing phase. However, respondents did not perceive the increase in air temperature to have had an impact upon their stimulation levels. They did not rate the environment as being more or less stimulating during the testing phase in the afternoon. These results demonstrate that participants did not notice a change in the air temperature and that they were satisfied with the air temperature both before and during the testing phase. Respondents cited not being aware of the change in air temperature as being the reason for them not perceiving the environment to have an impact upon their stimulation levels during the test conditions. In the interviews they reported that they did not perceive the environment to have had a negative impact upon their stimulation levels. Thus, it may have been other factors which led to the negative impact upon stimulation that were not related to the air temperature.

### 13.6 The Impact of the Breakout Space

The questionnaire data revealed that respondents' levels of stimulation were negatively affected in the afternoon when access to the new breakout space was provided. The difference between respondents' stimulation levels in the morning and afternoon were greater during the testing phase than before. This suggests that the provision of the breakout space had a negative impact upon stimulation levels. The interviews with respondents revealed further information about their responses in the questionnaire and helped to explain why the findings indicated that the breakout space had a negative impact upon stimulation. The addition of the new breakout space was noted by all participants and they were aware of when they had access to this space during the testing phase.

The respondents who were interviewed differed in their ratings of satisfaction with the breakout space. Whilst all respondents stated that they were very satisfied with the provision of a dedicated breakout space, away from the visitors waiting area and the main workspace, they expressed dissatisfaction with aspects of the design. The issues were highlighted in the interviews by respondents. The breakout space was perceived by all respondents to be too cold and therefore uncomfortable to sit in for long periods of time. Carpeting adjacent to the sink became dirty quickly and was difficult to clean which was expressed as a source of dissatisfaction by a number of respondents. The graphics within the breakout space were disliked by some respondents and were described by one as being 'like a nursery'. However, the main source of dissatisfaction

which was highlighted by all respondents was the inclusion of a Playstation computer games console in the break area. It was felt that the game dominated the break area when in use, which was most of the time, and was distracting for others wanting to make use of the breakout space. As respondents were not satisfied with the design, their overall levels of satisfaction with the breakout space were reduced. It appears that this was a direct result of the particular design as oppose to the principle of incorporating a designated and separate breakout space.

Although dissatisfied with the design of the breakout space, some respondents in the interviews did report perceiving themselves to be more stimulated during the testing phase. Of the six people interviewed, two respondents stated that the breakout space had a positive impact upon their stimulation levels. The remaining participants did not rate the breakout space as having a negative impact upon their stimulation levels but suggested that they may have been more stimulated if they were satisfied with the design. This suggests that satisfaction is strongly related to stimulation and that a dissatisfactory environment can reduce the positive impact that providing a breakout space can have upon stimulation. These findings are supported by the results of the first phase of the research when a strong, positive correlation was established between satisfaction and stimulation. Low levels of satisfaction were related to low levels of stimulation. Thus, because respondents were dissatisfied with the aspects of the breakout space their overall satisfaction levels were affected. The results from the first phase of the research, and participants responses in the interviews, suggests that this may have had an effect upon stimulation levels.

### 13.7 The Impact of Personal Control

The responses from the questionnaires indicated that the greatest, negative impact upon stimulation levels in the afternoon was discovered when personal control of the internal climate was increased. This suggests that offering respondents greater personal control over the internal climate, in particular the air temperature and ventilation, had a negative impact upon stimulation. The informal interviews with respondents provided greater insight into these results with the qualitative data obtained indicating that participants were not aware of the increase in personal control, which affected the impact that it had upon stimulation. During the interviews none of the respondents reported knowing that they had increased personal control of the internal climate through the provision of more control points and upgrading of the cooling system. Only one respondent from the six interviewed stated that they were

aware of having increased personal control. However, this was in a post room which was separate from the main workspace where the research was focused. As participants did not notice a change in their level of personal control they stated that it had no impact upon their satisfaction and stimulation levels. Respondents reported feeling equally as satisfied with their level of personal control before and during the testing phase. Whilst some stated that they would prefer increased personal control of the internal climate, two of the six respondents believed that it would be difficult to offer people greater autonomy and maintain an internal climate with which everyone was satisfied. The respondents reported not being stimulated by the increase in personal control as they did not perceive there to be any difference between the baseline and testing conditions. If participants had been given more instructions about the changes to the controls they may have perceived there to have been a difference in the testing phase. This could have had a greater impact upon stimulation levels. Respondents suggested other factors, such as their work tasks, had a greater impact upon their stimulation levels during the testing phase than the environment which may explain the results.

### 13.8 Summary

The quantitative and qualitative data demonstrate a relationship between the environment and stimulation levels. The questionnaire data indicates that incorporating artwork and changing the colour scheme of the wall was related to increased stimulation levels in the afternoon compared with the baseline measurement. This was supported by the qualitative data collected in the interviews with respondents. The quantitative data from the questionnaires also revealed a positive relationship between stimulation levels and increasing the air movement from the baseline level. This was not as conclusively supported by the qualitative data as respondents were not fully aware of changes to the air movement speed during the testing condition. Changes to the air temperature, personal control and breakout space were related to a reduction in stimulation levels compared with the baseline measurement. With regards to the air temperature and personal control, the qualitative data revealed that the majority of respondents were not aware of any changes to these factors during the testing phase and therefore did not believe that these aspects of the environment had an impact upon their stimulation levels. Whilst the breakout space provision was noticed by participants, their dissatisfaction with the design was cited by respondents as potentially having a negative impact upon stimulation.

## Chapter 14 Discussion of Results and Contribution to Knowledge

### 14.1 Discussion of Results of the Testing Phase

The testing phase of the research enabled greater understanding of the impact of the workplace upon stimulation levels to be determined. Satisfaction with each of the aspects analysed was significantly correlated with stimulation in the evaluation phase of the research. The results of the testing phase demonstrated that changing the colour scheme in the afternoon by washing a wall with either green or red light reduced the reported post-lunch dip in concentration levels. A similar but slightly smaller effect was discovered with the projection of artwork and an increase in air movement in the afternoon. These findings suggest that changing the environment can have an impact upon stimulation levels in the afternoon compared with making no changes to the environment. Increasing the air temperature, providing access to a break area and increasing the amount of personal control in the afternoon did not have a positive impact upon stimulation levels. The potential reasons for these results being obtained are detailed in the previous chapter and were established through informal discussions and interviews with some of the respondents. Overall the results reveal that the environment could potentially have an impact upon stimulation levels but that there are three caveats to this revealed by the findings from this research. The first is that to affect stimulation levels, people must be able to perceive that the environment has an impact upon them. When changes to the environment were perceived by respondents they were found to have a positive impact upon stimulation levels, providing respondents were satisfied with the changes. This leads to the second caveat which is that there is a strong correlation between satisfaction and stimulation. The results indicate that when people are dissatisfied with an aspect of the environment it can have an impact upon their stimulation levels. The third and final caveat is that the relationship between the workplace environment and stimulation levels is not simple and direct. There are several other factors that affect the results from organisational issues to job characteristics. Respondents in the discussions cited work colleagues and the tasks they were performing as having a greater impact upon their levels of stimulation than the environment. There is scope to explore the impact of the environment upon stimulation further based upon the findings of this study. There are two additional contributions to knowledge from this phase of the research: the methodology and the understanding of the potential impact of the workplace on stimulation levels.

### 14.2 Contribution to Knowledge of the Testing Phase

Understanding the methodology, findings and implications from previous research allowed the contribution to knowledge of this testing phase to be established. There were two gaps in the knowledge identified which this research was designed to address. Analysis of the current state of knowledge in terms of the impact of workplace environments upon users has revealed that the methodology of most workplace evaluations has involved monitoring aspects of the workplace environment in a real world setting (for example Cohen et al, 2001; Laing et al, 1998; Oseland, 2007; Preiser et al, 2001) and establishing significant correlations between the environment and users' perceptions. The analysis of the existing research revealed that there were very few studies in which a real world workplace environment was varied purposely and the impact measured. Thus, there appeared to be a gap in the knowledge as findings from the correlational and observational studies were not tested to establish causal relationships. Therefore there was an opportunity for the testing phase to make a contribution to knowledge and extend the understanding gained through analysis of the current state of knowledge. By testing the environment holistically, and then varying a specific aspect before analysing the impact that this has upon users' stimulation levels, provided the potential to gain further insight into the impact of the workplace environment upon stimulation which has not previously tested. Using the findings from the initial phase of the research, six aspects of the workplace environment were varied sequentially to establish the impact that this had upon users' perceived levels of stimulation. The use of an experimental methodology in a real world setting provided a useful contribution to the field of workplace evaluations, demonstrating the possibility of establishing causal relationships between changes to the environment and user satisfaction and stimulation.

There was a second contribution to knowledge from the testing phase of the research which was evidence to support a link between the environment and stimulation levels in users. Further analysis of the current state of knowledge with specific reference to creating a stimulating environment revealed that there is an optimal level of arousal for the performance of tasks according to the Yerkes-Dodson Principle (Yerkes Dodson, 1908) and this has been supported by more recent empirical studies (Anderson,1994; Coles, 1974). The studies evaluated within the current state of knowledge revealed that the majority of research into stimulation and motivation is focused upon organisational factors and job characteristics. There is little empirical evidence to support the theory that the workplace environment can have an impact upon stimulation levels as the

majority of studies have focused upon satisfaction and productivity. A model of motivation widely cited is the Herzberg 2 Factor Model (Herzberg et al, 1957; Herzberg, 1966) in which he defines hygiene and motivator factors. The motivator factors are those that actively increase people's motivation to complete tasks or their job. Hygiene factors are those that have a negative impact if they are not at an optimal level. Within Herzberg's model, workplace conditions are classified as hygiene factors. That is, they can have a negative impact but cannot actually motivate people. This implies a link with satisfaction rather than productivity. There is no discussion around the ability of the environment to stimulate people and thus motivate them. However, there is some evidence linking aspects of the workplace environment with stimulation. Air temperature (Abdou & Lorsch, 1994), noise (Smith & Miles, 1986) and colour (Kwalleck & Lewis, 1990) have all been found to be related to perceived levels of arousal. Whilst this research suggests that there is a link between stimulation and the environment, the evidence is not conclusive. This leaves a gap in the understanding of the impact of the environment and how the design of the workplace can be developed to have a positive impact upon users through, for example, increasing their levels of stimulation when they are at their lowest.

Thus, in addition to the development of experimental methodology to evaluate the impact of the workplace environment, a contribution to knowledge comes from establishing a link between the environment and increased levels of perceived stimulation. Through analysis of the results from the first phase of the research, and assessing which aspects of the workplace could easily be varied between the morning and afternoon, six aspects of the workplace were selected and analysed to determine whether varying them between the morning and afternoon had an impact upon stimulation. The results from this research demonstrated that there is potential to influence stimulation levels by changing the colour of the workplace in the afternoon, projecting artwork and increasing the air movement speed. To have an impact upon stimulation levels it appears that participants need to perceive the change taking place and need to like the changes. When participants were not satisfied with the new workplace provision, stimulation levels were not affected positively. Thus, the second contribution to knowledge from the results is that the workplace environment can be designed to have a positive impact upon stimulation but further research is required to determine how this can be achieved effectively by understanding in greater depth the complexity of the relationship between the environment and users.

## Chapter 15 Overall Discussion and Conclusions

### 15.1 Introduction

The challenge set at the beginning of this thesis was to: establish whether the impact of the workplace environment on users can be effectively measured, demonstrate how the workplace is perceived by users and determine whether the environment can be designed to have a positive impact upon users. This thesis was developed to provide greater understanding of the impact of the workplace environment that could benefit designers, organisations and users themselves. For many individuals the workplace environment is somewhere they spend a significant proportion of their time. Thus, how they perceive the environment could have an impact upon their lives. For organisations the cost of the workplace environment can be high, however, it is considerably less than the employee costs such as salaries, etc. Therefore understanding how the environment can be designed to have a positive impact upon users could allow the workplace to become an asset to the organisation. For designers, the findings of this thesis provide an objective understanding of the impact of workplace environments i.e. how they are perceived by users and how they actually function. This allows designers to learn about the real impact of the workplace and use this understanding to inform future design, rather than basing design decisions upon personal experiences and anecdotal evidence.

Analysis of the current state of knowledge revealed that the design of the workplace environment had evolved over time, and in response to changing management theory (Sundstrom, 1986). The focus first on process and the design of workplaces which reflected the principles of Taylor's Scientific Management Theory (Taylor, 1911) followed by a shift to focusing upon people and social relations and the development of the Bürolandschaft layout (Duffy, 1969; Klein, 1982). More recently the need for organisations to adapt easily to changing situations has been reflected by the development of more flexible workplaces and so called alternative ways of working (Zelinsky, 1998). Whilst this evolution in workplace design suggests an understanding of the relationship between the environment and the users or occupying organisation, the research into the impact of the workplace environment was found to be inconsistent through analysis of the current state of knowledge. A considerable amount of research into the more easily quantifiable aspects of the workplace environment had led to the development of design guidance in relation to these aspects (for example, ASHRAE, 2001; British Council for Offices, 2000; British Council for Offices, 2005; CIBSE, 1994).

However, there has been less research into the qualitative aspects of the workplace environment and as a result no design guidance developed. In addition, much of the research into the impact of the workplace has been focused upon isolated aspects of the environment. Therefore the analysis of the current state of knowledge revealed a need for a more holistic approach to evaluating workplace environments and greater understanding of the impact of all aspects of the environment upon users. The impact upon users was identified as being overall satisfaction with the workplace environment and perceived productivity. These were the two measures most frequently taken when considering the impact of the environment. However, there was also consideration for other ways in which the environment may affect users, such as stimulating them, and a need to understand how any causal relationships between the environment and the users' perceptions and experience could be identified. The overall aim of this thesis was to make a contribution in terms of adding to the understanding gained from the current state of knowledge.

To achieve the aims of this thesis and make a contribution to knowledge, the specific objectives were: to develop an holistic methodology to evaluate the workplace environment; to carry out an evaluation of workplace environments and identify patterns and trends through analysis of the data; and to understand the relationship between the user perceptions and their levels of satisfaction, stimulation and perceived productivity. Following the completion of the workplace evaluations, the testing phase of the thesis was developed. The aim of this phase was to establish whether there was a causal relationship between the workplace environment and stimulation levels based upon the gaps identified in the current state of knowledge. There was research indicating that the environment has an impact upon users but there was little research identified in the current state of knowledge which allowed causal relationships to be established between the independent variables of the aspects of the workplace and the dependent variables of impact upon users. In particular, the positive impact of an optimum level of stimulation was identified within the Yerkes-Dodson Principle (1908) and the relationship between perceived stimulation and productivity revealed (Folkard, 1983; Hull et al, 2003). The current state of knowledge also revealed that there was a change in perceived stimulation levels throughout the day and that people reported their levels of stimulation during the working day as being lowest just after midday. However, there was little research identified which brought together the design of the workplace environment and the stimulation of workplace occupants other than in a few isolated studies. Thus, the testing phase was developed to bring together the findings from different research areas and analyse causal relationships between the variables.

The specific objectives were to analyse how users perceived the workplace in the morning and afternoon, and determine whether changing aspects of the environment would have an impact upon their perceptions and level of stimulation.

### 15.2 Approach to Achieving the Aims of the Thesis

To understand where there was an opportunity to make a contribution to knowledge, an analysis of the existing research was undertaken. The results of this analysis revealed that some aspects of the workplace environment had been the subject of research but that these tended to be individual aspects of the environment and those that were more easily quantified when objective measures were taken. For example there was a considerable amount of research into the impact of different thermal conditions upon satisfaction and productivity (Sundstrom, 1986) and this informed the calculations of thermal comfort (Fanger, 1970; Humphreys, 1976). These results led to the development of standards. However, the research tended to focus on one or two aspects and was often carried out in laboratory settings. By examining the research into the impact of the workplace environment it became apparent that there was no robust and conclusive evidence base revealing the impact of the workplace environment as a whole and therefore there was an opportunity to make a contribution to knowledge. Understanding how the design of workplace environments evolved in response to changing management theories suggests that there is some connection between the environment and the way in which organisations work. Despite this, research into the impact of workplace environments is not comprehensive (Marans & Sprekelmeyer, 1981). Research interest from social science, architecture, engineering and business management disciplines has provided an insight into the impact of the workplace environment from different perspectives (for example Brill et al, 1984 (business management); Cohen et al, 2001 (engineering); Oseland, 2007 (social science); Preiser, 1988 (architectural)). However, the separate approaches have led to an evidence base which is somewhat disjointed and inconclusive. Researchers have tended to focus on specific aspects of the environment such as the air temperature, rather than evaluating the impact of the workplace holistically. The findings from the research have demonstrated that the environment may have an impact upon users but the findings cannot readily be assimilated due to the different approaches taken to the research. Where researchers have adopted a more holistic approach to evaluating the workplace, results have begun to demonstrate patterns in user perceptions of the environment and the impact that this has upon them and the organisation they work for (for example Leaman et al, 1997; Leaman & Bordass, 1998; Leaman & Bordass, 2001;

Osland 2007; Preiser, 1988) . However, these evaluations have tended to include only the user perceptions without objective evaluation of the workplace or focus on only some aspects of the environment such as the internal climate. By establishing the current state of knowledge it became clear that there was evidence demonstrating that the workplace environment could have an impact upon users and that it was possible to evaluate this effect. At the same time, the disparate nature of the research of others to date highlighted the complexity of the workplace environment and the need to develop an holistic approach to evaluation.

Using the positive principles of previous research, particularly where a more holistic approach was taken, a methodology was developed for this thesis. Establishment of the current state of knowledge revealed that many aspects of the workplace environment had an impact upon users, including those that were less easily quantifiable. Despite a much less well established evidence base demonstrating the impact of qualitative variables, the research which had been conducted indicated that these aspects had an impact upon users' satisfaction, and in some cases, productivity. For example analysis of the existing research revealed that identical rooms with different colour schemes affected participants' performance on tasks (Küller et al, 2009; Kwallek & Lewis, 1990; Stone, 2003; Stone & English, 1998) although there was not enough research to demonstrate a consistent effect. Thus, an holistic evaluation of the environment would need to incorporate an analysis of a range of aspects of the workplace to fully demonstrate the impact upon users and the analysis of the current state of knowledge revealed that these aspects were often not included in the research. The aspects selected for analysis were those that had been found in the current state of knowledge to have had some impact upon workplace users previously. In addition, existing research demonstrated the importance of taking both objective and subjective measures of the environment (Preiser, 1988) . Methods for evaluating all aspects of the workplace identified, both subjectively and objectively, were developed. This produced a mixed-method evaluation model. The methodology incorporated questionnaires to gather data on user perceptions of the workplace and indicator variables of overall satisfaction with the workplace, stimulation and perceived productivity. To collect the objective data, environmental monitoring equipment, spatial layout plans, observational reports and other physical measures were used. Once the systematic method of evaluation was established data was successfully collected in a sample of 16 workplaces. This activity fulfilled the aim of developing a methodology for the holistic evaluation of workplaces and using the methods to collect data to determine perceptions of and the impact of the workplace environment on users.

There were some clear patterns revealed in the data collected from the workplaces. With regards to satisfaction with the environment, users were generally satisfied with the internal climate and spatial layout. Objective measures revealed that the internal climate of the majority of workplaces fell within the range specified by design guidance and users were satisfied. Users were satisfied with the spatial layout in all workplaces, with office type and location within the office not influencing the results. Spatial layout and internal climate are the two aspects of the workplace environment more easily quantified. They had received a significant amount of research attention which had led to the development of design guidance. Consequently, the environments evaluated were designed to meet industry recommendations for the most part and this may account for the high level of satisfaction. This supports the findings from the current state of knowledge which indicated that design guidance had been developed for the more quantitative aspects of the workplace and that a level of comfort for users had been established through research (Sundstrom, 1986). User perceptions of the interior design and workplace features were less positive. Whilst users were satisfied with the furniture provision, their location in relation to the window, and daylight, they were not satisfied with the view out of the windows, the amount of personal control and choice they had, the break areas and the decoration of the workplace. There were significant correlations between the objective and subjective measures, and variations in the data between workplaces where conditions were different. This provides support for the assertion that all aspects of the workplace can have an impact upon users' satisfaction. More natural views, increased personal control of the environment and choice in the design, break areas that provided an opportunity to get away from work and more colours, plants and artwork incorporated within the workplace were associated with increased levels of user satisfaction. These findings for qualitative aspects of the workplace in particular make a contribution to knowledge as they provided greater understanding of the impact of these factors on user attitudes which was lacking in the current state of knowledge. When analysed in relation to overall satisfaction with the workplace and stimulation, all aspects of the workplace were significantly correlated with these indicator variables. Regression analyses identified a number of both qualitative and quantitative variables as significant predictors of satisfaction. A similar pattern of results was established when analysing predictors of stimulation. The model containing all aspects of the environment was also able to predict some variation in perceived productivity, further demonstrating the importance of considering the workplace environment. These findings fulfil the objectives of this thesis to demonstrate

user perceptions of the workplace environment and the relationship between user perceptions and satisfaction, stimulation and perceived productivity.

Whilst the data from the evaluation phase of this thesis makes an important contribution to knowledge, it is unable to demonstrate any causal relationships between the environment and the impact upon users. A similar lack of research into the causal relationship between the workplace and user attitudes in real world settings was discovered through analysis of the current state of knowledge. Within the evaluation phase, users were identified as not perceiving themselves to be stimulated at work, particularly in the afternoon just after the traditional lunchtime period. Thus, a testing phase was introduced, from further analysis of the current state of knowledge and the results of the evaluation phase, to establish whether changing the environment could have an impact upon stimulation levels. A reported reduction in stimulation levels in the afternoon was identified in the evaluation phase of the thesis which was supported by the research of others from the current state of knowledge (for example Colquhoun et al, 1969; Folkard, 1983; Hildebrandt et al, 1974). A methodology was developed to test the impact of changing aspects of the environment in the afternoon and measuring perceived stimulation levels to determine whether workplace variations had an impact upon users. The results of the testing phase were mixed, with some changes to the environment having a positive impact upon users by reducing the afternoon dip in stimulation levels. Other changes to the workplace environment did not have a positive impact upon stimulation levels in the afternoon. The reasons for this are discussed in the previous two chapters. The findings suggest that changing the colour of the workplace, introducing artwork and increasing air movement speeds in the afternoon could have a positive effect upon the stimulation levels of workplace users. The testing phase fulfils the final objective of this thesis, to evaluate whether there was an impact of the environment upon users' stimulation levels.

### 15.3 Limitations of the Research

Whilst the thesis was able to meet the objectives set, there are some limitations to the research. The most notable limitation is the scope of the analysis. As highlighted by previous researchers who have attempted to conduct holistic evaluations, the workplace environment is highly complex and there are a considerable number of aspects that can be identified for analysis. Leaman and Bordass, in reference to the scope of the Probe studies, state:

"*We do not attempt to cover all possible issues. Buildings are complex, total systems, and one has to draw the line somewhere. Otherwise we would be overwhelmed by the amount of data, the analytical effort of finding significance in it, and the difficulty of reporting it all*." (Leaman and Bordass, 2001, p130)

Whilst it is not possible to evaluate all aspects of the workplace environment, this thesis has highlighted that qualitative aspects of the environment (which have previously not received as much research attention) were significantly correlated with satisfaction and stimulation. They were also incorporated within a model to predict perceived productivity. Therefore, there is a high probability that other aspects of the workplace environment not analysed within this thesis, may have an impact upon users and should be considered within future evaluations. By identifying methods of measuring any other aspects of the environment objectively and devising further questionnaire items to establish user perceptions, other aspects of the workplace environment could easily be incorporated into the methodology developed for this thesis. The incorporation of other aspects of the workplace for analysis would also reveal whether there were any interaction effects between the aspects of the workplace which would give a more true understanding of the impact of the environment on users.

A second limitation of this research are the objective measurements used. As identified, some aspects of the workplace environment are easily quantifiable such as air temperature and illuminance levels. However, there are other aspects of the environment which are less easily quantifiable and therefore more difficult to measure objectively. Whilst objective, observational reports were used within this thesis, and consistency of the ratings maintained by using the same researcher, more objective measures that do no rely upon the judgements of researchers would be beneficial and could be developed further to refine the objective measurements. The third limitation identified is the data collected and analysed within the testing phase. As a research area not previously explored in great depth, the testing phase of this thesis provides initial insight into the impact that the workplace may have upon stimulation in a real world environment. The findings indicate that the environment may have an impact upon stimulation, but they are not conclusive. Further research into the complex relationship between the environment and stimulation would provide a more robust evidence base to inform future workplace design.

### 15.4 Implications and Future Research

The implications of this thesis are to inform both future design and the evaluation of workplace environments. The methodology developed enabled data to be collected from a number of different workplaces and compared. The analysis allowed patterns in the data between workplaces to be established and revealed how users perceived their workplace environments. Comparison with the objective measures of the environments highlighted how workplace design is related to user satisfaction. Making changes to the environment and evaluating the impact upon users' stimulation levels also provided a greater understanding of how the workplace can affect users. The findings from the research demonstrated that differences in the workplace environment are related to differences in user perceptions and their levels of satisfaction, stimulation and perceived productivity. A future implication for the use of the methodology developed is the continued adoption of this methodology to evaluate workplace environments. The research included 16 workplaces which were diverse in terms of the nature of the business of the organisations occupying them. Consequently the impact of many of the extraneous variables, such as organisational culture and the work actually being conducted, was limited as the large sample reduced their impact upon the results. In addition, the results of the evaluation phase of the research support many of the conclusions reached in the current state of knowledge. The internal climate, when within or close to recommendations from the design guidance, was found in previous research to be satisfactory and this was supported by the findings of the evaluation phase of this thesis. Similarly analysis of the current state of knowledge demonstrated that spatial layout, when in accordance with the design guidance and providing a comfortable and satisfactory environment for users was perceived positively and this was supported by the findings of the evaluation phase. In relation to the interior design and workplace features the current state of knowledge was not as able to provide conclusive evidence to demonstrate the impact of many of these qualitative aspects of the workplace. Therefore there was little design guidance. The evaluation of the current state of knowledge revealed that there was more variety in the workplace design and that satisfaction levels varied, with many people being dissatisfied with these aspects of the workplace environment. The evaluation phase also supported the need for a more holistic evaluation of workplace environments with both quantitative and qualitative aspects of the environment assessed using objective measures and user perceptions. This was a gap in the knowledge identified from analysis of the current state of knowledge.

Thus, the findings and methodological approach from this thesis make a useful contribution and there is an opportunity to generalise these findings and the approach to other modern workplaces in England. One potential limitation which must be taken into account is the design approach to the development of the workplace environment. As all workplaces were developed by Ryder Architecture this may have affected the design of the workplaces. However, the differences between the workplaces and the strong influences of the occupying clients ensured that there was a great deal of variety as indicated in Chapter 8.

To demonstrate the way in which the results of this thesis can be applied the methodology developed for this thesis has already been utilised by architecture practices and others to evaluate workplace environments. Previously a lack of evidence demonstrating good practice and effective evaluation methods prevented design teams from adopting an approach of evidence-based design. They did not have the information readily available to them or the means of collecting it. In addition, the methodological approach has been used to inform the development of evaluation models of other building types including schools, universities and healthcare facilities in the real world through understanding of the research findings and utilisation of the evaluation methodology and approach. The methodology is already available for architects to use and the findings are being fed back by those carrying out evaluations to inform future design. Workplace strategy and post-occupancy evaluation are currently gaining popularity with the introduction and expansion of organisations such as Buildings and Social Science (BASS) and Workplace Consulting Organisation (WCO). In addition to this, the methodology and findings are being developed to form part of a consultancy service offered to both end users and designers. The need to evaluate all aspects of the workplace environment and understand the impact that they can have upon users is being recognised and implemented and contributions have been made from this research to publications such as the British Council for Offices Guide to Post Occupancy Evaluation (Oseland, 2007)

There are also implications for the findings of the evaluations as workplace conditions with which users were satisfied were identified. Internal climate conditions within the ranges specified in the design guidance, and a range of spatial layouts were considered satisfactory by users. Greater variety in the colour scheme; a greater number of plants and artwork; more natural views out of the window; break areas that provide people with the opportunity to escape from work; and greater personal control and choice are all correlated with increased user satisfaction. Designers, and those

managing workplace environments, can use this knowledge to inform future workplace design and increase the opportunity to have a positive impact upon users. Furthermore, understanding that the workplace environment can have an impact upon stimulation levels could influence design. The results of this thesis suggest that this could be achieved through incorporation of more colour, artwork and air movement in areas of the workplace, or at times of the day, when greater levels of stimulation are desirable. The implications for this work are being considered in both commercial and education environments by end users at the time of submission.

In terms of benefits to future research, there is scope for further analysis, based upon the findings of this thesis. Further analysis of this model needs to be conducted to test whether additional aspects of the workplace environment need to be incorporated and develop a more conclusive evidence base to understand the impact of the qualitative aspects of the workplace, within a holistic evaluation process. As revealed, the qualitative aspects of the workplace produced the greatest variation in user perceptions and the greatest degree of dissatisfaction. The qualitative aspects were identified, when establishing the current state of knowledge, as being those which had received the least research attention compared with the quantitative variables. The internal climate and spatial layout had received the most research attention and were the aspects with which users were satisfied in the research for this thesis. Furthermore, the objective measures of the internal climate and many aspects of the spatial layout met the recommendations set-out in design guidance described in the current state of knowledge. These findings suggest that design guidance influenced the design of the workplace environments and that these conditions were rated as being satisfactory by users. Conversely, a lack of research into the impact of qualitative variables prevents us from knowing how these aspects of the environment affect users. As a result, design guidance has not been developed and the qualitative aspects of the environment vary between workplaces to a greater extent than the quantitative aspects. To further understanding of the impact of the qualitative aspects of the workplace environment upon users, research is required to obtain more conclusive evidence. The significant correlations revealed between the objective measurements and user perceptions of the qualitative aspects suggest that users' perceptions are shared and therefore good practice could potentially be identified. There is also scope to further the evaluation of the impact of the workplace environment on stimulation. The initial findings from this thesis highlight the potential to influence stimulation levels in workplace users in the afternoon. However, the relationship between the environment and stimulation appears to be complex and therefore further investigation to establish the nature of this

relationship would be an interesting extension of the work in this thesis. If other ways in which the workplace environment impacted upon users were established then further analysis of areas such as new ways of working and the links between the workplace environment and management theories could be more clearly established.

Finally, there is scope to further the research findings of this thesis by addressing the impact of the workplace in relation to other major issues affecting organisations and the environments in which they operate. The first major issue is advances in technology, which was identified in the introduction to this thesis. Although classified as an organisational issue, the impact of new technologies upon workplace design could be significant. In particular the invention of wireless technology allows people to work from a range of different environments outside of the traditional workplace and may have a significant impact not only upon how the workplace environment affects them but also in how they use it. Just as changing technology is likely to influence the jobs that people do; it will no doubt have an impact upon the design of future workplaces. A second major issue is environmental sustainability. The focus of designers and others on creating sustainable environments is likely to have an impact upon the design of workplaces and the way in which they are operated. Thus, it would be beneficial to identify how the sustainability agenda manifests itself in design and analyse this to further the contribution to knowledge made by this thesis.

# Appendix A

Ryder

supportive welcoming relaxing flexible motivating inspiring stimulating satisfying creative

performance consultancy

# pre-visit questionnaire

1 How many occupants are there in your workplace ?

2 Has the number of occupants increased or decreased since the workplace was designed ?

3 Is the company likely to increase or decrease in size further in the future ? If yes, to what extent ?

4 Why did you commission a new workplace design (eg workplace in need of refurbishment, workplace too small, workplace in wrong location, etc) ?

5 Could you give a brief description of the type of work your company does.

6 What jobs do the occupants of the workplace have (rough breakdown of proportion of employees – eg clerical, managerial, etc) ?

7 What input did the workplace occupants have over the layout of the workplace (ie did they chose the type of office - open plan / cellular / etc, and/or the location of their desk) ?

8 What input did the workplace occupants make towards choosing the decoration (ie colour scheme / artwork / plants) ?

9 How many of the windows in the workplace open ? If none, is there a reason for this ?

10 How much input did the workplace occupants have in the choice of their furniture ?

11 Do occupants have any personal storage space ? If yes, what do they have ?

12 How much equipment do the workplace occupants have at their workstation (eg PC, printer, etc) ?

13 How many people, on average, share the communal equipment (eg photocopier, printer, etc) ?

14 Is there a break out area provided in the workplace ? If yes, how much is it used by the occupants ?

15 How is the temperature in the workplace controlled (eg individual control, centrally controlled, etc) ?

16 How are the light levels in the workplace controlled (eg individual control, centrally controlled, etc) ?

17 Do the occupants have any way of controlling the noise levels in their office (eg sound proof panels, door on their office, etc) ?

18 How is the amount of ventilation in the workplace controlled (eg individual control, centrally controlled, etc) ?

19 From your perspective, how satisfied are the occupants with the workplace overall ?

**20** Do you feel that the workplace creates a stimulating environment, which encourages people to be more productive ?

**21** Do you feel that productivity overall has increased since moving into the new workplace ?

22 Any other comments?

Ryder

Generator Studios
Trafalgar Street
Newcastle upon Tyne NE1 2LA
United Kingdom

T: +44 (0)191 269 5454
F: + 44 (0)191 269 5455

info@ryderarchitecture.com
www.ryderarchitecture.com

# Appendix B

supportive welcoming relaxing flexible motivating inspiring stimulating satisfying creative

Ryder

performance consultancy

# Workplace Evaluation

This questionnaire has been designed to enable us to obtain feedback about how well your new workplace is performing. The findings of this study will be used to inform future commercial office space design.

Please read all the questions carefully and attempt to answer them all. However, if there are individual questions you feel unable to answer or uncomfortable answering, please leave that question and move on to the next one.

It is important that you try to give us your own personal views without talking to your colleagues. All responses to this questionnaire will be kept in complete confidence and no information will be given to anyone, including your employers, which could identify you. If at any point you feel uncomfortable with the questionnaire, you may withdraw from the study and your responses will not be recorded.

If you have any questions or queries regarding this study, please do not hesitate to contact me on 0191 269 5454 or 07855 276173, email jthomas@ryderhks.com

Thank you very much for your time.

Jenny Thomas

Please supply us with the following information about yourself.

Sex ☐ Male ☐ Female

Age ☐ 16 – 20 years ☐ 21 – 25 years ☐ 26 – 30 years ☐ 31 – 40 years ☐ 41 – 50 years ☐ 50 years +

To enable us to link this questionnaire with the correct environmental measurements, could you please tell us the time and date that you filled in this questionnaire.

Date ☐ / /

Time ☐ : am/pm

Occupant ☐

## 1 Your Job

Please tick the boxes which apply to you and your job. Please read the questions carefully, you may be asked for more than one response.

### 1.1 Which of these best describes your job ?

(please tick **1** only)

- Administration / Secretarial
- Finance / legal assistant
- Director / owner
- Customer services
- Machine operator
- Researcher
- Human resources
- Managerial
- Marketing
- Professional
- Sales
- Supervisor
- Trades person
- Technician
- Other

If other, please specify

### 1.2 Please identify up to **2** tasks that make up the main part of your working day ?

- Working on the PC
- Photocopying
- Filing
- Reading documents / letters
- Answering the telephone
- Problem solving
- Dealing with incoming information
- Creative tasks
- Attending internal meetings
- Attending external meetings
- Supervising others work
- Other

If other, please specify

### 1.3 What percentage of the day do you spend at your desk ?

0 - 20% | 20 – 40% | 40 – 60% | 60-80% | 80 – 100%

### 1.4 How long have you worked for the company ?

0-6 months | 6–12 months | 1–3 years | 3-5 years | 5-10 years | 10 years or more

### 1.5 How many people do you have to work with in your job ?

None | A small team (0-10) | A large team (10-20) | Many different people (20 or more)

### 1.6 How many days have you been absent from work through illness in the last **6** months ?

days

**The following sections are concerned with your perceptions of your workplace. Please tick 1 box only to indicate how you feel about each aspect of the workplace.**

## 2 Layout

Think about the way your office is designed. Whether it is a small enclosed office or a big open plan space, and how the desks are laid out.

How do you feel about

**2.1** Where you sit ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Very happy | | | | | | | | Very unhappy |

**2.2** Your office type (eg small enclosed, open plan, etc) ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Very happy | | | | | | | | Very unhappy |

**2.3** The amount of privacy you have ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Too much privacy | | | | | | | | Not enough privacy |

**2.4** The amount of social contact you have ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Too much social contact | | | | | | | | Not enough social contact |

**2.5** The impact of the layout on your attention levels ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Stimulating | | | | | | | | Boring |
| Relaxing | | | | | | | | Distracting |

**2.6** The choice you had over your office layout?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Total freedom | | | | | | | | No choice |
| Happy with level of choice | | | | | | | | Unhappy with level of choice |

## 3 Decoration

Think about the decoration of your office in terms of what you can see from your desk.

How do you perceive :

**3.1** The colour scheme ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Very attractive | | | | | | | | Very Unattractive |

**3.2** The artwork ? (if none, cross out this question)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Very attractive | | | | | | | | Very unattractive |

**3.3** The plants ? (if none, cross out this question)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Very attractive | | | | | | | | Very unattractive |

**3.4** The appearance of the decoration overall ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Minimal | | | | | | | | Decorative |

**3.5** The impact of the decoration on your attention levels ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Stimulating | | | | | | | | Dull |
| Relaxing | | | | | | | | Distracting |

**3.6** The choice you had in your office decoration ?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Total freedom | | | | | | | | No choice |
| Happy with level of choice | | | | | | | | Unhappy with level of choice |

## 4 Density

Think about the number of people in your office and the amount of furniture.

How do you feel about :

**4.1** The number of people ?

| Too many | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Not enough |
|---|---|---|---|---|---|---|---|---|

**4.2** The number of desks ?

| Too Many | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Not enough |
|---|---|---|---|---|---|---|---|---|

**4.3** The distractions from others sitting close to you ?

| Too distracting | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Not distracting |
|---|---|---|---|---|---|---|---|---|

**4.4** Atmosphere created by people in the office ?

| Lively atmosphere | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Quiet atmosphere |
|---|---|---|---|---|---|---|---|---|

## 5 Windows

Think about the windows in your office, particularly those closest to where you are sitting.

How do you feel about :

**5.1** The distance you are sitting from a window ?

| Too close | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too far away |
|---|---|---|---|---|---|---|---|---|

**5.2** The view from your windows ?

| Very pleasant | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unpleasant |
|---|---|---|---|---|---|---|---|---|

**5.3** The amount of daylight from your window ?

| Too much | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Not enough |
|---|---|---|---|---|---|---|---|---|

**5.4** The amount you can open your windows ?

| Wide open | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Can't open |
|---|---|---|---|---|---|---|---|---|

## 6 Furniture

Think about the furniture you have in your workplace and at your desk, and how this helps you with your work.

What do you think of :

**6.1** Your chair ?

| Very comfortable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very uncomfortable |
|---|---|---|---|---|---|---|---|---|

**6.2** Your desk ?

| Too big | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too small |
|---|---|---|---|---|---|---|---|---|

**6.3** How you feel after sitting for long periods ?

| Very comfortable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very uncomfortable |
|---|---|---|---|---|---|---|---|---|

**6.4** Your personal storage space (for files, etc) ?

| Too much | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Not enough |
|---|---|---|---|---|---|---|---|---|

**6.5** Your equipment at your desk (eg PC, printer, etc) ?

| Too much | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Not enough |
|---|---|---|---|---|---|---|---|---|

**6.6** The communal equipment (eg photocopier, etc) ?

| Too close | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too far away |
|---|---|---|---|---|---|---|---|---|

**6.7** The amount of choice you had over your furniture ?

| Total freedom | 1 | 2 | 3 | 4 | 5 | 6 | 7 | No choice |
|---|---|---|---|---|---|---|---|---|

**6.8** The amount of choice you had over furniture ?

| Very happy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unhappy |
|---|---|---|---|---|---|---|---|---|

## 7 Break Areas

Think about the areas in your workplace which have been set aside for people to use for taking breaks from their work.

What do you think of :

**7.1** Their size ?

| Too big | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too small |
|---|---|---|---|---|---|---|---|---|

**7.2** Their decoration ?

| Very attractive | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unattractive |
|---|---|---|---|---|---|---|---|---|

**7.3** Break areas as a place to 'get away from work' ?

| Easy to relax | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Hard to relax |
|---|---|---|---|---|---|---|---|---|

**7.4** Amount you use break areas ?

| Frequently | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Never |
|---|---|---|---|---|---|---|---|---|

**This next section refers to the physical environment of your workplace. Please indicate how you feel about each aspect for both summer and winter, and morning and afternoon.**

## 8 Temperature

Think about the temperature in your office and at your desk.

What is the temperature like in :

**8.1** Summer ?

| Too hot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too cold |
|---|---|---|---|---|---|---|---|---|

**8.2** Winter ?

| Too hot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too cold |
|---|---|---|---|---|---|---|---|---|

**8.3** Morning (at the current time of year) ?

| Too hot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too cold |
|---|---|---|---|---|---|---|---|---|

**8.4** Afternoon (at the current time of year) ?

| Too hot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too cold |
|---|---|---|---|---|---|---|---|---|

## 9 Light

Think about the light levels in your office and at your desk.

What is the light like in :

**9.1** Summer ?

| Too bright | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dull |
|---|---|---|---|---|---|---|---|---|

**9.2** Winter ?

| Too bright | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dull |
|---|---|---|---|---|---|---|---|---|

**9.3** Morning (at the current time of year) ?

| Too bright | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dull |
|---|---|---|---|---|---|---|---|---|

**9.4** Afternoon (at the current time of year) ?

| Too bright | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dull |
|---|---|---|---|---|---|---|---|---|

## 10 Noise

Think about the noise levels in your office and at your desk when you are trying to work.
What is the noise like in :

**10.1** Summer ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too loud | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too quiet |

**10.2** Winter ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too loud | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too quiet |

**10.3** Morning (at the current time of year) ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too loud | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too quiet |

**10.4** Afternoon (at the current time of year) ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too loud | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too quiet |

## 11 Air

Think about the air in your office and what it is like at your desk
What is the air like in :

**11.1** Summer ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too damp | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dry |
| Too draughty | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too still |

**11.2** Winter ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too damp | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dry |
| Too draughty | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too still |

**11.3** Morning (at the current time of year) ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too damp | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dry |
| Too draughty | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too still |

**11.4** Afternoon (at the current time of year) ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Too damp | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too dry |
| Too draughty | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Too still |

## 12 Personal Control

Think about the amount of control you personally have over your workplace environment
How do you feel about :

**12.1** Control of temperature ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total control | 1 | 2 | 3 | 4 | 5 | 6 | 7 | No control |
| Very happy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unhappy |

**12.2** Control of light ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total control | 1 | 2 | 3 | 4 | 5 | 6 | 7 | No control |
| Very happy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unhappy |

**12.3** Control of noise ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total control | 1 | 2 | 3 | 4 | 5 | 6 | 7 | No control |
| Very happy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unhappy |

**12.4** Control of ventilation ?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total control | 1 | 2 | 3 | 4 | 5 | 6 | 7 | No control |
| Very happy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unhappy |

**This last section refers to your overall feelings about the workplace, your job and how much impact the workplace has on your productivity.**

## 13 Overall Satisfaction

Think about your workplace environment as a whole.

**13.1** What impact does your workplace have on your ability to do your work ?

Positive impact | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Negative impact

**13.2** How do you feel in your workplace ?

Very comfortable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very uncomfortable

**13.3** How do you feel about this as a place to work ?

Very happy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very unhappy

**13.4** How do you feel about your workplace overall ?

Very satisfied | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very dissatisfied

## 14 Overall Impact

Think about how your workplace makes you feel.

**14.1** When do you feel most active and awake at work ?

Before 8am ☐ 8-10am ☐ 10am-midday ☐ 12-2pm ☐ 2-4pm ☐ 4-6pm ☐ After 6pm ☐

**14.2** How does your workplace environment make you feel ?

Very alert | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very tired

**14.3** What impact does the workplace environment have on your work ?

It helps me to concentrate | 1 | 2 | 3 | 4 | 5 | 6 | 7 | It distracts me

**14.4** Overall, what sort of atmosphere do you feel the workplace environment creates ?

Energising | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Relaxing

## 15 Overall Performance

Think about your overall performance at work.

**15.1** Relatively speaking, how much work did you do on your most recent full day at work ?

A great deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Not very much

**15.2** What was the quality of your work on your most recent full day at work ?

Very high quality | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very poor quality

**15.3** How often do you meet deadlines that are set for you ?

All the time | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Never

**15.4** How would you rate your overall productivity at work ?

Very high | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Very low

Thank you very much for taking part in this study.

If you have any queries, please do not hesitate to contact me on 0191 269 5454 or 07855 276173
Email jthomas@ryderhks.com

Ryder

Generator Studios
Trafalgar Street
Newcastle upon Tyne NE1 2LA
United Kingdom

T: +44 (0)191 269 5454
F: + 44 (0)191 269 5455

info@ryderarchitecture.com
www.ryderarchitecture.com

# Appendix C

supportive welcoming relaxing flexible motivating inspiring stimulating satisfying creative

# performance consultancy

## objective measures checklist

code

| Factor | Time | 1st Measure | 2nd Measure | 3rd Measure | 4th Measure |
|---|---|---|---|---|---|
| Temperature | Morning | | | | |
| | Afternoon | | | | |
| Humidity | Morning | | | | |
| | Afternoon | | | | |
| Radiant temp | Morning | | | | |
| | Afternoon | | | | |
| Light | Morning | | | | |
| | Afternoon | | | | |
| Air Movement | Morning | | | | |
| | Afternoon | | | | |
| Noise | Morning | | | | |
| | Afternoon | | | | |

## Furniture

### Chair

| | |
|---|---|
| Arms | |
| Height | |
| Tilt back | |

### Desk

| | |
|---|---|
| Size | |
| Shape | |

### Personal Equipment

| | |
|---|---|
| PC | |
| Printer | |
| Other | |

### Storage

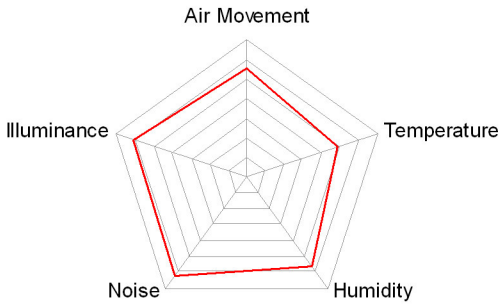
| | |
|---|---|
| Drawer / Cabinet | |
| Paper piled on desk | |

### Other

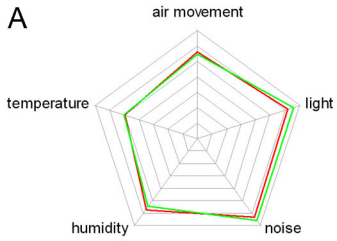
| | |
|---|---|
| Partitions | |
| Light on desk | |
| Plants | |
| Colour of walls | |

# Appendix D

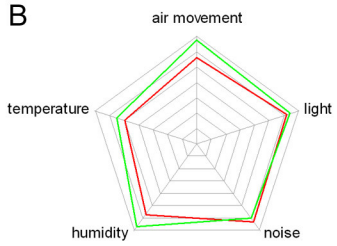
Key:
Mean
Individual Workplace



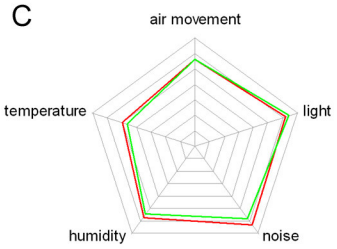

A



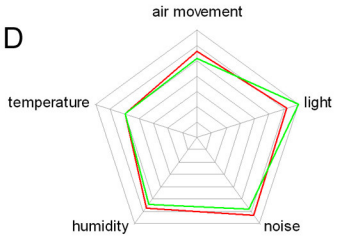

B



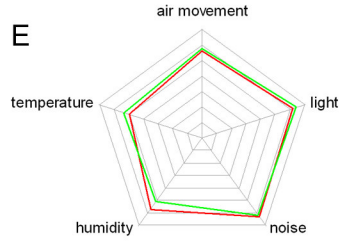

C



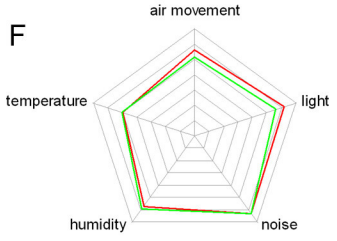

D



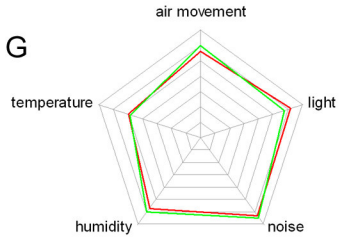

E



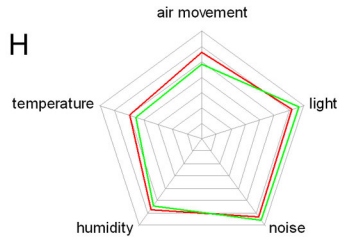

F



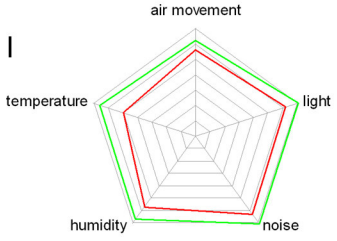

G



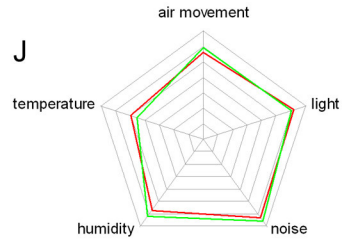

H



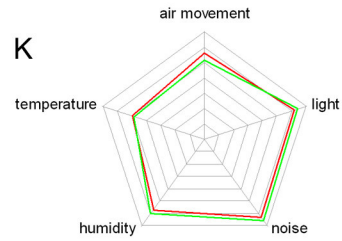

I



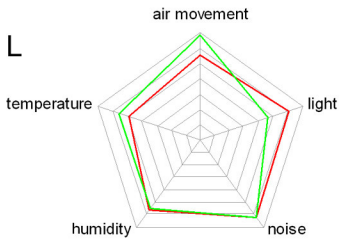

J



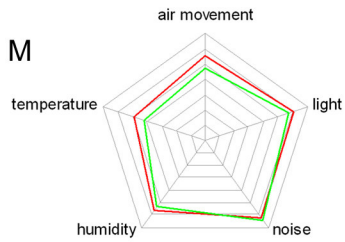

K



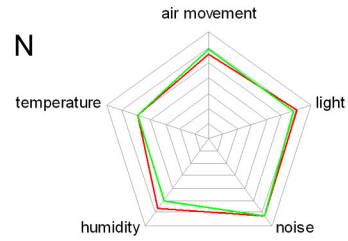

L



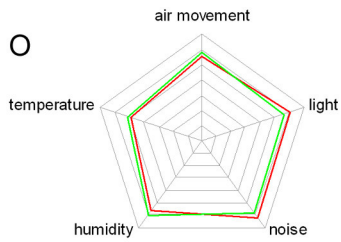

M



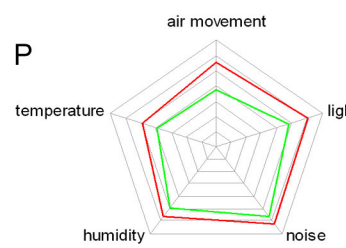

N



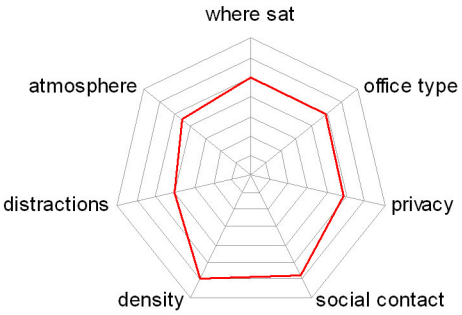

O



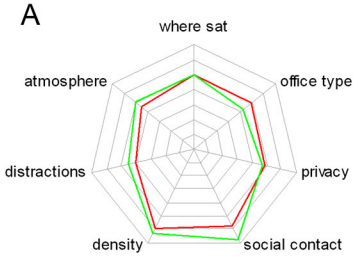

P



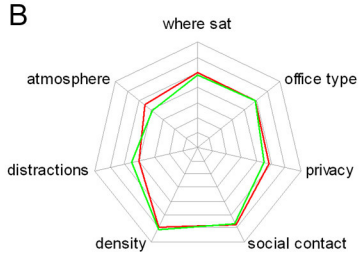
Key:
Mean
Individual Workplace



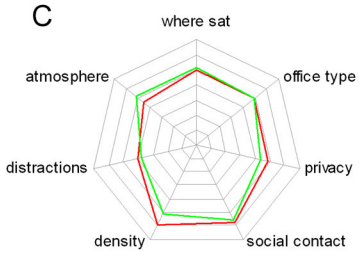

A



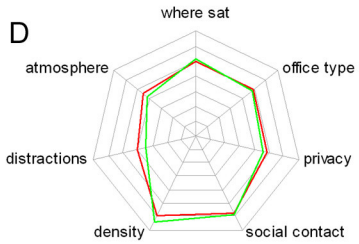

B



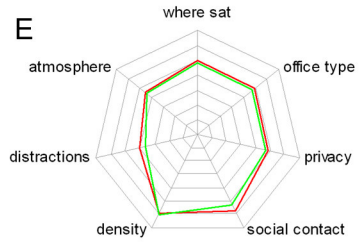

C



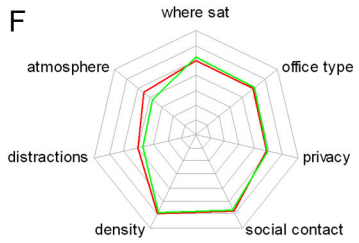

D



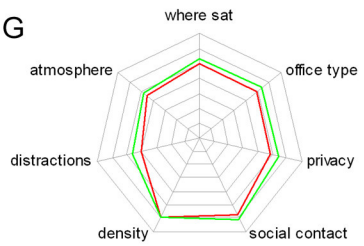

E



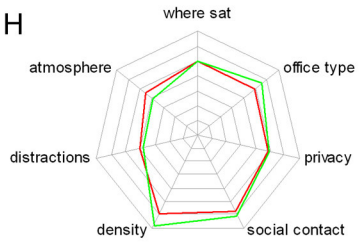

F



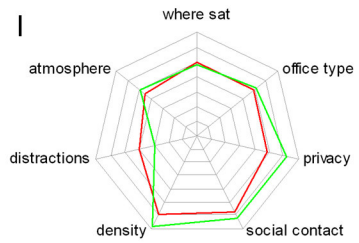

G



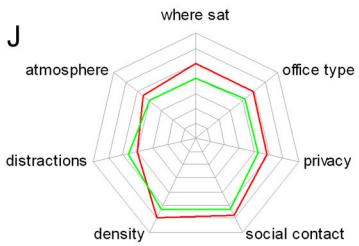

H



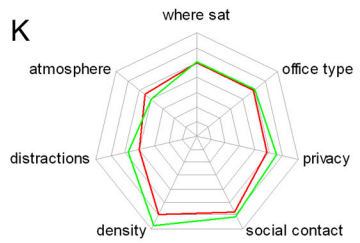

I



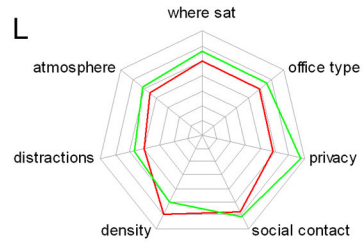

J



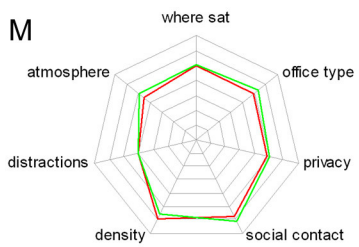

K



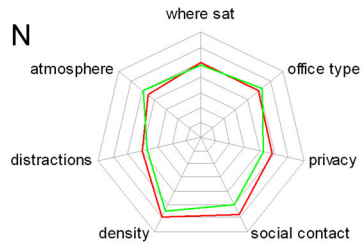

L



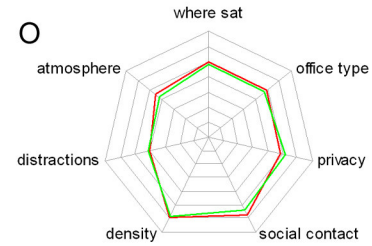

M



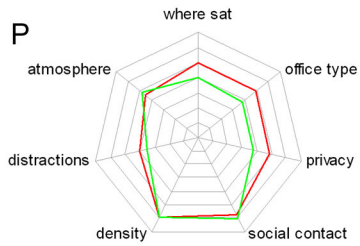

N



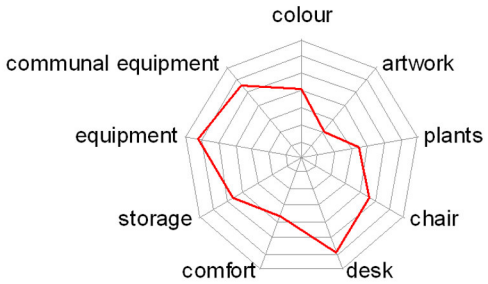

O



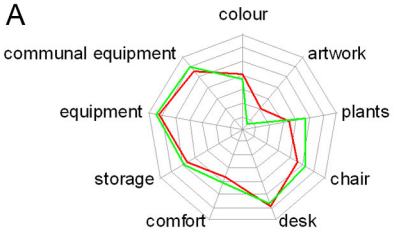

P



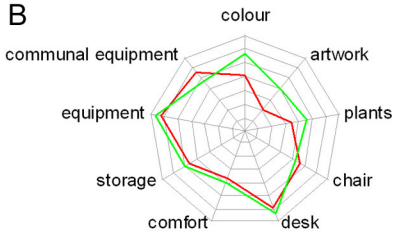
Key:
Mean
Individual Workplace



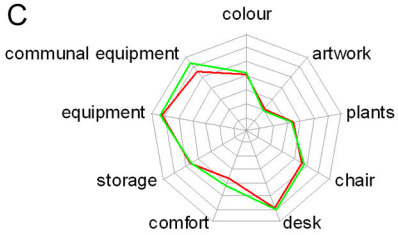

A



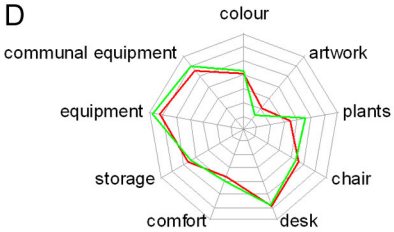

B



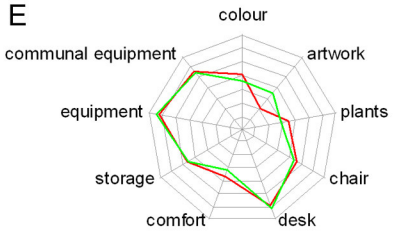

C



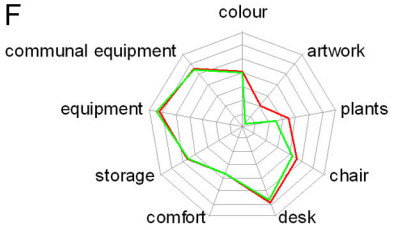

D



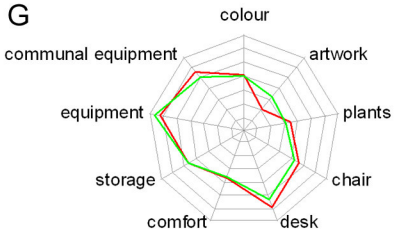

E



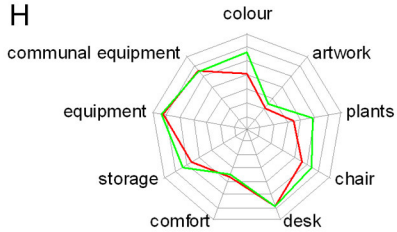

F



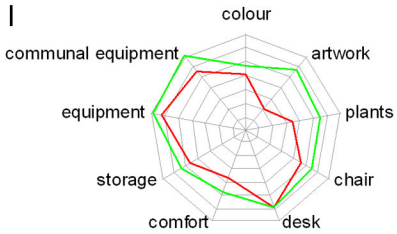

G



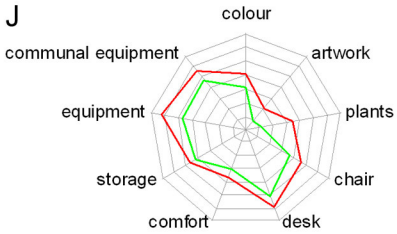

H



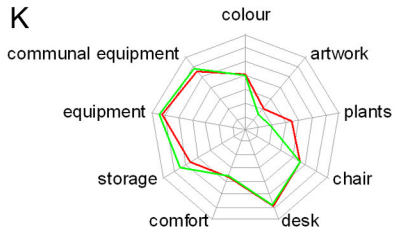

I



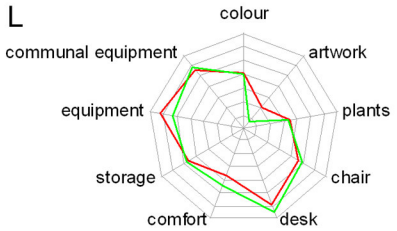

J



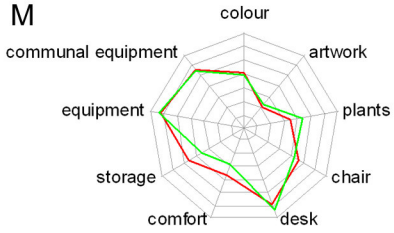

K



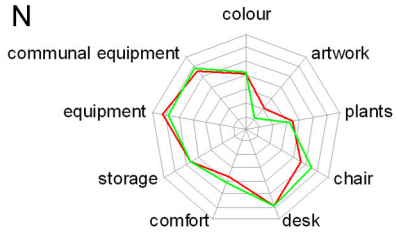

L



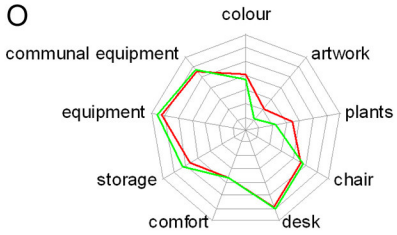

M



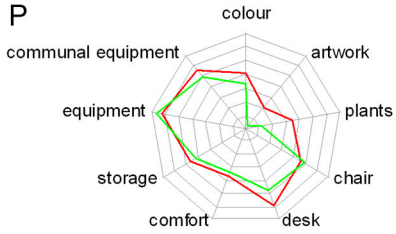

N

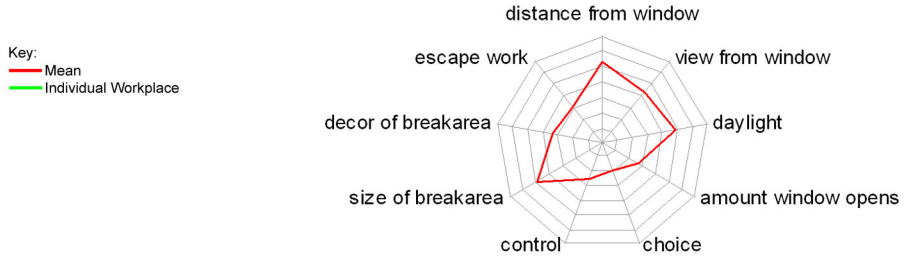


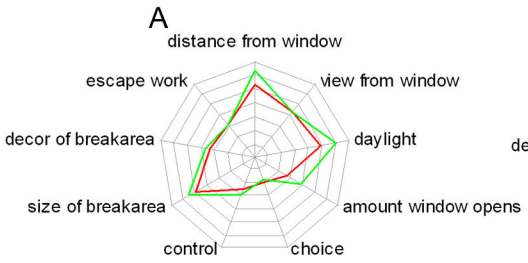

O

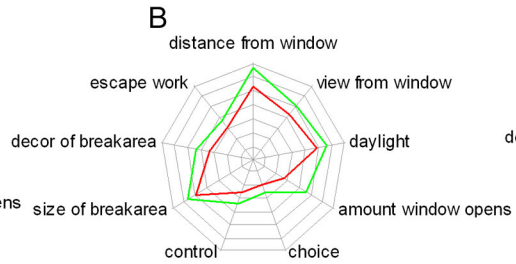


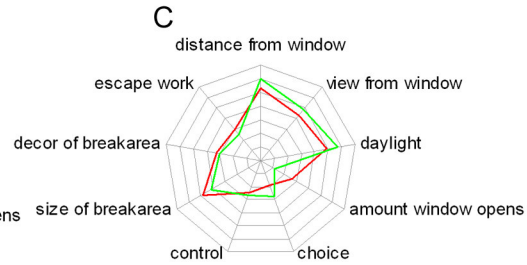

P

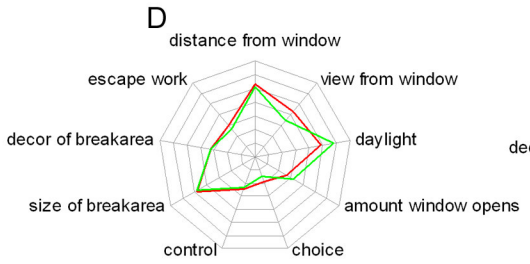


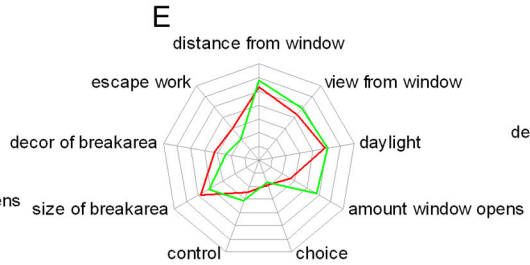

Key:
Mean
Individual Workplace
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

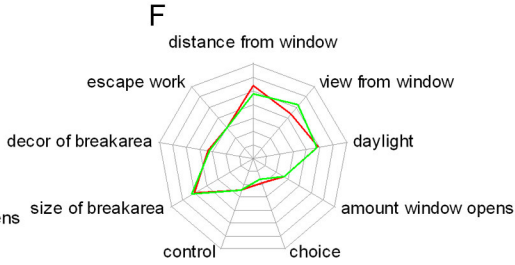

A
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

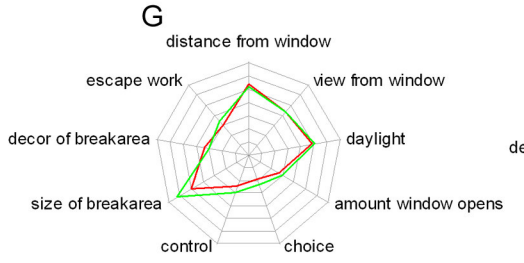

B
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

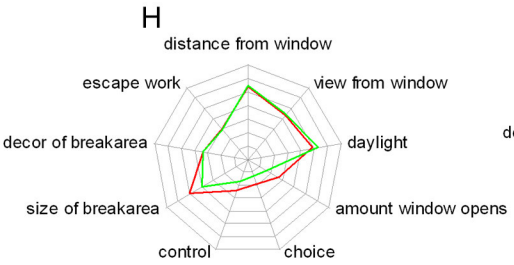

C
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

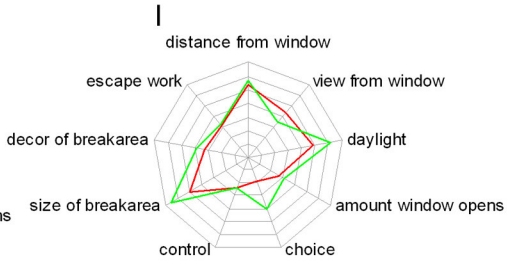

D
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

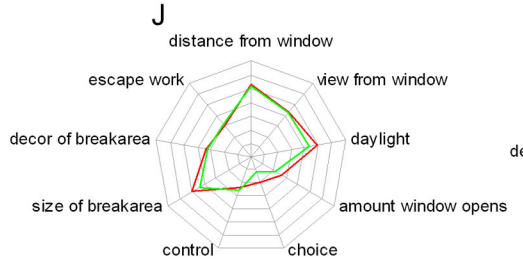

E
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

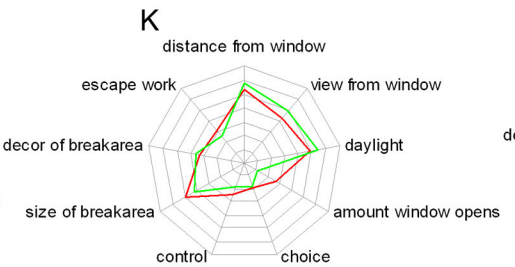

F
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

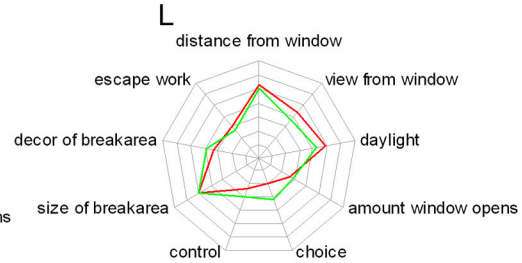

G
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

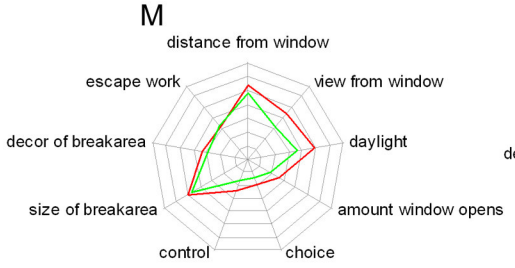

H
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

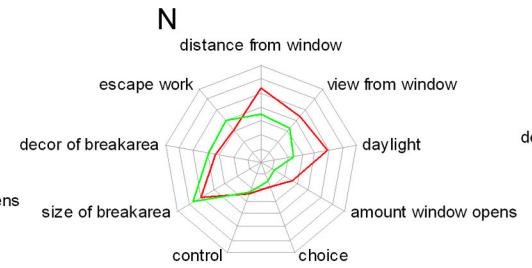

I
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

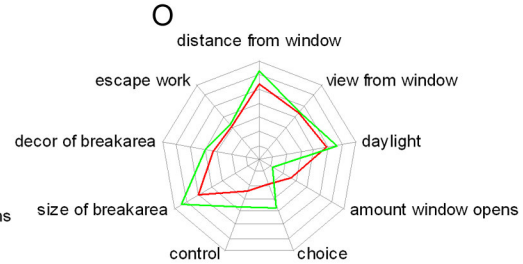

J
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

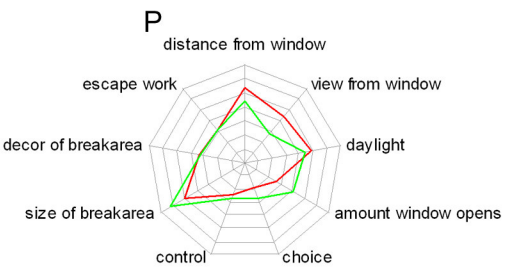

K
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work


L
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work


M
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work


N
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work


O
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work


P
distance from window
view from window
daylight
amount window opens
choice
control
size of breakarea
decor of breakarea
escape work

# Appendix E

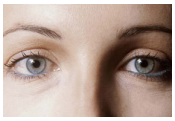
supportive welcoming relaxing flexible motivating inspiring stimulating satisfying creative

Ryder

# performance consultancy

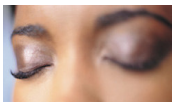
## Psychological Profile

**1.0** Think about work today



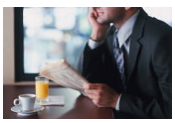
**1.1** When did you feel **most** active and alert at work ?

Before 8am ☐ 8-10am ☐ 10am-midday ☐ 12-2pm ☐ 2-4pm ☐ 4-6pm ☐ After 6pm ☐



**1.2** When did you feel **least** active and alert at work ?

Before 8am ☐ 8-10am ☐ 10am-midday ☐ 12-2pm ☐ 2-4pm ☐ 4-6pm ☐ After 6pm ☐



**1.3** How did your workplace make you feel this morning ?

Tired | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Alert

Distracted | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Relaxed

**1.4** How did your workplace make you feel this afternoon ?

Tired | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Alert

Distracted | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Relaxed

**2.0** Did you perceive a change in any of the following factors this week in the **mornings** in comparison to the normal conditions within your workplace ?

| Factor | Please indicate whether there was a change and if so which direction it was in | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temperature | Colder | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Hotter |
| Light | Darker | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Lighter |
| Air Movement | Stiller | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More draughty |
| Noise | Quieter | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Louder |
| Humidity | Drier | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More damp |
| Colour | Neutral | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Brighter |
| Artwork | Less than normal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More than normal |
| Plants | Less planting | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More planting |
| Layout | Lower density | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Higher density |
| Type of Office | Move to private office | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Move to open plan office |
| Privacy | Less privacy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More privacy |
| Distractions | More distractions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Fewer distractions |
| Windows | Worse view | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Better view |
| Furniture | Less comfy furniture | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More comfy furniture |
| Personal Control | Less control of environment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More control of environment |

**3.0** Did you perceive a change in any of the following factors this week in the **afternoons** in comparison to the normal conditions within your workplace ?

| Factor | Please indicate whether there was a change and if so which direction it was in | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Temperature | Colder | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Hotter |
| Light | Darker | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Lighter |
| Air Movement | Stiller | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More draughty |
| Noise | Quieter | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Louder |
| Humidity | Drier | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More damp |
| Colour | Neutral | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Brighter |
| Artwork | Less than normal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More than normal |
| Plants | Less planting | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More planting |
| Layout | Lower density | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Higher density |
| Type of Office | Move to private office | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Move to open plan office |
| Privacy | Less privacy | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More privacy |
| Distractions | More distractions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Fewer distractions |
| Windows | Worse view | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Better view |
| Furniture | Less comfy furniture | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More comfy furniture |
| Personal Control | Less control of environment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | More control of environment |

# Appendix F

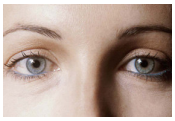
supportive welcoming relaxing flexible motivating inspiring stimulating satisfying creative

# performance consultancy

## Psychological Profile

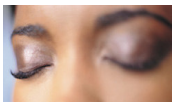
Ryder

**1.0** Think about work today



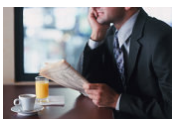
**1.1** When did you feel **most** active and alert at work ?

Before 8am ☐ 8-10am ☐ 10am-midday ☐ 12-2pm ☐ 2-4pm ☐ 4-6pm ☐ After 6pm ☐



**1.2** When did you feel **least** active and alert at work ?

Before 8am ☐ 8-10am ☐ 10am-midday ☐ 12-2pm ☐ 2-4pm ☐ 4-6pm ☐ After 6pm ☐



**1.3** How did your workplace make you feel this morning ?

Tired | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Alert

Distracted | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Relaxed

**1.4** How did your workplace make you feel this afternoon ?

Tired | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Alert

Distracted | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Relaxed

# Appendix G

| | Satisfaction DV | Sound | Humidity | Light | Personal Control Climate | Air movement | Aesthetic | Satisfaction with control | Temperature | Control of aesthetic | Spatial layout | Break area | Windows | Social interaction | Sitting at work | Relaxing environment | Equipment | B | β |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sound | .271 | | | | | | | | | | | | | | | | | | |
| Humidity | .264 | .155 | | | | | | | | | | | | | | | | .058* | .085 |
| Light | .302 | .292 | .298 | | | | | | | | | | | | | | | | |
| Personal control (climate) | .394 | .103 | .308 | .242 | | | | | | | | | | | | | | | |
| Air movement | .291 | .154 | .491 | .227 | .385 | | | | | | | | | | | | | | |
| Aesthetic | .365 | .178 | .166 | .172 | .181 | .076 | | | | | | | | | | | | | |
| Satisfaction with control | .604 | .232 | .310 | .301 | .676 | .331 | .408 | | | | | | | | | | | .324** | .295 |
| Temperature | .355 | .176 | .779 | .300 | .449 | .853 | .137 | .424 | | | | | | | | | | | |
| Control of aesthetic | .479 | .139 | .157 | .198 | .363 | .164 | .578 | .588 | .193 | | | | | | | | | | |
| Spatial layout | 5.13 | .310 | .118 | .259 | .209 | .158 | .330 | .450 | .194 | .382 | | | | | | | | .303** | .291 |
| Break area | .337 | .205 | .185 | .110 | .185 | .088 | .263 | .309 | .164 | .197 | .284 | | | | | | | .103* | .113 |
| Windows | .302 | .167 | .218 | .534 | .322 | .133 | .190 | .356 | .185 | .269 | .306 | .054 | | | | | | | |
| Social interaction | .377 | .270 | .210 | .305 | .150 | .117 | .284 | .284 | .214 | .212 | .455 | .252 | .231 | | | | | .113* | .110 |
| Sitting at work | .524 | .118 | .113 | .182 | .335 | .163 | .377 | .581 | .174 | .434 | .365 | .278 | .193 | .277 | | | | .221** | .192 |
| Relaxing environment | .218 | .231 | .155 | .097 | .178 | .049 | .295 | .316 | .135 | .201 | .332 | .344 | .159 | .271 | .290 | | | | |
| Equipment | .028 | .152 | .040 | .202 | -.032 | .022 | .123 | .123 | .048 | .070 | .157 | .131 | .076 | .333 | .109 | .144 | | -.116* | -.131 |

| | Satisfaction DV | Sound | Humidity | Light | Personal Control Climate | Air movement | Aesthetic | Satisfaction with control | Temperature | Control of aesthetic | Spatial layout | Break area | Windows | Social interaction | Sitting at work | Relaxing environment | Equipment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 4.67 | 6.16 | 5.53 | 5.70 | 2.74 | 5.36 | 3.34 | 3.52 | 5.23 | 2.17 | 5.05 | 3.84 | 4.65 | 5.78 | 3.99 | 4.35 | 5.90 | |
| Sd. | 1.24 | 1.40 | 1.88 | 1.53 | 1.13 | 1.94 | 1.12 | 1.12 | 1.53 | 1.21 | 1.12 | 1.35 | 1.70 | 1.26 | 1.07 | 1.21 | 1.41 | |

** p<001
* p<01

**$R^2$ = .526**
**Adjusted $R^2$ = .515**
**R = .725**

| | Impact DV | Sound | Humidity | Light | Personal Control Climate | Air movement | Aesthetic | Satisfaction with control | Temperature | Control of aesthetic | Spatial layout | Break area | Windows | Social interaction | Sitting at work | Relaxing environment | Equipment | B | β |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sound | .251 | | | | | | | | | | | | | | | | | | |
| Humidity | .301 | .155 | | | | | | | | | | | | | | | | | |
| Light | .218 | .292 | .298 | | | | | | | | | | | | | | | | |
| Personal control (climate) | .472 | .103 | .308 | .242 | | | | | | | | | | | | | | .171** | .225 |
| Air movement | .374 | .154 | .491 | .227 | .385 | | | | | | | | | | | | | .071** | .158 |
| Aesthetic | .296 | .178 | .166 | .172 | .181 | .076 | | | | | | | | | | | | | |
| Satisfaction with control | .530 | .232 | .310 | .301 | .676 | .331 | .408 | | | | | | | | | | | | |
| Temperature | .395 | .176 | .779 | .300 | .449 | .853 | .137 | .424 | | | | | | | | | | | |
| Control of aesthetic | .428 | .139 | .157 | .198 | .363 | .164 | .578 | .588 | .193 | | | | | | | | | .088* | .123 |
| Spatial layout | .421 | .310 | .118 | .259 | .209 | .158 | .330 | .450 | .194 | .382 | | | | | | | | .183** | .252 |
| Break area | .283 | .205 | .185 | .110 | .185 | .008 | .263 | .309 | .164 | .197 | .284 | | | | | | | .064* | .101 |
| Windows | .262 | .167 | .218 | .534 | .322 | .133 | .190 | .356 | .185 | .269 | .306 | .054 | | | | | | | |
| Social interaction | .256 | .270 | .210 | .305 | .150 | .117 | .284 | .284 | .214 | .212 | .455 | .252 | .231 | | | | | | |
| Sitting at work | .419 | .118 | .113 | .182 | .335 | .163 | .377 | .581 | .174 | .434 | .365 | .278 | .193 | .277 | | | | .108* | .135 |
| Relaxing environment | .310 | .231 | .155 | .097 | .178 | .049 | .295 | .316 | .135 | .201 | .332 | .344 | .159 | .271 | .290 | | | | |
| Equipment | -.004 | .152 | .040 | .202 | -.032 | .022 | .123 | .123 | .048 | .070 | .157 | .131 | .076 | .333 | .109 | .144 | | | |

| | Impact DV | Sound | Humidity | Light | Personal Control Climate | Air movement | Aesthetic | Satisfaction with control | Temperature | Control of aesthetic | Spatial layout | Break area | Windows | Social interaction | Sitting at work | Relaxing environment | Equipment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 4.05 | 6.16 | 5.53 | 5.70 | 2.74 | 5.36 | 3.34 | 3.52 | 5.23 | 2.17 | 5.05 | 3.84 | 4.65 | 5.78 | 3.99 | 4.35 | 5.90 | |
| Sd. | 0.87 | 1.40 | 1.88 | 1.53 | 1.13 | 1.94 | 1.12 | 1.12 | 1.53 | 1.21 | 1.12 | 1.35 | 1.70 | 1.26 | 1.07 | 1.21 | 1.41 | |

** p<001
* p<05

**$R^2$ = .433**
**Adjusted $R^2$ = .423**
**R = .658**

**References**


Abdou, H.G. and Lorsch, O.A. (1994) The impact of the building indoor environment on occupant productivity - part 2: Effects of Temperature. *ASHRAE Transactions, 100*(2), 895-901.

Adler, D. (eds) (1999) *Metric Handbook. Planning and Design Data*. 2nd Edition. Oxford: Butterworth - Heinemann

Ainsworth, R.A., Simpson, L. and Cassell, D. (1993) Effects of 3 colors in an office interior on mood and performance. *Perceptual and Motor Skills*, 76(1) p235-241

Allen, T.J. and Gerstberger, P.G. (1973) A field experiment to improve communications in a product engineering department. The non-territorial office. *Human Factors* 15(5) 487-498

Anderson, A.H. and Kyprianou, A. (1994) *Effective Organizational Behavior*. Blackwell Publishers: Oxford

Anderson, K.J. (1994) Impulsivity, caffeine, and task difficulty: A within-subjects test of the Yerkes-Dodson law. *Personality and Individual Differences*, 16 , p813-830

Anderton, F. (1998) Design notebook; virtual officing comes in from the cold. *The New York Times.* December 17th 1998

ASHRAE (1966). *ASHRAE Thermal Comfort Standards. Standard 55-66*. Atlanta: American Society of Heating, Refrigeration and Air Conditioning Engineers

ASHRAE (1996) *ASHRAE Thermal Comfort Standards. Standard 55-96*. Atlanta: American Society of Heating, Refrigeration and Air Conditioning Engineers

ASHRAE (2001) *ASHRAE Handbook. Fundamentals. SI Edition*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE (2002) *Refrigeration Handbook 2002*. Atlanta: American Society of Heating, Refrigeration and Air Conditioning Engineers

ASHRAE (2004). *Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality*. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Azer, N.Z., McNall, P.E. and Leung, H.C. (1972) Effects of heat stress on performance. *Ergonomics, 15*(6), 681-691

Banbury, S. and Berry, D.C. (1998) Disruption of office-related tasks by speech and office noise. *British Journal of Psychology*, 89, p499-51

Banbury, S.P. and Berry, D.C. (2005) Office noise and employee concentration: Identifying causes of disruption and potential improvements. *Ergonomics*, 48(1), p25-37

Baron, R.A. and Rea, M.S. (1991) Lighting to soothe the mood. *Lighting Design and Application*, 12, p30–32

Becker, F. (1991) Workplace planning, design, and management. In: Zube, E.H. and Moore, G.T. (Eds) *Advances in Environment, Behavior and Design Vol. 3*. New York: Plenum Press, p115–151

Becker, F. and Steele, F. (1995) *Workplace by Design. Mapping the High Performance Workscape*. Jossey-Bass Publishers: San Francisco

Becker, F. D. (1981) *Workspace. Creating Environments in Organisations*. Praeger Publishers : New York

Becker, F.D., Gield, B., Gaylin, K. & Sayer, S. (1983) Office design in a community college. *Environment and Behavior*, 15, p699-726

Biner, P.M. (1991) Effects of lighting-induced arousal on the magnitude of goal valence. *Personality and Social Psychology Bulletin* 17(2) 219-226

Biner, P.M., Butler, D.L. and Winsted III, D.E. (1991) Inside windows. An alternative to conventional windows in offices and other settings. Environment and Behavior 23(3) 359-382

Birren, F. (1982) Light, Color and Environment. Revised Edition. Van Nostrand Reinhold: New York

Block, L.K. and Stokes, G.S. (1989) Performance and satisfaction in private versus nonprivate work settings. *Environment and Behavior* 21(3) 277-297

Boutellier, R., Ullman, F., Schreiber, J. and Naef, R. (2008) Impact of office layout on communication in a science-driven business. *Research and Development Management*, 38(4) p372-391

Boyce, P.R. (1979) Users' attitudes to some types of local lighting. *Lighting Research and Technology*, 11(3), p158-164

Boyce, P.R. (2003) *Human Factors in Lighting. Second Edition.* Taylor and Francis: London

Brager, G.S., and de Dear, R.J. (1998) Thermal adaptation in the built environment: a literature review. *Energy and Buildings, 27*, 83-96.

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

Brill, M., Margulis, S., Konar, E. and BOSTI (1984) *Using Office Design to Increase Productivity*. Buffalo, New York: Workplace Design and Productivity

Bringslimark, T., Hartig, T. and Patil, G.G. (2007) Psychological benefits of indoor plants in workplaces: Putting experimental results into context, *Hortscience*, 42(3), p581-587

British Council for Offices (2000) *The BCO Guide*. http://www.bco-officefocus.com/download/ accessed on 12/09/2004

British Council for Offices (BCO) (2003) *British Council for Offices. Office Fit-out Guide*. London: British Council for Offices

British Council for Offices (BCO) (2005) *British Council for Offices. Office Guide 2005. Best Practice in the Specification for Offices.*. London: British Council for Offices

Bromley, A.K.R., Bordass, W.T. and Leaman, A. (1993) Are you in control? User and occupant controls in office buildings. *Building Services Journal*, 5(4), p30-32

Brooks, M.J. and Kaplan, A. (1972) The office environment. Space planning and affective behavior. *Human Factors*, 14(5), 373-391

Brown, G. and Gifford, R. (2001) Architects predict lay evaluations of large contemporary buildings: whose conceptual properties? *Journal of Environmental Psychology,* 21, p93-99

Burger, J. (1989) Negative reactions to increases in perceived control. *Journal of Personality & Social Psychology*, 56( 2), p246–256

Butler, D.L. and Biner, P.M. (1989) Effects of settings on window preferences and factors associated with those preferences. *Environment and Behavior* 21(1) 17-31

Butler, D.L. and Steuerwald, B.L. (1991) Effects of view and room size on window size and preferences made in models. *Environment and Behavior* 23(3) 334-358

Carter, D.J., Slater, A.I., Perry, M.J., Mansfield, K.P., Loe, D.L. and Sandoval, J. (1994) The influence of luminance distribution on subjective impressions and performance within a non-uniformly lit office. *Proceedings CIBSE National Lighting Conference*, Cambridge, p61-74

Cena, K.M., Ladd, P.G. and Spotila, J.R. (1990) A Practical approach to thermal comfort surveys in homes and offices: discussion of methods and concerns. *ASHRAE Transactions, 96*(1), 853-858

Chartered Institute of Building Services Engineers (1999) *Daylighting and Window Design*. Chartered Institute of Building Services Engineers: London

Chartered Institute of Building Services Engineers (CIBSE) (1994) *Interior Lighting Code*, London: CIBSE

Chartered Institute of Building Services Engineers (CIBSE) (2006) *Energy Assessment and Reporting Methodology. 2nd Edition*. London: CIBSE

Chiles, W.D. (1968) Effects of elevated temperatures on performance of a complex mental task. *Ergonomics, 11*, 89-96

Christie, M. and McBrearty, E. (1979) Psychophysiological investigations of post-lunch state in male and female subjects. *Ergonomics*, 22(3), p307–323

Cohen, R., Field, J. and Leaman, A. (2000) PROBE 20: Barclaycard headquarters. *Building Services Journal*. 22(3) p37-43

Cohen, R., Standeven, M., Bordass, B. and Leaman, A. (1999) *PROBE Strategic Review 1999. Report 1: Review of Probe Process.* www.useablebuildings.co.uk. Accessed on 18/02/03

Cohen, R., Standeven, M., Bordass, B. and Leaman, A. (2000) Assessing building performance in use 1: the PROBE process. *Building Research and Information*, 29(2), p85-102

Collins, B.L. (1976) Review of the psychological reaction to windows. *Lighting Research and Technology* 8(2) 80-88

Colquhoun, W.P. (1971) *Biological Rhythms and Human Performance*. London: Academic Press

Colquhoun, W.P. (1981) Rhythms in performance. In Aschoff, J. (ed) *Handbook of Behavioural Neurobiology: Biological Rhythms*, p333-349. New York: Plenum Press

Colquhoun, W.P., Blake, M.J.F. and Edwards, R.S. (1969) Experimental studies of shift-work III. Stabilized 12-hour shift systems. *Ergonomics*, 12, p865-882

Cook, M. (2007) *The Design Quality Manual*. Oxford; Wiley-Blackwell

Cooper, I. (2001) Post-occupancy evaluation – where are you? *Building Research and Information*, 29(2), p158-163

Coren, S., Ward, L.M. and Enns, J.T. (1999) *Sensation and Perception. Fifth Edition*. Harcourt Brace College Publishers: Orlando

Craig, A., Baer, K. and Diekmann, A. (1981) The effects of lunch on sensory-perceptual functioning in man. *International Journal of Occupational and Environmental Health*, 49, p105–114

Croome, D.J., Gan, G. and Awbi, H.B. (1992) Evaluation of thermal comfort and indoor air quality in offices. *Building research and information, 20*(4), 211-225

Crouch, A. and Nimran, U. (1989) Perceived facilitators and inhibitors of work performance in an office environment. *Environment and Behavior* 21(2) 206-226

Danielsson, C.B. and Bodin, L. (2008) Office type in relation to health, well-being, and job satisfaction among employees, *Environment and Behavior*, 40(5), p636-668

De Croon, E.M., Sluiter, J.K., Kuijer, P.P.F.M. and Frings-Dresen, M.H.W. (2005) The effect of office concepts on worker health and performance: a systematic review of the literature. *Ergonomics*, 48(2) p119-134

de Dear, R.J. (1998) Developing an adaptive model of thermal comfort and preference. *ASHRAE Transactions, 104*(1a), 145-167.

de Dear, R.J. and Brager, G.S. (2002) Thermal comfort in naturally ventilated buildings: revisions to ASHRAE Standard 55. *Energy and Buildings, 34*, 549-561

Deffenbacher, K.A. (1994) Effects of arousal on everyday memory. *Human Performance*, 7, p141-161

Desor, J.A. (1972) Towards a psychosocial theory of crowding. *Journal of Personality and Social Psychology*. 21(1) 79-83

Dickman, S.J. (2002) Dimensions of arousal: wakefulness and vigor. *Human Factors*, 44(3), p429-442

Doherty, T.J. and Arens, E.A. (1988) Evaluation of the physiological bases of thermal comfort models. *ASHRAE Transactions*, 94(1), p15

Dravigne, A., Waliczek, T.M., Lineberger, R.D. and Zajicek, J.M. (2008) The effect of live plants and window views of green spaces on employee perceptions of job satisfaction, *Hortscience*, 43(1) p183-187

Duffy, F. (1969) *Office Landscaping. A New Approach to Office Planning*. Anbar Publications Ltd: London

Duffy, F. (1992) *The Changing Workplace*. London: Phaidon

Duffy, F. (1997) *The New Office*. London: Conran Octopus

Dul, J. (2009) Business ergonomics beyond health and safety: Work environments for employee productivity, creativity and innovation in Bust, P.D., (eds) Contemporary Ergonomics, Boca Rayton: CRC Press

Duvall-Early, K. and Benedict, J.O. (1992) The relationships between privacy and different components of job satisfaction. *Environment and Behavior* 24(5) 670-679

Egan, D. (1975) *Concepts in Thermal Comfort*. Englewood Cliffs, New Jersey: Prentice-Hall

Eley, J. and Marmot, A. (1995) *Understanding Offices*. Penguin Group : London

Ellis, H.D. (1982) The effects of cold on the performance of a serial choice reaction time and various discrete tasks. *Human Factors, 24*(5), 589-598

Evans, G.W. and Johnson, D. (2000) Stress and open-office noise. *Journal of Applied Psychology*, 85(5), p779-783

Fairweather, L. and Silwa, J.A. (1977) *Architects Journal Metric Handbook. Third Edition*. Architectural Press: London

Fang, L., Wyon, D.P., Clausen, G.. and Fanger, P.O. (2004) Impact of indoor air temperature and humidity in an office on perceived air quality, SBS symptoms and performance. *Indoor Air*, 14 p74-81

Fanger, P.O. (1970) *Thermal Comfort. Analysis and Applications in Environmental Engineering*. New York: McGraw – Hill

Fanger, P.O. and Langkilde, G. (1975) Individual differences in ambient temperatures preferred by seated persons, *ASHRAE Transactions*, 81, p140

Fanger, P.O. and Toftum, J. (2002) Extension of the PMV model to non-air-conditioned buildings in warm climates. *Energy and Buildings, 34*(6), 533-536

Finnegan, M.C. and Solomon, L.Z. (1981) Work attitude in windowed versus windowless environments. *Journal of Social Psychology* 115 291-292

Fjeld, T. (1998) Effect of indoor foliage plants on health and discomfort symptoms among office workers. *Indoors and Built Environment*, 7, p204-206

Flynn, J.E. and Spencer, T.J. (1977) Effects of light-source color on user impression and satisfaction *Journal of the Illuminating Engineering Society* 6(3) 167-179

Folkard, S. (1983) Diurnal variation. In: Hockey, R. (ed). *Stress and Fatigue in Human Performance*, p245-272. Chichester: Wiley

Follenius, M., Brandenberger, G. and Hietter, B. (1982) Diurnal cortisol peaks and their relationship to meals. *Journal of Clinical Endocrinology*, 55, p757-761

Fountain, M., Brager, G.. and de Dear, R. (1996) Expectations of indoor climate control. *Energy and Buildings, 24*, 179-182

Fried, Y. (1990) Workspace characteristics, behavioral interferences, and screening ability as joint predictors of employee reactions: An examination of the intensification approach. *Journal of Organizational Behavior* 11(4) 267-280

Fried, Y., Slowik, L., Ben-David, H.A. & Tiegs, R. B. (2001). Exploring the relationship between workspace density and employee attitudinal reactions: An integrative model. *Journal of Occupational And Organizational Psychology*, 74, 359-372

Gagge, A.P., Fobelets, A.P. and Berglund, L.G. (1986) A standard predictive index of human response to the thermal environment. *ASHRAE Transactions*, 92, p709–731

Glass, D.C. and Singer, J.E. (1972) *Urban Stress: Experiments on Noise and Social Stressors*. New York: Academic

Gossauer, E. and Wagner A. (2008) Thermal comfort and satisfaction at workplaces - a field study in office buildings. *Bauphysik*, 30(6) p445-452

Gupta, S. (1991) Effect of time of day and personality on intelligence test scores. *Personality and Individual Differences*, 12(11), p1227-1231

Haghighat, F. and Donnini, G. (1999) Impact of psycho-social factors on perception of the indoor air environment studies in 12 office buildings. *Building and Environment, 34*, 479-503

Hancock, G.R. and Klockars, A.J. (1991) The effect of scale manipulations on validity: targeting frequency rating scales for anticipated performance levels. *Applied Ergonomics*, 22, p147-154

Hartig, T., Mang, M. and Evans, G.W. (1991) Restorative effects of natural environment experiences. *Environment and Behavior* 23(1) 3-26

Haves, P., Linden, P.F. and Carrilho Da Graça, G. (2004) Use of simulation in the design of a large, naturally ventilated office building. *Building Services Engineering Research and Technology*, 25(3), p211-221

Haynes, B.P. (2007) An evaluation of office productivity measurement. *Journal of Corporate Real Estate*, 9(3), p144-155

Hedge, A. (1982) The open-plan office: A systematic investigation of employee reactions to their work environment. *Environment and Behavior* 14 (5) 519-542

Hedge, A., Sims, W.R. and Becker, F.D. (1995) Effects of lensed-indirect and parabolic lighting on the satisfaction, visual health, and productivity of office workers. *Ergonomics* 38(2) 260-280

Heerwagen, J.H. and Heerwagen, D.R. (1986) Lighting and psychological comfort. *Lighting Design and Application* 16(4) 47-51

Heidari, S. and Sharples, S. (2002) A comparative analysis of short-term and long-term thermal comfort surveys in Iran. *Energy and Buildings, 34*, 607-614.

Hershberger, R.G. (1969) A study of meaning and architecture. In Nasar, J. (eds) *Environmental Aesthetics: Theory, Research and Applications*. New York: Cambridge University Press p175-194

Herzberg, F. (1966) *Work and the Nature of Man*. Cleveland: World Publishing

Herzberg, F., Mausner, B., Peterson, R.D. and Capwell, D.F. (1957) *Job Attitudes: Review of Research and Opinions*. Pittsburgh: Psychological Service of Pittsburgh

Herzberg, F., Mausner, B. and Snyderman, B.B. (1959) *The Motivation to Work*. New York: John Wiley

Herzog, T.R., Black, A.M., Fountaine, K.A. and Knotts, D.J. (1997) Reflection and attentional recovery as distinct benefits of restorative environments. *Journal of Environmental Psychology* 17(2) 165-170

Herzog, T.R., Maguire, C.P. and Nebel, M.B. (2003) Assessing the restorative components of environments. *Journal of Environmental Psychology*, (23) p159-170

Hildebrandt, G., Rohmert, W. and Rutenfranz, J. (1974) 12 and 24 hour rhythms in error frequency of locomotive drivers and the influence of tiredness. *International Journal of Chronobiology*, 2, p175-180

Hollingworth, H.L. (1914) *Outlines for Experimental Psychology*. Oxford, England: Seiler

Hopkinson, R.G. and Kay, J.D. (1972) *The Lighting of Buildings*. Faber and Faber: London

Hubbard, P. (1996) Conflicting interpretation of architecture: an empirical investigation. *Journal of Environmental Psychology*, 16, p75-92

Hughes, W.P. (2003) A comparison of two editions of the RIBA Plan of Work. *Engineering, Construction and Architectural Management*. 10(5), p302-311

Hull, J.T., Wright, K.P. and Czeisler, C.A. (2003) The influence of subjective alertness and motivation on human performance independent of circadian and homeostatic regulation. *Journal of Biological Rhythms*, 18, p329-338

Humphreys, M. (1976) Field Studies of thermal comfort compared and applied. *Building Services Engineer, 44*, 5-27

Humphreys, M. (1978) Outdoor temperatures and comfort indoors. *Building research and practice, 6*(2), 92-105.

Humphreys, M.A. (1995) Thermal comfort, temperatures and the habits of hobbits. Comfort temperatures and climate. In Humphreys, M., Nicol, F., Roaf, S. and Sykes, O. (eds) *Standards for Thermal Comfort. Indoor Air Temperature Standards for the 21st Century*. London: Taylor and Francis

Humphreys, M. A. and Nicol, J.F. (1995) An adaptive guideline for UK office temperatures. In Nicol, J.F., Humphreys, M.A., Sykes, O., and Roaf, S. (1995) *Standards for Thermal Comfort. Indoor Air Temperature Standards for the 21st Century.* E& F Spon : London

Hygge, I. and Knez, S. (2001) Effects of noise, heat and indoor lighting on cognitive performance and self-reported affect. *Journal of Environmental Psychology, 21*, 291 – 299

Iaffaldano, M.T. and Muchinsky, P.M. (1985) Job satisfaction and job performance: a meta-analysis. *Psychological Bulletin*, 97, p251-73

James, W. (1890) *The Principles of Psychology*. New York: Henry Holt

Johl, M.V. (1995) New thermal comfort standards of the Czech republic. In Nicol, M.H.F., Sykes, O. and Roaf, S. (Ed.), *Standards for thermal comfort. Indoor air temperature standards for the twenty-first century*. London: E & F Spon

Jones, B.W. (2002) Capabilities and limitations of thermal models for use in thermal comfort standards. *Energy and Buildings, 34*, 653-659

Judge, T.A., Thoresen, C.J., Bono, J.E. and Patton, G.K. (2001) The job satisfaction-job performance relationship: A qualitative and quantitative review. *Psychological Bulletin*, 127, p376-407

Kaarlela-Tuomaala, A., Helenius, R., Keskinen, E. and Hongisto, V. (2009) Effects of acoustic environment on work in private office rooms and open-plan offices - longitudinal study during relocation. *Ergonomics*, 52(11), p1423-1444

Kaplan, R. and Kaplan, S. (1989) *The Experience of Nature. A Psychological Perspective*. Cambridge University Press : Cambridge

Karjalainen, S. and Koistinen A. (2007) User problems with individual temperature control in offices. *Building and Environment*. 42(8) p2880-2887

Katzev, R. (1992) The impact of energy-efficient office lighting strategies on employee satisfaction and productivity. *Environment and Behavior* 24(6) 759-778

Keighly, E.C. (1973a) Visual requirements and reduced fenestration in office buildings – a study of window shape. *Building Science* 8 311

Keighly, E.C. (1973b) Visual requirements and reduced fenestration in offices – a study of multiple apertures and window area. *Building Science* 8 32

Klein, J.G. (1982) *The Office Book. Ideas and Designs for Contemporary Workspaces*. Frederick Muller Ltd: London

Konar, E. (1982) Status demarcation in the office. *Environment and Behavior* 14(5) 561-580

Konar, E., Sundstrom, E., Brady, C., Mandel, D. and Rice, R.W. (1982) Status Demarcation in the Office. *Environment and Behavior*, 14(5), p561-580

Kostiainen, T., Welling, I., Lahtinen, M., Salmi, K., Kahkonen, E. and Lampinen, J. (2008) Modeling of Subjective Responses to Indoor Air Quality and Thermal Conditions in Office Buildings. *HVAC&R Research*, 14(6) p905-923

Kristiansen, J., Mathiesen, L., Nielsen, P.K., Hansen, A.M., Shibuya, H., Petersen, H.M., Lund, S.P., Skotte, J., Jorgensen, M.B. and Sogaard, K. (2009) Stress reactions to cognitively demanding tasks and open-plan office noise. *International Archives of Occupational and Environmental Health*, 82(5), p631-641

Kroemer, K.H.E. and Kroemer, A.D. (2001) *Office Ergonomics*. London: Taylor and Francis

Kroner, W., Stark-Martin, J.A. and Willemain, T. (1992) *Using Advanced Technology to Increase Productivity*. Troy, New York: Rensselaer Polytechnic Institute, Center for Architectural Research

Kuchen, E. and Fisch, M.N. (2009) Spot Monitoring: Thermal comfort evaluation in 25 office buildings in winter. *Building and Environment*, 44(4) p839-847

Kupritz, V.W. (1998) Privacy in the workplace: The impact of building design. *Journal of Environmental Psychology* 18(4) 341-356

Kupritz, V.W. (2000) Privacy management at work: A conceptual model. Journal of Architectural and Planning Research. 17, p47-63

Kupritz, V.W. (2003) Accommodating privacy to facilitate new ways of working. *Journal of Architectural and Planning Research*. 20, 122-135

Kwallek, K.P. and Lewis, C.M. (1990*)* Effects of Environmental color on males and females: a red or white or green office. *Applied Ergonomics* 21: 275-278.

Kwallek, N., Lewis, C.M., LinHsiao, J.W.D. and Woodson, H. (1996) Effects of nine monochromatic office interior colors on clerical tasks and worker mood, *Color Research and Application*, 21(6), p448-458

Laing, A., Duffy, F., Jaunzens, D. and Willis, S. (1998) *New Environments For Working*. Construction Research Communications Ltd: London

Lan, L. and Lian, Z.W. (2009) Use of neurobehavioral tests to evaluate the effects of indoor environment quality on productivity. *Building and Environment*, 44(11) p2208-2217

Larsen, L., Adams, J., Deal, B., Kweon, B. and Tyler, E. (1998) Plants in the workplace: The effects of plant density on task performance, attitudes and perceptions. *Environment and Behavior*, 30(3) p261-281

Leaman, A. and Bordass, B. (2001) Assessing building performance in use 4: the Probe occupant surveys and their implications. *Building Research and Information* 29(2) 129-143

Leaman, A. and Bordass, W. (1998) Probe 15: Productivity in buildings: The Killer Variables, *Building Services Journal,* p41-43

Leaman, A., Bordass, W., Cohen, R. and Standeven, M. (1997) How buildings really work. The Probe Occupant Surveys. *Proceedings of Buildings in Use '97*. London

Leather, P., Pyrgas, M., Beale, D. and Lawrence, C. (1998) Windows in the workplace. Sunlight, view and occupational stress. *Environment and Behavior* 30(6) 739-762

Leea, S.L. and Brandb, J.L. (2005) Effects of control over office workspace on perceptions of the work environment and work outcomes. *Journal of Environmental Psychology*, 25(3) p323-333

Leibig, J. and Roll, K.F. (1983) Acceptable luminances reflected on VDU screens in relation to the level of contrast and illumination. *Proceedings of 20th Session, Commission Internationale de L'Éclairage*

Loe, D.L. and Rowlands, E. (1996) The art and science of lighting: A strategy for lighting design. *Lighting Research and Technology*, 28(4), p153-164

Lofquist, L.H. and Dawis, R.V. (1969) *Adjustment to Work*. New York: Appleton-Century-Crofts

Lomonaco, C. and Miller, D. (1997) Workstation comfort and control. *ASHRAE Journal*, 38(9), p215–223

Lorsch, H.G. and Abdou, O.A. (1994) The impact of the building indoor environment on occupant productivity – part 1: Recent studies, measures and costs. *ASHRAE Transactions 100 (2)* 741-749

Lott, D.F. and Sommer, R. (1967) Seating arrangements and status. *Journal of Personality and Social Psychology* 7(1) p90–95

Louis Harris and Associates, Inc. (1980) *The Steelcase National Study of Office Environments. No. 2*. Grand Rapids, MI: Steelcase Inc

Ludlow, A.M. (1976) The function of windows in buildings. *Lighting Research and Technology.* 8(2) 57-68

Lupton, T. (1971) *Management and the Social Sciences. 2nd Edition*. Penguin: Harmondsworth

Mallory-Hill, S., van der Voordt, T.J.M. and van Dortmont, A. (2005) Evaluation of innovative workplace designs in the Netherlands. In Preiser, W.F.E. and Vischer, J.C. *Assessing Building Performance*. Oxford: Elsevier

Marans, R.W. and Spreckelmeyer, K.F. (1981) *Evaluating Built Environments: A Behavioral Approach.* Michigan: Survey Research Centre and Architectural Research Laboratory

Marans, R.W. and Spreckelmeyer, K.F. (1982) Measuring overall architectural quality: A component of building evaluation. *Environment and Behavior* 14(3) 333-351

Marans, R.W. and Yan, X. (1989) Lighting quality and environmental satisfaction in open and enclosed offices. *Journal of Architectural and Planning Research*, 6, p118-131

Marks, M. and Folkard, S. (1984) In Nicholson, J. and Beloff, H. (Eds.). *Psychology Survey 5*. Leicester: The British Psychological Society

Markus, T. (2001) Forum: does the building industry suffer from collective amnesia. *Building Research and Information*, 29(6), p473-476

Markus, T.A. (1967) The function of windows: a reappraisal. *Building Science*, 2, p97–121

Marmot, A. and Eley, J. (2000) *Office Space Planning. Designing for Tomorrows Workplace*. McGraw Hill : New York

Maslow, A.H. (1943) A theory of human motivation. *Psychological Review*, 50, p370-396

Maslow, A.H. (1970) *Motivation and Personality*. Harper & Row: London

Mayo, E. (1933) *The Human Problems of an Industrial Civilization*. New York: MacMillan

McCloughan, C.L.B., Aspinal, P.A. and Webb, R.S. (1996) The effects of lighting upon mood and decision making. *Proceedings of CIBSE National Lighting Conference*, Bath

McCoy, J.M. (2002) Chapter 29. In Bechtel, R.B. and. Churchman, A. (Ed.), *Handbook of Environmental Psychology* (pp. 443). New York: Wiley and Sons.

McGuire, P. (2003). Public image: Expansion of a leading advertising agency is another stage on its imaginative flight from stifling corporate design. *The Architectural Review*. April Issue

McKeown, C. (2008) *Office Ergonomics. Practical Applications*. Boca Raton: CRC Press

Meese, G.B., Kok, R., Lewis, M.I. and Wyon, D.P. (1984) A laboratory study of the effects of moderate thermal stress on the performance of factory workers. *Ergonomics, 27*(1), 19-43

Mehta, R. and Zhu, R. (2009) Blue or Red? Exploring the Effect of Color on Cognitive Task Performances, *Science* 323(5918) p1226-1229

Mendl, M. (1999) Performing under pressure: stress and cognitive function. *Applied Animal Behaviour Science*, 65, p221–244

Mikellides, B. (1980) (eds). *Architecture for People. Explorations in a New Humane Environment*. London: Studio Vista London

Mullins, L.J. (2005) *Management and Organisational Behaviour. 7th edition*. Essex, England: Pearson Education Limited

Murphy, L.R. (1988) Workplace interventions for stress reduction and prevention. In Cooper et al (eds), *Causes, Coping and Consequences of Stress at Work*. Chichester: Wiley

Nakano, J., Tanabe, S. and Kimura, K. (2002) Differences in perception of indoor environment between Japanese and non-Japanese workers. *Energy and Buildings, 34*, 615-621

Nasar, J.L. and F, W.F.E. (Eds.) (1999) *Directions in Person-Environment Research and Practice*. Aldershot: Ashgate

Ne'eman, E. and Hopkinson, R.G. (1970) Critical minimum acceptable window size: a study of window design and provision of a view. *Lighting, Research and Technology* 2(1) 17-27

Ne'eman, E., Sweitzer, G. and Vine, E. (1984) Office worker's response to lighting and daylight issues in workspace environments: A pilot survey. *Energy and Buildings*, 6, p159-171

Nelson, T.M., Nilsson, T.H. and Johnson, M. (1984) Interaction of temperature, illuminance and apparent time on sedentary work fatigue. *Ergonomics, 27*(1), 89-101.

Newsham, G., Brand, J., Donnelly, C., Veitch, J., Aries, M, and Charles, K. (2009) Linking indoor environment conditions to job satisfaction: a field study. *Building Research and Information.* 37(2) p129-147

Newsham, G.R. & Veitch, J.A. (2001) Lighting quality recommendations for VDT offices: a new method of derivation. *Lighting Research and Technology*, 33(2), p97-116

Newsham, G.R., Veitch, J.A. and Charles, K.E. (2008) Risk factors for dissatisfaction with the indoor environment in open-plan offices: an analysis of COPE field study data. *Indoor Air*, 18(4), p271-282

Nicol, J.F. and Humphreys, M.A. (2002) Adaptive thermal comfort and sustainable thermal standards for buildings. *Energy and Buildings, 34*, 563-572.

O'Neill, M.J. (1994) Work space adjustability, storage and enclosure as predictors of employee reactions and performance. *Environment and Behavior* 26(4) 504-526

O'Driscoll, M.P. and Cooper, C.L. (1996) A critical incident analysis of stress-coping behaviors at work. *Stress Medicine*, 12, p123-128

Office of National Statistics (2005) *National Statistics Online* http://www.statistics.gov.uk/ Visited on 09/02/2005

Oldham, G.R. (1988) Effects of changes in workspace partitions and spatial density on employee reactions: A quasi-experiment. *Journal of Applied Psychology* 73(2) 253-258

Oldham, G.R. and Brass, D.J (1979) Employee reactions to an open-plan office: A naturally occurring quasi-experiment. *Administrative Science Quarterly*, 24: 267-284

Oldham, G.R. and Fried, Y. (1987) Employee reactions to workspace characteristics. *Journal of Applied Psychology* 72(1) 75-80

Oldham, G.R. and Rotchford, N.L. (1983) Relationships between office characteristics and employee reactions: A study of the physical environment. *Administrative Science Quarterly* 28(4) 542-556

Oseland, N. (ed) (2007) *British Council for Offices Guide to Post-Occupancy Evaluation*. London: British Council for Offices

Oseland, N.A. (1995) Predicted and reported thermal sensation in climate chambers, offices and homes. *Energy and Buildings, 23*, 105-115

Oseland, N.A. (1999) *Improving office productivity : a guide for business and facilities managers.* Longman: Harlow

Parker, S.K., Wall, T.D. and Cordery, J.L. (2001) Future work design research and practice: Towards an elaborated model of work design. *Journal of Occupational and Organizational Psychology*, 74, p413-440

Paulus, P.B. (1976) Density does affect task performance. *Journal of Personality and Social Psychology* 34(2) 248-253

Pepler, R.D. (1958) Warmth and performance: An investigation in the tropics. *Ergonomics, 2*, 63-88

Petty, M.M., McGee, G.W. and Cavender, J.W. (1984) A meta-analysis of the relationships between individual job satisfaction and individual performance. *Academy of Management Review*, 9, p712-721

Potter, D. and Keeling, D. (2005) Effects of Moderate Exercise and Diurnal Rhythms on Memory. *Journal of Sports and Exercise Psychology*, 27(1), p117-125

Preiser, W. (2001) Feedback, feedforward and control: post occupancy evaluation to the rescue. *Building Research and Information*, 29(6), p456-459

Preiser, W.F.E., Rabinowitz, H.Z. and White, E.T. (1988) *Post-Occupancy Evaluation*. New York: Van Nostrand Reinhold

Raw, G.J. (1992) *Sick Building Syndrome: A Review of the Evidence on Causes and Solutions*. London: Her Majesty's Stationery Office

Robson, C. (2002) *Real World Research. 2nd Edition*. Oxford: Blackwell

Roethlisberger, F.J. and Dickson,W.J. (1939) *Management and the Worker*. Cambridge, Massachusetts: Harvard University Press

Rose, M. (1988). *Industrial Behaviour*. London: Penguin

Rosenfeld, R.H. and Wilson, D.C. (1999) *Managing Organisations. Text Readings and Cases. 2nd Edition*. McGraw-Hill: London

Rowe, D.M., Lambert, S.G. and Wilke, S.E. (1995) Pale green, simple and user friendly: Occupant perceptions of thermal comfort in office buildings. In Nicol, M.H.F., Sykes, O. and Roaf, S. (Ed.), *Standards for thermal comfort. Indoor air temperature standards for the twenty-first century*. London: E & F Spon

Royal Institute of British Architects (RIBA) (2007). *RIBA Outline Plan of Work 2007*. London: RIBA

Sapsford, S. (2007) *Survey research. 2nd Edition*. Los Angeles: Sage

Schein, E.H. (1988) *Organizational Psychology. 3rd Edition*. Prentice-Hall Inc: New Jersey

Shibata, S. and Suzuki, N. (2004) Effects of an indoor plant on creative task performance and mood, *Scandinavian Journal of Psychology*, 45(5) p373-381

Slater, A.I., Perry, M.J. and Carter, D.J. (1993) Illuminance differences between desks: Limits of acceptability. *Lighting Research and Technology*, 25(2), p91-103

Smith, A.P. and Miles, C. (1986) The combined effects of occupational health hazards: an experimental investigation of the effects of noise, nightwork and meals. *International Archives of Occupational and Environmental Health*, 59(1), p83-89

Smith, M.J. (1998) *Social Science in Question: Towards a Postdisciplinary Framework*. London: Sage Publications

Smith-Jackson, T.L. and Klein, K.W. (2009) Open-plan offices: Task performance and mental workload. *Journal of Environmental Psychology*, 29(2) p279-289

Spring, B., Maller, O., Wurtman, J., Digman, L. and Cozolino, L. (1983) Effects of protein and carbohydrate meals on mood and performance: Interactions with sex and age. *Journal of Psychiatric Research*, 17, p155–167

Staats, H., Kieviet, A. and Hartig, T. (2003) Where to recover from attentional fatigue: An expectancy-value analysis of environmental preference. *Journal of Environmental Psychology*, (23) p147-157

Starbuck, W.H. (1983) Organizations as action generators. *American Sociological Review*, 48, p91-102

Steelcase (1990) *The Responsive Office*. Streatley-on-Thames, Berkshire: Polymath Ltd

Stone, N.J. (1998) Windows and environmental cues on performance and mood. *Environment and Behavior* 30(3) 306-321

Stone, N.J. (2003) Environmental view and color for a simulated telemarketing task. *Journal of Environmental Psychology* 23 63-78

Stone, N.J. and English, A.J. (1998) Task type, posters, and workspace color on mood, satisfaction, and performance. *Journal of Environmental Psychology* 18(2) 175-185

Stone, N.J. and Irvine, J.M. (1994) Direct or indirect window access, task type and performance. *Journal of Environmental Psychology* 14(1) 57-63

Sundstrom, E.D. (1986) *Workplaces. The Psychology of the Physical Environment in Offices and Factories.* Cambridge University Press: Cambridge

Sundstrom, E., Herbert, R.K. and Brown, D.W. (1982) Privacy and communication in an open-plan office: a case study. *Environment and Behavior*, 14(3), p379-392

Sutton, R.L. and Rafaeli, A. (1987) Characteristics of workstations as potential occupational stressors. *Academy of Management Journal, 30*(2), 260-276

Symonds, P.M. (1924) On the loss of reliability in ratings due to coarseness of the scale. *Journal of Experimental Psychology*, 7, p456-461

Szigeti, F. and Davis, G. (2002) Forum: the turning point for linking briefing and POE?. *Building Research and Information*, 30(1), p47-53

Tanabe, S. and Kimura, K. (1994) Effects of air temperature, humidity and air movement on thermal comfort under hot and humid conditions. *ASHRAE Transations, 100*(2), 953-969

Tanabe, S., Nishihara, N. and Haneda M. (2007) Indoor temperature, productivity, and fatigue in office tasks, *HVAC&R Research*, 13(4) p623-633

Taylor, F.W. (1911). *The Principles of Scientific Management*. New York: Harper and Brothers

Tennessen, C.M. and Cimprich, B. (1995) Views to nature. Effects on attention. *Journal of Environmental Psychology*, 15, p77-85

Thorndike, E. (1900) Mental fatigue. *Journal of the American Medical Association*, 12, p726-728

Toftum, J., Andersen, R.V. and Jensen K.L. (2009) Occupant performance and building energy consumption with different philosophies of determining acceptable thermal conditions. *Building and Environment*, 44(10) p2009-2016

Turner, G. and Myerson, J. (1998) *New Workspace, New Culture. Office Design as a Catalyst for Change*. Gower Publishing Ltd: Aldershot

van der Burgt, P.J.M., and van Kemenade, J.T.C. (1992) Designing for the individual: Can all be satisfied in lighting design? *Proceedings of the National Lighting Conference*, Manchester

Veitch, J.A. and Gifford, R. (1996) Choice, perceived control, and performance decrements in the physical environment. *Journal of Environmental Psychology*, 16, p269-276

Veitch, J.A. and Newsham, G.R. (2000) Exercised control, lighting choices, and energy use: An office simulation experiment. *Journal of Experimental Psychology* 20(3) 219-237

Vernon, M.D. (1965) *The Psychology of Perception*. University of London Press: London

*Vindolanda Tablets Online* (2003) http://vindolanda.csad.ox.ac.uk/ Visited on 10/02/2005

Vroom, V. (1964) *Work and Motivation*. New York: Jon Wiley & Sons

Walden, R. (2005) Assessing the Performance of Offices of the Future. In Preiser, W.F.E.and Vischer, J.C. (Eds.), *Assessing Building Performance: Methods and Case Studies*, p118-127. Oxford: Elsevier, Butterworth-Heineman

Warr, P. (1994) A conceptual framework for the study of work and mental health. *Work and Stress*, 8, p84-97

Warr, P. (2002) *Psychology at Work. 5th Edition*. Penguin Books: London

West, R., Murphy, K.J., Armilio, M.L., Craik, F.I.M. and Stuss, D.T. (2002) Effects of time of day on age differences in working memory. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 57B, p3-10

Weston, H.C. (1945) *Work on Visual Performance and Illuminance*, Industrial Health Research Board, Report No. 87

Wilson, G.D. (1990) Personality, time of day and arousal. *Personality and Individual Differences*,11, p153–168

Wilson, M.A. (1996) The socialization of architectural preference. *Journal of Environmental Psychology,* 16, p33-44

Wineman, J.D. (1986) *Behavioral Issues in Office Design*. New York: Van Nostrand Reinhold

Witterseh, T., Wyon, D.P. and 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, p30-40

Wright, A. (1998) *The Beginners Guide to Colour Psychology*. Colour Affects Ltd: London

Wyon, D.P. (1974) The effects of moderate heat stress on typewriting performance. *Ergonomics, 17*(3), 309-318

Wyon, D.P. (2000) Individual control at each workplace: the means and the potential benefits. In *Creating the Productive Workplace*, Derek Clements-Croome (eds.), London: Taylor and Francis

Yates, S.J. (2004) *Doing Social Science Research*. Revised and Expanded Edition. London: Sage/Open University

Yerkes, R.M. and Dodson, J.D. (1908) The relation of strength of stimulus to rapidity of habit formation. Journal of Comparative Neurology and Psychology, 18, p459-48

Zelinsky, M. (1998) New Workplaces for New Workstyles. McGraw Hill: New York

Zhang, H., Arens, E., Fard, S.A., Huizenga, C., Paliaga, G., Brager, G. and Zagreus L. (2007) Air movement preferences observed in office buildings, International Journal of Biometeorology,51(5) p349-360