

# **The impact of the physical office environment on occupant wellbeing**

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## Summary

### *Background*

There is increasing interest in the physical office environment's effect on wellbeing; however, much of the research is correlational, and more longitudinal research is needed.

### *Aims*

The primary aim of this research was to investigate the relationship between office design and wellbeing. A secondary aim was to create a tool to measure wellbeing and environmental satisfaction in office occupants. Finally, a third aim was to develop office design recommendations to support wellbeing.

### *Methods*

In Study 1, 215 UK office workers completed an online questionnaire study. The data was used to examine the relationship between office design and wellbeing while also accounting for other wellbeing predictors. Models of wellbeing and environmental satisfaction were tested, showing the pathways linking environmental satisfaction, wellbeing outcomes, and other predictors of wellbeing. A questionnaire was developed to use in the context of office design evaluation. Studies 2 and 3 used longitudinal designs to measure differences in individuals' environmental satisfaction and wellbeing after an office redesign or when employees were given access to work booths. This was a collaboration between industry and academia, and the partner was given summaries and design recommendations based on the research.

### *Main results*

Study 1 results indicated that satisfaction with the physical office environment was linked to wellbeing outcomes, separate from the impact of other wellbeing predictors. However, in Study 2, there was no improvement in psychological wellbeing after environmental satisfaction increased following an office redesign. Qualitative data provided insights into aspects of office design that occupants felt affected their wellbeing. Data from the three studies revealed that psychosocial factors, work-related factors, and design implementation issues should be considered in office design interventions aimed at improving wellbeing.

*Conclusion*

The physical office environment does impact occupants' wellbeing; however, changes to office environments should be made holistically to support employees for maximum benefit.

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## Publications in thesis

Some of the data presented in Chapter 7 of this thesis has been published in the article below.

Langer, J., Smith, A. P., & Taylour, J. (2019). Occupant psychological wellbeing and environmental satisfaction after an open-plan office redesign. In R. Charles & D. Golightly (Eds.), *Contemporary Ergonomics and Human Factors 2019* (pp. 223-233). Leicester, UK: Chartered Institute of Ergonomics and Human Factors.

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# 1 Introduction

## 1.1 Background: Office design and wellbeing

Workers spend a lot of time in the office, and there is increasing interest in how the workplace environment affects employee wellbeing. Investing in office design to potentially improve employee wellbeing and productivity can be financially beneficial for companies, as employees are a significant resource and cost (Harris, 2019; Oseland & Burton, 2012). In the United Kingdom, 23.5 million working days were lost due to illness from 2018 – 2019 at a cost of £9.8 billion, with mental health (stress, depression, or anxiety) and musculoskeletal disorders accounting for the majority of cases (Health and Safety Executive, 2019). Research indicates that the built environment and design of the office has an effect on occupants' physical health, psychological health, wellbeing, and productivity (Clements-Croome, 2018a; World Green Building Council, 2015). Positive workplace perceptions and feelings have been shown to be important for business outcomes, such as increased productivity and retention of staff (Harter, Schmidt, & Keyes, 2003); and office environmental satisfaction has been linked with higher job satisfaction (Veitch, Charles, Farley, & Newsham, 2007).

Historically, there have been negative wellbeing outcomes and employee dissatisfaction associated with certain types of office environments. In the 1980s, researchers identified Sick Building Syndrome (SBS), which consists of flu-like symptoms of lethargy, stuffiness, and headaches (Ghaffarianhoseini et al., 2018; Myerson, 2014). This syndrome has been attributed to poor indoor air quality; however, it has been observed that these environments also had other negative qualities, such as a lack of opportunities for personal control of the environment (Myerson, 2014).

Dissatisfaction with the office environment continued with the increased use of open-plan offices, which was driven by cost and efficiency, as well as the perception that it would boost collaboration and communication (Myerson, 2014; Vischer, 2005). Working in open-plan offices has been linked to reductions in perceived privacy, job satisfaction, health, wellbeing, and productivity (De Croon, Sluiter, Kuijer, & Frings-Dresen, 2005; James, Delfabbro, & King, 2021; A. Richardson et al., 2017).

Recently, there has been a surge in building and office design innovations aimed at environmental practices and promoting occupant wellbeing. A *green building* trend aims to provide healthier buildings for workers, and address indoor environmental quality (IEQ) and occupant health issues (Gou, Lau, & Shen, 2012). Wellbeing building standards, such as WELL (The International WELL

Building Institute™, n.d.) and LEED (U.S. Green Building Council, n.d.-b), are being adopted by a growing number of projects internationally. These standards recognise the importance of building physical environments that support occupant wellbeing and productivity. Better building strategies (e.g., improved ventilation, enhanced lighting, green building certification) have similar benefits to organisational productivity as other corporate strategies, such as workplace health programs and financial incentives (Newsham, Veitch, Zhang, & Galasiu, 2019). Interest in healthier buildings has focused attention on the impact of the built environment on occupants and evaluation of user satisfaction and wellbeing in offices. Thinking about occupant wellbeing and buildings has evolved from the viewpoint of ensuring comfort and avoiding disease to providing environments that are salutogenic (Roskams & Haynes, 2020; Ruohomäki, Lahtinen, & Reijula, 2015), where people “thrive and flourish” (Clements-Croome, 2018a, p. 27).

An emerging office design trend is activity-based working (ABW), which provides occupants with more flexibility in work areas and furnishings, and choice of where to work for particular tasks (Engelen et al., 2018; Wohlers & Hertel, 2017). Sit-stand desks, which are height adjustable to enable changes in posture, are a typical feature of ABW offices (Engelen et al., 2018). There is a developing awareness that being sedentary for long periods is unhealthy, and both ABW and sit-stand desks may allow for more movement during the workday. As well as opportunities for increased activity, the trend towards ABW offers office workers greater control over their environment. While ABW offices may have advantages for occupants’ wellbeing, they also feature open-plan areas, in addition to other task-specific areas, so they may suffer from similar problems associated with fully open-plan offices.

The changing landscape of the modern office and new ways of working offers an exciting time to research the connection between the physical environment and wellbeing, and explore solutions to office design problems. The literature investigating the relationship between the physical environment and occupant wellbeing outcomes has been criticised as “scattered” and “poorly linked” to engineering and designing disciplines that could use the information in practice (Veitch et al., 2007, p. 177). Considering that workers spend much of their week in an office environment, and the detrimental impact of employee stress and ill health to individuals and companies, it is important to explore further how office design impacts occupant wellbeing, and how offices may be designed to support, or improve, occupants' wellbeing.

### 1.1.1 Defining wellbeing

There is inconsistency in the definition and concept of wellbeing in the built environment literature, which makes comparing the literature difficult due to the variety of wellbeing outcomes measured (R. Cooper & Burton, 2014). In office design literature, the concept can refer to health and comfort (Bluyssen, Janssen, van den Brink, & de Kluzenaar, 2011). It has been argued that comfort is an over-used word, and building environments should be stimulating, creative, and productive places where people may flourish (Clements-Croome, 2018a).

Wellbeing is a multi-faceted concept. The National Institute for Health and Care Excellence (NICE, 2015, para 1) defines wellbeing as “the subjective state of being healthy, happy, contented, comfortable and satisfied with one's quality of life.” Diener, Suh, Lucas, and Smith (1999) use words such as “broad” and “global”, which indicate the encompassing nature of wellbeing. They state that “Subjective wellbeing is a broad category of phenomena that includes people’s emotional responses, domain satisfactions, and global judgements of life satisfactions” (Diener et al., 1999, p. 277). In relation to wellbeing at work, it has been suggested that greater wellbeing may also increase productivity (Tehrani, Humpage, & Willmott, 2007).

Well-being is more than an avoidance of becoming physically sick. It represents a broader bio-psycho-social construct that includes physical, mental and social health. Well employees are physically and mentally able, willing to contribute in the workplace and likely to be more engaged at work. (Tehrani et al., 2007, p. 4)

In 1948, the World Health Organization (WHO) defined health as wellbeing in several domains. The WHO stated that “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (n.d., para 1). Social wellbeing is mentioned by the WHO, and this may be important in office environments, where employees may be affected by interactions with colleagues and managers. In light of the variety of wellbeing definitions, it is not surprising that a multitude of wellbeing measurements are used, and outcomes reported, in the office design literature.

### 1.1.2 Strengths of office design intervention studies

This thesis focuses on the relationship between office design interventions and wellbeing. The majority of studies in the literature use cross-sectional research, a form of research that is observational rather than experimental (Field, 2013). Generally, the studies have contrasted wellbeing among groups of employees in different office environments, using between-subjects comparisons. One difficulty with between-subjects designs that contrast employees in different office environments is the lack of control of other possible confounding factors, such as individual differences, job type, and organisational factors. A stronger method uses repeated-measures or within-subjects design, whereby the same participants are measured at different times or conditions (Field, 2013). In the latter design, the participants are controls for themselves, as the comparisons are made within individuals, so there is no concern that factors such as individual differences or job type could affect the results.

In office design intervention studies, participants' outcomes may be measured longitudinally to investigate any impact of design changes (e.g. comparisons of pre- and post- office design outcomes). Office design intervention studies are important to assess whether office design does affect wellbeing, as they provide an experimental approach (changing the office environment) rather than an observational approach using between-subjects comparisons of participants' outcomes in different environments. Office design intervention studies offer more ecological validity than laboratory-based office simulation studies by allowing application of the results to real office environments. Due to the methodological benefits of office design intervention studies as outlined above, and the under-representation of this type of study in the literature, this PhD research included longitudinal within-subjects research which involved changes to office design.

### 1.1.3 Collaboration between academia and industry

This PhD research project was a collaboration between an industrial research partner, an office furniture design and manufacturing company, and Cardiff University. The industrial partner was interested in the use of furniture and office design to promote employee wellbeing and productivity, and wished to collaborate with Cardiff University to research this topic. The researcher's primary academic supervisor was Prof. Andrew Smith, at the Centre for Occupational and Health Psychology (COHP), Cardiff University. Prof. Andrew Smith's research has an emphasis on wellbeing, and he has developed the Smith Wellbeing questionnaire (SWELL; Smith & Smith, 2017) used in this thesis. A second academic supervisor, Prof. Wouter Poortinga, is a professor of environmental psychology at the Welsh School of Architecture and the School of Psychology at Cardiff University. Mr Jim Tylour,

the industrial partner's Head of Design & Wellbeing, was the industrial supervisor. This research collaboration allowed for the uniting of rigorous academic research and practical design insights from industry. The researcher also was able to gain valuable industry experience, observing the design and engineering process involved in the partner's furniture manufacture.

## 1.2 Research aims and objectives

The primary aim of this research was to investigate the relationship between office design and wellbeing. Previous research has neglected to account for known wellbeing predictors when testing the relationship between wellbeing and the physical environment. This research explored the relationship further between wellbeing and environmental satisfaction, allowing for other predictors of wellbeing and using longitudinal and qualitative data. The objectives were:

1. Review the office design and wellbeing literature to describe existing knowledge.
2. Conduct a questionnaire study to measure the relationship between office environmental satisfaction and wellbeing when controlling for other predictors of wellbeing.
3. Model the relationship between wellbeing and environmental satisfaction using structural equation modelling (SEM).
4. Conduct research using longitudinal and qualitative data to further examine the relationship between office design and wellbeing.

A secondary aim was to create a tool to measure wellbeing and environmental satisfaction in office occupants. This tool could be used by the industrial partner to inform and evaluate office designs for their clients. The objectives for this aim were:

1. Review the office design and wellbeing literature to describe measures currently used.
2. Use principal components analysis (PCA) of data from a questionnaire study to create a short questionnaire measuring wellbeing and environmental satisfaction.

Finally, a third aim was to develop office design recommendations to support wellbeing. The objective was to develop design recommendations from review of the office design and wellbeing literature, and the present research results.

### 1.3 Scope

The current research explored the relationship between the physical environment and wellbeing in office employees. Participants were UK office workers, primarily in open-plan offices. The effect of the physical environment in other environments, such as schools and factories, was not investigated in this thesis. As the research was a collaboration with a furniture design and manufacturing company, the impact of office design interventions was evaluated. It is recognised that factors unrelated to the physical environment, such as management and organisational issues, impact wellbeing in the office (Newsham et al., 2009). While it is acknowledged that management and organisational issues affect wellbeing, the effect of the physical environment is central to this thesis, and so is the focus, rather than other work-related variables. The researcher was based in the School of Psychology at Cardiff University, and a psychological perspective was taken, with an emphasis on mental wellbeing rather than physical health. Wellbeing is considered in this thesis to include mental wellbeing, social wellbeing (e.g., colleague relationships, teamwork, collaboration), productivity, and physical health. While productivity may be considered a separate outcome from wellbeing, it is sometimes referred to as an indicator of wellbeing in the office design and wellbeing literature.

### 1.4 Overview

The research consists of a literature review, an online questionnaire study (Study 1), and two office design intervention studies (Studies 2 and 3). The online questionnaire study data was used to create a measurement tool and conduct multivariate analysis which assessed the relationship between office design and wellbeing. Study 2 investigated changes in wellbeing and environmental satisfaction after an office redesign, and also the effect that individuals felt the office design had on their wellbeing, productivity, and teamwork. Study 3 was a preliminary study to test a methodology for evaluation of a design solution proposed by the industrial partner to improve wellbeing and productivity. The studies took place from 2017 – 2019, prior to the COVID pandemic.

#### 1.4.1 Literature review

A literature review of office design and wellbeing literature was conducted. The literature was grouped into themes, under main themes of office design features (Chapter 2) and wellbeing outcomes (Chapter 3).

### *Chapter 2. Office design features and wellbeing*

In Chapter 2, the reviewed literature is grouped by office design features. The evidence for an impact on occupant wellbeing is discussed for each office feature, investigating whether certain aspects of the physical environment may be beneficial or detrimental to occupants' wellbeing. Establishing what is currently known about the positive and negative impacts of certain office design features was necessary to identify best practice for designing offices for wellbeing and any gaps in the literature.

### *Chapter 3. Wellbeing outcomes in office design literature*

In Chapter 3, the reviewed literature is grouped by wellbeing outcomes, which enables consideration of how office design impacts individual wellbeing outcomes (e.g., job satisfaction, mental wellbeing, physical health). This differs from Chapter 2, as the focus is on wellbeing outcomes rather than office features. As wellbeing outcomes are disparate, this is an important distinction, as the office environment may affect one wellbeing outcome, but not another, or affect each outcome differently.

#### **1.4.2 Study 1. Online wellbeing and office design questionnaire**

Study 1 consisted of an online questionnaire measuring environmental satisfaction and wellbeing in 215 UK office workers. The questionnaire data was used to evaluate the relationship between wellbeing and satisfaction with the office environment through regression analyses (Chapter 4) and structural equation modelling (Chapter 5), as well as to develop a shorter questionnaire for office design evaluations (Chapter 6).

### *Chapter 4. Association of environmental satisfaction and employee wellbeing when controlling for other wellbeing predictors*

In Chapter 4, the data from Study 1 was used to investigate the relationship between UK office occupants' environmental satisfaction, and positive and negative wellbeing outcomes, when controlling for known wellbeing predictors. In the literature review, it was noted that previous studies rarely account for other known predictors of wellbeing in the relationship between environmental satisfaction and wellbeing. Using multiple regression analyses allowed for the effects

of other wellbeing predictors, as well as environmental satisfaction, and provided more robust evidence of the relationship between satisfaction with office design and wellbeing outcomes.

*Chapter 5. The relationship between employee wellbeing and environmental satisfaction: A structural equation modelling (SEM) approach*

In this chapter, an SEM approach was used to model the theoretical relationships and pathways between environmental satisfaction, wellbeing predictors, and wellbeing outcomes. Existing wellbeing theory was drawn upon to develop the models. Previous research has largely focused on binary associations between aspects of the physical environment and wellbeing outcomes rather than testing more complex relationships. The SEM analysis described in this chapter provided a more in-depth investigation of the relationship between wellbeing and environmental satisfaction in models that also contained work-related wellbeing predictors. The models were discussed in relation to existing research and other relevant wellbeing models.

*Chapter 6. Well Office Questionnaire (WOQ) development*

One of the research aims was to create a measurement tool for the industrial research partner to use in the context of office design evaluations. Chapter 6 described the design of the Well Office Questionnaire (WOQ). Study 1 environmental satisfaction and wellbeing outcome responses were entered into separate Principal Components Analyses (PCAs). The environmental satisfaction and wellbeing outcome items were grouped into literature review themes identified in Chapters 2 and 3. An approach to combine or eliminate some items using literature review themes and PCA was used to reduce the initial questionnaire to a shorter version. Additional items were added to the questionnaire due to some missing variables identified in the literature, resulting in a final questionnaire consisting of 40 items. Regression analyses were conducted to assess the environmental satisfaction items as predictors of negative and positive wellbeing outcomes.

#### 1.4.3 Study 2. Office design intervention study

Study 2 used a longitudinal mixed-methods design to evaluate the impact of an office redesign and explore how occupants felt the office environment affected their wellbeing, productivity, and teamwork. Teamwork was not the main focus of the thesis; however, it was measured in this study as it was one of the motivations behind the office redesign and could also be an indicator of social wellbeing.



### *Chapters 7 and 8. Occupant wellbeing in an open-plan office: Impact of an office redesign*

In Chapter 7, an office design intervention study (Study 2) is described. The study used quantitative methods to measure employees' changes in self-assessed environmental satisfaction, wellbeing, productivity, and teamwork after an office redesign. Qualitative data from interviews and open-ended questionnaire responses was used to explore employees' perceptions of any impact of office design on wellbeing, productivity, and teamwork. Chapter 7 includes the introduction, methodology, and quantitative results while Chapter 8 includes the qualitative results and discussion. This study addressed gaps in current knowledge about the impact of changing office design on occupant wellbeing outcomes, and also occupants' perceptions of the impact of office features on their wellbeing.

#### **1.4.4 Study 3. A preliminary study of work booths and wellbeing**

While Study 2 was an office design intervention involving a number of changes, Study 3 investigated the effect of an intervention involving one change, the addition of work booths to an open-plan office. The study explored the use of work booths as an intervention to improve wellbeing and productivity in open-plan offices.

### *Chapter 9. A preliminary study of work booths and wellbeing*

In Chapter 9, Study 3 is described. The preliminary study aimed to explore participants' use of different areas for activities, including work booths, to understand the impact of work booths and how to implement them successfully in an open-plan office. In Study 2, employees reported that noise and distractions negatively affected their productivity and wellbeing. The industrial partner proposed a solution targeting this problem, using work booths for occupants to conduct focused work. In this randomised crossover-design study, occupant wellbeing and productivity outcomes were compared during periods when work booths were available vs when they were unavailable.

## **1.5 Chapter summary**

This chapter introduced the topic, outlined the purpose and scope of the research, and gave an overview of the thesis. In the next two chapters, the office design and wellbeing literature will be reviewed.

## 2 Office design features and wellbeing

In this chapter, research investigating the relationship between office design features and occupant wellbeing will be reviewed. Current knowledge and gaps in research will provide the background to the studies conducted during the researcher's PhD.

### 2.1 Introduction

There are several challenges in summarising the research about the relationship between office design and wellbeing. As mentioned in Chapter 1, there is inconsistency in conceptual understanding and measurement of wellbeing in office design research. Another difficulty in reviewing the literature on this topic is the diversity of office design features studied, as well as the differences in offices. A further complication is that the relationship between the workplace environment and wellbeing is not a simple one. The first issue was discussed in Chapter 1, while the latter two are described below.

#### 2.1.1 Comparison of office environments and design features

Researchers have studied the relationships between various wellbeing measures and a wide variety of indoor environmental features (e.g., windows, privacy, office layout). As well as different aspects of the office environment being researched, the actual workplaces vary from study to study. The differences between offices in terms of design, layout, ambient conditions, furnishings, building maintenance, and other factors can make comparisons difficult between studies, and also within studies that use participants from different offices (Hongisto, Haapakangas, Varjo, Helenius, & Koskela, 2016; J. Kim, Candido, Thomas, & de Dear, 2016). Furthermore, occupants' ways of working may differ between offices, e.g. some offices may be less sedentary or allow more home-working. Offices are elaborate ecosystems made up of many interacting elements, and therefore, attributing wellbeing outcomes to particular design features may be problematic. For example, open-plan layouts are one office design feature generally linked with lower wellbeing; however, some open-plan studies show positive outcomes. While all of the offices may be categorised as open-plan, other factors may be responsible for the contradictory results. Due to the complexity of study comparisons in this field, there are challenges in establishing clear evidence to guide office design recommendations for wellbeing.

### 2.1.2 Wellbeing and the office environment: A complicated relationship

The relationship between wellbeing and the office environment is complex. In built-environment wellbeing research, some findings may be conflicting (R. Cooper & Burton, 2014). R. Cooper and Burton (2014) have illustrated this conflict with an example of the introduction of green areas to a neighbourhood. This may provide positive changes for people's wellbeing, but make the walk to facilities further, resulting in gains and losses in wellbeing. Likewise, in an office environment, redesigning a workspace to be more open can result in fewer physical barriers to communication by increasing visibility and accessibility, while also hampering communication by increasing noise and decreasing privacy. Therefore, office design features can both positively and negatively impact occupants' wellbeing. Furthermore, the association between indoor environmental quality (IEQ), and comfort and wellbeing parameters is complicated, as there are relationships between these parameters (Al horr, Arif, Katafygiotou, et al., 2016). In addition, the importance of IEQ factors in occupant satisfaction can be a non-linear relationship, with less satisfactory conditions becoming more salient to the occupant (J. Kim & de Dear, 2012). Individual factors, such as age and gender, can also affect occupants' satisfaction with IEQ conditions (Choi & Moon, 2017). Therefore, the relationship between the physical environment and wellbeing may be affected by interactions between factors and individuals' perceptions of the environment.

## 2.2 Literature review method

The literature review aimed to give context for the research conducted during the PhD, identify any areas of insufficient research in the literature, and provide a summary for the industrial partner. The industrial partner was interested in office design for wellbeing research and evidence-based best practices. There has been a recent surge in interest in the topic, particularly from the year that the present PhD research commenced (2017). A broad narrative review of the literature was conducted to establish the relationship between office design and wellbeing. Narrative reviews provide interpretation and critique of the literature, and they contribute to deepening understanding of a topic (Greenhalgh, Thorne, & Malterud, 2018). This may be contrasted with systematic reviews, which are useful when there is a need for summarising data to solve a problem. A narrative review was considered more appropriate in part due to the broadness of the topic, and also owing to the need for exploration of the topic to gain further insight.

Searches for peer-reviewed English language journals and conference papers were conducted using Scopus, Web of Science, and PsycInfo databases, with a combination of keywords relating to the workplace environment (e.g., “indoor environment”, IEQ, “environmental satisfaction”, “office design”, “office redesign”, “office refurbishment”, “office layout”, open-plan OR “open plan”) and occupant wellbeing outcomes (e.g., wellbeing OR well-being, “job satisfaction”, “mental health”, productivity, mood). Studies were identified which were relevant to the topic of wellbeing outcomes in regard to office design. Wellbeing outcomes included were mental health, physical health, productivity, comfort, cognitive functioning, environmental satisfaction, job satisfaction, and psychosocial factors. While productivity is arguably not a wellbeing outcome, in the building literature, it is sometimes used as an indicator of wellbeing. Collaboration was also included as a wellbeing outcome, as a possible indicator of social wellbeing and productivity. Residential, healthcare, and academic settings were excluded, except academic settings that studied employee or researcher outcomes (i.e. knowledge workers) in office environments. References and citations of relevant studies were used in the identification of additional research. Influential books in the field were also read, and references were gained from these sources. Identified abstracts were scanned, and if deemed relevant, the articles were then perused, and the researcher included ones that fit the criteria above, using personal judgement to decide appropriateness for inclusion in the review. There is an abundance of *grey literature* in the area of office design and wellbeing, and while this literature is useful to gain an understanding of the research in this area, the lack of description in study methodology generally made critical review impossible. Therefore, some grey literature has been referred to in this review, but the focus is on peer-reviewed articles.

Initially, the research findings were grouped into three main categories: office design features, occupant wellbeing outcomes, and individual differences. The latter two will be discussed in Chapter 3, and the first category will be discussed in this chapter.

### 2.3 Office design features

The office design features were grouped into themes by the researcher. The review found seven main themes that have been studied in relation to occupant wellbeing: ambient conditions; office layout/ways of working; privacy and noise; environmental control; density; biophilia, windows and views; and furnishings and décor. The literature is discussed by office design features below, and a summary is provided in Table 2.1.

### 2.3.1 Ambient conditions

A large body of research has been conducted investigating ambient conditions (noise, lighting, temperature, and air quality), occupant comfort, and environmental satisfaction. Post-occupancy studies frequently measure IEQ satisfaction, with the focus being on ambient conditions. Research indicates that ambient conditions may affect employee wellbeing, performance, job satisfaction, and satisfaction with the office environment (Agha-Hosseini, El-Jouzi, Elmualim, Ellis, & Williams, 2013; Kang, Ou, & Mak, 2017; Lamb & Kwok, 2016; Sadick, Mallory-Hill, & Issa, 2015; Veitch et al., 2007).

Attempts have been made to identify the most important IEQ factors for occupant wellbeing. In a review investigating IEQ and workplace stress, the main IEQ factors associated with workplace stress were adverse acoustics, thermal environment, lighting, and indoor air quality (Sadick et al., 2015). Some reviews of the literature have concluded that thermal comfort may be the most important factor in satisfaction with the indoor environment (Frontczak & Wargocki, 2011; Kamaruzzaman, Ashiqin, Ahmad Zawawi, & Riley, 2016); however, this conclusion has been criticised due to some studies showing higher importance of other IEQ factors (J. Kim & de Dear, 2012). J. Kim and de Dear (2012) have shown that the importance of IEQ factors in occupant satisfaction can be a non-linear relationship, with less satisfactory conditions becoming more important to occupants. Therefore, individuals' perception of unsatisfactory ambient conditions could explain differences found between studies in the most critical ambient condition for wellbeing.

There may be different optimal levels for certain ambient conditions (noise, light) for productivity and wellbeing, dependent on whether the task being conducted is high or low complexity (Mateo-Cecilia, Navarro-Escudero, Escrig-Meliá, & Estreder, 2018). More significant pathways between the perception of IEQ and sickness absence via mediators (job satisfaction, general health, affective wellbeing) have been found in workers whose jobs involve high complexity tasks and interacting with people (Soriano, Kozusznik, Peiró, & Mateo, 2018). These studies indicate that other factors may affect the relationship between ambient conditions and wellbeing.

The literature suggests there is a link between ambient conditions and occupant wellbeing, and this relationship may be stronger for unsatisfactory ambient conditions and certain job requirements. The relationship between specific ambient conditions and wellbeing is discussed further in the following sections.

### 2.3.1.1 *Lighting*

Lighting is important in indoor environment satisfaction and comfort (Veitch et al., 2007; Veitch, Stokkermans, & Newsham, 2013; Vischer, 2005), and studies suggest appraisals of lighting may affect mood and productivity (Küller, Ballal, Laike, Mikellides, & Tonello, 2006; Veitch et al., 2013). A literature review concluded that adequate light levels and quality contribute to better physical wellbeing and mood (Colenberg, Jylhä, & Arkesteijn, 2021). Veitch et al. (2013) analysed data ( $N = 111$ ) from an experimental study using four different lighting conditions in laboratory offices. In the study, positive lighting appraisals predicted higher workplace satisfaction and work engagement. Participants who had more positive lighting appraisals also considered the room to be more attractive and reported a more pleasant mood. Variation in lighting levels in another lab study was found to affect performance on cognitive tasks (Vimalanathan & Babu, 2014). The relationship between satisfaction with lighting and mood is supported by another study, which consisted of 988 participants, mainly office workers (Küller et al., 2006). Küller et al. (2006) found a decrease in mood when lighting was perceived to be too dark or too bright; however, objective measurements of lighting had no significant impact on mood. Thus, perception of lighting appears to be key. Other lighting factors discussed in the literature are control over lighting conditions (Boyce et al., 2006; Uttley, Fotios, & Cheal, 2013) and access to a window and natural light (Boubekri, Cheung, Reid, Wang, & Zee, 2014; Gou, Lau, & Qian, 2015; Harb, Hidalgo, & Martau, 2015; Leder, Newsham, Veitch, Mancini, & Charles, 2016).

Control may affect occupant satisfaction with lighting. Boyce et al. (2006) found that individually controllable lighting conditions were rated as more comfortable by participants in an experimental study than conventional fixed lighting conditions. Participants with light dimming control had more sustained motivation than a group with no lighting control. Control was investigated in another experimental study ( $N = 40$ ), where it was shown that participants were more satisfied with lighting levels adjusted by themselves vs lighting levels adjusted by an experimenter, although the lighting levels were the same (Uttley et al., 2013). As individuals vary in their satisfaction with levels of illuminance, giving some control over their workstation lighting may improve their environmental satisfaction.

Access to windows and natural light are generally associated with positive outcomes. It is difficult to separate the effect of natural light and views when considering the impact of windows on occupant wellbeing. Views will be discussed further in a later section, and this section will consider natural light only. In two large field studies of open-plan and green buildings, satisfaction with lighting was

most strongly affected by window access and glare conditions (Leder et al., 2016). Having access to a window was related to higher satisfaction with lighting, while glare contributed negatively to lighting satisfaction. Occupants tend to prefer to have access to natural light and believe that it is healthier and supports productivity (Gou et al., 2015). In an experimental study, lack of access to natural light in an office was related to high levels of cortisol and lower levels of melatonin at night (Harb et al., 2015). These biochemical changes were related to depressive symptoms and poor sleep quality. This area needs to be investigated further, but other preliminary research also draws a connection between windowless offices and poor sleep quality (Boubekri et al., 2014). Exposure to natural sunlight in offices predicted lower depressed mood, and higher job satisfaction and organisational commitment in a cross-sectional study (An, Colarelli, O'Brien, & Boyajian, 2016). In contrast to this, one laboratory study found there were possible negative effects on mood from short exposure to daylight while performing a cognitive task (Gou et al., 2015), which may have been caused by temperature changes due to heat transfer. Although occupants appear to prefer access to a window, this may also contribute negatively to wellbeing via heat transfer and glare.

#### 2.3.1.2 *Noise*

Noise is one of the most common reasons for complaints in open-plan offices (Kaarlela-Tuomaala, Helenius, Keskinen, & Hongisto, 2009; Pejtersen, Allermann, Kristensen, & Poulsen, 2006; Sundstrom, 1986). A literature review concluded that noise in offices negatively affects health and wellbeing (Colenberg, Jylhä, & Arkesteijn, 2021). Employees affected by noise and distractions use coping techniques, such as working away from the office or at home, moving to a quiet area, coming to work earlier or later, making a greater effort, speaking to colleagues about the problem, and using headphones (Appel-Meulenbroek, Steps, Wenmaekers, & Arentze, 2021; Di Blasio, Shtrepi, Puglisi, & Astolfi, 2019; Maher & von Hippel, 2005; Oseland & Hodsman, 2018). Individual differences in noise sensitivity appear to be important in determining acoustic comfort in open-plan offices (Roskams, Haynes, Lee, & Park, 2019). In experimental studies, noise has been found to impact cognitive function and performance (Banbury & Berry, 1998; Jahncke, Hygge, Halin, Green, & Dimberg, 2011; Purdey & Leifer, 2012; Smith-Jackson & Klein, 2009).

A large cross-sectional survey of shared and open-plan office workers ( $N = 1078$ ) found nearly 70% of participants reported that the main feeling caused by irrelevant noise (conversations, telephone calls, laughter) was difficulty in concentration, with lower numbers mentioning poorer mental health, negative feelings, and physical symptoms, as main consequences of the noise (Di Blasio et al., 2019). In the latter study, irrelevant speech increased noise annoyance, decreased productivity, and

increased symptoms of negative mental health and wellbeing more in open-plan offices as compared to shared offices. Less satisfaction with noise has been found to mediate lower office satisfaction found in open-plan offices as compared to private and shared offices (Otterbring, Bodin-Danielsson, & Pareigis, 2021). In an academic open-plan setting, Kang et al. (2017) found that the quality of the acoustic environment had the greatest influence on perceived productivity, with conversation noise having the highest negative impact on ratings of the acoustic environment. One study reported no effect of noise on symptoms of ill health and job satisfaction, although lower levels of ambient noise buffered the negative impacts of psychosocial stress on these factors (Leather, Beale, & Sullivan, 2003).

Laboratory studies simulating office conditions have shown performance decrements in high noise conditions. In one study ( $N = 47$ ), participants in a high noise environment had decreased memory for words, felt more tired, and were less motivated with work than participants in a low noise environment (Jahncke et al., 2011). Several other cognitive measures were not affected in this study by the high noise condition, which the authors suggested could have been due to the short exposure period (2 hours), and the similarity of intelligibility of speech in the low noise condition and the high noise condition. It has been proposed that intelligible speech has more impact on performance in an office than noise level itself, with the largest performance impairments occurring when speech is perfectly heard (Hongisto, 2005). Smith-Jackson and Klein (2009) found that noise condition (quiet, intermittent speech [one side of a conversation], continuous speech [two people speaking in a conversation]) affected participants' performance on a proofreading task ( $N = 54$ ), and also workload ratings, with individual differences shown, suggesting that there may be variation in how noise affects employees in an open-plan environment. They found that workload ratings increased with noise, but there were higher completion rates with intermittent speech as compared to quiet. The authors suggested that increased completion rates with intermittent speech may have been due to a higher state of arousal in this condition as compared to the quiet condition. In general, the poorest performance and highest workload ratings were found in the continuous speech condition, which may support the theory that intelligible speech causes the greatest performance impairment. Following four empirical studies by a group of researchers, it was concluded that reducing both intelligibility of speech and noise levels may help minimise the impact of background noise on cognitive performance and perceived disturbance (Schlittmeier & Liebl, 2015). In laboratory-based tasks, it is possible to examine noise in controlled conditions, but the use of simple tasks for short periods is unlikely to give an accurate picture of the effect of working on complex tasks over a long period in a noisy environment.



It has been suggested that individual differences are important in occupants' reactions to noise. A field study in open-plan offices ( $N = 166$ ) found that noise sensitivity was a significant predictor of acoustic comfort (Roskams et al., 2019). Other individual differences were measured (age, gender, extraversion); however, only higher age had small effects on lower acoustic comfort, while gender and extraversion were not predictors. Participants with more interactivity with colleagues were also less disturbed by noise, suggesting that job requirements may be important. Therefore, individuals may have different acoustic requirements in offices.

Improving noise absorption may result in more positive occupant outcomes in open-plan offices. Seddigh, Berntson, Jönsson, Danielson, and Westerlund (2015) conducted a field study ( $N = 145$ , longitudinal  $n = 40$ ) in an open-plan office building and found that enhanced acoustical conditions, created by absorbing tiles and wall absorbents, were associated with lower perceived disturbances and cognitive stress. The results of the study suggested that even small differences in acoustical room properties could impact self-rated health and disturbances. Furthermore, the researchers observed higher effects from the manipulation on a floor where participants reported more meetings in the open-plan area. The researchers commented that although the self-rated differences were significant, the variation in subjective responses and physical measurements of noise were quite small between conditions. The authors suggested that possibly large changes to the physical environment are needed to make a bigger impact on the acoustical conditions of the office.

#### 2.3.1.3 *Temperature*

Office occupants often disagree as to what is a comfortable temperature, and complaints are frequently made about thermal comfort (Vischer, 2005). Standards are well developed in this area; however, thermal comfort may be perceived differently in certain indoor environments and by individuals. For example, open-plan office occupants are more likely to perceive thermal discomfort (Pejtersen et al., 2006), and gender differences have been found in relation to satisfaction with office temperature (Kang et al., 2017).

In an experimental study in a laboratory setting ( $N = 21$ ), it was found that thermal discomfort had adverse effects on aspects of performance on a computerised task, motivation, mood, and wellbeing (Lan, Lian, & Pan, 2010). Accuracy and speed of the computerised task performance decreased in the thermal discomfort conditions; however, performance on most of the computerised tasks was not significantly different between conditions. The participants had more negative moods, such as tension and anger, at 28°C (warm condition) and less negative moods at 21°C (neutral condition).

Participants also had higher perceived wellbeing in cool (17°C) and neutral conditions than in the warm condition. They had significantly higher motivation to do work in the neutral condition vs in the warm condition. Perceptions of workloads were significantly higher in the cool and warm conditions than in the neutral condition. The study found that the participants' ratings of wellbeing and motivation were correlated, and these diminished as negative mood and workload ratings increased. No significant effect of air temperature was observed on most computer tests, which the researchers suggested was due to participants increasing their efforts to cope with the demands of the adverse environment. In contrast to this, another small lab study ( $N = 10$ ) found that temperature accounted for variance in performance on cognitive tasks, with 21°C identified as the optimal temperature (Vimalanathan & Babu, 2014).

#### 2.3.1.4 *Air quality*

Air quality is commonly considered to be an important factor in occupant wellbeing in offices. It has been considered to be a contributor to Sick Building Syndrome (SBS), although buildings with poor air quality often have other negative qualities that may help to explain the relationship (Myerson, 2014). OFFICAIR, a large European study of 7,441 occupants in 167 buildings, found that over one-third of office workers complained about air quality (Bluyssen et al., 2016). Dry air and stuffy air were the most frequent complaints. In a series of studies, a link between air quality and performance was found (summarised in Wyon, 2004). Wyon (2004) estimated that poor air quality could affect productivity by 6 - 9 %. Although mechanisms through which air quality affects performance are not clear, an assumption is that people may feel unwell or become distracted by poor air quality (Wargocki & Wyon, 2018). Air quality and ventilation are important factors in green buildings (MacNaughton et al., 2016). There is evidence from one small study to suggest that both psychological and physiological pathways may affect health symptoms reported by occupants in conventional and green building conditions (MacNaughton et al., 2016). Ventilation, CO<sub>2</sub>, and volatile organic compound (VOC) levels were altered in this experiment to match conventional and green building indoor environmental quality (IEQ) conditions. Participants reported fewer symptoms of ill health in the green building conditions; however, the number of symptoms was more closely associated with perceptions of the environment rather than objective IEQ levels. With increased CO<sub>2</sub> exposure, there was a physiological impact of increased heart rate.

#### 2.3.2 *Office layout/ways of working*

Workplaces and the way that people work are changing. Space per worker is reported to be decreasing over time, with a trend towards using standardised non-dedicated space and allowing

employees greater flexibility in terms of where they work (Miller, 2014). Newer office designs are moving from enclosed offices to more open layouts, and switching from fixed desks to non-dedicated desks (J. Kim et al., 2016; Wohlers & Hertel, 2017). The newest trend for modern office design are activity-based flexible offices where workers can choose different areas to work depending on their task (Wohlers & Hertel, 2017). Another recent trend is the introduction of sit-stand desks, which are considered to be a way to reduce sedentary behaviour. Changing workplaces and ways of working provide opportunities to investigate occupant wellbeing in innovative offices.

In the literature, different terminology is used to refer to types of office layouts. Bodin Danielsson and Bodin's (2008) definitions of office types are often used by studies in the office design literature. Bodin Danielsson and Bodin (2008) described seven office types. *Private or cell-offices* are individual offices, and *shared-room offices* may have two to three people in one room. Open-plan offices were defined as *small open-plan offices* (4 – 9 people per room), *medium-sized open-plan offices* (10 – 24 people per room), and *large open-plan offices* (greater than 24 people per room). Two types of flexible or activity-based offices are described as *flex-office* (no individual workstations) and *combi-office* (greater than 20% of the work in the office is not conducted at the workstations, team-based work). While activity-based offices are different from open-plan offices, as they provide a variety of areas to work, they are similar in that they also have open-plan areas.

#### 2.3.2.1 *Open-plan offices*

Open-plan office layouts are often studied in the wellbeing and indoor environment literature. Open-plan offices are popular due to the advantages in cost and speed of remodelling to suit a company's needs, and also the ability to reduce occupancy costs by fitting more employees into a smaller area (Hedge, 1982; Vischer, 2005). Much of the research on open-plan offices and occupant wellbeing uses cross-sectional designs, comparing occupants' outcomes in different office types. A smaller selection of studies has investigated employee outcomes after an office relocation to a different office type.

Systematic literature reviews of studies comparing occupant outcomes in private vs open-plan offices have found generally poorer outcomes in relation to wellbeing, environmental satisfaction, and productivity (De Croon et al., 2005; James et al., 2021; A. Richardson et al., 2017). De Croon et al. (2005) reviewed literature from the 1970s to 2003 and concluded that there was strong evidence for a reduction in job satisfaction and privacy in open-plan offices. Limited evidence of increased cognitive workload and poorer interpersonal relationships in open workplaces was also found. A.

Richardson et al. (2017) reviewed more recent literature from 2000 to 2017. Their review found that open-plan or shared workspaces, as compared to private offices, were associated with consistent negative impacts on employee health, wellbeing, and productivity. A literature review by James et al. (2021) covered a similar period, with the review ending in 2018. Results indicated that occupants in open-plan offices had poorer outcomes on many measures relating to health, environmental satisfaction, productivity, and social relationships. Colenberg, Jylhä, and Arkesteijn (2021) conducted a review focused on relationships between the interior space of offices and health and wellbeing, and concluded that shared and open-plan offices are negatively related to health and wellbeing. Some literature reviews have identified facilitation of communication and co-worker proximity or accessibility as positive open-plan office design features (James et al., 2021; Shafaghat, Keyvanfar, Lamit, Mousavi, & Majid, 2014); however, there are some studies that do not support improved communication in open-plan environments (Brennan et al., 2002; Kaarlela-Tuomaala et al., 2009; R. L. Morrison & Macky, 2017; Otterbring, Pareigis, Wästlund, Makrygiannis, & Lindström, 2018; Pejtersen et al., 2006). Social wellbeing was associated with small shared rooms in one review (Colenberg, Jylhä, & Arkesteijn, 2021).

In several studies, open-plan offices have been linked to dissatisfaction with the environment, such as increased noise (Brennan, Chugh, & Kline, 2002; Sundstrom et al., 1980) and distractions (Hedge, 1982; Sundstrom et al., 1980), loss of privacy (Brennan et al., 2002; Hedge, 1982; Sundstrom et al., 1980; Sundstrom, Herbert, & Brown, 1982), increased feeling of crowding (Sundstrom et al., 1980), and overall decreased environmental satisfaction (Brennan et al., 2002; Herbig, Schneider, & Nowak, 2016; Pejtersen et al., 2006). This office type has also been associated with poorer outcomes, such as decreased performance (Bergström, Miller, & Horneij, 2015; Brennan et al., 2002; Herbig et al., 2016), job satisfaction (Bergström et al., 2015; Bodin Danielsson & Bodin, 2008; Otterbring et al., 2018), perceived health (Bergström et al., 2015; Bodin Danielsson & Bodin, 2008; D. H. Kim & Bluysen, 2020; Pejtersen et al., 2006); increased sick leave (Bodin Danielsson, Chungkham, Wulff, & Westerlund, 2014; Pejtersen, Feveile, Christensen, & Burr, 2011); and poorer relations with colleagues (Brennan et al., 2002). Generally, the research shows poorer wellbeing in open-plan offices, although the evidence is mainly cross-sectional, with some exceptions (e.g., Bergström et al., 2015; Brennan et al., 2002).

Some small longitudinal studies have shown mainly negative outcomes after employees have moved from private offices to open-plan offices, which persist over time (Bergström et al., 2015; Brennan et al., 2002). Brennan et al. (2002) surveyed occupants in an office relocation from traditional offices to

open-plan offices at three times: before relocation, 4 weeks after relocation, and 6 months after relocation (longitudinal  $N = 21$ ). Occupants reported an increase in physical stress, and a decrease in their environmental satisfaction, team member relations, and perceived performance. The negative impact was maintained, and team member relations had worsened at the 6 months follow-up. Similarly, Bergström et al. (2015) conducted a longitudinal study ( $N = 20$  to 27, depending on variable/category) following relocation from private offices to an open-plan office environment, and found that perceived health, job satisfaction, and performance declined. Surveys were conducted before relocation and 3, 6, and 12 months post-relocation. Negative effects persisted, although at some follow-ups not all differences were significant. One measure that significantly declined in the longitudinal study was *individual experience*, a measure to assess the employees' perception that their work is meaningful, joy in going to work, and the possibility of developing their skills at work. A notable result from this study was that there was a marked decrease in the number of employees who thought they would remain in their current work for the next two years, with the percentage dropping from 71% at baseline to 41% at the 12 months follow-up. Both studies had a small number of participants, and larger longitudinal studies would help evaluate the long-term effect of moving to an open-plan office.

While it is possible in longitudinal studies that the change itself could affect people's perceptions, one relocation study showed similar perceptions of shared/open offices regardless of whether the participants had moved from private or shared/open offices (Morrison & Stahlmann-Brown, 2021). In the latter study of 185 knowledge workers (mainly scientists), it was found that shared/open offices were rated as having higher distraction, less privacy, and worse IEQ, than private offices. Furthermore, perceptions of collaboration declined in the shared/open workspaces. The researchers found that increased distractions and lack of privacy were linked with lower self-rated productivity.

A large study in Denmark ( $N = 2,301$ ) found that occupants in open-plan offices had more health complaints and decreased environmental satisfaction compared to other office types (Pejtersen et al., 2006). Occupants from 22 buildings, comprising a mix of office types, completed retrospective surveys measuring their environmental satisfaction, psychosocial factors, and health symptoms in the past four weeks. Employees in open-plan offices were more likely to report dissatisfaction with thermal conditions, air quality, and noise. In addition, open-plan office occupants were more likely to report CNS symptoms (e.g., fatigue, headache, and difficulties in concentrating) and mucous membrane symptoms (e.g. irritation of eyes, nose, or throat) than occupants in multi-person and

private offices. This study was cross-sectional, so other variables may have been responsible for the increase in dissatisfaction and poor health.

One study compared cognitive evaluations (office satisfaction questions, e.g. my office is bad–good) and affective evaluations (e.g. tired–alert) in different office types (Otterbring et al., 2021). This data had been gathered for a previous study described in Otterbring et al. (2018). While both cognitive and affective evaluations were worse in medium open-plan offices compared to other office types, only the difference in cognitive evaluations was significant for office type. Further analysis revealed that these results were mediated by perceived noise, with open-plan occupants reporting less satisfaction with noise and, in turn, lower cognitive evaluation scores. While the link between noise and decreased satisfaction in open-plan offices is not an original finding, few studies measure mood as an outcome, and the results suggest a possible link of lower mood in more open environments (although not significant).

Although the literature on open-plan offices is mainly negative, it is difficult to compare employee outcomes due to the variation in physical and organisational features of these offices (Hongisto et al., 2016). Hongisto et al. (2016) found that making changes to an open-plan environment resulted in increased environmental and job satisfaction (between-subjects sample  $N = 79, 84$ ; within-subjects sample  $n = 40$ ). The increases in environmental satisfaction could be linked to the physical changes brought about by the refurbishment of the office and supported by the physical measurements of the office. Job satisfaction changes were suggested to have been influenced by change management, and also involving employees in the redesign and taking care with the planning of the refurbishment. This study demonstrates that positive wellbeing outcomes may result from open-plan office refurbishment and provides a more optimistic outlook on open-plan layouts.

Similarly, other studies have shown positive occupant outcomes in certain open-plan environments. An office relocation study showed that employees moving from an open-plan office to a more modern open-plan office had higher environmental satisfaction and wellbeing (Agha-Hosseini et al., 2013). One mixed-methods study found mainly positive outcomes and perceptions of a new modern open-plan office, as compared to retrospective ratings and opinions of a previous office that consisted of private offices and open-plan areas (R. L. Morrison & Smollan, 2020). A study using cross-sectional and longitudinal methods ( $N = 490$ ) found that environmental satisfaction was higher in larger open-plan office occupants than those in other office types; however, the authors commented this result may have been affected by comparing offices from different organisations

(Lütke Lanfer, Becker, & Göritz, 2021). In contrast, subjective wellbeing was higher in private offices in the latter study than shared offices and medium open-plan offices. Higher job satisfaction in occupants of open-plan offices who have higher environmental satisfaction has been shown in another study (Veitch et al., 2007). Improvements in perceived crowding, privacy, and satisfaction, have been found in an office relocation study in which occupants moved from an open-plan office to one that had lower density or partitions (Oldham, 1988). Access to breakout areas (places for informal discussion) in open-plan offices has been linked with ease of communication, higher job satisfaction, and wellbeing (Davis, Leach, & Clegg, 2020). The evidence suggests that there may be factors that could be improved in an open-plan environment, which could result in increased wellbeing, and environmental and job satisfaction.

There may be some advantages to open-plan offices in regard to wellbeing. For example, one study utilising wearable technology ( $N = 231$ ) found that employees who had *open bench* workstations (no partitions or partitions that could be seen over) had more physical activity than employees in cubicle or private offices (Lindberg et al., 2018). Lindberg et al. (2018) used structural equation modelling (SEM) analysis to show a relationship between open bench workstations and higher physical activity than cubicles and private office occupants. There was lower perceived stress at the office in open bench workstations as compared to cubicles. Higher physical activity at the office was related to lower physiological stress outside of the office. While this was a cross-sectional study and the relationship may have been caused by another variable, the authors did control for age, gender, BMI, and job type. Increased physical activity in these open-plan workstations may have been related more to a different culture in the office, as there may have been more encouragement of physical activity, or job needs relating to moving about the office, e.g. for meetings.

Job and individual differences may affect how satisfied occupants are with open-plan environments. Oldham (1988) found that employees who had low levels of stimulus screening or high privacy needs reported the largest decreases in perceived crowding after relocating from an open-plan office to one that had lower density or partitions. Individual differences in stimulus screening ability were a significant determinant of employees' reactions to the open-plan workplace in another study (Maher & von Hippel, 2005). Managerial staff reported more problems with concentration, lack of privacy, dealing with confidential matters, and decision making, after moving to an open-plan environment (Hedge, 1982). Women were reported in one study to be more affected by the feeling of being observed in an open-plan office (R. L. Morrison & Smollan, 2020), suggesting that gender may impact how employees react to this office layout. Research investigating occupant wellbeing and workplace

design may need to consider job type, individual differences, and gender. Furthermore, office designers should consider employees' needs for privacy and an environment conducive to work requiring concentration.

Considering the negative outcomes associated with open-plan offices, it has been suggested that "if you're going to do it, do it right" (R. L. Morrison & Smollan, 2020). As noted previously, open-plan offices can vary greatly, and one study found that a thoughtfully designed open-plan office was well-received by employees (R. L. Morrison & Smollan, 2020). R. L. Morrison and Smollan (2020) conducted a retrospective pre-test quasi-experiment in a New Zealand law firm, whereby they asked participants to assess their liking of their old office retrospectively, and their attitudes and perceptions towards their new office. Measurements occurred 6 and 20 months (time 1 and 2, respectively) after moving to the new open-plan office. The study included a questionnaire ( $N = 101$  at time 1, and  $N = 70$  at time 2) and interviews ( $N = 24$  at time 1). The new open-plan office design included an abundance of windows and natural light, a large glass ceiling atrium in the centre, over 1,300 plants including *green walls*, acoustic quietening measures, 28 sound-proofed collaborative rooms, library room, lunch room, bookable conference rooms, staff lockers and showers, state of the art technology, sit-stand desks, and hydration stations. Change management procedures included a high level of consultation throughout, which resulted in ergonomic assessment of employee needs and requirements of their tasks.

At time 1, within-subjects comparisons of participants' liking of the old and new office showed that participants were significantly more positive about the new office. As the surveys were anonymous, and new employees responded to the time 2 questionnaire, group comparisons were made between time 1 and 2, rather than within-individuals comparisons. At time 2, participants' positive ratings for their new workplace were maintained, and they also rated their individual workstations highly. Features that the participants commented on positively included: variety of spaces (e.g. collaboration areas and library), plants, general aesthetics (e.g., natural light, décor), kitchen and reception area, and opportunities for increased interactions. Less often mentioned positive features were sit-stand desks and dual screens, and hydration areas. There were few negative comments at time 1, although there were some complaints about lack of storage space. At time 2, more employees had joined the office, and crowding had become an issue for participants, and they mentioned wanting more space, storage, and collaboration/meeting areas. Most participants felt that there were increased collaboration and more positive colleague relationships in the new office; however, some participants commented negatively about distractions. Some participants felt the



new office increased their productivity by greater ease of accessing information and collaborating, as well as with the improvements in equipment and communication technology provided in the new office. However, some people felt they were more productive as they felt monitored or accountable, suggesting that presenteeism may have been a negative consequence of the open layout.

Participants mentioned distractions in relation to productivity and coping strategies used to maintain productivity. The study found that there was a gender-specific impact of the open-plan environment, with only female participants reporting feeling observed. In an ethnographic study, female participants also reported feeling observed, with some changing how they dressed in the open-plan office (Hirst & Schwabenland, 2018).

While R. L. Morrison and Smollan's (2020) study investigated a high-quality office design that may not be attainable for every company, it offers insight into best practices for open-plan office design and shows that with careful design and change management strategy, outcomes and perceptions of open-plan offices can be positive. In addition, sources of dissatisfaction relating to issues such as distraction, privacy, crowding, and feeling observed point to some common pitfalls in open-plan design that need to be overcome by office designers.

Few researchers have used experimental designs to assess reactions to open-plan offices. One experimental crossover design study tested four different office designs with workers spending two weeks in each office (Pitchforth, Nelson-White, Van Den Helder, & Oosting, 2020). ABW and open-plan office designs performed worse than zoned open-plan (open plan with soundproof doors between working and collaboration spaces) and team offices (cubicles of four to six desks). The open-plan office was rated more poorly by employees and had higher levels of unsafe noise. Furthermore, it was found that occupants spent more time at their desks in other office designs, compared to when they had to work in the open-plan office. More experimental research of this type should be conducted to test how to improve office designs for occupants. This study suggests that open-plan offices may be more acceptable with the use of soundproofing.

In summary, open-plan office studies suggest that generally, the layout is linked with poorer occupant wellbeing. However, the literature highlights some negative features of open-plan offices which could be addressed with better design practices. Some studies indicate that with open-plan design improvements, there may be concurrent increases in occupant wellbeing.

### 2.3.2.2 *Shared desks (flexi-desking)*

Some offices provide a non-territorial environment for their employees, whereby they do not have allocated desks, and instead share desks (also referred to as flexi-desking or hot-desking). This has benefits for the company in terms of reducing the amount of space being wasted when desks are not in use (J. Kim et al., 2016). Although there are obvious economic benefits to shared desks, there may be costs, such as concerns about hygiene, and time wasted setting up and packing away (J. Kim et al., 2016). Some resistance may be encountered when trying to implement non-territorial offices, and occupants may colonise space by either sitting in the same place repeatedly or leaving belongings at a desk after they have finished work for the day (Lansdale, Parkin, Austin, & Baguley, 2011). In addition, shared desks have been linked with lower subjective wellbeing (Lütke Lanfer et al., 2021).

One study highlighted some positive outcomes associated with flexi-desking. J. Kim et al. (2016) analysed data from the Building Occupant Survey System Australia (BOSSA), comparing 3,967 survey responses grouped into fixed-desk and flexi-desk groups. Satisfaction with the majority of IEQ factors measured was higher in the flexi-desk group. There were no significant differences between flexi-desk and fixed-desk users in regard to perceived health and productivity. As this analysis included participants from 20 different buildings, the authors attempted to minimise the variability of environments by conducting a study using a smaller sample from three buildings. In the smaller sample, flexi-desk occupants still had higher IEQ satisfaction in regard to air quality and temperature. Over 80% of occupants agreed that IEQ affected their choice of seat location, so their satisfaction was thought to be related to being able to control their environment, for example, by avoiding drafts or excessively warm areas. The smaller sample groups did not differ on noise and lighting satisfaction, or interruptions, suggesting that flexi-desking does not affect the occupants' perception of these factors. Open-ended comments were solicited, and the feedback on flexi-desks was primarily negative, with complaints about the insufficient number of desks, difficulty locating team members, wasting time setting up and packing away, limitations in personalisation and adjustment of the workspace, insufficient storage, and hygiene risk. These comments highlight some of the problems associated with non-territorial environments, although they were made by a minority of the participants.

J. Kim et al. (2016) found that predictors of occupants' ratings of health and productivity were different for flexi-desk and fixed desk users, and these differences logically pointed to deficiencies in the occupants' environment. For example, the ability to adjust or personalise the workspace, and

storage space, were significant predictors of productivity in shared desk occupants, but not in fixed desks. Presumably, the fixed desk occupants found their ability to adjust and personalise their workspace was satisfactory, and they had no concerns about storage, whereas these were unsatisfactory for shared desk occupants. Similarly, the greatest predictor for decreases in self-rated productivity among fixed desk participants was space for breaks, but this was not significant for flexi-desk users. Comfort of furnishing and space for breaks were the two strongest predictors for negative ratings of health in both groups. In flexi-desk participants, comfort of furnishing was more influential, while space for breaks had more of an influence on fixed-desk participants. The majority of the analysis was from 20 buildings, so there could be confounding factors in terms of the variability of the environments. This study provides evidence which suggests that other factors, not just desk sharing, may be important in flexi-desk occupants' satisfaction. It also suggests there may be some positive benefits from flexi-desk arrangements, such as the ability to exercise personal control by choosing where to sit.

In a study investigating demands (distractions, uncooperative behaviours, distrust, and negative relationships) and resources (co-worker friendships and supervisor support) in relation to flexi-desk environments, less positive results were found (R. L. Morrison & Macky, 2017). In a survey of 1,000 Australian workers, it was found that as work environments became more shared, there were increases in demands, co-worker friendships were not improved, and perceptions of support from supervisors declined. This result would suggest that shared-desk environments may negatively affect worker wellbeing. There could be other factors, such as differences in jobs, management, and workplaces, which could have had an effect in this study. The study's authors commented on features that may help reduce some of the negative effects of a shared work environment, such as allowing some personalisation of spaces, using partitions or plants to reduce visual distraction, and using noise reduction equipment such as noise-cancelling headphones.

Shared desks can be a feature of activity-based working (ABW) offices, which will be discussed in the next section. Some negative results have been attributed to dissatisfaction with shared desks in ABW offices, including time loss due to shared desks and feelings of *dispossession* due to not having a space in the office (Rolfö, Eklund, & Jahncke, 2018; Taskin, Parmentier, & Stinglhamber, 2019). In contrast, one ABW study found that increased workplace switching was associated with positive outcomes (Haapakangas, Hallman, Mathiassen, & Jahncke, 2018). In a green ABW office, 52% of participants expressed a preference for working at the same desk every day; however, more mobile participants had higher satisfaction levels (Göçer, Göçer, Ergöz Karahan, & İlhan Oygür, 2018). The

more mobile group in the latter study was mainly younger and newer to the company, and there may be differences in regard to how flexible environments are perceived by different age groups. Choice of workstation was driven by choosing a quieter place to work, sitting by colleagues, and increased access to daylight. Higher-status employees needing more auditory privacy tended to regularly use certain meeting rooms, resulting in an understanding of ownership of these offices.

In conclusion, shared desks have been linked with some positive outcomes in ABW studies; however, there are drawbacks such as time loss, psychological discomfort, and resistance to switching desks.

### 2.3.2.3 *Innovative office design/Activity-based flexible offices*

Activity-based flexible offices, or innovative offices, are offices which have different areas that workers can choose to work in, depending on their current task (Wohlers & Hertel, 2017). In a recent review, it was concluded that activity-based working (ABW) may be beneficial for interaction, communication, control of time and space, and satisfaction with the workplace (Engelen et al., 2018). The review found that ABW is detrimental to concentration and privacy; however, more research is required to evaluate the effects on occupants' physical and mental health. Some ABW office design studies have described occupants' reactions and wellbeing outcomes (Berthelsen, Muhonen, & Toivanen, 2018; Candido et al., 2019; Candido, Gocer, et al., 2021; Haapakangas, Hallman, et al., 2018; Hodzic, Kubicek, Uhlig, & Korunka, 2021; Meijer, Frings-Dresen, & Sluiter, 2009; Rolfö et al., 2018; Taskin et al., 2019; Wijk, Bergsten, & Hallman, 2020). As with open-plan offices, ABW offices can vary greatly, and likewise, occupants' perceptions of these environments and way of working can differ. Some studies are discussed below, with descriptions of the changes where available, and the impact on occupants.

Meijer et al. (2009) conducted a longitudinal study ( $N = 138$ ) investigating employee health and productivity following an innovative office concept redesign. The innovative office design included different areas for workers to perform specific tasks and shared desk space with adjustable desks, chairs, and computer screens. There was also a change to working techniques due to a commitment to using less paper, whereby documents were electronically scanned and emailed to workers. This change enabled workers to choose where they wanted to work in the office. Different areas were incorporated in the new design, including *working areas* for more concentrated work, *teamwork areas*, and *corporate areas* for activities such as eating lunch and having breaks. In the short term, there were no significant changes, apart from a decrease in the self-reported quantity of performed work. In the long-term, there was an increase in self-reported general health, a decrease in the

prevalences of upper extremity complaints, and an increase in perceived productivity. The redesign involved several changes including ergonomic furniture and updated décor, so it is not possible to conclude which factors were responsible for the positive results. Hodzic et al. (2021) also used a longitudinal design, which assessed work outcomes following a relocation to an ABW office from a small open office or shared offices. The study had three measurement points (before the relocation, 2 months after, and 12 months after), with 247 participants in the pre-relocation and 2 months after comparisons, and 127 participants in the longitudinal comparisons of all three times. After the relocation to an ABW office, distraction and fatigue increased while work engagement decreased, although there was no significant decline in job satisfaction. Distractions after the move were linked to higher fatigue and lower work engagement and job satisfaction. In situations of increased time pressure and unpredictability, there were stronger relationships between distraction and fatigue and decreased work engagement. After 12 months, the increase in distraction persisted. The above longitudinal studies show mixed wellbeing results following redesign/relocation to ABW offices.

In a small within-subjects mixed-methods study (longitudinal  $n = 34$ , retrospective  $n = 66$ ), individuals showed an increase in satisfaction with the office after moving from an open-plan office to an ABW office (Rolfö et al., 2018). There were significant improvements in satisfaction with noise and auditory privacy, air quality, view, and aesthetics. Poorer communication within teams was reported, which the researchers suggested may have been caused by a high people-to-workstation ratio and lack of rules pertaining to the use of the office space. There was no significant change in performance after relocation. In the new ABW office, there was improved satisfaction with noise, which may have been beneficial for concentration; however, time loss due to hot-desking was also reported. Time wasted by the use of shared desks has been reported in another study (J. Kim et al., 2016). The redesigned ABW did not have much variety in terms of acoustic conditions in different areas, which may have resulted in less incentive for workers to change areas for different tasks, and this may have detracted from the possible performance benefits from an ABW.

One cross-sectional study ( $N = 239$ ) has investigated the association between ABW, and predictors of wellbeing and productivity (Haapakangas, Hallman, et al., 2018). Haapakangas, Hallman, et al. (2018) used linear regression analyses and found that satisfaction with the physical environment, privacy, and communication had the strongest positive associations with self-rated productivity and wellbeing at work. Satisfaction with other aspects of the environment (personalisation, IT, personal storage, cleaning) had weaker associations with wellbeing and productivity. Satisfaction with privacy and communication had the largest effect sizes among the activity-based environment satisfaction

predictors, and these factors have been highlighted in previous ABW literature (De Been & Beijer, 2014; Engelen et al., 2018). Higher productivity was linked to increased workplace switching, while lower productivity and wellbeing were associated with time loss searching for a workspace. Wellbeing was higher when workspaces were switched 1 – 3 times a day vs. not switching, and using 7 – 15 different workspaces was linked with better wellbeing than using 1 – 3 workspaces. The researchers controlled for physical health and found the link between use and perceptions of ABW, and higher productivity and wellbeing persisted, suggesting that the effect cannot be explained solely by an impact on health. They proposed that the benefits of ABW offices may be explained by three different mechanisms: employees choosing workplaces where they can be most effective, environmental control, and increased physical activity and breaks from sedentary work.

In a mixed-methods study of 2,090 surveys from offices designed to support ABW, most occupants reported a positive impact of their office on productivity (Candido, Gocer, et al., 2021). The strongest predictors of productivity were satisfaction with interior design and office design allowing collaboration. Biophilic, interior design, and air quality/thermal comfort factors were rated highly by occupants, while distraction and privacy were the factors that occupants were least satisfied with. Additional comments obtained from the survey indicated several sources of dissatisfaction (e.g., difficulties booking meeting rooms, noise, problems finding a desk or colleagues). While the ABW environments in this study clearly had some unsatisfactory elements, the participants' ratings suggest that overall, the perceived effect of the workplace on productivity was positive.

ABW offices may have negative consequences for wellbeing, as illustrated in one mixed-methods study (survey  $N = 534$ , interviews  $N = 12$ ) comparing “*organizational de-humanization*” (example question: “My organization considers me as a number”) in three office types (private, open-plan, and flex-office or ABW; Taskin et al., 2019). The study found that ABW offices had the highest dehumanisation levels and private offices had the lowest. Dehumanisation predicted more psychological strain and turnover intention; and lower job satisfaction, affective commitment, and extra-role performance. A small number of interviews provided some insight into some drawbacks of ABW offices. Interviewees commented on feelings of *dispossession* due to factors such as not having a say in the office design or a fixed place of their own in the office. Similar results have been found in another study described above, where participants commented on a lack of sense of belonging and not having their own desk (Candido, Gocer, et al., 2021). In Taskin et al. (2019), comments were also made about feeling abandoned and isolated in this type of office. Finally, interviews highlighted negative feelings concerning perceived pressure to adapt to the new way of working. Some of the

negative aspects of ABW mentioned in the study may not be relevant for other ABW environments, and they highlight what can go wrong in flexible office environments. Some ABW offices do provide fixed desks for employees in addition to shared spaces; however, other ABW offices use entirely shared workstations, and this study's qualitative data emphasises possible emotional consequences from not providing employees with their own space. Other negative perceptions relating to occupants' feelings of needing to adapt to a new environment may relate to how changes are managed in office design.

Similar negative results were found in a Swedish study of university employees (pre  $N = 217$ , post  $N = 200$ ) relocating from private offices to an ABW office (Berthelsen et al., 2018). Questionnaires were given to employees 3 months prior to relocation, and 9 months post-relocation. After relocating to the new office, employees had lower job satisfaction and higher turnover intention. In addition, employees perceived a decline in support from colleagues and less social community at work. Work demands remained the same, and there were no improvements in any psychosocial measures. None of the physical environment features were rated significantly better in the new environment, and the majority were rated significantly poorer. Participants expressed concerns about disturbing others, were dissatisfied with the lack of privacy, and found it difficult to concentrate. The latter complaints are common issues in open-plan environments and, unsurprisingly, occupants would complain about these issues having relocated from private offices. Employees may not have taken advantage of ABW, as the majority reported sitting in the same seat daily, and also home-working increased in the new office. The researchers commented that results may have been affected by organisational and change management factors. Employees had been consulted prior to the redesign and the original plan had been to have cell offices; however, this plan was later changed to an ABW office without consultation. Change management may be important for positive results (Brunia, De Been, & van Der Voordt, 2016; Hongisto et al., 2016), and it is possible that employees reacted negatively owing to the communication of the new design. Academic workers often require the ability to work individually and concentrate on tasks, and open and ABW offices may not be suitable for this job type.

In a cross-sectional study in South Africa ( $N = 1,853$ ) comparing ABW office occupants' wellbeing with that of occupants in private, shared office, open-plan, and reservable space, further negative outcomes were found (Laughton & Thatcher, 2019). ABW office occupants had the highest physical discomfort in shoulder, lower back, and wrist/hand regions. In addition, ABW office occupants had higher psychological discomfort than open-plan offices and private offices. Participants in ABW

offices felt they belonged in their workplace, but they rarely experienced control and privacy. In terms of psychological wellbeing, ABW offices had higher ratings than open-plan offices but lower ratings than private offices.

Few studies focus on qualitative data. A small interview study with 16 participants working in ABW offices found both positive and negative consequence of this office design (Fincke, Hieb, Harth, & Mache, 2020). Increased job and environmental control, and improved communication and collaboration between departments, were perceived to have a positive impact on wellbeing, performance, and motivation. Job demands (e.g., lack of territoriality, noise and distractions) led to perceived strain. The qualitative data in this study provides information about how occupants are affected by ABW, although the study is limited by a small sample size. In an analysis of focus group data, researchers used concept mapping to identify factors to do with social wellbeing in ABW offices (Colenberg, Appel-Meulenbroek, Herrera, & Keyson, 2021). The categories resulting from this analysis were social needs (e.g., ease of meeting colleagues, feeling disconnected from colleagues), experiences with (anti-)social behaviour (e.g., territoriality, hostility), and perceived social affordances of the physical environment (e.g., noise, crowding). The two studies above provide qualitative data showing occupants' perceptions of how ABW offices negatively and positively affect their wellbeing.

A mixed-methods study using data from questionnaires at three time points and also 15 focus groups found some facilitators and barriers to the successful implementation of ABW (Wijk et al., 2020). The study investigated health, wellbeing, work satisfaction, and *sense of coherence* (SOC) indicators (meaningfulness, manageability, and comprehensibility) in employees relocating to ABW offices. Longitudinal comparisons of the questionnaire responses ( $n = 246$ ) showed a small increase in perceived health and a decrease in wellbeing at 3 months post-relocation, but no change between 9 months and prior to the move. Physical and psychosocial work satisfaction were significantly lower at 9 months post-relocation compared to baseline. The qualitative data indicated the importance of change management in moving to ABW, with several facilitating factors and barriers identified (e.g., communication, support, preparatory activities prior to relocation, ABW office working rules). The questionnaire data showed an increase in SOC at 9 months post-relocation compared to before the move, suggesting that perceptions improved over time. The SOC indicators were associated with health, wellbeing, and work satisfaction, while employees with high meaningfulness ratings had smaller reductions in work satisfaction during relocation. The authors suggested that measures to



increase meaningfulness during the ABW implementation process may help to ameliorate possible decreases in satisfaction with the new environment.

It is apparent from the reviewed literature that some ABW offices elicit more positive reactions than others. A comparison of four ABW offices with high or low satisfaction levels ( $N = 930$ ) described differences between two successful cases and two less-successful cases (Brunia et al., 2016). Factors linked with success were layouts that facilitated communication and concentration, attractive design, ergonomic furniture, storage, and meeting psychological and physical needs (e.g., privacy, thermal comfort, daylight, and views). Other factors differentiating the higher satisfaction offices were change management procedures, satisfaction with the organisation, and commitment of managers to the design.

More research is needed to understand how these offices affect occupant wellbeing; however, ABW may provide solutions to some of the negative aspects of open-plan offices, such as noise and difficulty doing work requiring concentration, by providing a choice of where to work. Shared desks may be viewed negatively by occupants, and employees may also be dissatisfied with the open areas in ABW offices. As with open-plan offices, ABW offices differ in terms of quality and design, and this may partly explain why some studies report more positive or negative outcomes. Open and ABW environments may also be less suited to jobs that involve more individual, concentrated work. How changes are managed may be important to the success or failure of ABW implementation (Berthelsen et al., 2018; Brunia et al., 2016; Hongisto et al., 2016).

#### 2.3.2.4 *Sit-stand desks*

Sedentary behaviour and insufficient physical activity are global threats associated with health risks, and sit-stand desks are a workplace intervention that decreases sedentary behaviour (Zhu et al., 2020). Sit-stand desks are a trend in modern offices and may be a feature of activity-based offices (Engelen et al., 2018). In reviews of sit-stand desk research conducted up to 2013 and 2014 (MacEwen, MacDonald, & Burr, 2015; Tew, Posso, Arundel, & McDaid, 2015), the authors concluded that there is insufficient evidence, or mixed evidence, of the effects on physical health and mental health outcomes. In a review covering research conducted up to 2017, Chambers, Robertson, and Baker (2019) found few studies indicated a significant improvement in productivity or psychological outcomes. There was more evidence to indicate that sit-stand desks may decrease discomfort, specifically back pain. It should be noted that one small study ( $N = 20$ ) found increased discomfort after prolonged standing (2 hours), as well as deterioration in attention reaction time (Baker et al.,

2018). In the latter study, discomfort was associated with deterioration of mental state. A randomised controlled trial comparing workers using sit-stand desks ( $n = 77$ ) with a control group ( $n = 69$ ) found significant improvements on several wellbeing outcomes (Edwardson et al., 2018). Edwardson et al. (2018) compared wellbeing outcomes longitudinally in the Stand More AT (SMaRT) Work intervention in UK National Health Service (NHS) office workers, and found that there were improvements in job performance, work engagement, fatigue, presenteeism, anxiety, and quality of life. There were no differences in sickness absenteeism. Higher health, productivity, and environmental satisfaction ratings were given by sit-stand desk users compared to other office occupants in one study (Candido, Marzban, Haddad, Mackey, & Loder, 2021). In-depth interviews ( $n = 17$ ) with people responsible for making furniture purchase decisions indicated that they felt sit-stand desks reduced employee discomfort and increased employee satisfaction and productivity (Zerguine, Johnston, Healy, Abbott, & Goode, 2021). More research is needed, but initial results show promise that sit-stand desks may positively affect occupants' wellbeing.

### 2.3.3 Privacy and noise

Privacy allows employees to have more control over their accessibility to others, is generally preferred, and has been linked to increased workplace and job satisfaction (Sundstrom et al., 1980). Lack of privacy and increased noise are common complaints in open-plan offices (Brennan et al., 2002; De Croon et al., 2005; Hedge, 1982; Morrison & Stahlmann-Brown, 2021; Sundstrom, 1986; Sundstrom et al., 1980) and ABW offices (Berthelsen et al., 2018; Hodzic et al., 2021; Lusa, Käpykangas, Ansio, Houni, & Uitti, 2019). Perceived noise has been shown to mediate lower office satisfaction with more open-plan offices (Otterbring et al., 2021). Working in a more open environment results in less visual and auditory privacy, as employees can be observed, and their conversations can be heard. Confidential conversations can be difficult unless there are separate areas for private meetings. Irrelevant speech, such as from conversations, has been linked with decreases in wellbeing and productivity, and increases in noise annoyance, more in open-plan offices than shared offices (Di Blasio et al., 2019). In ABW offices, satisfaction with acoustics has been linked with good self-perceived future work ability, recovery from work strain, and *social capital* (e.g. cooperation between colleagues; Lusa et al., 2019). A relocation study found that distractions increased after moving to an ABW office, and distractions were linked to higher fatigue and lower work engagement and job satisfaction (Hodzic et al., 2021). There is strong evidence from the literature that working in open-plan offices reduces privacy, and limited evidence that close workstations are associated with less privacy (De Croon et al., 2005). In a small office relocation study, Oldham (1988) found that moving from an open office to a low-density open office, or a

partitioned office, had positive effects on measures of privacy, crowding, and environmental satisfaction. In another study, there was no relationship between perceived privacy and task performance (assessed by managers' ratings) or job satisfaction (Maher & von Hippel, 2005). The Stroop test was correlated with perceived privacy, which the researchers suggested indicated that employees better able to inhibit environmental distractions also perceive their environment to be more private. Maher & von Hippel (2005) found evidence to suggest that when perceived privacy is low and task complexity is high, people with a weaker ability to inhibit stimuli report lower job satisfaction.

Lack of privacy in open-plan environments can make it difficult to have confidential conversations. Sundstrom et al. (1982) found that among employees moving from different office types to an open-plan office, managerial staff that were originally in private, enclosed offices experienced the greatest decline in satisfaction with visual and auditory privacy. Their questionnaire data and acoustic measurements suggested the decline in satisfaction with privacy was linked to a reduction in the ability to have confidential conversations in the open-plan environment. In the study, satisfaction with communication and privacy were strongly correlated, which contradicts the belief that open-plan environments facilitate communication. Lack of privacy and difficulty having confidential conversations also affect non-managerial employees. In a longitudinal study measuring employees' satisfaction with a relocation from a traditional office to an open-plan office, the main complaints were lack of privacy and confidentiality, and increased noise (Brennan et al., 2002). Brennan et al. (2002) also found a decrease in team member relations after relocation to the new office, which did not improve 6 months after the move. The researchers recommended some solutions to the client to combat problems with privacy and noise: additional *break out rooms* for confidential conversations, meetings, and phone calls; and establishing and encouraging open-plan office protocols.

Bridger & Brasher (2011) suggested that in situations where lack of privacy increases the need for self-control, privacy is important in maintaining mental wellbeing in employees doing cognitively demanding work. In a study comparing outcomes between participants in a large open-plan building to several smaller buildings with ten people or less per room ( $N = 196$ ), it was found that mental wellbeing was more closely linked to an interaction between cognitive task and self-control demands in the open-plan layout (Bridger & Brasher, 2011). Previously, the occupants of the large open-plan building had completed another survey and had complained about the lack of privacy. The open-plan

employees' complaints about privacy varied from sitting next to staff of different levels of seniority, distractions from phones and conversations, and public visibility of their computer screens.

One method of dealing with the problem of lack of visual and auditory privacy in an open-plan environment is the use of partitions. Partitions around workstations have been shown in some studies to be related to increased satisfaction with privacy, office satisfaction, and job satisfaction (Oldham, 1988; Oldham & Rotchford, 1983; Sundstrom et al., 1980). In a study conducted by Oldham (1988), employees moving from an open-plan office to one that had three sound-absorbing partitions around their workstation of 4 to 6 feet in height experienced improvements in perceptions of privacy. Interestingly, Y. S. Lee (2010) found that workers in open-plan offices without partitions had more satisfaction with auditory privacy and noise level than workers with high partitions. They found no significant difference in satisfaction with visual privacy between open-plan office workers with high partitions vs those without partitions. The authors suggested that possibly having visual cues may help with noise and privacy, e.g. co-workers being able to visually assess if a colleague can be interrupted. In the latter study, it is possible that some respondents had differing needs for privacy, which were related to the office layout, i.e. more open-plan environment offices may have been designed for collaboration which was important for some jobs. Similarly, Maher & von Hippel (2005) found that high privacy was a factor in lower job satisfaction in certain participants. They proposed that the higher partitions in their study provided visual privacy, but not auditory privacy, causing greater problems for the occupants. In contrast, employees in another open-plan office study had greater privacy satisfaction with higher partitions (140 cm) vs lower partitions (120 cm), and employees with high partitions and access to a window were most satisfied with privacy (Yildirim, Akalin-Baskaya, & Celebi, 2007). In the latter study, some complaints from participants sitting away from windows indicated that they were disturbed more by colleagues (e.g. using a corridor), so the relationship between window access and privacy may have been an artefact of being further from the pathway. The evidence seems to suggest that there may be a benefit in using partitions, but very high partitions may be undesirable.

Density of the workplace may also impact the perception of privacy (Oldham, 1988). Oldham (1988) found that employees experienced improvements in perceived privacy when moving from an open-plan office to either a low-density open-plan office, or an office which had partitioning around the workstations. Although there were improvements in the perception of privacy in both offices, there were more positive improvements in work satisfaction from employees who moved to the low-

density open-plan office. More research needs to be done in this area, but it is possible that density may be another factor to consider when designing offices that provide privacy for the occupants.

In conclusion, privacy and noise disturbance may be problematic in some office environments, and may impact occupants' wellbeing, environmental satisfaction, and communication with colleagues. Several design considerations may ameliorate the lack of privacy in open-plan environments, such as partitions, lower density, and separate areas to use outside of open-plan areas. Lack of privacy in open-plan environments may be viewed as an absence of environmental control, a concept discussed in the next section.

#### 2.3.4 Environmental control

Some of the office design and wellbeing literature focuses on the possible benefits of increasing occupants' environmental control (Huang, Robertson, & Chang, 2004; Y. S. Lee & Brand, 2005; Y. S. Lee & Brand, 2010). A review found the evidence for an impact of control on health and wellbeing was weak, due to a small number of studies, mainly cross-sectional, and mixed results (Colenberg, Jylhä, & Arkesteijn, 2021). Y. S. Lee & Brand (2005) examined the effect of various factors, including personal control, over the work environment. They found that perceived control had a significant, positive influence on job satisfaction, group cohesiveness, and environmental satisfaction. Y. S. Lee & Brand (2010) found that perceived personal control over occupants' physical environment mediated the relationship between distraction and perceived job performance. The latter study indicated that increasing control via adjustability of occupants' work environment may reduce the effect of distractions. In a literature review of comfort and the indoor environment, the evidence was mixed, but in the main, suggested that providing occupants with the possibility to control the indoor environment improves thermal and visual comfort, and satisfaction with the air quality (Frontczak & Wargocki, 2011).

Huang et al. (2004) conducted a study to investigate whether providing office workers with more control over their workplace, in terms of adjustability and flexibility of the layout, via ergonomics training, would affect psychological stress, communication, and satisfaction. The ergonomics training provided information about various topics related to the adjustment of workstations and work habits. Training was found to increase the perception of control, environmental satisfaction, and the degree to which the environment supported communication with co-workers. Contrary to expectation, there was no change in psychological stress after training. In their study, there were several aspects of the workstation that were adjustable and that occupants had control over (desk

and keyboard heights, task lights, and movable privacy walls). By learning how to adjust their workplace, employees were able to configure their workstations to support their work tasks. This study provides insight into using training to improve environmental control and assisting occupants to gain the most from their furnishings and office layout.

It has been suggested previously that it is beneficial to involve occupants in the design of their office (Vischer, 2005), another method of allowing environmental control. A series of two laboratory office studies ( $N = 112$ ,  $N = 47$ ) investigated wellbeing and productivity on a cognitive task when participants were allowed the opportunity to design their office space (Knight & Haslam, 2010). The studies compared outcomes between participants randomly assigned to one of four conditions: *lean* (no plants or art), decorated by the experimenter (with plants and art), decorated by the participant, and decorated by the participant then changed by the experimenter. While there were improvements in experiments seen for the decorated conditions vs the undecorated, or lean, conditions, there were further increases in wellbeing and productivity seen for the condition when participants decorated their office. Furthermore, when the experimenter removed environmental control from participants by changing their decoration, wellbeing and productivity were reduced, as compared to the condition in which participants decorated their office and the experimenter did not change anything. These controlled laboratory experiments illustrate the beneficial impact of environmental control on wellbeing.

Control can be problematic in some environments. One study reported complaints from open-plan workers with access to control over temperature (Agha-Hosseini et al., 2013). In the open-plan environment, employees had some control over the temperature; however, they preferred different temperatures. Other researchers discovered that occupants in green *intelligent building* offices did not know how to use environmental controls, as they were busy or had neglected to read instructions sent via email (Göçer et al., 2018). Personal control opportunities are lower in open-plan offices, at least for temperature, due to sharing the same physical environment. Some aspects of the environment are easier to give employees access to control, such as adjustable furniture and task lighting. As discussed previously, control over lighting conditions may result in increased environmental satisfaction (Boyce et al., 2006; Uttley et al., 2013). ABW may assist with control over the environment, as occupants can move to areas that suit their preferences (Candido et al., 2019).

The reviewed literature indicates that environmental satisfaction and wellbeing increase with heightened environmental control. Several ways of achieving environmental control have been

studied, such as via training, involvement in office design, individually adjustable environmental conditions, and ABW.

### 2.3.5 Density

Density in the office environment can be considered as the amount of space per worker or the number of people within an enclosed office. Density in office spaces has been associated with reductions in job and environmental satisfaction, privacy, and concentration (Oldham, 1988; Oldham & Rotchford, 1983); and increased psychological and physical discomfort (Aries, Veitch, & Newsham, 2010), crowding (Oldham & Rotchford, 1983), and adverse health effects (Herbig et al., 2016). Oldham (1988) found that moving from an open office to a lower density open office had positive effects on measures of crowding, privacy, job and office satisfaction. Herbig et al. (2016) investigated self-reported health and psychosocial work stressors in a cross-sectional study of open-plan, shared office, and private office employees ( $N = 207$ ). They found that higher numbers of people in one enclosed office space were associated with increased psychosocial work stressors and environmental dissatisfaction, which were related to psychosomatic complaints, emotional and cognitive irritation, and lower self-rated work ability. More positive results were found in a study by Szilagyi & Holland (1980). The researchers investigated changes in job characteristics and work satisfaction among employees who experienced different changes in social density due to a relocation to a new office ( $n = 31$  to  $33$  in each group). Workers who experienced increased density had less role stress and job autonomy; and more job feedback, friendship opportunities, and work satisfaction. Employees in this study required interaction to do their jobs, so this result may not be found in other types of jobs. The reviewed studies show generally poorer wellbeing outcomes in higher density environments.

### 2.3.6 Biophilia, windows and views

Biophilia has been defined as “the innate tendency to focus on life and lifelike processes” (Wilson, 1984, p. 1) and is a concept that “describes the innate relationship between humans and nature, and concerns the need we have to be continually connected to nature” (C. Cooper & Browning, 2015, p. 7). There is much research investigating the impact of nature on people's health and wellbeing (C. Cooper & Browning, 2015; Grinde & Patil, 2009; M. Richardson et al., 2017; Sadick & Kamardeen, 2020), and exposure to nature has been linked with restoration, and greater health and wellbeing (M. Richardson et al., 2017). A recent systematic literature review concluded that indoor nature exposure is beneficial to office workers' health and motivation (Sadick & Kamardeen, 2020), while another review found only limited evidence of a positive impact on health and wellbeing from

workplace greenery (Colenberg, Jylhä, & Arkesteijn, 2021). A Human Spaces global study of 7,600 office workers in 16 countries found that employees who work in environments with elements of nature, such as greenery and natural light, reported 15% higher perceived well-being, 6% more productivity, and 15% more creativity (C. Cooper & Browning, 2015). While the benefits of nature have been researched extensively, workplaces are quite often devoid of natural elements, with 47% of office employees in the latter study having no natural light, and 58% having no live plants, in their workplace. The literature includes studies on interaction with nature, having a view of nature (actual or in pictures), and indoor plants. It is thought that some of the positive effects reported in studies may be mediated by visual contact with plants, actual or perceived effects on air quality, and positive perceptions of management (Grinde & Patil, 2009; Nieuwenhuis, Knight, Postmes, & Haslam, 2014). In the next sections, studies will be highlighted that have investigated the impact of plants and windows/views on occupant wellbeing in offices.

#### 2.3.6.1 *Biophilia*

A relationship between natural elements in the office (e.g., plants, photos of nature, viewing natural elements in windows) and wellbeing has been shown in a cross-sectional study with 444 participants (An et al., 2016). Exposure to natural elements in the office predicted lower depressed mood, and higher job satisfaction and organisational commitment. Natural elements acted as a buffer in the relationship between role stressors, and job satisfaction, depressed mood, and anxiety. With cross-sectional studies, causality cannot be established, and the relationship between more natural elements and positive outcomes could have been related to other factors, such as job type and company variables. Experimental field and laboratory studies, discussed below, provide supporting evidence of a positive impact of nature on occupant wellbeing.

Positive improvements have been shown in a series of field studies with the addition of plants to *spartan* or *lean* office environments (Nieuwenhuis et al., 2014). Nieuwenhuis et al. (2014) found there were improvements in workplace satisfaction, self-reported levels of concentration, perceived air quality, perceived productivity, and actual productivity on a cognitive task, after the addition of plants. Experimental studies conducted in laboratory offices ( $N = 112$ ,  $N = 47$ ) found that participants in enriched offices decorated with plants and paintings reported increased wellbeing and organisational identification, and increased productivity on cognitive tasks (Knight & Haslam, 2010). In a cognitive task study, participants who viewed a nature movie and listened to river sounds in a restoration phase reported higher energy levels than participants who listened to river sounds but did not watch a nature movie (Jahncke et al., 2011). Improvements in wellbeing, performance,



creativity, and health were shown in a small pilot study ( $N = 8$ ), following the introduction of daylight and greenery in a laboratory office environment (Ayuso Sanchez, Ikaga, & Vega Sanchez, 2018). Another small study ( $N = 40$ ) showed that the introduction of two plants per workstation was associated with increased perceived performance and creativity, while removal of plants was linked to negative impacts on perceived performance and stress (Hähn, Essah, & Blanusa, 2020). In one study, participants in laboratory office settings with plants ( $n = 18$ ) had increased attention between entering the office and finishing a cognitive task, whereas participants without plants ( $n = 16$ ) did not have the same gains in attention (Raanaas, Evensen, Rich, Sjøstrøm, & Patil, 2011). While the above studies generally found positive outcomes linked with plants and nature, one series of studies found that participants in laboratory conditions with indoor plants had higher performance; however, higher perceived wellbeing and productivity were not found with exposure to indoor plants in two call centre field studies (Thatcher, Adamson, Bloch, & Kalantzis, 2020).

Although the mechanism of biophilia is not known, the reviewed studies suggest that there may be a positive impact of nature on employee wellbeing and productivity.

#### 2.3.6.2 *Windows/views*

Windows and views are considered important for occupant satisfaction. Views of nature in offices have been associated with increased job satisfaction, less frustration and more patience, higher life satisfaction and overall health (Kaplan, 1993). Kaplan (1993) suggested that views of nature may allow occupants to rest for brief or longer moments during focused work. It has been proposed that access to windows may compensate for negative perceptions of open-plan offices, as one study found that those participants with access to windows were more satisfied with office planning, privacy, and lighting (Yıldırım, Güneş, & Yilmaz, 2019). In a study assessing comfort and access to window views ( $N = 333$ ), physical and psychological discomfort was reduced for occupants with window views that were rated as more attractive (Aries, Veitch, & Newsham, 2010). Contrary to the idea that nature is generally good for occupants' wellbeing, it was found that views of nature directly increased discomfort in this study; however, nature views did have a positive effect on office impressions, which reduced discomfort. Views rated as better quality were related to reduced discomfort, which in turn was associated with improvements in self-reported sleep quality. Quality of view was shown to also be important in another study ( $N = 402$ ) which found that office workers preferred views of nature, and high view satisfaction was associated with high work ability and high job satisfaction (Lottrup, Stigsdotter, Meilby, & Claudi, 2015). These relationships were independent of various confounding factors. Although studies have generally focused on the beneficial impact of

views of nature, urban views with certain features have also been linked with positive wellbeing outcomes (van Esch, Minjock, Colarelli, & Hirsch, 2019). As with other IEQ factors, it may be difficult to pinpoint the mechanism of the positive impact of windows, as they offer both views and natural light.

Green buildings are currently a popular trend and are designed to be environmentally sustainable and also healthy for occupants. Dreyer, Coulombe, Whitney, Riemer, and Labbé (2018) proposed that the high-quality environment (e.g. access to natural light) and nature-based experiences of green buildings may increase occupant wellbeing. The researchers conducted a survey in a LEED-certified office building in Canada ( $N = 213$ ). While a view to the outside was positively correlated with wellbeing, it was not a unique predictor after accounting for satisfaction with other environmental features. In a post-occupancy study comparing 12 green and conventional buildings, it was found that green buildings were associated with higher satisfaction with the view of outside (Newsham et al., 2013). Furthermore, greater access to windows was one of several physical features linked with improved occupant outcomes.

The evidence discussed so far concerning windows/views is from field studies. In a randomised crossover laboratory study ( $N = 86$ ) conducted with a warm temperature, participants conducting cognitive tasks with windows had more positive outcomes than those without windows (Ko et al., 2020). It was found that participants with windows had more thermal comfort and felt cooler. They also had higher positive emotions and lower negative emotions, as compared to the windowless condition participants. On a cognitive task, some improvements in performance were identified in the window condition vs the windowless condition (working memory, ability to concentrate), but there were no significant differences in other measures (short-term memory, planning, creativity). Perceived stress levels were not significantly different between the two conditions, which the authors suggested could be due to low levels of stress induced by the task, or by the short-term exposure in the experiment to the window condition (55 minutes). The researchers commented that all effect sizes in this study were small; however, considering the short-term nature of this lab study and the multiple positive impacts, even small effects show promise. This laboratory study provides some evidence to suggest that windows may be useful in office design to improve psychological wellbeing, comfort, and productivity. In contrast to this, another laboratory study found lower positive mood in a natural light condition with windows to the outside, compared to an artificial light condition with windows open to the indoor area (Gou et al., 2015).

The reviewed studies indicate that windows have benefits for occupant wellbeing, but other factors need to be taken into consideration. Quality of views is important, and also placement of desks to avoid negative consequences from glare and uncomfortable temperatures.

### 2.3.7 Furnishings and décor

Furniture has a role to play in air quality, and certifications such as WELL and LEEDS outline standards for manufacturers, e.g. to minimise the effect of volatile organic compounds (International WELL Building Institute™, 2017; U.S. Green Building Council, n.d.-a). Furniture is an important part of the office, affecting comfort and aesthetics. Décor has been defined as “the colour, style, and arrangement of the objects in a room” (“Décor”, n.d., para 1) and is important for the look and feel of the workspace. It has been proposed that small things such as the décor may be important for lifting occupants’ spirits (Clements-Croome, 2018a). Although furnishings and décor are integral parts of an office, few studies in the reviewed literature have mentioned them in any detail, except for specific elements such as sit-stand desks, partitions, and plants.

Some studies suggest that furnishings and décor may affect occupant wellbeing. In a study investigating a move to a more open-plan environment ( $n = 127$  relocated employees,  $n = 144$  employees that did not relocate), the researchers discussed the addition of new furniture, an updated décor, reduced partition height to increase natural light, and brighter colours (McElroy & Morrow, 2010). The most frequently cited positive comments from the occupants who relocated were about the design, décor, and furniture. More favourable perceptions of culture and work-related attitudes were reported after the move; however, there were several changes made in the new environment, so it is difficult to know which features influenced the changes. In a study comparing fixed desk and shared desk occupants, comfort of furnishing was found to be a strong predictor for self-reported health, although it was more important for shared desk users (J. Kim et al., 2016). Improvements in employees’ general health and upper extremity complaints were reported after the introduction of an activity-based flexible office, which involved several changes, including the addition of ergonomic furniture (Meijer et al., 2009). In the latter study, there may have also been some positive health impacts from ABW, and the effect of adding ergonomic furniture cannot be isolated. Studies in green buildings have highlighted that ergonomic factors may need more consideration as musculoskeletal symptoms are prevalent (Hedge & Dorsey, 2013; Hedge, Miller, & Dorsey, 2014), and dissatisfaction with workstation design has been associated with musculoskeletal complaints (Hedge et al., 2014). In one study, the majority of survey participants in green buildings reported that the office furniture and workstations affected their performance and

health (Hedge & Dorsey, 2013). Similarly, another correlational study found relationships between dissatisfaction with furnishings and perceptions of a negative impact of the workplace on health and performance (Bae, Martin, & Asojo, 2021).

More research needs to be done in this area, as there are few studies, and the small number of studies involved many changes in addition to furniture and décor. Greater attention should be given to how furniture can impact occupants' wellbeing, particularly considering ergonomic factors.

Table 2.1. *Summary of Office Design Features and Relationships to Wellbeing Outcomes*

Office design features	Wellbeing outcomes
<b>Ambient conditions (lighting, noise, temperature, air quality)</b>	In general, satisfaction with ambient conditions is associated with more positive wellbeing outcomes, whereas adverse ambient conditions are associated with poorer wellbeing outcomes (e.g., Kang et al., 2017; Küller et al., 2006; Lamb & Kwok, 2016; Veitch et al., 2013; Wyon, 2004). Personal control of conditions such as lighting may be beneficial (Boyce et al., 2006; Uttley et al., 2013), as individuals' satisfaction with ambient conditions varies. Access to windows and natural light generally is associated with better wellbeing outcomes (An et al., 2016; Boubekri et al., 2014; Harb et al., 2015), although there may be negative effects from glare and thermal transfer (Gou et al., 2015). In laboratory studies, noise has been associated with performance decrements (e.g. Jahncke et al., 2011). Using noise-absorbing materials may be beneficial in open-plan spaces (Seddigh, Berntson, et al., 2015).
<b>Office layout/ways of working</b>	Open plan layouts are consistently associated with poorer wellbeing outcomes (e.g., Bergström et al., 2015; Bodin Danielsson & Bodin, 2008; Bodin Danielsson et al., 2014; Brennan et al., 2002; De Croon et al., 2005; Hedge, 1982; Pejtersen et al., 2006; Pejtersen et al., 2011; A. Richardson et al., 2017; Sundstrom et al., 1980; Sundstrom et al., 1982). Some studies suggest that with better design, wellbeing outcomes may be improved (e.g., Agha-Hosseini et al., 2013; Hongisto et al., 2016). New ways of working, such as flexi-desking and activity-based working (ABW), need further investigation. ABW may help to overcome some of the common open-plan office complaints. Mixed wellbeing outcomes have been found in ABW offices (e.g., Berthelsen et al., 2018; Candido, Gocer, et al., 2021; Rolfö et al., 2018; Taskin et al., 2019), and lessons may be learned from comparisons of successful and unsuccessful designs (Brunia et al., 2016). Sit-stand desks are associated with some positive wellbeing outcomes (e.g., Candido, Marzban, et al., 2021; Chambers et al., 2019; Edwardson et al., 2018), but some reviews have highlighted the evidence is mixed or insufficient, and more research is required (MacEwen et al., 2015; Tew et al., 2015). One small study found prolonged standing was linked with increased discomfort (Baker et al., 2018).
<b>Privacy and noise</b>	Occupants of more open offices frequently complain about privacy and noise issues (Berthelsen et al., 2018; Brennan et al., 2002; De Croon et al., 2005; Hedge, 1982; Hodzic et al., 2021; Lusa et al., 2019; Morrison & Stahlmann-Brown, 2021; Sundstrom, 1986; Sundstrom et al., 1980). Perceived noise has been shown to mediate lower office satisfaction with more open-plan offices (Otterbring et al., 2021). Lack of privacy may affect mental wellbeing (Bridger & Brasher, 2011) and communication with colleagues (e.g., Brennan et al., 2002; Sundstrom et al., 1982). Partitions or screening and decreased density may improve perceptions of privacy (Oldham, 1988; Oldham & Rotchford, 1983; Sundstrom et al., 1980), although high partitions may be undesirable (Y. S. Lee, 2010; Maher & von Hippel, 2005).

Table 2.1. (continued)

<b>Office design features</b>	<b>Wellbeing outcomes</b>
<b>Environmental control</b>	The reviewed literature suggests that increased environmental control improves occupant environmental satisfaction and wellbeing (Boyce et al., 2006; Frontczak & Wargocki, 2011; Huang et al., 2004; Knight & Haslam, 2010; Y. S. Lee & Brand, 2005; Y. S. Lee & Brand, 2010; Uttley et al., 2013). Environmental control can be implemented through office design (e.g., involvement of occupants in office design, adjustability of furniture, control of workstation lighting, and ABW layouts).
<b>Density</b>	Increased density is generally associated with poorer wellbeing outcomes (Aries et al., 2010; Herbig et al., 2016; Oldham, 1988; Oldham & Rotchford, 1983). One study found positive impacts on workers' perceptions after relocating to an increased density office, which may have been related to their need for collaboration (Szilagyi & Holland, 1980).
<b>Biophilia, windows and views</b>	Introduction of plants in offices has generally been associated with better wellbeing and productivity outcomes (Ayuso Sanchez et al., 2018; Hähn et al., 2020; Knight & Haslam, 2010; Nieuwenhuis et al., 2014; Raanaas et al., 2011), although one series of studies found different results in field studies as compared to laboratory studies (Thatcher et al., 2020). The reviewed literature suggests that access to windows and pleasant views generally has a positive impact on wellbeing (Aries et al., 2010; Kaplan, 1993; Ko et al., 2020; Lottrup et al., 2015).
<b>Furnishings and décor</b>	In the reviewed literature, there was limited evidence to suggest that furnishings and décor may impact occupant wellbeing (Bae et al., 2021; J. Kim et al., 2016; McElroy & Morrow, 2010; Meijer et al., 2009). Ergonomic factors require more consideration (Hedge & Dorsey, 2013; Hedge et al., 2014). Further research is needed in this area.

## 2.4 Discussion

A review of the literature found there is a plentitude of research investigating the relationship between various office environment features and occupant wellbeing outcomes. The literature supports a relationship between certain office design features and occupant wellbeing; however, there are some caveats. Much of the research on wellbeing and the office environment has been conducted using post-occupancy evaluations and cross-sectional studies, which only show relationships rather than permit inferences about indoor environment effects. There are fewer experimental or longitudinal studies, and the ones that exist often use small samples. Furthermore, there is a wide variety of wellbeing outcomes and office features that have been studied, which also makes comparisons between studies difficult. It has been noted that this is a complex area, with effects from the environment exerted additively or through interactions, individual differences in perceptions of indoor environments, and differences in the perceived importance of IEQ factors between studies (Bluyssen, Janssen, et al., 2011; Frontczak & Wargocki, 2011; J. Kim & de Dear, 2012). To further complicate matters, confounding factors such as job characteristics and organisational issues have likely affected the results of the available literature. Not only do wellbeing and environmental factors being measured vary, but also, the workplaces themselves can be vastly different.

The reviewed research indicates features of office environments that are associated with occupant wellbeing. Office environment factors that are associated with poorer wellbeing are open-plan offices, unsatisfactory ambient conditions, lack of privacy and noise dissatisfaction, and increased density. More positive wellbeing outcomes have been associated with the following office features: private offices, presence of environmental control, biophilia (e.g. plants in the office), and windows and views. Some emerging office trends such as flexi-desking, sit-stand desks, and activity-based offices, are currently being investigated by researchers. There are aspects of the physical office environment which have been studied extensively in the wellbeing literature, such as ambient conditions, and others which we know relatively little about, such as furniture, visual aesthetics, and the effect of the entire office layout.

Open-plan environments have been the subject of much investigation in the office design and wellbeing literature, and the layout is generally associated with poorer employee wellbeing and increased environmental dissatisfaction. One goal of open-plan office design is increased collaboration; however, the present review did not find supporting evidence for this aim. Occupants have complained about dissatisfaction with qualities of open-plan environments, such as noise and

privacy. Furthermore, open-plan offices may impact occupants' productivity and ability to do work requiring concentration (Bergström et al., 2015; Brennan et al., 2002; Herbig et al., 2016). Better open-plan office design may improve users' experiences. Noise and privacy issues may be partly remedied with design solutions (e.g., screening, partitioning, sound absorbing materials) and acoustic etiquette. ABW office design may reduce some of the negative effects of open-plan offices by allowing occupants the option to move to different areas to suit their preferences. More care in open-plan design should be taken to improve occupant satisfaction and wellbeing.

The literature provides some reasons to be optimistic about future wellbeing outcomes and modern workplace design. Recently, there have been some positive changes in office design, such as the introduction of green building standards and innovative design trends. Evaluation of wellbeing in green buildings using post-occupancy studies has resulted in more information to assist our knowledge of how the indoor environment affects occupant wellbeing. Some studies have shown superior occupant wellbeing outcomes after making improvements to the office environment (Hongisto et al., 2016; Meijer et al., 2009). The reviewed literature suggests that some of the negative wellbeing outcomes attributed to open-plan offices could be ameliorated with better open-plan design practices to promote occupant wellbeing. With continued research into this area and examination of which office design features are associated with greater wellbeing, increased knowledge may allow the development of improved design practices for wellbeing.

#### 2.4.1 Conclusion

The literature provides evidence to indicate office features that are associated with positive and negative wellbeing outcomes. Office design and wellbeing is a complex area of research, as there is variability in individuals' reactions to their work environment, differences between offices studied, and interactions between both wellbeing outcomes and office design features. Methodological issues, such as the use of cross-sectional studies rather than experimental designs, and a variety of physical features and wellbeing outcomes studied, cause difficulties in making conclusions about office design and wellbeing. In the next chapter, the office design and wellbeing literature will be reviewed, but with a focus on wellbeing outcomes rather than on the physical features of the office.



## 2.4.2 Industrial partner summary

### *Office layout/ways of working*

Open-plan offices are generally associated with poorer wellbeing outcomes, as compared to private offices. Some new ways of working (ABW and sit-stand desks) may offer design improvements for open-plan offices, but more research into their effects on wellbeing is required.

### *Noise and privacy*

Noise and lack of privacy are two common issues in open-plan offices and are associated with poorer wellbeing. Office design for wellbeing should maximise privacy and minimise noise disturbance.

### *Environmental control*

The reviewed literature suggests that increased environmental control improves occupant environmental satisfaction. Office design that allows some individual control of the environment (e.g. desktop lighting) may help improve wellbeing outcomes.

### *Density*

Research indicates that offices with lower density are associated with better wellbeing outcomes. Space should be considered in the design of offices for improved wellbeing.

### *Biophilia, windows and views*

Plants and access to windows/pleasant views should be considered when designing for wellbeing.

### *Furnishings and décor*

In the reviewed literature, there was some evidence to suggest that furnishings and décor may impact occupant wellbeing. Further research needs to be conducted in this area, as few studies focus solely on the effect of furnishings and décor on wellbeing.

### 3 Wellbeing outcomes in office design literature

The following chapter will review studies relating to individual wellbeing outcomes in the office design literature. The methodology for the review is described in Chapter 2. This literature review will provide a rationale for the wellbeing outcomes measured in the current PhD research and establish current knowledge about the relationship between specific wellbeing outcomes and office design. Individual differences measured in relation to wellbeing outcomes and office design will also be reviewed, as they may have an impact on understanding wellbeing and office design research and interventions.

#### 3.1 Measurement of wellbeing in office design research

Wellbeing has been measured in office design literature using a variety of methods. Typically, studies have investigated environmental comfort and wellbeing using post-occupancy questionnaires, which may include questions about satisfaction with certain office and psychosocial factors (e.g., Y. S. Lee & Brand, 2005; Veitch et al., 2007). Some studies have measured physical health symptoms (e.g., Meijer et al., 2009; Pejtersen et al., 2006), sick leave days (Bodin Danielsson et al., 2014; Pejtersen et al., 2011), mental wellbeing (Bridger & Brasher, 2011), and mood (Boyce et al., 2006; Gou et al., 2015; Lamb & Kwok, 2016; Lan et al., 2010; Veitch et al., 2013). Productivity is sometimes measured and is thought to be related to wellbeing (e.g., Agha-Hosseini et al., 2013; Lamb & Kwok, 2016; Y. S. Lee, 2010). Collaboration, a possible indicator of knowledge workers' productivity, has also been investigated in office design research (e.g. Lansdale et al., 2011). Studies commonly use a combination of several measures to evaluate wellbeing in the indoor environment.

#### 3.2 Occupant wellbeing outcomes

Review of the literature indicated the main wellbeing outcomes measured are comfort, environmental and job satisfaction, mental wellbeing, health and sickness absence, productivity, collaboration, and cognitive functioning. The following section will describe existing evidence about the relationships between the office environment and each of the wellbeing outcomes. A summary is provided in Table 3.1.

### 3.2.1 Comfort

Comfort is often measured in post-occupancy studies, usually in respect to satisfaction with ambient conditions (noise, lighting, air quality, temperature). Fewer studies refer to comfort in regard to office furniture.

Two large studies which examined ambient conditions and comfort in office buildings demonstrated that perception of comfort is complex and affected by factors other than the indoor environment (Bluyssen, Aries, & van Dommelen, 2011; Sakellaris et al., 2016). Bluyssen, Aries, and van Dommelen (2011) analysed data from the European Health Optimisation Protocol for Energy-efficient buildings (HOPE) study ( $N = 5,732$ ; 59 office buildings) and found that perceived comfort was influenced by personal, social, and building factors. In the OFFICAIR study, a logistic regression analysis conducted on questionnaire data ( $N = 7,441$ ; 167 offices) examined the association with overall comfort and ambient conditions (thermal, noise, light, and indoor air quality) in 'modern' office buildings (Sakellaris et al., 2016). In the latter study, the relationship between indoor environmental quality (IEQ) and comfort differed with personal and building factors. Evidence from these two studies suggests that the relationship between comfort and IEQ is not a simple one and is affected by other factors.

The importance of IEQ factors for comfort has varied in studies. In the above OFFICAIR study, the highest association with occupants' comfort was noise. In order, the next highest associations with comfort were satisfaction with air quality, light, thermal conditions, and layout of the offices (Sakellaris et al., 2016). Noise was most important for comfort in the analysis by Sakellaris et al. (2016) but a literature review identified thermal comfort as the most influential factor (Frontczak & Wargocki, 2011). There is some evidence to suggest that unsatisfactory environmental conditions are more important to occupants, and this could explain the variation in relative importance of ambient conditions between studies, as each office may have particular sources of environmental dissatisfaction (J. Kim & de Dear, 2012).

Although standards have been developed to define acceptable ranges for comfort, building occupants may still be dissatisfied with the indoor environment even when the standards are met (Frontczak & Wargocki, 2011). The same indoor environment can result in different subjective responses, which could be due to individual differences and factors unrelated to environmental quality that affect satisfaction. Providing occupants with the possibility to control the indoor environment improves satisfaction and comfort (Frontczak & Wargocki, 2011).

Few studies in the office design and wellbeing literature investigate the impact of the comfort of office furnishings, such as workstations, on employee comfort. References to furniture in the literature generally consider its effects on musculoskeletal symptoms, i.e. viewing furniture as a preventative of ill health rather than as a contributor to general comfort. Comfort of furnishings has been associated with occupant ratings of health (J. Kim et al., 2016), and sit-stand desks have been shown to reduce the discomfort of musculoskeletal symptoms (Chambers et al., 2019).

There is evidence for an association between occupant comfort and satisfaction with ambient conditions. The strength of the relationship may differ in studies due to differences in office environments being investigated. Other factors, such as individual differences, social factors, and building factors, impact occupants' perception of comfort (Bluyssen, Aries, & van Dommelen, 2011; Sakellaris et al., 2016). Designing offices that permit occupants to control ambient conditions where practical (e.g. individual lighting) may improve comfort. The literature focuses on ambient conditions, and there has been less attention given to the comfort of furnishings in offices, with the exception of recent interest in sit-stand desks. Strong evidence exists that ambient conditions affect occupant comfort, while further research should be conducted investigating the comfort of furniture and wellbeing outcomes.

### 3.2.2 Environmental and job satisfaction

Research has generally found positive links between environmental satisfaction and job satisfaction (Carlopio, 1996; Newsham et al., 2009; Veitch et al., 2007; Wells, 2000), while some studies have not found a significant relationship (P. J. Lee, Lee, Jeon, Zhang, & Kang, 2016; Y. S. Lee & Brand, 2005). Particular features of the office environment have been associated with increased job satisfaction, such as exposure to natural elements and views of nature (An et al., 2016; Kaplan, 1993; Lottrup et al., 2015), perceptions of privacy (P. J. Lee, Lee, Jeon, Zhang, & Kang, 2016; Sundstrom et al., 1980), lower distractions (Hodzic et al., 2021), and environmental control (Y. S. Lee & Brand, 2005). There is strong evidence of lower job satisfaction in more open-plan environments (De Croon et al., 2005), although increases in both environmental satisfaction and job satisfaction have followed improvements to open-plan offices (Agha-Hosseini et al., 2013; Hongisto et al., 2016). Generally, satisfaction with the environment is linked with job satisfaction, and measures taken to improve the physical office environment are likely to result in higher job satisfaction.

Many studies have found a link with lower job satisfaction in open-plan or ABW offices (Bergström et al., 2015; Berthelsen et al., 2018; Bodin Danielsson & Bodin, 2008; De Croon et al., 2005; Leder et

al., 2016; Otterbring et al., 2018). In a regression analysis using cross-sectional data gathered from two field studies including the Cost-effective Open-Plan Environments project (COPE; Veitch et al., 2007) and a comparison of green and regular office buildings ( $N = 779$ ,  $N = 2,545$ ), job satisfaction was most strongly affected by pollutant concentration and office type, with higher job satisfaction for private offices (Leder et al., 2016). In a mediation analysis of cross-sectional data, Otterbring et al. (2018) found a relationship between lower job satisfaction and an increased number of people sharing an office (i.e. more open-plan or higher density), which was mediated by lower ease of interaction and subjective wellbeing. The link in cross-sectional studies between open-plan offices and lower job satisfaction could be associated with other variables, such as psychosocial and work-related factors. In a longitudinal within-subjects study, job satisfaction also decreased in employees after relocating from private offices to an open-plan office (Bergström et al., 2015). One open-plan study found a link with access to break-out areas and higher job satisfaction (Davis et al., 2020), suggesting that with considered design, open environments may have better employee outcomes. Similarly, an ABW study found that increased distractions were linked with decreased job satisfaction (Hodzic et al., 2021). While the evidence indicates that open-plan offices are associated with lower job satisfaction, improving environmental satisfaction in open offices may ameliorate this negative relationship.

In longitudinal studies, both environmental satisfaction and job satisfaction have increased after relocation to modern offices or refurbishment of an existing office. Agha-Hosseini et al. (2013) conducted an office relocation study and found that the occupants' environmental satisfaction increased, as did perceived productivity, wellbeing, and enjoyment at work. Similarly, in an office refurbishment study, both environmental satisfaction and job satisfaction increased (Hongisto et al., 2016). Hongisto et al. (2016) proposed that the main reason for increased job satisfaction in their refurbishment study was how the redesign was managed (change management, the involvement of employees, planned refurbishment agenda). Longitudinal studies support the link between environmental satisfaction and job satisfaction.

Satisfaction with the physical office environment may impact job satisfaction via direct and indirect pathways, and a model approach may be important in understanding the relationship between the two variables. Newsham et al. (2009) investigated a model to test the relationships between environmental satisfaction, job satisfaction, and other related measures. Environmental satisfaction was significantly linked with job satisfaction, and this association was mediated by satisfaction with management and compensation. The authors raised the suggestion that employees may consider

the physical workplace environment to be part of their “compensation package” (p. 141), and the quality of the physical environment may affect their opinion of management. Y. S. Lee & Brand (2005) used a structural equation model (SEM) approach to test relationships between control, environmental satisfaction, job satisfaction, and other variables. They did not find a significant relationship between environmental satisfaction and job satisfaction; however, environmental control was a significant predictor of job satisfaction. The researchers suggested that there may be a mediating variable not included in their model, which may explain the lack of relationship found. Similarly, another SEM study found no relationship between environmental satisfaction and job satisfaction; however, speech privacy was a significant predictor of job satisfaction (P. J. Lee et al., 2016).

The literature suggests that satisfaction with the office has a positive relationship with job satisfaction, although the research is mainly non-experimental, and there may be other variables that are mediating the relationship. Some studies did not find a significant relationship between environmental satisfaction and job satisfaction (P. J. Lee et al., 2016; Y. S. Lee & Brand, 2005). More experimental research needs to be conducted to test whether increasing environmental satisfaction will change individuals' job satisfaction. Lessons may be learned from studies showing improvements in job satisfaction after successful office redesigns and relocations (Agha-Hosseini et al., 2013; Hongisto et al., 2016).

### 3.2.3 Mental wellbeing

There is little research investigating the impact of office design on mental wellbeing. One literature review found positive results relating to certain aspects of the indoor environment (lighting/daylight, views, control, plants) and psychological wellbeing (Colenberg, Jylhä, & Arkesteijn, 2021). Mental wellbeing outcomes such as mood, stress, and psychological wellbeing have been measured in some of the reviewed studies.

Field and laboratory-based studies have researched the relationship between mood and various aspects of the physical office environment. Lamb and Kwok (2016) conducted a large longitudinal within-subjects study over 8 months ( $N = 114$ ), and found that unsatisfactory IEQ factors (noise annoyance, lighting, and thermal comfort) reduced mood and increased the risk of headaches and “feeling ‘off’”, which caused an indirect deterioration in productivity. A more pleasant mood has been associated with satisfaction with lighting (Küller et al., 2006; Veitch et al., 2013). In a laboratory study, there were possible negative effects on mood in a daylight exposure condition, which may

have been caused by temperature changes (Gou et al., 2015). A higher temperature condition (28° C) was associated with negative moods in another laboratory cognitive task experiment (Lan et al., 2010). Lower affective ratings (an average of tired–alert, bored–enthusiastic, and fed up–engaged) have been found in more open-plan offices compared to other office types; however, this comparison was not significant (Otterbring et al., 2021). In a post-occupancy study investigating wellbeing and environmental satisfaction outcomes in North American green buildings vs conventional office buildings ( $N = 2,545$ ), various outcomes were better in the green buildings, including a more positive mood (Newsham et al., 2013). Although the mechanism behind this was not investigated, several environmental factors had higher occupant satisfaction in the green buildings. Exposure to natural elements (e.g. plants) and natural light have been linked with a lower depressed mood score (An et al., 2016). The literature suggests that uncomfortable ambient conditions can affect mood adversely, while environmental satisfaction (e.g. positive lighting appraisals) may have a beneficial impact on mood.

The reviewed literature has investigated several aspects of the office environment in relation to mental wellbeing and psychological stress. In one cross-sectional study ( $N = 1,830$ ), adverse environmental conditions were related to poorer psychological wellbeing, with air quality and noise being the strongest predictors of psychological wellbeing (Klitzman & Stellman, 1989). The study found that ergonomic factors and privacy were also associated with psychological wellbeing, although to a lesser degree. Importantly, after controlling for demographic characteristics, occupation, and psychosocial factors, satisfaction with office environment features was still significantly associated with psychological wellbeing. Increased environmental control has been associated with improved satisfaction and wellbeing outcomes. In an ergonomics training intervention study aimed at increasing personal control, several positive wellbeing outcomes were reported; however, psychological stress was unchanged (Huang et al., 2004). A study investigating the impact of open-plan office features, environmental satisfaction, and working conditions on subjective wellbeing and irritation showed that only wellbeing, not irritation, was affected by size of the office (Lütke Lanfer et al., 2021). Subjective wellbeing was higher in private offices than shared and medium open-plan offices (10 – 24 workstations). Wellbeing was positively predicted by environmental satisfaction, job control, supportive leadership, and resilience; and negatively predicted by desk-sharing and workload. Higher irritation was linked with a higher workload, and lower environmental satisfaction, supportive leadership, and resilience.

There is some evidence to indicate an association with a greater number of occupants in an enclosed office space (increased density) with poorer mental wellbeing outcomes (Bridger & Brasher, 2011; Herbig et al., 2016). In a cross-sectional study ( $N = 196$ ) of office workers from a large open-plan building or several smaller buildings with ten people or less per room, both cognitive task demands and self-control demands were associated with mental wellbeing while controlling for psychosocial factors (Bridger & Brasher, 2011). Mental wellbeing was most strongly linked with an interaction between cognitive task demands and self-control demands, with an increased negative effect of one demand when the other was present. The association was found to be stronger for occupants of the open-plan office, as compared to those working in smaller offices with more privacy. Frustration of work goals was the cognitive task demand with the most detrimental impact on mental wellbeing. Similarly, another cross-sectional study ( $N = 207$ ) found that a higher number of people in an enclosed office space (increased density) was associated indirectly with psychosomatic complaints, and emotional and cognitive irritation (Herbig et al., 2016). These outcomes were related to higher density via higher psychosocial work stressors and environmental dissatisfaction. The studies above provide additional support to suggest that larger open-plan offices negatively affect occupants' wellbeing. Another study found that, while subjective wellbeing was higher in private offices compared to shared and medium open-plan offices, environmental satisfaction was high in larger open-plan offices with more than 25 workstations (Lütke Lanfer et al., 2021). Lack of privacy and increased density are part of current open-plan office design, and designs that maximise occupant privacy and decrease the number of occupants per room may be beneficial to employee mental wellbeing.

In a review by Veitch (2011), it was observed there is little attention given to mental health outcomes in the office design literature. According to Veitch (2011), research suggests workplace design can affect mental health via the effects of lighting, visual aesthetics, access to nature, and privacy and stimulus control. Furthermore, Veitch suggested that providing suitable workplace conditions for all employees would be a non-stigmatising way to support people with mental health problems and may also be preventative. This is a topic that requires investigation, and no studies using participants with mental health problems were found in the present literature review. While there were no studies specifically investigating mental health problems, one cross-sectional study in a green office building in Canada ( $N = 213$ ) found that environmental satisfaction was linked with higher positive wellbeing and reduced negative wellbeing (Dreyer et al., 2018). The negative wellbeing score used by the researchers was a summed total from negative feelings and symptoms of anxiety and depression. The latter study shows a link between negative mental health and lower



environmental satisfaction; however, this is a cross-sectional relationship, and further research with experimental or longitudinal designs would be useful to gain stronger evidence of an effect of the environment.

Although few studies investigate the effect of workplace environment features on mental wellbeing, the existing literature suggests that the physical environment can have a positive or a negative effect. There has been some experimental research investigating the effect of temperature and lighting on mood; however, the remainder of the research into the impact of office design on mental wellbeing is primarily cross-sectional. Although some studies have controlled for possible confounding factors such as psychosocial conditions, there may be other variables accounting for the effects. Further research needs to be conducted using longitudinal and experimental research to establish causality. Studies measuring the effect of office design on mental wellbeing tend to measure mental wellbeing in addition to several other outcomes, i.e. it is rarely the focus of the research. Research has indicated some factors which may be beneficial for mental wellbeing, including satisfactory ambient conditions, increased privacy, and decreased density. Investigation into the effect of altering these environmental conditions on mental wellbeing may increase understanding in this area.

#### 3.2.4 Health and sickness absence

Several office features have been investigated in connection with physical health and sickness absence. The main finding has been the negative impact of open-plan layouts on health and sickness absence. Increasingly, there is interest in physical activity in the workplace, achieved by factors such as ABW and sit-stand desks. A literature review concluded that open-plan offices, shared offices, and background noise, are features that had negative relationships with health; while positive relationships were found with features encouraging physical activity (e.g. sit-stand desks), day(light), views, control, and plants (Colenberg, Jylhä, & Arkesteijn, 2021).

There is some evidence from cross-sectional studies that suggests health may be poorer in open-plan offices. Sickness absence in a large cross-sectional survey ( $N = 2,403$ ) was related to having a greater number of occupants in the office after controlling for several confounding variables (Pejtersen et al., 2011). Compared to occupants in private offices, occupants in open-plan offices (greater than 6 occupants) had the highest self-reported days of sickness absence (62% more days). Occupants in small shared offices (2 occupants) had 50% more days of sickness absence, and occupants in larger shared offices (3 - 6 occupants) had 36% more days of sickness absence. In a

large prospective study ( $N = 1,852$ ) of sick leave and different office types, there were significantly more short sick leave (7 days or less) in open-plan offices, compared to other office types (Bodin Danielsson et al., 2014). Another study ( $N = 2,301$ ) found that occupants in open-plan offices were more likely to report certain symptoms (e.g. headaches and mucous membrane symptoms, such as irritation of eyes, nose, or throat) than occupants in private and shared office types (Pejtersen et al., 2006). In these cross-sectional studies (Bodin Danielsson et al., 2014; Pejtersen et al., 2006; Pejtersen et al., 2011), the mechanisms behind higher rates of sick leave and ill health symptoms in certain office types cannot be inferred. Considering past research, Pejtersen et al. (2011) speculated five issues concerning poorer health outcomes and open-plan offices: higher exposure to noise, mechanical vs natural ventilation, increased exposure to viruses, differences in the psychosocial work environment, and reduced employee autonomy.

Longitudinal studies have shown conflicting results concerning the relationship between open-plan offices and health. Lack of support for increased ill-health in open-plan offices was provided by a study (longitudinal  $n = 138$ ) assessing worker's health over a period of 15 months after relocation from private offices to activity-based working (ABW) offices (Meijer et al., 2009). Employees reported better general health and a decrease in prevalences of upper extremity complaints after the move in the long-term (15 months post-relocation), but not in the short-term (6 months post-relocation). Further analysis showed that general health did not seem to improve because of the decrease in prevalences of upper extremity complaints. Many small changes occurred as part of a large office innovation, so it was not possible to identify what was responsible for the improvement in health. Meijer et al. (2009) suggested that ergonomic changes and an extensive office innovation implementation strategy may have been responsible for the positive effects. Another possibility is that the increase in activity or perceived control from choosing where to work in the office, dependent on task, may have improved outcomes. It should be noted that the open-plan office in this study had different areas that employees could work in, so it was dissimilar to traditional open-plan offices. In another longitudinal study (longitudinal comparisons  $n = 20 - 27$ ), where occupants relocated from private offices to an open-plan office, there was a decline in perceived health at the 12-month post-relocation measurement (Bergström et al., 2015). These two longitudinal studies show changes in individuals' perceived health after relocating to open-plan offices, although one shows a decline (Bergström et al., 2015), and the other shows an improvement (Meijer et al., 2009). The two offices in these studies were likely dissimilar (ABW vs traditional open-plan), and also, the change management approaches may have been different.

In a survey assessing IEQ satisfaction, productivity, and health in occupants with shared desks vs those with fixed desks ( $N = 3,794$ ), differences were found in factors that were predictors of perceived health (J. Kim et al., 2016). The two strongest predictors of perceived negative health for both shared desk and fixed desk occupants were comfort of furnishing and space for breaks. Comfort of furnishing was a stronger predictor for those in shared-desk environments, whereas space for breaks was a stronger predictor for those working at a fixed desk. The differences between the two groups may indicate separate sources of environmental dissatisfaction. These results provide some insight into how to design healthier open-plan offices, as providing more comfortable furniture and space for breaks may impact occupants' perceived health. A benchmark study from 41 different workplace buildings with unspecified office types using responses from 2,836 participants over 11 years, found that perceived negative impact of the workplace on health was linked with dissatisfaction with all 26 IEQ factors measured (Bae et al., 2021). The strongest association was found with the ability to hear desired sounds, followed by satisfaction with furniture. It is important to note that relationships found in both of these studies may be affected by which aspects of the office environment are sources of dissatisfaction.

The current trend in office design towards less sedentary working is shown by an increased interest in sit-stand desks and ABW. Studies have shown that employees' sitting time at work is reduced with the use of sit-stand desks on average between 84 to 116 minutes per day (Shrestha et al., 2016). Reviews have found that sit-stand desks may decrease discomfort, in particular, back pain (Chambers et al., 2019), and show promise in improving health outcomes with regular use (MacEwen et al., 2015). However, one review found there was insufficient evidence to make firm conclusions about the effect of sit-stand desks on health outcomes (Tew et al., 2015). Physical activity in offices may also be encouraged by the layout, and higher perceived health ratings have been found in participants relocating to ABW workplaces from combi offices (Candido et al., 2019). In the latter study, the ABW offices included sit-stand desks, so the health benefit may have been derived from the ABW, or a decrease in sedentary behaviour from the use of sit-stand desks, or a combination of the two. Occupants' steps were monitored pre and post-relocation to the ABW offices, and it was found that there were no significant changes in daily step count and distance travelled; however, there were significant increases in active time and reductions in sedentary time in the ABW offices. Increased physical activity at work intuitively appears to be a factor that would increase health in occupants and initial research show some positive results, but further studies are needed to fully understand best practices concerning how to encourage physical activity and the impact on employees.

The reviewed literature provides evidence that open-plan environments are associated with poorer health outcomes, although the study designs are mainly cross-sectional, and other factors may be responsible for the relationship. One study does not support this conclusion; however, the difference may be due to ABW and change management procedures (Meijer et al., 2009). The quality of open-plan offices may vary, likely affecting outcomes. Office design trends moving away from sedentary working, such as the use of sit-stand desks and ABW, show initial positive results in terms of employee physical health. More longitudinal research should be conducted, investigating changes in health after office design improvements are made.

### 3.2.5 Productivity

It has been argued that the indoor environment affects health and wellbeing, which is important for productivity (Clements-Croome, 2018b). A report by the British Council for Offices (BCO) proposed that productive offices should support and improve occupants' wellbeing, be engaging, and enable employees to work efficiently and effectively (Greenhill, Mactavish, Harris, & Katsikakis, 2017). Positive workplace perceptions and feelings are important for business outcomes, such as greater productivity and retention of staff (Harter et al., 2003). Increased interest in productivity has been a result of the recognition that it has a larger impact on organisational performance in comparison to property cost savings (Harris, 2019). It has been estimated that average productivity gains of between 1 – 2% may be achieved by changing a single office environmental feature (Oseland & Burton, 2012). While productivity is clearly important for organisations, measurement of performance in offices is challenging and often ignored as a result (Oseland & Burton, 2012).

As it is quite difficult to assess knowledge workers' productivity, studies have often inferred productivity from environmental satisfaction or self-reported measures of productivity. Some lab studies have used cognitive computer tasks as a way to objectively measure productivity. Collaboration is also a possible indicator of productivity in office environments where the transfer of information is important. A number of other metrics may be used to assess productivity, such as absenteeism and employee turnover (see Greenhill et al., 2017); however, this section will focus on perceived productivity. Cognitive function and collaboration are discussed in subsequent sections.

Researchers have attempted to identify which workplace features are more strongly associated with productivity, often using regression analysis. In a literature review, Al Horr, Arif, Kaushik, et al. (2016) described eight areas that affect occupant productivity: indoor air quality and ventilation, thermal comfort, lighting and daylighting, noise and acoustics, office layout, biophilia and views, look

and feel, and location and amenities. They concluded that thermal comfort, indoor air quality, office layout, and noise and acoustics were highly significant in affecting occupant productivity. The authors commented on the interaction between these physical environment factors. Studies tend to differ on the features of the physical environment that most strongly are associated with productivity. For example, in a study of fixed and shared desk users (J. Kim et al., 2016), various office and workstation spatial factors were shown to be important to perceived productivity (e.g., office layout allowing ease of interaction with colleagues, ability to adjust/personalise workspace, and the amount of storage space) The acoustic environment had the greatest influence on perceived productivity in an open-plan academic office study ( $N = 231$ ; Kang et al., 2017). Indoor air quality was the most important factor for productivity in a literature review of green offices, and thermal control also affected productivity (Esfandiari, Zaid, Ismail, & Aflaki, 2017). In a study of primarily open-plan office workers, Agha-Hosseini et al. (2013) split environmental satisfaction into three categories: *interior use of space* (e.g., office layout, areas in the office, privacy), *physical conditions* (ambient conditions, outside view, personal control, noise), and *indoor facilities* (e.g., kitchen facilities, shower facilities). The combination of satisfaction with interior use of space and physical conditions was the best predictor of productivity, while satisfaction with indoor facilities was not a good predictor. In a large benchmark study of unspecified office types, dissatisfaction with all 26 IEQ factors measured were linked with a perceived negative impact of the workplace on productivity; however, the highest associations were found with privacy, ability to hear desired sounds, and furnishings (Bae et al., 2021). The studies described above show the association of satisfaction with a variety of environmental factors and productivity.

In a study of London, UK knowledge workers ( $N = 213$ ) in consultancy, financial, and media sectors, participants were asked to rate office features that affect their productivity (Chadburn, Smith, & Milan, 2017). The strongest physical environment drivers for productivity were comfort (e.g. good ventilation and control of temperature), convenience (e.g. proximity to printers and copiers), IT connectivity, and good design (e.g. smart and professional). Participants also felt that privacy and quiet helped them to be more productive. The study suggested that a variety of office spaces are beneficial, to enable workers to have distraction-free spaces where they can work individually, and also areas where they can collaborate with colleagues. While the study commented on more negativity about open-plan layouts from workers in private offices, it highlighted that workers in open-plan offices were more positive about the layout. The contrasting attitude towards open-plan offices may have been affected by participants' jobs (i.e. those in private offices and open-plan offices may have different requirements), or it may suggest that initial resistance may be overcome

after working in an open environment. The results of this study may be specific to the sectors and London workers, and so may not be generalisable to other office populations. One potential problem in open-plan offices is the inability to control distractions when trying to work productively. A study of New Zealand knowledge workers relocating to shared/open offices found that the shared/open environments were rated as providing more distraction and less privacy, and lower self-rated productivity was linked with these factors (Morrison & Stahlmann-Brown, 2021). Although the occupants' work required collaboration, productivity was not associated with collaboration. Both of these studies highlight that distractions should be minimised, and privacy increased, to target productivity in open-plan offices.

The literature shows that, in general, environmental satisfaction is associated with productivity, and the association with specific features of the office varies from study to study. It seems likely that the association may vary due to different environmental requirements of occupants (e.g. academics may have high requirements for a quiet environment), sources of dissatisfaction present in the buildings studied, and the methods used in the studies (e.g. the factors measured and the measurement tools used). A different viewpoint was advanced by Leaman and Bordass (1999), who suggested that personal control and *responsiveness* (e.g. ability to reconfigure the furniture) were important for productivity. This is an alternative way of designing for productivity, as instead of defining which features are most important, the focus is on giving more control to the occupants to increase comfort.

Fewer studies have investigated the effect of the office environment on productivity in longitudinal, within-subjects designs. Agha-Hosseini et al. (2013) conducted a longitudinal study with occupants relocating to a new office building, although the comparisons made were between groups, not within-subjects, and they found higher self-rated productivity and increased environmental satisfaction after the relocation. Meijer et al. (2009) used within-subjects analyses in a longitudinal study of an innovative office redesign (paperless, ABW office). The latter study showed increases in perceived productivity measures (quantity and quality of work) from 6 to 15 months; however, there were no significant differences between productivity measures when comparing baseline and 15 months post-implementation. Employees may have needed time to adjust to the new way of working, and there was an initial decrease in productivity at the 6-month post-implementation measure. One longitudinal within-subjects study has provided compelling evidence that productivity can be affected by dissatisfaction with the office environment. Lamb and Kwok (2016) conducted a study over eight months ( $N = 114$ ), using surveys to measure occupants' thermal comfort, lighting

comfort, noise annoyance, work performance, and wellbeing. Inadequate aspects of the IEQ were classified as environmental stressors, and they found that these stress factors reduced self-reported productivity and objectively measured cognitive performance by between 2.4% and 5.8% in most situations, and by up to 14.8% in rare cases. The above longitudinal studies provide evidence that mainly supports the argument that environmental satisfaction affects productivity.

Enriching environments with plants and art, and increasing environmental control, have led to increased productivity in experimental laboratory and field studies (Knight & Haslam, 2010; Nieuwenhuis et al., 2014). Nieuwenhuis et al. (2014) conducted a series of studies in call centres and used call handling time as a productivity measure. There was no effect on this measure of productivity in their study, which involved the addition of plants to the office; however, the authors argued that using time as a measure of call handling productivity may not be meaningful. Therefore, they conducted a more controlled study using a task-based measure of productivity, which did show that tasks were completed faster and without increasing the error rate. In a series of two studies also investigating the impact of enriching an environment with plants and art, enriched environments resulted in productivity increases, and greater control (allowing participants to design their office) led to further improvements (Knight & Haslam, 2010). Productivity was lower between the increased control condition and one in which control was removed by the experimenter altering changes that the participant had made to the office design. The above studies used experimental designs and provide strong evidence that enriching offices with plants and allowing occupants to have input into the design can result in productivity gains. Similar experimental research is needed to investigate other office design features' impacts on productivity.

The reviewed studies provide evidence to support a relationship between office satisfaction and productivity; however, more longitudinal and experimental research should be conducted. The few longitudinal studies reviewed provide support for the view that environmental satisfaction affects productivity. In the main, the research conducted uses cross-sectional methods and relies on regression analyses. Associations between productivity and the environment could be accounted for by other factors not measured in the studies. Different environmental factors appear to be important in predicting productivity in studies, and this may be due to employees' needs and their perceptions of flaws in their workplace environment. In addition, studies often use self-report measures of productivity, as it is difficult to measure knowledge workers' productivity objectively.

### 3.2.6 Collaboration

Collaboration may be an indicator of social wellbeing and also may be related to productivity in offices where information sharing is important. The most researched factor in office design and collaboration is the effect of office layout, specifically open-plan offices.

It is generally believed that knowledge sharing should be better facilitated in open-plan office environments (J. Kim & de Dear, 2013; Pejtersen et al., 2006); however, this belief does not appear to be supported by the literature review. There is some evidence which suggests that open-plan environments may harm collaboration, teamwork, and communication (Brennan et al., 2002; R. L. Morrison & Macky, 2017; Morrison & Stahlmann-Brown, 2021; Otterbring et al., 2018; Parkin, Austin, Pinder, Baguley, & Allenby, 2011), and one study reported no effect on collaboration (Pejtersen et al., 2006). In addition, J. Kim & de Dear (2013) found that the benefits of ease of interaction in an open-plan environment were smaller than the detrimental effects of increased noise level and decreased privacy in a large cross-sectional study ( $N = 42,764$ ). Furthermore, open-plan office occupants' level of satisfaction with ease of interaction was no greater than private office occupants', although there were low levels of dissatisfaction for ease of interaction for all office types, so it may not have been a salient issue for these participants. The above studies suggest that open-plan offices may be detrimental to collaboration.

In a qualitative study using group interviews of occupants in ABW offices, aspects of the office design that impacted negatively and positively on social wellbeing were found (Colenberg, Appel-Meulenbroek, et al., 2021). ABW offices are largely open-plan, so they may have similar advantages and disadvantages to open-plan offices in regard to collaboration. In the interviews, occupants mentioned negative points commonly discussed in the literature, such as lack of privacy and noise. They also mentioned some positive social wellbeing aspects of the ABW environment, such as spontaneous interactions with colleagues while moving around the office. The authors suggested several factors to facilitate social wellbeing in ABW offices, including change management and participatory design, supporting privacy, identity marking and a sense of community, and a diversity of informal interaction spaces and quiet areas.

Some studies have looked at the relationship between collaboration, density, and architectural accessibility (openness, visibility; Sundstrom et al., 1980). In three cross-sectional studies ( $N = 85, 30,$  and  $98$ ), practically no relationship was found between architectural accessibility and social interaction among co-workers (Sundstrom et al., 1980). Sundstrom et al. (1980) found there was no



relationship between physical accessibility and contact with colleagues; however, there was an increase in supervisor contact with increased physical accessibility. In a more recent cross-sectional study with a larger sample size ( $N = 2,301$ ), the dimension *social support and feedback* was measured, which the researchers considered may be an important component of knowledge sharing (Pejtersen et al., 2006). The analysis showed that social support and feedback was independent of office size (i.e. increasing number of occupants in an office). In a cross-sectional study of occupants in different office types ( $N = 271$ ), employees working in smaller (3 - 9 co-workers), or medium-sized (10 - 20 co-workers), open-plan offices reported lower ease of interaction with colleagues than those in shared (1- 2 co-workers) or private offices (Otterbring et al., 2018). These studies do not provide support for the theory that more open-plan environments, with increased accessibility to colleagues, result in greater collaboration.

Communication may be hindered in a more open environment, as found in case studies ( $N = 32$  and  $27$ ) describing academics' satisfaction in two environments (Parkin et al., 2011). One of the environments provided allocated workstations in shared/open-plan areas, whereas the other environment provided allocated workstations in private offices. Both environments had additional areas provided for different types of work (e.g., meetings, private work). In the open-plan environment, some of the academics reported that they felt it was difficult to speak on the phone or have meetings, because of interrupting their colleagues or being overheard in an open environment. While some academics felt the open-plan environment increased the possibility of informal interaction and knowledge sharing, others voiced a reluctance to communicate due to concerns of disturbing colleagues. Although there were alternative areas in the open-plan environment that could be used for privacy and meetings, the occupants provided some reasons that they did not use these (e.g., drawing attention to confidential discussions, needing to transfer work from the desk). In contrast, academics in the environment that provided private offices had higher levels of satisfaction with support for collaboration and privacy. These case studies provide a rich account of difficulties associated with communication in open-plan environments and support previous quantitative research indicating that people prefer privacy. It is also worth noting that occupants reported limited use of the alternative working areas, and possibly, this highlights a training requirement and a need for a shift in the occupants' accustomed way of working.

In addition to hampering communication, open-plan environments may have negative effects on teamwork and colleague relationships. A small longitudinal study ( $N = 21$ ) found some evidence that there was more dissatisfaction with team member relations after relocation to an open-plan office,

and this became worse over time (Brennan et al., 2002). Similar negative results were found in a cross-sectional study ( $N = 1,000$ ) that compared psychosocial demands and resources in employees in private and shared offices (R. L. Morrison & Macky, 2017). R. L. Morrison and Macky (2017) discovered that the work environment with the highest level of demands (distrust, distractions, uncooperative behaviours, and negative relationships) was open-plan offices, with flexi-desking open-plan environments having the most demands. Furthermore, occupants in more shared environments (open-plan, flexi-desking) did not report higher level of friendships and had lower perceived supervisor support. Decreased privacy and dissatisfaction with employee relationships may be unintended negative outcomes of open-plan offices.

Attempts to design for collaboration may be unsuccessful. One small longitudinal study, consisting of 18 occupants that relocated and 51 that did not (fewer completed questionnaires and interviews), investigated the outcomes associated with an effort to design for increased collaboration among researchers in a university (Lansdale et al., 2011). Researchers who moved to a high-quality open-plan environment from “drab and cramped” (Lansdale et al., 2011, p. 408) shared offices reported environmental satisfaction but behaviourally did not collaborate more. The university designed a large non-territorial, open-plan accommodation for PhD and research staff, with one of the aims being increased collaboration. A smaller-scale pilot room was designed, and a sample of researchers moved into the test area for a year. The researchers’ old accommodation was in shared offices (eight or more occupants) with high partitions and provided limited space for interaction. The pilot room was open-plan and consisted of several different areas for different tasks. There was a shared desk policy in the pilot room, and occupants were provided with laptops to work on. Although the researchers were satisfied with their new environment, the behavioural data showed that there was no evidence of increased interaction, and attendance decreased over 12 months. Some complaints made by occupants were regarding noise distractions and loss of privacy. Comments were made about distracting social conversations and concerns that talking would disturb others, and there were no reports of increased useful work-related interactions. Other areas that may have been used for interaction, for example, a break-out area with sofas, were used rarely, which suggests the possibility that simple provision of facilities may not be enough for people to change working practices. This study provides some insight into the failure of the design to achieve the objective of increased collaboration, with occupants finding collaboration difficult due to decreased privacy in the open environment.

In another longitudinal study of professional workers ( $N = 31$ ) relocating from private to open-plan offices, it was found that there was no increase in collaboration, and cooperation became less pleasant and direct (Kaarlela-Tuomaala et al., 2009). There was also a significant decrease in privacy. The researchers commented that, in this study, the participants were conducting mainly individual work, so frequent collaboration was not required. They suggested that open-plan environments may be more suitable for certain job types, but not others.

A more positive result was found in a cross-sectional study (relocated occupants  $n = 127$ , non-relocated occupants  $n = 144$ ) comparing occupants who moved from a 1970s cubicle-based office to a more open-plan office, with occupants who did not relocate (McElroy & Morrow, 2010). McElroy and Morrow (2010) found that occupants who moved to the new office space reported more collaboration and co-worker satisfaction than those who did not move. Several changes were made in the new office building (meeting areas added, reduced partition height, changes to furniture and décor, less space per workstation), so it is not possible to identify which changes were responsible for the employees' perception of increased collaboration. In addition, employees who moved felt that the organisation's culture was significantly less formal, based more on professional control, and more innovative. The participants were not randomly assigned to conditions, so there is a possibility that there were some differences in the occupants that relocated, which may have affected the results. Possibly, the perceptions of increased collaboration could be related to the decrease in partition height allowing visual accessibility to colleagues, and also the addition of meeting areas may have contributed.

While the interaction and office layout literature focuses more on the individual's workstation, in an open-plan environment there are also shared areas to consider (Hua, Loftness, Heerwagen, & Powell, 2011). In a study by Hua et al. (2011) with 308 office workers in 27 offices, there were certain characteristics of workplace spatial settings that were associated with perceived support for collaboration. More perceived support for collaboration was reported for closer distance to the nearest meeting room from the workstation, greater distance to the shared kitchen/coffee area from the workstation, and a higher proportion of the floor space dedicated to shared service and amenity areas. Furthermore, floor-plan layout variables were more significant predictors of perceived support for collaboration than workstation variables, such as density and partition height. Hua et al. (2011) advised that a desirable office design for collaboration would ensure short distances from workstations to meeting areas, and good acoustic isolation in meeting areas to stop them from becoming distractions in the workplace. This study offers a unique angle as compared to

other research, as the researchers considered a more holistic view of the workplace, encompassing all of the areas that the employees use. Caution should be exercised, as this study was non-experimental, and collaboration could reflect other variables, such as the management and culture of the offices.

Few studies measure collaboration objectively, and most are based on occupants' self-reports. Bernstein and Turban (2018) conducted two quasi-field experimental studies ( $N = 52$ ,  $N = 100$ ), where they compared occupants' face-to-face interactions (using sensors which captured location, who they were interacting with, audio, body movement and posture), emails, and instant messaging before and after they transitioned to an open-plan environment. In open-plan environments, face-to-face interactions decreased in both studies (by approximately 70%), and electronic communication (emails, instant messages) increased. Furthermore, the authors highlighted the finding that occupants interact face-to-face with different people than they interact with via email, and therefore, an environment that reduces face-to-face interaction may result in loss of collaboration with individuals outside of occupants' email networks. Reasons why people do not appear to collaborate in more open environments need to be investigated further. For example, one qualitative study revealed several mechanisms that employees in an open-plan office used to avoid collaboration in a building designed for collaboration (Irving, Ayoko, & Ashkanasy, 2020). It is possible that simply providing a more open-plan environment that appears to be conducive to collaboration may not achieve the desired results.

Research on collaboration in the office design literature focuses on the effect of open-plan layouts. Overall, the evidence indicates that open-plan environments do not improve collaboration, although there are exceptions to this (McElroy & Morrow, 2010). In fact, the literature suggests that privacy may be important for communication, and a lack of privacy can prevent people from having conversations (Parkin et al., 2011). In addition, open-plan offices are associated with complaints of noise and distractions, which is related to a lack of privacy. As open-plan office design is a trend that is likely to remain, alternative arrangements for privacy in open-plan offices should be investigated. Occupants may need training in new ways of working, as previous research has indicated that alternative areas may not be utilised (Lansdale et al., 2011). Hua et al. (2011) investigated the overall office layout's effect on collaboration and found spatial variables were important. As discussed by Hua et al. (2011), it is important to provide areas for collaboration while preventing noise and distraction from disturbing employees (e.g. by moving noisy activities away from workstations). Further research needs to be done in this area to investigate how collaboration can be improved in

modern offices. As with much of the office design and wellbeing literature, the focus is on cross-sectional research, and within-subject research showing the effect of office design on collaboration is needed.

### 3.2.7 Cognitive functioning

As an attempt to measure knowledge workers' productivity, some researchers use cognitive functioning tests (e.g., proofreading, memory tests, reaction time tests). These tests are used to emulate knowledge workers' tasks and act as an objective measurement of productivity. Primarily, research has addressed the effect of noise on cognitive functioning. Difficulty in concentration has been reported to be a main consequence of noise in shared and open-plan office workers (Di Blasio et al., 2019). In open-plan offices, both noise levels and intelligibility of speech may impact cognitive performance and perceived disturbance (Schlittmeier & Liebl, 2015). Noise is an issue in open-plan offices, and it is important to understand how noise affects office workers' cognitive ability. A recent systematic review of studies investigating the effect of the indoor environment, which included office studies as well as other settings, such as schools, concluded that, in general, poor IEQ is associated with reduced cognitive function (Wang et al., 2021). The authors of this review commented that there are some inconsistencies in the literature, possibly owing to several factors, including different approaches to measuring cognitive function, varied levels of IEQ levels, and other confounding/mediating factors.

Some studies have compared high distraction conditions (i.e. more noise) in lab environments, or normal distraction conditions in open-plan environments, with quiet conditions (Banbury & Berry, 1998; Jahncke et al., 2011; Purdey & Leifer, 2012; Seddigh, Stenfors, et al., 2015; Smith-Jackson & Klein, 2009). In noisy and distracting conditions, there is impairment of reaction time, decision making, learning, and memory (Banbury & Berry, 1998; Jahncke et al., 2011; Purdey & Leifer, 2012; Seddigh, Stenfors, et al., 2015). Noise in offices may be from speech, or other background noise, such as noise from printers and phones. A series of three laboratory experiments found both speech and noise without speech impaired memory for prose and mental arithmetic tasks (Banbury & Berry, 1998). In contrast, one study showed some performance decrements on a cognitive task in a quiet condition compared to an intermittent speech condition, which the authors attributed to under-arousal in the quiet condition (Smith-Jackson & Klein, 2009). In a within-subjects repeated measures design study ( $N = 527$ ), decrements in memory in normal distraction conditions compared to quiet were shown to be higher in large vs smaller open-plan offices (Seddigh, Stenfors, et al., 2015). Contrary to expectation, private offices had higher performance decrements than small and

medium-sized open-plan offices (Seddigh, Stenfors, et al., 2015). Seddigh, Stenfors, et al. (2015) suggested that there is a possibility that distractions in private offices are higher than expected due to various interruptions, such as emails. The researchers also considered that open-plan office occupants may have developed coping mechanisms to deal with distractions. The experimental studies mentioned are short-term, and longer-term effects of noise and distractions may be different. For example, it has been suggested that occupants may habituate to noise, although one study found no evidence of habituation based on length of time working in the office and reported disruption from noise (Banbury & Berry, 2005).

Other features measured in connection with cognitive function are ambient conditions, enriched offices (plants and art), and environmental control. As mentioned previously, adverse ambient conditions (noise annoyance, lighting, and thermal comfort) reduced cognitive performance in one field study (Lamb & Kwok, 2016). Lighting and temperature levels affected cognitive task performance in a small lab study, with temperature accounting for the most variation (Vimalanathan & Babu, 2014). In an experiment assessing cognitive function and thermal discomfort, it was found that accuracy and speed of the computerised task showed a decreasing trend in thermal discomfort; however, most of the measures of performance on the task were not significantly different (Lan et al., 2010). The participants' ratings of workload increased during thermal discomfort, and the researchers suggested that participants were able to maintain performance due to increased effort in the adverse conditions. Increased workload and fatigue, and lower motivation have been shown in studies measuring functioning on cognitive tasks in noisy environments (Jahncke et al., 2011; Smith-Jackson & Klein, 2009). It is possible that in brief tasks, participants are able to work harder, and their performance is unaffected; however, in an actual workplace situation, this increased effort may be difficult to sustain. Studies investigating cognitive function in the reviewed literature generally use fairly simple tasks such as memory tests and proofreading documents. One study used a test that assessed higher-order decision making with 24 professional-grade employees in a double-blind investigation into the effect of working in green building air quality conditions vs conventional building air quality conditions (Allen et al., 2016). There was an average increase in cognitive functioning of 61% and 101% in two green conditions. As well as a negative effect of the office environment on cognitive function via dissatisfactory environmental conditions, there may also be office features that can contribute positively to cognitive performance. Studies have shown faster performance of tasks in offices enriched with either plants (Nieuwenhuis et al., 2014), or plants and artwork (Knight & Haslam, 2010). Environmental control over the design of the office has also been linked to increases in performance in laboratory studies (Knight & Haslam, 2010).

Adverse environmental conditions, such as noise and distraction, and unsatisfactory ambient conditions have been shown in the reviewed literature to mainly reduce performance on cognitive tasks (Jahncke et al., 2011; Lamb & Kwok, 2016; Purdey & Leifer, 2012; Seddigh, Stenfors, et al., 2015). Some studies have shown an increase in workload (Lan et al., 2010; Smith-Jackson & Klein, 2009) and fatigue (Jahncke et al., 2011) during the completion of cognitive tasks in adverse environmental conditions (noise and thermal discomfort). Enrichment of offices and environmental control have been linked with faster performance of cognitive tasks (Knight & Haslam, 2010; Nieuwenhuis et al., 2014). The reviewed research was mainly experimental and conducted over short durations. Less is known about the impact of the physical office environment on cognitive functioning over longer times and with occupants performing their usual tasks. Reported increases in workload and fatigue in lab studies during short cognitive tasks suggest that longer-term exposure to adverse conditions could have a more detrimental impact on performance.

Table 3.1. *Summary of Wellbeing Outcomes and Relationships to Office Design*

<b>Wellbeing outcomes</b>	<b>Relationship to office design</b>
<b>Comfort</b>	The relationship between comfort and satisfaction with IEQ satisfaction differs with personal, social, and building factors (Bluyssen, Aries & van Dommelen, 2011; Sakellaris et al., 2016). Some evidence suggests that the salience of IEQ factors may increase when they are perceived as unsatisfactory (J. Kim & de Dear, 2012). There is a large body of research focusing on comfort of ambient conditions, and fewer studies investigate the impact of comfort of furnishings on occupant wellbeing outcomes. The reviewed literature indicates that ambient conditions affect occupant comfort.
<b>Environmental and job satisfaction</b>	Satisfaction with the indoor environment is generally associated with job satisfaction (Carlopio, 1996; Newsham et al., 2009; Veitch et al., 2007; Wells, 2000). Some studies did not find a significant relationship between overall environmental satisfaction and job satisfaction, but found links between satisfaction with certain aspects of the environment (environmental control, speech privacy) and job satisfaction (P. J. Lee et al., 2016; Y. S. Lee & Brand, 2005). Lower job satisfaction has been associated with open-plan or ABW offices, as compared with private offices (Bergström et al., 2015; Berthelsen et al., 2018; Bodin Danielsson & Bodin, 2008; De Croon et al., 2005; Leder et al., 2016; Otterbring et al., 2018). Evidence suggests that improving open-plan environments may result in higher job satisfaction (Agha-Hosseini et al., 2013; Hongisto et al., 2016). Further research should be conducted using experimental or longitudinal designs.
<b>Mental wellbeing</b>	Few studies investigate mental wellbeing in relation to office design. The reviewed literature suggests that uncomfortable ambient conditions can affect mood adversely (Gou et al., 2015; Lan et al., 2010; Lamb & Kwok, 2016), while positive lighting appraisals may have a beneficial impact on mood (Küller et al., 2006, Veitch et al., 2013). Increased number of occupants per office (density) and lack of privacy appear to have a negative impact on mental wellbeing (Bridger & Brasher, 2011; Herbig et al., 2016). A non-significant trend towards worse affective states in more open environments has been reported in one study (Otterbring et al., 2021), and higher subjective wellbeing has been found in private offices in another study (Lütke Lanfer et al., 2021). Environmental satisfaction has been linked with mental wellbeing (Dreyer et al., 2018; Klitzman & Stellman, 1989; Lütke Lanfer et al., 2021). Further research is required, particularly experimental and longitudinal designs.
<b>Health and sickness absence</b>	There is some evidence of lower self-reported health in open-plan offices (Bodin Danielsson et al., 2014; Pejtersen et al., 2006; Pejtersen et al., 2011), but this is mainly cross-sectional data, so there may be confounding variables. One study reported the opposite effect (Meijer et al., 2009); however, the office was activity-based working (ABW) and not a traditional open-plan office. Recent trends in reducing sedentary working via ABW and sit-stand desks show initial promising results (e.g., Candido et al., 2019; Chambers et al., 2019), although further research is needed in this area.



Table 3.1. (continued)

<b>Wellbeing outcomes</b>	<b>Relationship to office design</b>
<b>Productivity</b>	The literature highlights the difficulty in measuring productivity in offices, with many using perceived productivity. There is evidence to suggest that the indoor environment affects productivity (e.g., Al Horr, Arif, Kaushik, et al., 2016; J. Kim et al., 2016), although more experimental and longitudinal research is needed. Experimental research has shown increases in productivity when the office is enriched (plants, art) and/or occupants have input into the design (Knight & Haslam, 2010; Nieuwenhuis et al., 2014). Longitudinal office intervention studies (redesign, relocation) showed improvement in productivity in one study (Agha-Hosseini et al., 2013), and mixed results in another (Meijer et al., 2009). Strong evidence exists that unsatisfactory ambient conditions reduce productivity (Lamb & Kwok, 2016). In open environments, increased distractions and lower privacy may decrease productivity (Morrison & Stahlmann-Brown, 2021).
<b>Collaboration</b>	There is a lack of evidence to show support for increased collaboration in open-plan offices. Some evidence suggests that open-plan environments may have a negative effect on collaboration, teamwork, and communication (Brennan et al., 2002; R. L. Morrison & Macky, 2017; Morrison & Stahlmann-Brown, 2021; Otterbring et al., 2018; Parkin et al., 2011), and one study reported no effect on collaboration (Pejtersen et al., 2006). Improvements in collaboration were shown in participants moving from cubicle offices to a more open-plan office (McElroy & Morrow, 2010). Face-to-face interactions reduced, and electronic communications increased in occupants after moving to more open-plan offices (Bernstein & Turban, 2018). Shared areas may be important for collaboration (Hua et al., 2011). Privacy appears to be important for collaboration (Lansdale et al., 2011; Parkin et al., 2011), and office design interventions to improve collaboration in open offices should be evaluated (e.g. private meeting areas).
<b>Cognitive functioning</b>	There is evidence that cognitive functioning is reduced in high noise/distraction environments (e.g., Jahncke et al., 2011; Purdey & Leifer, 2012; Seddigh, Stenfors, et al., 2015), although one study found some performance impairments in a quiet condition vs an intermittent speech condition (Smith-Jackson & Klein, 2009). Adverse ambient conditions have been linked with reduced cognitive performance (Lamb & Kwok, 2016), while improved cognitive performance has been found in higher air quality conditions (Allen et al., 2016). Workload and fatigue have increased in some studies with noise and thermal discomfort (Jahncke et al., 2011; Lan et al., 2010; Smith-Jackson & Klein, 2009). Enrichment of offices and environmental control have been linked with faster performance of cognitive tasks (Knight & Haslam, 2010; Nieuwenhuis et al., 2014). The longer-term effects of environmental conditions on cognitive functioning should be researched, as well as the impact of the physical environment on cognitive function using workers' normal tasks.

### 3.3 Individual differences

The reviewed literature has investigated some individual differences, which may influence how occupants perceive their workplace environment. These factors include age/generation, gender, stimulus screening ability, and personality. The literature will be discussed below and is summarised in Table 3.2.

#### 3.3.1 Age/generation

There is some research that has investigated how wellbeing outcomes are affected by office design in different age groups.

Generation differences were reported in a study assessing occupant satisfaction after moving to a more open-plan office (McElroy & Morrow, 2010). Decreases in office space and increases in distraction in the open-plan environment were felt to a much lower degree among Millennials (those born after 1976; 30 years or younger in the sample) than Gen Xers (born between 1965 and 1976; 31 to 42 years in the sample) and Boomers (born before 1965; over 42 years in the sample). In addition, Millennials who moved to the more open-plan environment were much more positive about the layout of the office and meeting spaces, when comparing it to the previous office. Generation Y employees (born in the 1980s and early 1990s) in Finland call centres were found to be positive about open-plan offices in thematic interviews (Rasila & Rothe, 2012). The Generation Y call centre workers ( $N = 20$ ) tended to perceive the typical open-plan office problems identified in the literature but felt that negative aspects were “trade-offs” (p. 362) for positive benefits, e.g. having a social environment. This result is likely affected by the occupation of the participants (call centre workers), and reactions may be different in office workers with higher requirements for focused work and privacy. In contrast, younger participants (under 34 years) in a Middle East study considered the office environment to have more of a negative impact on their productivity compared to older participants (Haynes, Suckley, & Nunnington, 2017). In the latter study, older workers were significantly more positive about the impact of social interaction areas (e.g., refreshment areas, canteen) on their productivity. The evidence suggests that different generations may have contrasting evaluations of the office environment.

Several differences have been found in IEQ satisfaction in different age groups. In a study in an academic open-plan office, age differences in satisfaction with IEQ were evident even in a young

sample (Kang et al., 2017). Researchers aged 24 to 35 had significantly lower satisfaction with lighting and noise, as compared to the younger group of researchers, aged less than 24 years. In a US study using post-occupancy questionnaire data ( $N = 2,275$ ), less satisfaction with IEQs was shown by a middle-age group (35 - 54 years), as compared to younger and older groups (Bae, Asojo, & Martin, 2020). Varying IEQ preferences for different age groups have also been shown in a study where the IEQ was measured at occupants' workstations (Choi & Moon, 2017). Some small effects were found for higher age and lower acoustic quality, and higher disturbances from speech ratings in open-plan offices (Roskams et al., 2019).

Differences in age groups may be less than previously thought, as some environmental perceptions, such as privacy, did not significantly differ between younger and older employees in a study of 1,106 office workers in Helsinki, Finland (Rothe, Lindholm, Hyvönen, & Nenonen, 2012). On the other hand, the study found that older participants felt it was more important to be able to adjust furniture and ambient conditions, whereas office environments that supported team working and socialising were more important for younger participants.

Further research is needed in this area; however, the reviewed studies indicate there may be different IEQ preferences and perceptions of office environments, dependent on age or generation.

### 3.3.2 Gender

Gender differences have been shown in some studies, with some evidence of different IEQ requirements and reactions to office layouts.

An association has been found with higher levels of building-related health symptoms and lower office satisfaction in females (D. H. Kim & Bluysen, 2020). Female researchers in an open-plan environment were more comfortable than males at warmer temperatures (Kang et al., 2017). In addition, females had significantly higher requirements for ventilation, and there was a non-significant trend towards higher requirements for personal space, and a higher sensitivity to conversation noise. Some statistically significant gender differences in IEQ preferences (aspects of air quality and lighting) were shown in a study that measured the physical environment objectively (Choi & Moon, 2017). In a study of ABW offices in Turkey, females were more sensitive to environmental factors (e.g. noise and visual exposure) and were less satisfied with the office's clean-desk policy (Göçer et al., 2018). Increased noise annoyance from irrelevant speech noise was reported more by females than males in open-plan offices (Di Blasio et al., 2019), while gender was

not a significant predictor of acoustic discomfort in another open-plan study (Roskams et al., 2019). More psychological and physical discomfort was reported by women in a study in the Netherlands (Aries et al., 2010). In contrast to the above results generally indicating higher IEQ requirements for females, female office workers in a Middle East study perceived the office environment had a more positive impact on their productivity as compared to male employees (Haynes et al., 2017). In the latter study, females had more positive perceptions of the impact of an interaction factor (e.g. proximity to managers and colleagues) on productivity.

Office type may have a different impact on genders. Some research has indicated that women may feel more observed in open-plan offices (Hirst & Schwabenland, 2018; R. L. Morrison & Smollan, 2020), and this may lead to adjustments such as changing how they dress at work (Hirst & Schwabenland, 2018). Females have also been reported to have lower environmental satisfaction in an open-plan office (Yıldırım et al., 2007). Gender differences were found in a prospective study investigating sick leave in different office types (Bodin Danielsson et al., 2014). Women had a higher risk of short sick leave (7 days or less) in open-plan offices, whereas men had an increased risk in flex-offices (ABW with no allocated workstation). For long sick leave (greater than 7 days) women had a higher risk in large open-plan offices (greater than 24 people per room), and men had a higher risk of greater total number of sick days in flex-offices. Office type has been shown to have a significant relationship with workplace conflicts in women, but not in men, with increased workplace conflicts reported in two types of ABW offices (flex and combi; Bodin Danielsson, Bodin, Wulff, & Theorell, 2015). Interestingly, one survey study of mainly open-plan office workers found that men and women had similar perceptions of office noise but used different coping strategies, with men more likely to change desks or put music on, and women preferring to speak to colleagues about the issue or work more quietly (Appel-Meulenbroek et al., 2021).

Although few studies have been conducted and further investigation is required, the research suggests IEQ needs and preferences, and wellbeing in different office layouts may vary according to gender.

### 3.3.3 Stimulus screening ability

The research provides some preliminary evidence to suggest that some individuals are affected less in a distracting environment, at least regarding productivity, job satisfaction, and perceived crowding. *Stimulus screening* in studies has referred to the effectiveness of participants' ability to cope with environmental stimuli and maintain focus (Maher & von Hippel, 2005; Oldham, 1988). In

one study ( $N = 109$ ), difference in stimulus screening ability was a significant determinant of employees' reactions to the open-plan workplace (Maher & von Hippel, 2005). Employees in the open-plan office with better stimulus screening ability had higher performance and job satisfaction. An earlier study found that employees with low levels of stimulus screening experienced bigger decreases in perceived crowding after moving to a low-density open-plan office, or one with partitioning (Oldham, 1988). Individual differences in the ability to conduct focused work in distracting environments may be important to consider when designing offices, as some employees may prefer, and work more productively, in quieter and less distracting surroundings.

#### 3.3.4 Personality

There is little academic research studying personality in reference to workplace design and wellbeing outcomes. There has been some interest in how introverted people may react to different office types, generated by a popular book (Cain, 2013). Seddigh, Berntson, Platts, and Westerlund (2016) investigated the effect of interaction of personality and office type on self-rated measures of distraction, job satisfaction, and job performance. Regression analyses were conducted on data from 1,205 occupants in five organisations. Few interactions were observed in the cases of performance and job satisfaction, suggesting that personality may not affect how productive or satisfied workers are in particular office types. An exception to this was the finding that while conscientious employees, in general, had higher self-rated job satisfaction, their satisfaction was lower in open-plan compared with private offices. There were interactions observed in the case of personality traits and office type on the level of distraction reported. Both agreeableness and openness to experience were related to higher levels of self-rated distraction in open-plan compared to private offices. Lower distraction ratings were reported by more emotionally stable workers, especially those working in flex offices.

A survey study about noise and coping strategies in offices found that personality (levels of extraversion and neuroticism) did not change the perception of noise, but high extroverts favoured different noise coping mechanisms than medium extroverts (Appel-Meulenbroek et al., 2021). Evidence for a lack of effect of extraversion on noise perception has been reported in open-plan office workers (Roskams et al., 2019). In contrast, another survey study found that personality (particularly extraversion and neuroticism) did affect noise perception; however, approximately 18% of the sample worked from home and approximately 12% in private offices, which may explain the differing result (Oseland & Hodsman, 2018).

At present, there is insufficient evidence to make any conclusions about any interaction between personality and the physical office environment on wellbeing outcomes.

Table 3.2. *Summary of Individual Differences in Wellbeing Outcomes and Relationships to Office Design*

<b>Individual differences</b>	<b>Relationship to wellbeing in office design literature</b>
<b>Age/generation</b>	Further research is needed in this area, but some studies have shown that age groups may have different requirements for IEQ and varying perceptions of office environments (e.g., Bae et al., 2020; Choi & Moon, 2017; Kang et al., 2017; McElroy & Morrow, 2010).
<b>Gender</b>	The reviewed literature shows some evidence there may be gender differences in IEQ requirements (Aries et al., 2010; Choi & Moon, 2017; Bodin Danielsson et al., 2014; Di Blasio et al., 2019; Kang et al., 2017; D. H. Kim & Bluysen, 2020), and reactions to open-plan and ABW environments (Bodin Danielsson et al., 2015; Göçer et al., 2018; Hirst & Schwabenland, 2018; R. L. Morrison & Smollan, 2020). In addition, one study has shown different sickness rates by gender and office type (Bodin Danielsson et al., 2014). Further research is required.
<b>Stimulus screening ability</b>	Two studies provided preliminary evidence that stimulus screening ability may affect reactions to a distracting environment (Maher & von Hippel, 2005) and perceptions of crowding (Oldham, 1988).
<b>Personality</b>	There is little research in this area. One study showed little support for any interaction between personality and office type on wellbeing outcomes (Seddigh et al., 2016). Another study showed that different noise coping behaviours were used dependent on levels of extraversion (Appel-Meulenbroek et al., 2021). There is mixed evidence in regard to an effect of personality on noise perception (Appel-Meulenbroek et al., 2021; Oseland & Hodzman, 2018; Roskams et al., 2019). Further research is required.

### 3.4 Discussion

Several wellbeing outcomes have been researched in the office design and wellbeing literature. Overall, evidence suggests there is an association between occupant wellbeing and satisfaction with the office environment. The literature consists of mainly cross-sectional research, and this may affect conclusions made, as other factors such as management, job, and individual differences, could be partly responsible for the results. More experimental studies should be conducted, such as office redesign and refurbishment studies, to assess wellbeing change within individuals when environmental satisfaction declines or increases. The wide range of wellbeing outcomes used in studies and different measurement tools to assess these outcomes makes comparisons difficult between studies. Of the wellbeing outcomes measured, much of the research focuses on comfort, and less is known about the effects of the environment on mental wellbeing.

The reviewed literature shows that features of office design, and satisfaction with the office, may impact occupants' comfort, job satisfaction, physical health, and mental wellbeing. The review has highlighted some negative impacts that the environment has had on occupant wellbeing, such as increased sickness in open-plan offices and negative moods associated with adverse IEQ conditions. There have also been some associations of positive wellbeing outcomes with the office environment, such as the link between increased environmental satisfaction and job satisfaction. In general, adverse IEQ conditions and open-plan offices appear to be detrimental to occupant wellbeing, while satisfaction with the office environment and private offices are linked with better wellbeing outcomes. While open offices have been associated with poorer wellbeing outcomes, it should also be noted that offices may vary considerably, and there may be differences between outcomes in poorly designed, lower quality open-plan offices vs carefully designed, modern open-plan offices.

Concerning productivity, the reviewed literature provides evidence that supports an effect of the physical environment, although the measurement of productivity in office workers is difficult. Studies have mainly used perceived productivity and performance on cognitive tasks to measure productivity. In experiments designed to assess performance in open-plan environments with noise and distractions, noise has generally been linked with decreased cognitive functioning (Jahncke et al., 2011; Purdey & Leifer, 2012; Seddigh, Stenfors, et al., 2015). Open-plan environments have been associated with decreases in self-rated productivity (Herbig et al., 2016) and sickness absence (Bodin Danielsson et al., 2014). Some studies have shown increased productivity after improvements to the office environment were made (Agha-Hosseini et al., 2013; Knight & Haslam, 2010; Nieuwenhuis et al., 2014). There is strong evidence to indicate that inadequate aspects of IEQ reduce self-reported

productivity and objectively measured cognitive performance by approximately 2 – 6% (Lamb & Kwok, 2016), which highlights the potential economic impact of unsatisfactory office conditions. More research needs to be done in this area; however, the reviewed evidence suggests that productivity may be impacted by level of satisfaction with the indoor environment, and noise minimisation is an important factor to consider in office design to maximise productivity.

A challenge for future research into wellbeing and office design is how office design can support communication and knowledge sharing among workplace occupants. Although more open-plan workplaces were intended to encourage collaboration, this has not been supported in the literature. In some studies, there are complaints about privacy and confidentiality in open environments, which can inhibit occupants from discussing matters (Parkin et al., 2011). There has been some interesting preliminary research into collaboration and configuration of the entire office area (Hua et al., 2011), which suggests that consideration of the office layout, including shared areas, may be important. Previous studies in academic environments have shown that the provision of areas for confidential conversations, and areas for collaborative group work, have not been successful, with these areas not being utilised by occupants (Lansdale et al., 2011; Parkin et al., 2011). These initiatives may require additional training so that occupants understand their use, or more input from occupants, to ensure user acceptability and functionality. Important office design considerations to support collaboration are measures to increase privacy (e.g., private offices, partitions, rooms for confidential discussions, increased space per workstation) and provision of shared and meeting areas. Care needs to be taken to ensure that shared and collaborative areas do not cause extra noise and distractions for employees conducting focused work, for example, by using acoustic isolation (Hua et al., 2011).

In the past, there has been a focus on preventing harm through office design; however, there is recent interest in designing offices to support, or improve, wellbeing and health (Forooraghi, Miedema, Ryd, & Wallbaum, 2020; Roskams & Haynes, 2020; Ruohomäki et al., 2015). It has been proposed that existing knowledge about workplace design could be used to create environments that support employees with mental health problems, and are preventative (Veitch, 2011). Lessons could be learned from successful office designs. Positive wellbeing outcomes have been found in studies after relocation or refurbishment, resulting in higher quality, more satisfactory office environments (Agha-Hosseini et al., 2013; Hongisto et al., 2016). A recent review of office design and health recommended a more holistic approach to office design, addressing a variety of environmental variables and occupant health outcomes, and incorporating salutogenic features



(Forooraghi et al., 2020). There is a need for further research that investigates features of the office environment that can support or improve wellbeing, and testing of office interventions, to provide practical design recommendations for wellbeing.

### 3.4.1 Conclusion

This chapter discusses research investigating wellbeing outcomes in the office and design literature. Summarising evidence on this topic is confounded by methodological issues, such as fewer experimental studies than cross-sectional studies, and differences in outcomes and measurement tools used in the assessment of wellbeing. While acknowledging these weaknesses, there is a body of evidence that has found links between wellbeing outcomes and the office environment. Some wellbeing outcomes have been studied more than others, and further research is needed to examine the relationship between office design and wellbeing. Considering much of the literature uses cross-sectional methods, other wellbeing predictors may have affected results. Therefore, stronger research designs controlling for other wellbeing predictors should be used to investigate the effect of office design on wellbeing outcomes.

In the next chapter, the relationship between satisfaction with the office environment and occupant wellbeing will be investigated using regression analyses of data from Study 1, a cross-sectional study. In the regression equations, other predictors of wellbeing will be controlled to investigate the relationship while accounting for possible confounders.

### 3.4.2 Industrial partner summary

#### *Wellbeing*

There is evidence to indicate an association between environmental satisfaction and occupants' wellbeing outcomes. The focus of the research is on cross-sectional studies, and more investigation is needed using pre and post office design intervention studies. In addition, use of different measurement tools makes comparisons difficult between studies.

#### *Productivity*

Productivity is difficult to measure in office environments and studies typically use perceived productivity or cognitive task performance as proxy measures. The literature suggests that improving occupants' environmental satisfaction and addressing noise disturbances may improve productivity.

#### *Collaboration*

There is a lack of evidence to show support for increased collaboration in open-plan offices. As collaboration is seen to be important for productivity, more research should be done in this area to understand how offices can be designed to improve collaboration. The studies reviewed suggest that office design for collaboration should consider shared areas for informal meetings, where discussions can occur without disturbing others, and areas for confidential conversations.

## 4 Association of environmental satisfaction and employee wellbeing when controlling for other wellbeing predictors

In Chapters 2 and 3, the office design and wellbeing literature was reviewed. This chapter will describe Study 1, an online questionnaire study that was conducted to gather data measuring UK office occupants' environmental satisfaction, wellbeing outcomes, and predictors of wellbeing. In this chapter, the links between environmental satisfaction and wellbeing in Study 1 will be investigated using regression analyses. The regression analyses will establish whether environmental satisfaction predicts wellbeing outcomes when other known wellbeing predictors are controlled for. In Chapter 5, structural equation modelling (SEM) of Study 1 data will be used to test models of the relationships between UK office occupants' environmental satisfaction, predictors of wellbeing, and wellbeing outcomes. In Chapter 6, the development of a questionnaire to measure wellbeing and satisfaction with the office environment will be described, using Study 1 data.

The regression analyses in Chapter 4 include both non-work-related wellbeing predictors (e.g., healthy lifestyle, optimism) and work-related wellbeing predictors (e.g., job demands, job control/support), while the analyses in Chapters 5 and 6 focus on work-related wellbeing predictors. The author recognises that non-work-related wellbeing predictors may contribute to wellbeing at work; however, this PhD research was primarily concerned with investigating the relationship between the physical office environment and occupant wellbeing. Therefore, after the impact of non-work-related wellbeing predictors is considered in this chapter, attention will be centred on work-related variables in later analyses. Focusing on work-related variables allows a more targeted approach to answering our research questions. Work-related predictors, such as support from colleagues, may be targeted by office interventions. For example, an office redesign that allows more accessibility to colleagues could potentially alter occupants' perceptions of support from colleagues. Non-work-related predictors, such as individual differences, are unlikely to be affected by office environment changes.

### 4.1 Introduction

Many studies have found a link between office design and occupants' wellbeing, as outlined in Chapters 2 and 3. The relationship between a variety of wellbeing outcomes (e.g., health, mental wellbeing, job satisfaction) and satisfaction with different aspects of the office environment (e.g.,

open-plan offices, noise and privacy, density) have been investigated in the office design literature. It is possible that the impact of the office environment on occupant wellbeing may have been overestimated in previous research, due to studies not including other predictors of wellbeing (Herbig et al., 2016). Wellbeing at work can be related to a number of work-related characteristics, such as psychosocial work characteristics (Glaser, Seubert, Hornung, & Herbig, 2015; Mark & Smith, 2008). It seems likely that higher environmental satisfaction and wellbeing could co-exist with better working conditions, and the reported link between environmental satisfaction and wellbeing may be partly due to confounding factors. Similarly, conflicting results found in wellbeing and open-plan office research could be due to the contribution of psychosocial working conditions (Lütke Lanfer et al., 2021).

Some evidence exists that the relationship between environmental satisfaction and wellbeing remains when controlling for other variables. An older study found that the relationship between lower environmental satisfaction and poorer mental wellbeing was present when the effects of other predictors of wellbeing (demographic characteristics, occupation, and psychosocial working conditions) were accounted for (Klitzman & Stellman, 1989). Although the latter study was conducted when office environments were much different to present-day offices, it highlights that the effect of the physical environment cannot be explained entirely by a relationship with improved psychosocial conditions. In a more recent cross-sectional study of office workers in private and open-plan offices, decreased mental wellbeing was associated with environmental dissatisfaction; however, psychosocial work stressors (interruptions from colleagues, and effects of adverse working conditions on job performance quality and effort) had the strongest relation to mental health (Herbig et al., 2016). Psychosocial work resources (social support, participative safety) were linked to less reporting of negative mental health. A study investigating the impact of open-plan office design features and psychosocial factors (job demands, job resources) on subjective wellbeing and irritations found that both contribute (Lütke Lanfer et al., 2021). The latter study demonstrated a stronger contribution of job demands and resources to subjective wellbeing and irritation than features of the physical office environment (e.g., office size, desk-sharing). The studies mentioned above indicate that both environmental satisfaction and work characteristics affect employee wellbeing. To increase confidence in the link between environmental satisfaction and wellbeing, studies in this area should consider other possible confounding factors, such as work characteristics, that may impact occupants' wellbeing.

#### 4.1.1 Models of wellbeing

Models of wellbeing may help to understand the relationship between work, wellbeing, and the physical environment. In the office design and wellbeing literature, several models exist to describe the relationship between the physical environment and occupant wellbeing. Wellbeing models outside of built-environment literature may further contribute to understanding in this area.

According to Maslow's motivational theory (Maslow, 1943, 1970), humans have a hierarchy of needs that must be met beginning with physiological needs (e.g., food, water, shelter). Once physiological needs are met, the person is motivated to achieve the next need in the hierarchy, which is safety. This pattern follows with the highest needs (belongingness, esteem, self-actualisation). As needs are satisfied, they become submerged, and the next need emerges and becomes dominant. In the context of the physical environment, the workplace is most important when it fails to fulfil basic needs; otherwise, it fades into the background (Sundstrom, 1986). An important implication of this model is that, theoretically, occupants may take a satisfactory work environment for granted and only attend to it when it is unsatisfactory (Sundstrom, 1986). In 1966, Herzberg proposed the motivation-hygiene theory, which considered the physical environment to be one of several *dissatisfiers* (or hygiene factors) that could lead to dissatisfaction when conditions are unsatisfactory, or indifference when conditions are satisfactory (Miner, 2005; Sundstrom, 1986). Both Maslow's motivational theory and Herzberg's motivation-hygiene theory do not consider positive wellbeing consequences of a satisfactory physical environment (Sundstrom, 1986).

Models that theorise a positive impact on productivity and wellbeing from the physical environment have been developed by Vischer (2005, 2007). Vischer's environmental comfort model (2005, 2007; Figure 4.1), also referred to as the Habitability Pyramid, makes the distinction of three levels of comfort: physical (e.g. building safety and hygiene), functional (e.g. ergonomics), and psychological (e.g. environmental control). Physical comfort is required for an acceptable workplace, and at a higher level of comfort are functional and psychological comfort. According to the model, the physical environment is most likely to be optimally supportive of occupant performance if all three levels of comfort are satisfied. Vischer's demand-control model of workspace productivity (2005, 2007; Figure 4.2) is an adaptation of the demand-control model (Karasek, 1979; Karasek & Theorell, 1990). The demand-control model predicts that mental strain occurs with high job demands and low job control. Demands in Vischer's adapted model are the degree to which the physical environment is supportive, and control is the level of involvement occupants have in the office design. Vischer considers a workplace that is supportive of the workers' tasks to be an *energy in* condition; and a

workplace that is unsupportive to be an *energy out* condition. Social support is a key factor in the demand-control-support model (Johnson & Hall, 1988), influencing job stress and coping, and social networks may be facilitated by office design (Vischer, 2007). Vischer (2007) has proposed that a model of workplace stress may build on stress research themes, and environmental psychology themes, such as the match between user and environment, environmental control, workspace demands, social support, and territoriality.

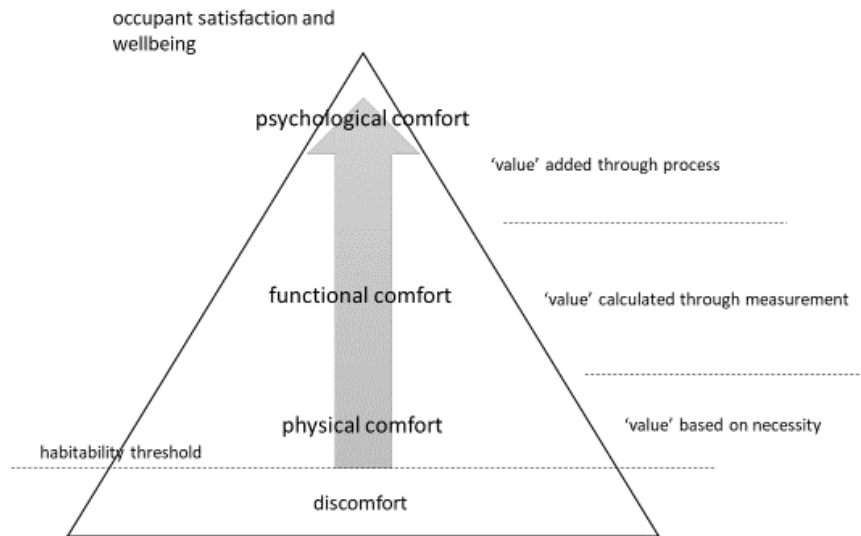


Figure 4.1. Habitability pyramid (Vischer, 2005).

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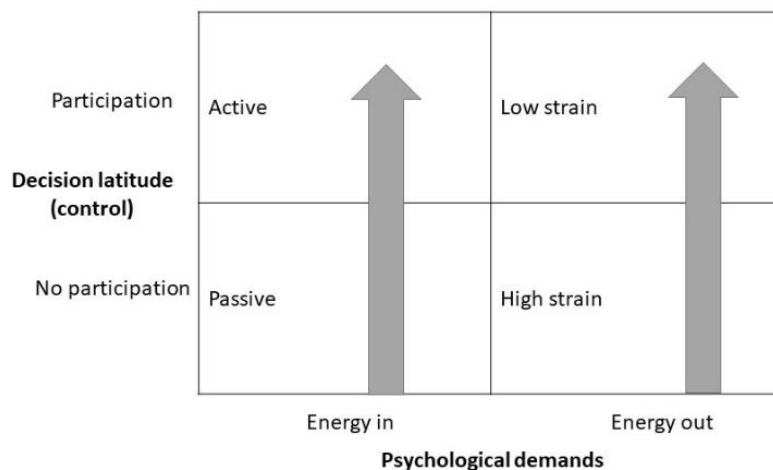


Figure 4.2. Demand-control model of workspace productivity (Vischer, 2005) after Karasek and Theorell (1990).

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The Flourish model (Clements-Croome, 2018a; UK Green Building Council, 2016) is based on the concept of environments that support optimal wellbeing. The model consists of three factors: *environmental* (standard comfort, health, and safety guidelines for ambient conditions), *perceptions and feelings* occupants have in different environments (e.g., security, happiness), and *economic consequences* of the environment (e.g., absenteeism, staff retention). The model also describes a *sparkle* layer that includes office design elements, such as views, aesthetics, colour, layout, and green spaces. The sparkle layer may be apparently small factors that elevate occupants' spirits. Environmental factors, perceptions and feelings, and the sparkle layer need to be addressed in order for people to thrive and flourish.

There are several current wellbeing process models, unrelated to office design, that consider other factors, such as individual characteristics and appraisals of stress. One such model is the Demands, Resources, and Individual Effects model (DRIVE; Mark & Smith, 2008; Figure 4.3), which incorporates work demands and resources, individual characteristics (e.g., positive personality, coping), personal resources and demands, perceived job stress, wellbeing outcomes, and job satisfaction. The DRIVE model includes features from earlier models of stress, but with more focus on individual characteristics and personal resources, such as coping styles (Smith, 2021). Wellbeing process questionnaires have been developed using the DRIVE model, including the Smith Wellbeing Questionnaire (SWELL; Smith & Smith, 2017), which was used in Study 1. These questionnaires measure both positive and negative wellbeing predictors and outcomes (Smith, 2021). For example, happiness is a positive wellbeing outcome, while anxiety and depression are negative outcomes.

The DRIVE model is useful as a theoretical framework when considering wellbeing and office design, as it incorporates research-based predictors of wellbeing, is a middle ground between simplicity and complexity, and has flexibility to allow inclusion of other factors (Mark & Smith, 2008). The impact of other potential wellbeing predictors may be assessed while controlling for the effect of established predictors (Smith, 2021). Several factors, including hassles, flourishing, and rumination, have been studied using this approach which increases the model's prediction of wellbeing (Smith, 2021). In the present study, selected work-related wellbeing predictors are used from the DRIVE model, and environmental satisfaction is included as another predictor of wellbeing. The impact of environmental satisfaction on wellbeing will be measured using the method described above, controlling for previously established wellbeing predictors.

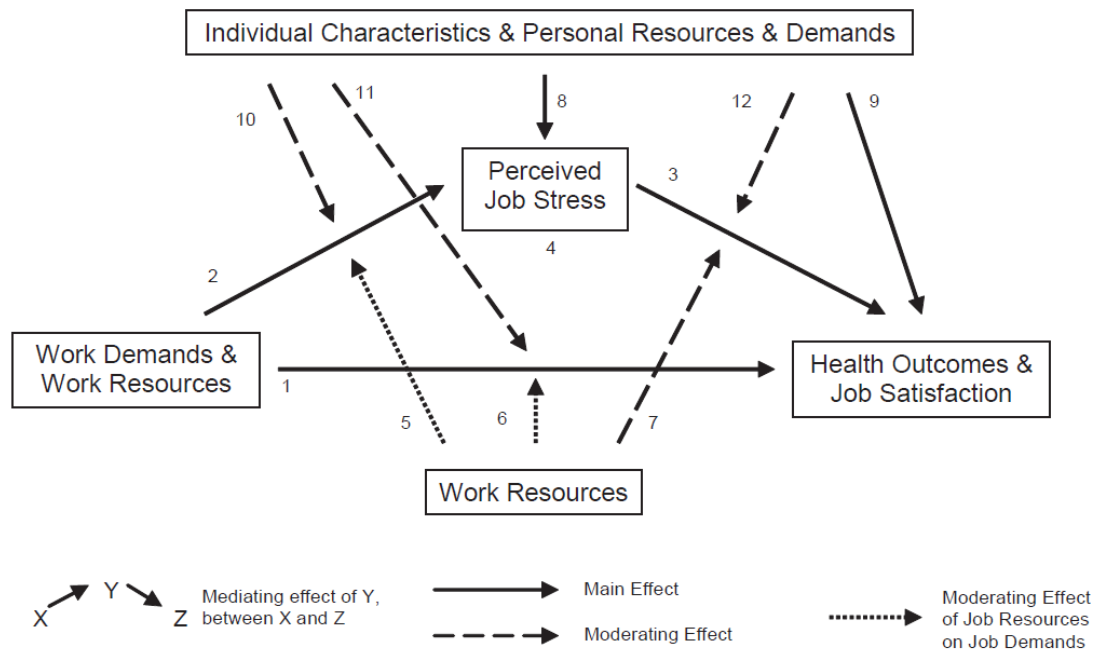


Figure 4.3. The DRIVE model (Mark & Smith, 2008).

From "Stress models: A review and suggested new direction," by G.M. Mark and A.P. Smith, in J. Houdmont and S. Leka (Eds.), *Occupational health psychology: European perspectives on research, education and practice* (Vol. 3, p. 134), 2008, Nottingham, UK: Nottingham University Press. Copyright 2008 by Nottingham University Press.

#### 4.1.2 Positive and negative wellbeing outcomes

Research suggests that positive and negative wellbeing outcomes should be measured separately rather than making speculations on one based on the other (Smith, Wadsworth, Chaplin, Allen, & Mark, 2011). In a cross-sectional study conducted using the SWELL, Smith and Smith (2017) used multiple regression analyses that demonstrated high job demands and lack of job control/support were predictors of stress at work (negative wellbeing outcome). High job control/support was a predictor of job satisfaction (positive wellbeing outcome), which in turn predicted happiness at work. Anxiety/depression was linked to a lack of control/support and stress at work. Their study highlighted the importance of including positive, and negative, wellbeing outcomes and predictors in wellbeing research. Their results also showed that positive wellbeing predictors were linked to positive wellbeing outcomes, and negative wellbeing predictors were associated with negative wellbeing outcomes. To account for the relationship between environmental satisfaction and wellbeing, it is necessary to also measure the impact of known wellbeing predictors (e.g., job control, support from colleagues, and work demands).



#### 4.1.3 Regression approach

In this chapter, regression analyses will be used to test the relationship between environmental satisfaction and wellbeing. Multiple regression analysis is used to investigate the relationship between a dependent variable (DV) and several independent variables (IVs; Tabachnick & Fidell, 2013). While the term correlation is used when the aim is to assess the relationship between the DV and the IVs, the term regression is used when the aim of the analysis is prediction (Tabachnick & Fidell, 2013). The regression analyses in this chapter will investigate environmental satisfaction, and individual and work characteristics, as predictors of wellbeing. In standard multiple regressions, all IVs are entered into the model at the same time (Tabachnick & Fidell, 2013). The contribution of each IV to predicting the DV is evaluated in terms of additional contribution not predicted by the other IVs. This approach is suitable for examining the predictive value of environmental satisfaction for work-related wellbeing, as it will demonstrate the unique contribution of environmental satisfaction. Regression analyses are common in the office design and wellbeing literature, as much of the research is cross-sectional, and has investigated the predictive value of various aspects of the environment for wellbeing outcomes.

#### 4.1.4 Aims and hypotheses

The present study aimed to investigate the relationship between UK office occupants' environmental satisfaction, and positive and negative wellbeing outcomes, when controlling for known wellbeing predictors. Chapters 2 and 3 indicated that environmental satisfaction is associated with wellbeing. Specifically, dissatisfaction with the environment is linked with negative outcomes, while satisfaction with the environment is linked with positive outcomes. Multiple regression analyses will test this relationship, using wellbeing predictors and outcomes from Study 1. Based on the results of previous research, relationships between positive wellbeing predictors and outcomes, and negative wellbeing predictors and outcomes are anticipated (Smith & Smith, 2017). Accounting for other known predictors of wellbeing in the relationship between environmental satisfaction and wellbeing will be more robust than previous studies that do not account for these factors.

*Hypothesis 1.* Office environmental satisfaction and positive wellbeing predictors are linked with greater positive wellbeing outcomes.

*Hypothesis 2.* Office environmental satisfaction is linked with lower negative wellbeing outcomes, and negative wellbeing predictors are linked with greater negative wellbeing outcomes.

## 4.2 Method

### 4.2.1 Participants

Participants were 215 office employees (108 females, 107 males) recruited by a Qualtrics panel (Table 4.1). The inclusion criteria required participants to be over 18 years old, residents of the United Kingdom, and have worked in their office for a minimum of one month prior to participating in the study. Participants received a financial incentive from Qualtrics for completing the questionnaire. The participants were a range of ages, with the median age category of 30 – 39 (37%). There was a fairly even spread of occupational groups represented, although there was greater representation in the more entry-level occupations. The majority of participants (95%) worked full time, 35 hours a week or more. More than one third (44%) had worked in their office for 2 – 5 years. Over half of the sample did not do any home working (60%), while the second biggest category was home working of up to 8 hours per week (23%). The participants were asked how many hours they worked away from the office per week, excluding home working, and over half of the sample did not do any away from the office working (61%). There were only two participants in a private office, and the remainder were in shared (17%) or open-plan offices (82%). The private office occupants were retained in the sample, as a relationship between environmental satisfaction and wellbeing was expected to exist in all office types. More participants were allocated fixed desks (78%) vs participants using flexi-desks, or hot-desking (21%). The average amount of time that participants spent at their desk per week was 79%, indicating that the occupants were predominantly desk-based.

Table 4.1. *Participant Descriptives and Office Type*

<b>Gender</b>					
Female <i>n</i> (%)			Male <i>n</i> (%)		
108 (50.2%)			107 (49.8%)		
<b>Age range</b>					
19 - 29 <i>n</i> (%)	30 - 39 <i>n</i> (%)	40 - 49 <i>n</i> (%)	50 - 59 <i>n</i> (%)	60 - 69 <i>n</i> (%)	
55 (25.6%)	79 (36.7%)	44 (20.5%)	30 (14.0%)	7 (3.3%)	
<b>Occupation</b>					
Secretary, clerk, trainee, student <i>n</i> (%)	Technician, controller, academic, consultant <i>n</i> (%)	Project leader, senior consultant <i>n</i> (%)	Director, head of department, manager <i>n</i> (%)		
87 (40.5%)	60 (27.9%)	27 (12.6%)	41 (19.1%)		
<b>Hours worked per week</b>					
Less than 35 hours a week <i>n</i> (%)			35 hours a week or more <i>n</i> (%)		
11 (5.1%)			204 (94.9%)		
<b>Years worked at their office</b>					
1 month to 1 year <i>n</i> (%)	2 years to 5 years <i>n</i> (%)	6 years to 10 years <i>n</i> (%)	Over 10 years <i>n</i> (%)		
49 (22.8%)	94 (43.7%)	30 (14.0%)	42 (19.5%)		
<b>Home working per week</b>					
None <i>n</i> (%)	1 – 8 hours <i>n</i> (%)	9 – 15 hours <i>n</i> (%)	16 – 23 hours <i>n</i> (%)	24 - 31 hours <i>n</i> (%)	32 – 40 hours <i>n</i> (%)
128 (59.5%)	49 (22.8%)	15 (7%)	8 (3.7%)	4 (1.9%)	10 (4.7%)
<b>Working away from office per week (excluding home working)</b>					
None <i>n</i> (%)	1 – 8 hours <i>n</i> (%)	9 – 15 hours <i>n</i> (%)	16 – 23 hours <i>n</i> (%)	24 - 31 hours <i>n</i> (%)	32 – 40 hours <i>n</i> (%)
132 (61.4%)	51 (23.7%)	18 (8.4 %)	7 (3.3%)	4 (1.9%)	10 (4.7%)
<b>Number of people in their office</b>					
1 person <i>n</i> (%)	2 people <i>n</i> (%)	3 - 6 people <i>n</i> (%)	7 - 28 people <i>n</i> (%)	29 - 50 people <i>n</i> (%)	over 50 people <i>n</i> (%)
2 (.9%)	5 (2.3%)	32 (14.9%)	48 (22.3%)	38 (17.7%)	90 (41.9%)
<b>Type of desk</b>					
Fixed desk <i>n</i> (%)			Flexi desk (hot desk) <i>n</i> (%)		
167 (77.7%)			44 (20.5%)		

Note. Figures do not always add up to 100% due to rounding and missing values.

## 4.2.2 Measures

Scales from the Study 1 survey used in the analysis are reported below. The Study 1 questionnaire is shown in Appendix B, Table 12.3.

### 4.2.2.1 *Demographics, office type, and ways of working*

Three demographic questions (age, gender, occupation), and 11 questions about the participants' office and way of working were included (e.g., hours worked per week, home working).

### 4.2.2.2 *Environmental satisfaction*

Twenty-nine environmental satisfaction questions were included. They were derived from environmental satisfaction research questionnaires (e.g. Veitch et al., 2007) and also from Study 2. An example question is, "What is your degree of satisfaction with the following: areas in your workplace for meetings". Items were rated on a 7-point Likert scale from 1 (*very unsatisfactory*) to 7 (*very satisfactory*).

### 4.2.2.3 *Wellbeing*

Wellbeing was measured using the Smith Wellbeing Questionnaire (SWELL; Smith & Smith, 2017). The SWELL includes 21 items, some of which are wellbeing predictors (e.g. job demands), and others which are wellbeing outcomes (e.g. work-related anxiety and depression). Furthermore, the scale measures both positive and negative wellbeing, resulting in four wellbeing components: positive predictors, positive outcomes, negative predictors, and negative outcomes. Seventeen items are rated on a 10-point Likert scale, three are binary response items (yes/no), and one is a scale response item. An example question is, "Thinking about the last 6 months: Are you anxious or depressed because of work?" rated on a scale from 1 (*never*) to 10 (*very often*).

## 4.2.3 Procedure

Participants were recruited by a Qualtrics panel. Ethics approval was granted by the School Research Ethics Committee (SREC) of Cardiff University, School of Psychology. An online questionnaire was used, including information about the study, informed consent, and a debrief. Participants were asked to indicate their consent by clicking on a button, which stated "I consent, begin the study", or "I do not consent, I do not wish to participate". In addition, there were five screening questions, which ensured only participants meeting the study criteria completed the questionnaire. At the end of the online questionnaire, a debrief was shown to participants.

## 4.3 Results

### 4.3.1 Data preparation

#### 4.3.1.1 *Environmental satisfaction*

Missing values of environmental satisfaction items were less than 3%, and medians were imputed. The total environmental score was computed by adding the scores for all 29 items and calculating a percentage. As this data was also used for structural equation modelling (SEM) analysis, reported in Chapter 5, skew and kurtosis were inspected. The score was normally distributed and did not have any concerning skew or kurtosis. Values of skew and kurtosis that are unsatisfactory for SEM can vary, and there are no clear guidelines; however, absolute values of skew greater than 3 and kurtosis above 10 may be problematic (Kline, 2011). Visual inspection of data distribution in larger samples (200 or more) to determine skew and kurtosis is recommended (Field, Miles, & Field, 2012), and the histogram and Q-Q plot revealed an approximately normal distribution. There were no outliers identified, as assessed by multiplying the Interquartile Range (IQR) by a factor of 2.2 (Hoaglin & Iglewicz, 1987).

#### 4.3.1.2 *Wellbeing*

Wellbeing missing values were less than 3%, and medians were imputed for ordinal items, and the mean imputed for one scale item (sickness absence days). Skew and kurtosis values were acceptable for SEM, although visual inspection of the histograms and Q-Q plots confirmed that some items were not normally distributed. In addition, three items (*SW14. Fatigue*, *SW17. Productivity*, and *SW21. Sickness absence days*) had outliers. Sickness absence days had nine responses above 13 days, which were capped at 13. After visual inspection of the other two items' histograms, the outliers were deemed to be genuine responses and were retained.

### 4.3.2 Descriptives

#### 4.3.2.1 *Environmental satisfaction*

Participants' satisfaction with aspects of their physical environment is shown in Table 4.2. The total average environmental satisfaction expressed as a percentage was 64%. Median responses for the 29 items were all 4 (neutral) or 5 (somewhat satisfactory). Occupants gave the highest satisfaction ratings for desk size, ability to move around at their workplace, and amount of space in their workplace. The lowest satisfaction ratings were given to wall decoration, options for working away from the desk, and plants.

#### 4.3.2.2 *Wellbeing*

Occupants' median ratings of positive work-related wellbeing outcomes, job satisfaction and happiness at work, indicated they were satisfied (Table 4.3). Both job satisfaction and happiness at work received median ratings of 6, on a scale from 1 – 10. Negative wellbeing outcomes, anxiety/depression, and stress at work had median ratings of 5 and 6, respectively. The negative wellbeing outcomes indicate that occupants experienced some stress at work but moderately low anxiety/depression. Predictors of positive wellbeing, healthy lifestyle and optimism, had median ratings of 7 and 6, respectively, indicating that occupants felt they adopted a healthy lifestyle and positive personality. Another predictor of positive wellbeing is job control/support from colleagues, which in this sample received a median rating of 6, indicating moderate satisfaction. Negative wellbeing predictors included noise at work, job demands, and shift work. Only 14% ( $n = 30$ ) of participants reported doing shift work or night working, and there was also low exposure to noise reported ( $Mdn = 3$ ). Participants reported a high amount of job demands ( $Mdn = 7$ ), indicating that they felt they had to do pressured work, work quickly, and use a lot of effort in their job.

Table 4.2. *Environmental Satisfaction Item Descriptives (N = 215, medians imputed)*

Item		<i>M</i>	<i>Mdn</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>
<b>What is your degree of satisfaction with the following:</b>						
<b>ES26</b>	Size of your desk.	5.10	5	1.42	-0.92	0.41
<b>ES25</b>	Ability to move around at your workplace.	4.92	5	1.55	-0.71	-0.04
<b>ES28</b>	Amount of space in your workplace.	4.91	5	1.47	-0.66	-0.21
<b>ES19</b>	Quality of lighting in your work area.	4.86	5	1.44	-0.60	-0.14
<b>ES3</b>	Areas in your workplace for meetings.	4.82	5	1.41	-0.55	-0.26
<b>ES7</b>	Visual appearance of your workplace.	4.81	5	1.37	-0.51	0.07
<b>ES27</b>	Distance between you and other people you work with.	4.81	5	1.51	-0.76	0.10
<b>ES2</b>	Your workplace (the office that you work in) overall.	4.80	5	1.33	-0.61	0.07
<b>ES16</b>	Cleanliness and tidiness of your workplace.	4.73	5	1.42	-0.52	-0.28
<b>ES18</b>	Quality and visual appearance of furniture in your workplace.	4.66	5	1.46	-0.50	-0.15
<b>ES1</b>	Your work area (workstation) overall.	4.66	5	1.37	-0.52	-0.16
<b>ES17</b>	Comfort of furniture in your workplace.	4.62	5	1.43	-0.41	-0.39
<b>ES10</b>	Amount of noise in your work area.	4.62	5	1.47	-0.28	-0.77
<b>ES29</b>	Your ability to personalise your work area.	4.60	5	1.60	-0.56	-0.38
<b>ES20</b>	Natural light (sunlight) in your workplace.	4.59	5	1.67	-0.65	-0.39
<b>ES4</b>	Areas in your workplace for doing work that requires focus and concentration.	4.55	5	1.51	-0.48	-0.29
<b>ES8</b>	Overall air quality in your work area.	4.53	5	1.53	-0.44	-0.42
<b>ES11</b>	Amount of noise from other people's conversations while you are at your work area.	4.47	5	1.60	-0.33	-0.65
<b>ES6</b>	Your ability to adjust or control your work area to suit your needs and preferences.	4.46	5	1.49	-0.32	-0.45
<b>ES15</b>	The amount of storage in your work area.	4.38	5	1.62	-0.29	-0.81
<b>ES12</b>	Your ability to have a private conversation in your workplace.	4.36	4	1.69	-0.29	-0.81
<b>ES9</b>	Temperature in your work area.	4.35	4	1.59	-0.13	-1.01
<b>ES21</b>	Outside view from where you sit.	4.23	4	1.89	-0.24	-1.03
<b>ES5</b>	Areas in your workplace for relaxing and taking breaks.	4.21	4	1.75	-0.22	-0.84
<b>ES14</b>	Frequency of distractions from other people.	4.13	4	1.51	-0.07	-0.72
<b>ES13</b>	Visual privacy in your work area.	4.06	4	1.66	-0.03	-0.81
<b>ES23</b>	Wall decoration including paint colour and art.	3.97	4	1.63	-0.22	-0.58
<b>ES24</b>	Ability to choose where to work in your workplace (options to work away from the desk).	3.70	4	1.79	0.02	-0.99
<b>ES22</b>	Amount of plants in your workplace.	3.69	4	1.92	0.04	-1.19
<b>Environmental satisfaction total (%)</b>		<b>64.35</b>	<b>64.53</b>	<b>15.38</b>	<b>-0.02</b>	<b>-0.08</b>

Table 4.3. *SWELL Wellbeing Item Descriptives (N = 215, medians or mean imputed)*

Item	Scale	M	Mdn	SD	Skewness	Kurtosis
<b>SW1</b> Healthy lifestyle	(1-10) not at all - very much so	6.26	7	2.09	-0.48	-0.40
<b>SW2</b> Optimism	(1-10) very negative - very positive	6.18	6	2.09	-0.46	-0.23
<b>Thinking about the last 6 months:</b>						
<b>SW3</b> How satisfied are you with life in general?	(1-10) not at all - very much so	6.05	6	2.24	-0.36	-0.46
<b>SW4</b> How much stress have you had in your life in general?	(1-10) very little - a great deal	6.63	7	2.10	-0.44	-0.34
<b>SW5</b> Would you say you are generally happy?	(1-10) not at all - very much so	6.13	7	2.12	-0.44	-0.29
<b>SW6</b> Would you say that you generally feel anxious or depressed?	(1-10) not at all - very much so	5.72	6	2.53	-0.10	-1.03
<b>SW7</b> Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)?	(1-10) not at all - very much so	3.96	3	3.06	0.62	-1.07
<b>SW8</b> Are you exposed to noise at work?	(1-10) not at all - very much so	3.67	3	2.41	0.75	-0.33
<b>SW9</b> Do you work shifts or work at night?	yes = 1/no = 2	1.86	2	0.35	-2.10	2.41
<b>SW10</b> How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)?	(1-10) not at all demanding - very demanding	6.33	7	2.31	-0.53	-0.19
<b>SW11</b> Do you feel you have control over your job and support from fellow workers?	(1-10) not at all - very much so	5.96	6	2.09	-0.41	-0.16
<b>SW12</b> How much stress do you have at work?	(1-10) very little - a great deal	6.01	6	2.28	-0.25	-0.56
<b>SW13</b> Are you satisfied with your job?	(1-10) not at all - very much so	5.98	6	2.22	-0.49	-0.26
<b>SW14</b> How physically or mentally tired do you get at work?	(1-10) not at all tired - very tired	6.58	7	2.19	-0.64	0.02
<b>SW15</b> Have you had an illness (either physical or mental) caused or made worse by work?	yes = 1/no = 2	1.75	2	0.43	-1.18	-0.60
<b>SW16</b> Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to?	yes = 1/no = 2	1.37	1	0.48	0.53	-1.73
<b>SW17</b> How efficiently do you carry out your work?	(1-10) not very efficiently - very efficiently	7.38	8	1.87	-1.09	1.15
<b>SW18</b> Do you find your job interferes with your life outside work or your life outside of work interferes with your job?	(1-10) never - very often	5.23	5	2.48	0.08	-0.92
<b>SW19</b> Are you happy at work?	(1-10) never - very often	5.98	6	2.17	-0.36	-0.48
<b>SW20</b> Are you anxious or depressed because of work?	(1-10) never - very often	4.80	5	2.62	0.23	-1.08
<b>SW21</b> Approximately how many days sick leave have you had in the last 12 months? (9 items capped at 13)		2.81	2	3.50	1.58	1.80



### 4.3.3 Multiple linear regressions

In a similar procedure used by Smith and Smith (2017), selected positive and negative work wellbeing outcomes were entered in regression analyses as the dependent variables. The positive outcomes variable was the sum of SWELL items *SW13. Job satisfaction* and *SW19. Happiness at work*. The negative outcomes variable was the sum of *SW12. Stress at work* and *SW20. Anxiety/depression at work*. As per Smith and Smith (2017), positive and negative wellbeing predictors were controlled for in the regressions. Positive wellbeing predictors included in the regressions were *SW1. Healthy lifestyle*, *SW2. Optimism*, and *SW11. Job control/support*. Negative wellbeing predictors were *SW8. Noise at work* and *SW10. Job demands*. The sample contained insufficient shift workers to include as a factor.

Preliminary data analyses of demographic characteristics' relationship with the dependent variables showed that age and gender were not related to positive and negative wellbeing outcomes, or environmental satisfaction, so they were not included as predictors. Job type was correlated significantly with negative wellbeing outcomes ( $p = .030$ ) and environmental satisfaction ( $p = .044$ ), but not positive wellbeing outcomes. As job type was related to both environmental satisfaction and negative wellbeing outcomes, it was included as a predictor in the regression analyses.

Standard linear multiple regressions were used to consider the contribution of IVs (predictors) to the DVs (positive and negative wellbeing outcomes). In this type of regression, an IV may have a small unique contribution and appear unimportant, even when highly correlated with the DV, as its contribution may be shared with other IVs (Tabachnick & Fidell, 2013). Therefore, it is important to also assess correlations of IVs with the DV when considering the IVs contribution. Prior to regression analysis, correlations were examined for wellbeing outcomes, environmental satisfaction, and wellbeing predictors (Table 4.4). In standard multiple regression, there should be some correlation between the independent variables and the dependent variable, but they should not be too high (preferably between .3 and .7; Pallant, 2016). The highest correlated value with positive wellbeing outcomes was environmental satisfaction (.61), and this was below the .7 value. Similarly, the highest correlated value with negative outcomes was job demands (.61), also within the acceptable range.

Table 4.4. *Pearson's Correlations for Positive and Negative Wellbeing Outcomes, Environmental Satisfaction, and Wellbeing Predictors*

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
<b>1. Positive outcomes</b>	-							
<b>2. Negative outcomes</b>	-.33	-						
<b>3. Environmental satisfaction</b>	.61	-.33	-					
<b>4. Occupation</b>	.04	.15	.14	-				
<b>5. SW1. Healthy lifestyle</b>	.32	-.08	.29	.02	-			
<b>6. SW2. Optimism</b>	.42	-.18	.32	.09	.47	-		
<b>7. SW8. Noise at work</b>	.08	.29	-.03	.06	.18	.10	-	
<b>8. SW10. Job demands</b>	-.06	.61	-.15	.17	-.04	-.01	.22	-
<b>9. SW11. Job control/support</b>	.58	-.17	.48	.11	.27	.38	.05	.02

#### 4.3.3.1 *Positive wellbeing outcomes regression analysis*

A multiple linear regression was conducted to investigate environmental satisfaction and wellbeing predictors' relationship with positive wellbeing outcomes (Table 4.5). The total variance explained ( $R^2$ ) by the model was 51%, and the regression equation was significant,  $F(7, 207) = 30.45, p < .001$ . Environmental satisfaction, optimism, and job control/support significantly predicted higher positive wellbeing outcomes. Occupation, healthy lifestyle, noise at work, and job demands were not significant predictors of positive wellbeing. Environmental satisfaction ( $\beta = .40$ ) and job control/support ( $\beta = .32$ ) were stronger predictors than optimism ( $\beta = .16$ ).

Table 4.5. *Regression Analysis for Wellbeing Predictors' and Environmental Satisfaction's Prediction of Positive Wellbeing Outcomes*

	<i>B</i>	<i>SE B</i>	$\beta$	<i>t</i>	<i>p</i>
<b>(Constant)</b>	-0.99	1.19		-0.83	0.409
<b>Environmental satisfaction</b>	0.11	0.02	.40	6.89	< .001***
<b>Occupation</b>	-0.26	0.18	-.07	-1.42	.157
<b>SW1. Healthy lifestyle</b>	0.07	0.11	.04	0.65	.516
<b>SW2. Optimism</b>	0.31	0.12	.16	2.72	.007**
<b>SW8. Noise at work</b>	0.10	0.09	.06	1.12	.265
<b>SW10. Job demands</b>	0.00	0.09	.00	0.00	.998
<b>SW11. Job control/support</b>	0.63	0.12	.32	5.41	< .001***

\*  $p < .05$

\*\*  $p < .01$

\*\*\*  $p < .001$

Problems with multicollinearity, a strong correlation between two or more predictors, can be a cause for concern when conducting multiple regression (Field, 2013). Typical cutoff values used to determine the presence of multicollinearity are tolerance values of less than .10, or variance inflation factor (VIF) values of above 10 (Pallant, 2016). Tolerance values were .69 or greater, and VIF values were all below 1.5, indicating no concerns for multicollinearity. Inspection of the probability plot (P-P) and scatterplot of the regression standardised residuals showed that assumptions of normality, linearity, and homoscedasticity, between predicted DV scores and errors of prediction, were met (Pallant, 2016; Tabachnick & Fidell, 2013). There was one outlier identified with a standardised residual value of  $-3.58$ , which was above the acceptable value of around  $\pm 3.3$  (Tabachnick & Fidell, 2013). When an outlier is found, a maximum Cook's Distance of 1 or greater indicates the case may be a problem for the regression model (Pallant, 2016). This unusual case did not affect the model, as observed by a maximum Cook's Distance of .1, a value less than 1.

#### 4.3.3.2 *Negative wellbeing outcomes regression analysis*

A separate multiple linear regression was conducted to investigate environmental satisfaction and wellbeing predictors' relationships with negative wellbeing outcomes (Table 4.6). The total variance explained ( $R^2$ ) by the model was 48%, and the regression equation was significant,  $F(7, 207) = 27.75$ ,  $p < .001$ . Environmental satisfaction and optimism significantly predicted lower negative wellbeing outcomes in the model. Noise at work and job demands significantly predicted higher negative wellbeing outcomes. Occupation, healthy lifestyle, and job control/support did not have significant relationships with negative wellbeing outcomes. The job demands variable was the strongest predictor of negative wellbeing ( $\beta = .53$ ).

Table 4.6. *Regression Analysis for Wellbeing Predictors' and Environmental Satisfaction's Prediction of Negative Wellbeing Outcomes*

	<b>B</b>	<b>SE B</b>	<b><math>\beta</math></b>	<b>t</b>	<b>p</b>
<b>(Constant)</b>	7.95	1.33		5.98	< .001***
<b>Environmental satisfaction</b>	-0.06	0.02	-.19	-3.23	.001**
<b>Occupation</b>	0.37	0.20	.09	1.82	.071
<b>SW1. Healthy lifestyle</b>	0.09	0.13	.04	0.73	.467
<b>SW2. Optimism</b>	-0.28	0.13	-.13	-2.20	.029*
<b>SW8. Noise at work</b>	0.32	0.10	.17	3.27	.001**
<b>SW10. Job demands</b>	1.04	0.10	.53	10.08	< .001***
<b>SW11. Job control/support</b>	-0.14	0.13	-.07	-1.10	.273

\*  $p < .05$

\*\*  $p < .01$

\*\*\*  $p < .001$

There were no multicollinearity concerns identified, with tolerance values all at .69 or greater, and VIF values all below 1.5. The P-P and scatterplot of the regression standardised residuals revealed the distribution met assumptions of normality, linearity, and homoscedasticity. There were no outliers identified with all standardised residual values below  $\pm 3.3$  (Tabachnick & Fidell, 2013).

## 4.4 Discussion

The predicted relationship between environmental satisfaction and wellbeing outcomes was found in this study. Positive wellbeing outcomes (happiness at work, job satisfaction) were predicted by greater environmental satisfaction, and negative wellbeing outcomes (stress at work, anxiety and depression related to work) were predicted by lower environmental satisfaction. In addition, the expected relationships between positive wellbeing predictors and outcomes, and negative wellbeing predictors and outcomes, were mainly observed. Positive wellbeing outcomes were predicted most strongly by environmental satisfaction and job control/support. Optimism also significantly predicted positive wellbeing outcomes, but to a lesser degree. Job demands was the strongest predictor of negative wellbeing outcomes, while noise at work was a weaker predictor. There were no a priori assumptions made about the effect of positive wellbeing predictors on negative wellbeing; however, the data revealed that optimism predicted lower negative wellbeing outcomes. The regression analyses in this chapter show that environmental satisfaction was linked with wellbeing outcomes in a model including other psychosocial factors. The relationship found between environmental satisfaction and wellbeing outcomes, when the effects of certain wellbeing predictors are controlled, has been demonstrated in other studies (Klitzman & Stellman, 1989; Lütke Lanfer et al., 2021). Similar to previous research, job demands was a stronger predictor of negative wellbeing than dissatisfaction with the physical office environment (Herbig et al., 2016).

### 4.4.1 Wellbeing predictors and outcomes

This study provides further evidence of the links between positive wellbeing predictors and outcomes, and negative wellbeing predictors and outcomes. This result has been found in a previous study by Smith and Smith (2017). In Smith and Smith, positive and negative wellbeing outcomes were included in the regression models as single items, as opposed to in the present study, where positive and negative outcomes were both summed scores from two items. In the present analysis, a healthy lifestyle and job type were not significant predictors of positive or negative wellbeing. Psychosocial work characteristics (job demands, job control/support) were stronger predictors of wellbeing outcomes than optimism. The results indicate that psychosocial work characteristics were important for occupant wellbeing in this sample, more so than individual characteristics, such as positive personality. As highlighted by other researchers, design for occupant wellbeing should consider targeting work characteristics (Herbig et al., 2016; Lütke Lanfer et al., 2021).

#### 4.4.2 Environmental satisfaction and wellbeing

The results show that environmental satisfaction predicts positive and negative wellbeing, above the effects of other established wellbeing predictors. Some studies in the office design literature have failed to measure other variables associated with wellbeing outcomes, such as work demands and resources, and this may have resulted in a limited view of the relationship between environmental satisfaction and wellbeing. Lack of consideration of the relationship between environmental satisfaction and other predictors of wellbeing can cause difficulty in discerning whether the effect of environmental satisfaction on wellbeing is related to another confounding factor. The question could be raised that unsatisfactory environmental conditions may be related to other variables, such as poorer psychosocial working conditions, which in turn could cause poorer wellbeing. The results from this study lend support for the view that environmental satisfaction has an impact on wellbeing, separate from the contribution of work demands and resources. Several other studies have also found that the relationship between environmental satisfaction and wellbeing outcomes exists when other working characteristics (e.g., psychosocial factors, organisational wellbeing) are considered (Klitzman & Stellman, 1989; Lütke Lanfer et al., 2021; Wells, 2000).

#### 4.4.3 Implications for models of work wellbeing

The present study's findings may be compared with models of wellbeing discussed earlier in this chapter. Maslow's motivational theory (1943, 1970) and Herzberg's motivation-hygiene theory (1966) do not outline any impact of the physical environment on positive wellbeing outcomes. It has been suggested that people may flourish when several conditions are met (Clements-Croome, 2018a), including environmental satisfaction, and the present study provides evidence that there is a link between environmental satisfaction and increased wellbeing. The results of this study agree with Vischer's demand-control model of workspace productivity (2005) theory that an unsupportive environment could be demanding for occupants, as lower ratings of environmental satisfaction predicted greater negative wellbeing outcomes. Modern wellbeing process models, such as the DRIVE model (Mark & Smith, 2008), provide a more complex model of the interaction between various wellbeing predictors and outcomes. In the DRIVE model, wellbeing is affected by work demands and resources, individual characteristics (e.g. optimism), and personal resources and demands. The present study controlled for the former two factors, but not the latter, personal resources and demands. Work demands and resources, and individual characteristics, were shown to predict wellbeing outcomes in this study. The impact of optimism on work-related wellbeing was

lower in the regression analyses than psychosocial work characteristics (job control/support and job demands) and environmental satisfaction.

Environmental satisfaction is not included in work wellbeing process theories, and the results of the present study and other research indicate that it is associated with work-related wellbeing outcomes. Therefore, a wellbeing theory that includes the concept of environmental demands from Vischer's model, and additional wellbeing predictors (e.g. job demands and support from colleagues) from wellbeing process models, may be best for explaining wellbeing in an office environment. This conclusion supports Vischer's (2007) argument that a model of workspace stress should build on themes from stress research and environmental psychology.

#### 4.4.4 Conclusion

In regression analyses of Study 1 data, environmental satisfaction predicted higher positive wellbeing outcomes, and lower negative wellbeing outcomes, when controlling for other known predictors of wellbeing. The effect of environmental satisfaction appears to be separate from the impact of the psychosocial work environment and individual factors, such as a healthy lifestyle and positive personality. In Chapter 5, the relationship between environmental satisfaction, wellbeing predictors, and wellbeing outcomes will be examined using an SEM approach. The next chapter will investigate a model to illustrate the pathways between work wellbeing predictors, environmental satisfaction, and work-related wellbeing outcomes.

#### 4.4.5 Industrial partner summary

In Study 1, environmental satisfaction of UK office workers predicted higher positive wellbeing and lower negative wellbeing, above the effects of other established wellbeing predictors.

## 5 The relationship between employee wellbeing and environmental satisfaction: A structural equation modelling (SEM) approach

In Chapter 4, multiple regression analyses using Study 1 data revealed that the relationship between wellbeing and satisfaction with the office environment remained after the effects of other wellbeing predictors were controlled. In the present chapter, structural equation modelling (SEM) of Study 1 data will be used to test theoretical models of the pathways between environmental satisfaction, and work-related wellbeing predictors and outcomes. Using SEM will enable goodness of fit assessment of theoretical models, as well as permit inclusion of latent (unobserved) variables and testing of several pathways at once. Environmental satisfaction will be included in the model as both a predictor of wellbeing and a mediating variable in the relationship between wellbeing and other wellbeing predictors.

### 5.1 Introduction

It was mentioned in Chapter 4 that much of the previous research has not accounted for other factors in the relationship between satisfaction with the office environment and wellbeing. The multiple regression analyses in Chapter 4 included other wellbeing predictors and found the relationship remained, and environmental satisfaction had a unique impact. This chapter will use SEM to extend the previous chapter's results by testing how these variables interact in a model explaining the relationship between environmental satisfaction and work-related wellbeing outcomes. The structural equation models will include work-related wellbeing predictor and outcome constructs identified in prior exploratory factor analyses (EFAs).

In the following section, the relationship between satisfaction with the office environment and the main wellbeing outcomes in the chapter's models (mental wellbeing, job satisfaction, and productivity) will be described. Studies of particular interest to this discussion are those which test models of environmental satisfaction and wellbeing or account for other predictors in the analyses.



### 5.1.1 Environmental satisfaction and wellbeing

#### 5.1.1.1 *Mental wellbeing*

As discussed in Chapter 4, some studies showing a relationship between satisfaction with the office environment and wellbeing have been cross-sectional and differences may have been partly owing to other predictors of wellbeing, such as psychosocial factors. Previous research has shown that there is a relationship between mental wellbeing and satisfaction with the office environment when psychosocial factors are controlled (Klitzman & Stellman, 1989; Lütke Lanfer et al., 2021). In one study, the relationship between work demands was found to be more closely related to mental health than environmental dissatisfaction (Herbig et al., 2016), and it is clear that other variables need to be considered in the relationship between environmental satisfaction and mental wellbeing. In the latter study, only certain aspects of environmental satisfaction were measured (privacy, acoustics, control), and other environmental features known to affect mental wellbeing were not included. Using a limited range of items to measure office satisfaction may have affected the strength of the relationship between mental health and environmental satisfaction. In the present analysis, a broader measure of environmental satisfaction will be used, and the relationship between mental wellbeing and work-related wellbeing predictors will be tested.

#### 5.1.1.2 *Job satisfaction*

As mentioned in Chapter 3, several studies have found positive associations between environmental satisfaction and job satisfaction (Carlopio, 1996; Newsham et al., 2009; Veitch et al., 2007; Wells, 2000), although some studies have not found a significant relationship (P. J. Lee et al., 2016; Y. S. Lee & Brand, 2005). In a frequently cited SEM analysis by Veitch et al. (2007), overall environmental satisfaction significantly predicted job satisfaction. Overall environmental satisfaction was measured with two questions, one that measured general environmental satisfaction, and the other that measured how productive employees were in the environment. Part of the link may have been explained by a relationship between job satisfaction and productivity, which has been demonstrated in another SEM analysis (Y. S. Lee & Brand, 2005). In the cross-sectional study by Veitch et al. (2007), other predictors of wellbeing were not considered, and the relationship may have been affected by additional variables, such as psychosocial work characteristics. In the office design literature, several studies have identified that more open-plan offices are associated with reduced job satisfaction (De Croon et al., 2005). Otterbring et al. (2018) used multiple mediation analysis to show a relationship between more open-plan offices and reduced job satisfaction, which was mediated by the ease of interaction with colleagues and *subjective wellbeing* (a measure comprising affective and office satisfaction items). The literature suggests that job satisfaction is affected by environmental

satisfaction and office type; however, the relationship is likely more complex, as shown in the latter study, and researchers should consider including other variables in their analyses.

Some studies have investigated the relationships between environmental satisfaction, organisational wellbeing, and job satisfaction (Newsham et al., 2009; Wells, 2000). Newsham et al. (2009) found that environmental satisfaction was significantly linked with job satisfaction in a mediated regression analysis, and this association was mediated by satisfaction with management and compensation. Wells (2000) used an SEM analysis that found environmental satisfaction significantly predicted job satisfaction, which in turn, significantly predicted wellbeing. Similar to Newsham et al.'s (2009) study, environmental satisfaction and job satisfaction predicted organisational wellbeing, which contained some items about the social climate (e.g. supportive interactions with co-workers).

In contrast to other studies, Y. S. Lee and Brand (2005) did not find a significant relationship between environmental satisfaction and job satisfaction in an SEM analysis; however, environmental control was a significant predictor of job satisfaction. The authors queried whether a mediating variable, not included in their model, may have explained the lack of relationship. In their model, fewer items were used to measure environmental satisfaction than environmental control, and the environmental control questions could arguably be considered a form of environmental satisfaction. Therefore, the contradictory result may be an artefact of the way that environmental satisfaction was measured. In the model, one variable named *group cohesiveness* measured aspects of teamwork (e.g. whether colleagues like one another and work well together). Environmental control had a significant positive influence on both job satisfaction and group cohesiveness, and group cohesiveness positively predicted job satisfaction. This study demonstrates that a form of environmental satisfaction (environmental control) predicted job satisfaction in a model that also incorporated psychosocial factors (group cohesiveness). Similarly, in another SEM study that did not find a relationship between environmental satisfaction and job satisfaction, speech privacy was a significant predictor of job satisfaction (P. J. Lee et al., 2016). The latter two studies highlight that the link between job satisfaction and environmental satisfaction may depend upon the way that the model is constructed, and how environmental satisfaction is measured. The studies both showed that aspects of environmental satisfaction predicted job satisfaction, but overall environmental satisfaction was not a predictor.

While the relationship between job satisfaction and environmental satisfaction appears in several studies, the link could be explained by higher quality environments co-existing with more

satisfactory job characteristics. Some SEM studies have included organisational wellbeing outcomes and have shown environmental satisfaction predicts job satisfaction even when accounting for organisational wellbeing. In these studies, organisational wellbeing measures may include items assessing work demands and resources, in conjunction with other variables, thus causing difficulty in assessing their individual contribution to relationships. However, these studies do indicate that the relationship between environmental satisfaction and job satisfaction endures when including other work-related variables. In addition, some studies have used limited measures of environmental satisfaction when testing the relationship between environmental satisfaction and job satisfaction. The relationship between environmental satisfaction and job satisfaction should be investigated using other predictors of wellbeing, such as work demands and resources, as well as more in-depth measures of environmental satisfaction.

#### 5.1.1.3 *Productivity*

Satisfaction with the office environment is generally thought to increase employees' wellbeing and productivity (Agha-Hosseini et al., 2013; Clements-Croome, 2018b). Some research suggests that the relationship between environmental satisfaction and productivity may involve other variables and pathways. In a multi-level model (MLM) analysis, Lamb and Kwok (2016) found that unsatisfactory environmental conditions (i.e. thermal comfort, lighting comfort, and noise annoyance), classified as *stress factors*, were associated with reductions in self-reported productivity and objectively measured cognitive performance. In addition, environmental stress factors decreased occupant wellbeing, which caused indirect reductions in work performance. Therefore, environmental satisfaction, wellbeing, and productivity were interrelated. One factor that is thought to be detrimental to productivity in open-plan offices is exposure to distractions. In an SEM analysis, distractions did not significantly impact productivity; however, environmental control predicted job satisfaction, which in turn was linked to higher productivity (Y. S. Lee & Brand, 2005). The latter studies (Lamb & Kwok, 2016; Y. S. Lee & Brand, 2005) provide evidence to suggest that the relationship between environmental satisfaction and productivity is likely more involved than merely the direct effect. In the current analysis, productivity will be included in a model with other wellbeing outcomes, environmental satisfaction, and wellbeing predictors.

#### 5.1.2 *Models of wellbeing*

In Chapter 4, some models were described to aid in conceptualisation of the relationship between the physical office environment and wellbeing. Mention was made of Vischer's (2005) adaptation of the demand-control model (Karasek, 1979; Karasek & Theorell, 1990) to explain the effect of a

demanding/supportive environment and personal control on the productivity of workers. This model is important to the development of the present structural equation models, as it proposes that the environment can either increase or decrease productivity. The Demands, Resources, and Individual Effects model (DRIVE; Mark & Smith, 2008) was introduced as a theoretical framework to use in consideration of the process of wellbeing at work. The DRIVE model specifies 12 key relationships involved in the wellbeing process. In this study, the focus is on the effect of environmental satisfaction on wellbeing, and only one pathway of the DRIVE model will be incorporated, in favour of examining a simple model. The DRIVE model specifies that work demands and resources will significantly relate to wellbeing outcomes and job satisfaction. This key relationship will be investigated in the present study, along with environmental satisfaction as another wellbeing predictor.

### 5.1.3 Structural equation modelling (SEM) approach

SEM is used in the present study to model the relationship between environmental satisfaction and wellbeing. SEM is a statistical methodology that uses a hypothesis-testing approach to the analysis of a structural theory on a topic of investigation (Byrne, 2010). SEM is a popular multivariate statistical approach and has several advantages, such as simultaneous estimation of multiple and interrelated relationships, estimation of error variance, ability to measure relationships with both observed and unobserved factors (i.e. latent variables), and defining a theoretical model to explain the relationships among variables (Byrne, 2010; Hair, Black, Babin, & Anderson, 2018). This approach is particularly suitable for modelling the relationship between environmental satisfaction and wellbeing, due to the number of factors involved, and the likely interrelated relationships among these factors. Using SEM in this study will allow investigation of a model that accounts for the relationship between environmental satisfaction and wellbeing when including other wellbeing predictors. Several previous studies have examined different models of office environmental satisfaction and wellbeing outcomes (job satisfaction, productivity, mental and physical wellbeing) using an SEM approach, indicating this method is well-established and suitable for the topic (Carlopio, 1996; P. J. Lee et al., 2016; Y. S. Lee & Brand, 2005; Y. S. Lee & Brand, 2010; Shin, Jeong, & Park, 2018; Veitch et al., 2007; Wells, 2000).

### 5.1.4 Aims and hypotheses

The present study aimed to use SEM to test models of the relationships between UK office occupants' environmental satisfaction, predictors of positive and negative wellbeing, and positive and negative wellbeing outcomes. The first conceptual model (Environmental Satisfaction and

Wellbeing Model) relates to the former four hypotheses described below and is illustrated in Figure 5.1. The second conceptual model (Environmental Satisfaction, Job Satisfaction, and Productivity Model) relates to the latter three hypotheses and is illustrated in Figure 5.2.

#### 5.1.4.1 *Environmental Satisfaction and Wellbeing Model (conceptual model 1)*

In multiple regression analyses of the same data, reported in Chapter 4, greater environmental satisfaction was linked with higher positive wellbeing outcomes and lower negative wellbeing outcomes. This relationship is anticipated to exist in the SEM model (Hypothesis 1). Regression analyses in Chapter 4 also found relationships between positive wellbeing predictors and positive wellbeing outcomes, and negative wellbeing predictors and negative wellbeing outcomes.

Furthermore, in a previous study using the SWELL, it was found that low job control/support (a positive wellbeing predictor) was related to negative wellbeing (Smith & Smith, 2017). In the current study, Hypothesis 2 extends on the results from Chapter 4 and theorises that positive wellbeing predictors will be linked with lower negative wellbeing outcomes, and negative wellbeing predictors will be linked with lower positive wellbeing outcomes. While the latter relationship was not found in the regression analyses in Chapter 4, the methodology used in the present SEM analysis may reveal different outcomes owing to factors such as the characteristic error containment in SEM and the use of latent structures. It is expected that negative wellbeing outcomes will predict less positive wellbeing outcomes (Hypothesis 3), as employees experiencing greater negative outcomes (e.g. stress) at work are likely to have lower positive outcomes (e.g. job satisfaction). It is predicted that environmental satisfaction will act as a mediator between other wellbeing predictors and wellbeing outcomes (Hypothesis 4). It is anticipated that other wellbeing predictors will impact how satisfied occupants are with their physical office environment, and this satisfaction will, in turn, affect wellbeing outcomes.

*Hypothesis 1.* Office environmental satisfaction predicts greater levels of positive wellbeing outcomes and lower levels of negative wellbeing outcomes.

*Hypothesis 2.* Positive wellbeing predictors predict higher positive, and lower negative, wellbeing outcomes; and negative wellbeing predictors predict higher negative, and lower positive, wellbeing outcomes.

*Hypothesis 3.* Negative wellbeing outcomes are linked with lower positive wellbeing outcomes.

*Hypothesis 4.* Environmental satisfaction mediates the relationships between wellbeing predictors and outcomes.

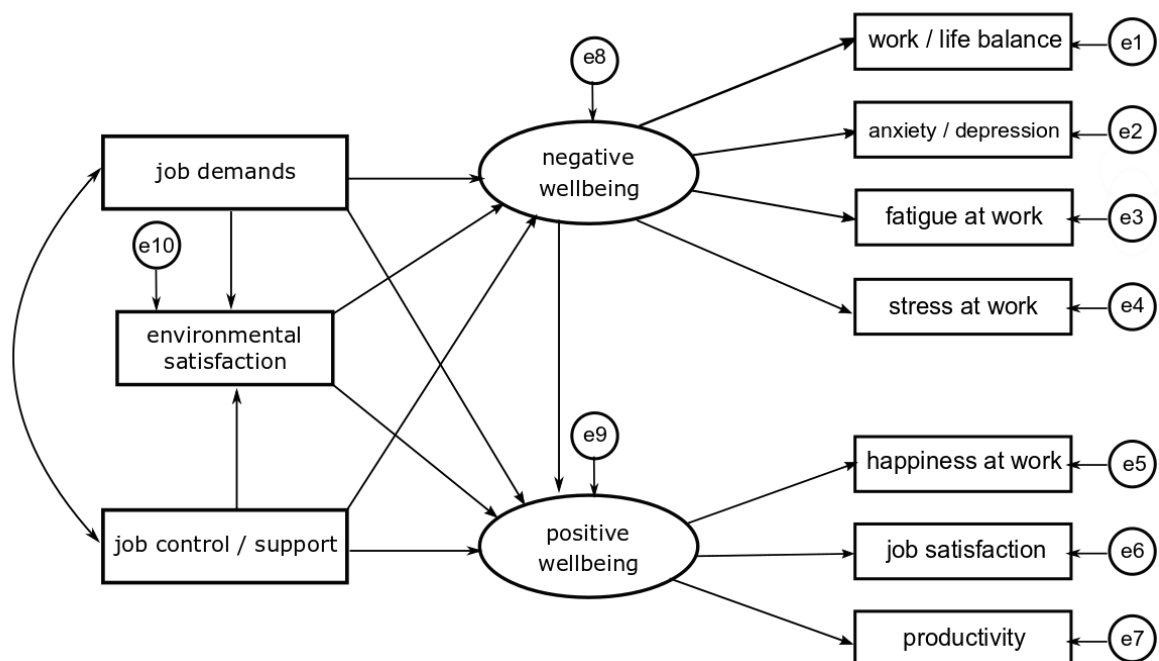


Figure 5.1. Environmental Satisfaction and Wellbeing Model (conceptual model 1).

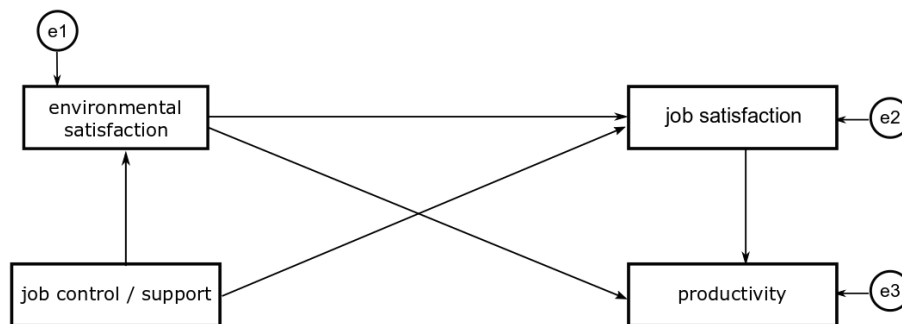
#### 5.1.4.2 *Environmental Satisfaction, Job Satisfaction, and Productivity Model (conceptual model 2)*

In the second conceptual model, job satisfaction and productivity will be examined as separate indicators, not as part of a latent construct, due to their importance in the literature. The literature review has demonstrated that environmental satisfaction is linked with job satisfaction and productivity (Hypothesis 5). It is predicted that job satisfaction will be linked with higher productivity (Hypothesis 7), as this has been demonstrated in another SEM analysis (Y. S. Lee & Brand, 2005).

*Hypothesis 5.* Environmental satisfaction predicts greater job satisfaction and productivity.

*Hypothesis 6.* Job control/support predicts greater job satisfaction.

*Hypothesis 7.* Job satisfaction predicts higher productivity.



*Figure 5.2.* Environmental Satisfaction, Job Satisfaction, and Productivity Model (conceptual model 2).

The present study seeks to use wellbeing theory and SEM to investigate the relationship between environmental satisfaction, positive and negative wellbeing predictors, and positive and negative wellbeing outcomes. To the author's knowledge, this has not been investigated in previous research.

## 5.2 Method

Participants, materials, and procedure are described in Chapter 4.

### 5.2.1 Analysis

Prior to SEM analysis, EFA of work-related wellbeing outcomes was conducted to determine latent structures. In the first stage of SEM analysis, work-related wellbeing outcome latent structures were entered into AMOS 25, and goodness of fit of the measurement model was evaluated. Then the entire hypothesised structural model, the Environmental Satisfaction and Wellbeing Model, was tested in AMOS, and modifications were made according to fit and theory. Regression pathway coefficients were reported for the final iteration of the Environmental Satisfaction and Wellbeing Model. To test relationships with environmental satisfaction, job satisfaction, and productivity, a path analysis model (Environmental satisfaction, Job Satisfaction, and Productivity Model) was constructed. This second model was necessary to examine job satisfaction and productivity as separate items rather than as part of the *Positive Wellbeing* construct in the previous structural model. The latter model was also entered in AMOS 25, and goodness of fit indices were reported, as well as regression pathway coefficients.



## 5.3 Results

### 5.3.1 Data preparation

#### 5.3.1.1 *Environmental satisfaction*

To reduce parameters and allow for a higher participant-to-parameter ratio, environmental satisfaction was included as a manifest variable in the SEM analyses, rather than using latent constructs derived from EFA. Various rules of thumb exist for determining the sample size required for SEM, such as 5 to 10 participants per parameter; however, other factors (such as numbers of items per latent construct and strength of factor loading) are important when considering sample size (Wolf, Harrington, Clark, & Miller, 2013). Models with more latent structures require larger samples (Wolf et al., 2013).

As described in Chapter 4, missing values of environmental satisfaction items were less than 3%, and medians were imputed. The manifest environmental satisfaction variable was computed by adding the scores for all 29 items and calculating a percentage score. The score was normally distributed and did not have any concerning skew or kurtosis (Table 4.2). Inspection of the histogram and Q-Q plot revealed an approximately normal distribution. There were no outliers identified, as assessed by multiplying the Interquartile Range (IQR) by a factor of 2.2 (Hoaglin & Iglewicz, 1987).

#### 5.3.1.2 *Wellbeing predictors and outcomes*

Data preparation for wellbeing items was described in Chapter 4. Wellbeing missing values were less than 3%, and medians were imputed for ordinal items, and the mean imputed for one scale item (sickness absence days). Skew and kurtosis values were acceptable for SEM (Table 4.3). Visual inspection of the histograms and Q-Q plots revealed that some items were not normally distributed. Three items (*SW14. Fatigue*, *SW17. Productivity*, and *SW21. Sickness absence days*) had outliers. Sickness absence days had nine responses above 13 days, which were capped at 13. Outliers were retained for fatigue and productivity items after the researcher visually inspected the histograms and judged the responses to be genuine.

### 5.3.2 Exploratory factor analysis of wellbeing outcome items

EFA of the wellbeing outcomes was conducted to determine latent structures used in the SEM model. Several items were excluded from the EFA (Table 5.1 and Table 5.2). Items related more to general wellbeing (e.g. "How satisfied are you with life in general?") were omitted from EFA, and only items directly related to work wellbeing (e.g. "Are you happy at work?") were included. In

addition, three binary response items were excluded (*SW9. Shift/night working*, *SW15. Work-related illness*, and *SW16. Presenteeism*). The work-specific wellbeing items were entered into two separate correlation matrices, one for positive wellbeing predictors and outcomes (Table 12.1), and the other for negative wellbeing predictors and outcomes (Table 12.2). The positive wellbeing predictors and outcomes correlated strongly, with most values above .30. One negative wellbeing predictor (*SW8. Noise at work*) and one negative wellbeing outcome (*SW21. Sickness absence days*) did not correlate strongly, i.e. all correlations were below .30. The items that did not correlate strongly were excluded from further analyses. There were no items that were singular, or perfectly correlated (Field, 2013), as indicated by an absence of correlations greater than 0.9 in both matrices.

Table 5.1. *Positive SWELL Outcomes' and Predictors' Inclusion in EFA/SEM*

<b>Positive SWELL item</b>	<b>Predictor/outcome</b>	<b>General/work-specific</b>	<b>Further analyses inclusion</b>
<b>1. SW1. Healthy lifestyle</b>	predictor	general	excluded as not work-specific
<b>2. SW2. Optimism</b>	predictor	general	excluded as not work-specific
<b>3. SW3. How satisfied are you with life in general?</b>	outcome	general	excluded as not work-specific
<b>4. SW5. Would you say you are generally happy?</b>	outcome	general	excluded as not work-specific
<b>5. SW11. Do you feel you have control over your job and support from fellow workers?</b>	predictor	work-specific	included
<b>6. SW13. Are you satisfied with your job?</b>	outcome	work-specific	included
<b>7. SW17. How efficiently do you carry out your work?</b>	outcome	work-specific	included
<b>8. SW19. Are you happy at work?</b>	outcome	work-specific	included

Table 5.2. *Negative SWELL Outcomes' and Predictors' Inclusion in EFA/SEM*

Item	Predictor/outcome	General/work-specific	Further analyses inclusion
1. SW4. How much stress have you had in your life in general?	outcome	general	excluded as not work-specific
2. SW6. Would you say that you generally feel anxious or depressed?	outcome	general	excluded as not work-specific
3. SW7. Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)?	outcome	general	excluded as not work-specific
4. SW8. Are you exposed to noise at work?	predictor	work-specific	excluded as did not correlate strongly
5. SW9. Do you work shifts or work at night?	predictor	work-specific	excluded binary item
6. SW10. How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)?	predictor	work-specific	included
7. SW12. How much stress do you have at work?	outcome	work-specific	included
8. SW14. How physically or mentally tired do you get at work?	outcome	work-specific	included
9. SW15. Have you had an illness (either physical or mental) caused or made worse by work?	outcome	work-specific	excluded binary item
10. SW16. Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to?	outcome	work-specific	excluded binary item
11. SW18. Do you find your job interferes with your life outside work or your life outside of work interferes with your job?	outcome	work-specific	included
12. SW20. Are you anxious or depressed because of work?	outcome	work-specific	included
13. SW21. Approximately how many days sick leave have you had in the last 12 months?	outcome	work-specific	excluded as did not correlate strongly

EFA of the seven retained work-related wellbeing outcomes (positive and negative) was conducted in SPSS 25, with maximum likelihood extraction (MLE) and promax rotation. The Kaiser-Meyer-Olkin (KMO; Kaiser, 1974) measure was .701 and Bartlett's test was statistically significant ( $p < 0.001$ ). It was decided that the data was acceptable for continuing with EFA. Two components (see Table 5.3) with an eigenvalue of greater than 1.0 were found, explaining 36% and 21% of the variance respectively, with a total explained variance of 57%. The components were named *Negative Work Wellbeing* and *Positive Work Wellbeing*.

The constructs' convergent and divergent reliability were assessed. Convergent validity indicates the extent that items in a construct share a high proportion of variance in common, while divergent

validity is the extent that a construct is distinct from other constructs (Hair et al., 2018). Convergent validity was acceptable as demonstrated by average variance extracted (AVE) values above 0.5 and composite reliability (CR) values above 0.7 (Hair et al., 2018). There were no issues with discriminant validity for positive and negative wellbeing, as evidenced by the constructs having higher AVE values than the square of the correlation between the constructs (Hair et al., 2018).

Table 5.3. *Wellbeing Outcomes Constructs and Loadings*

Constructs and Items	Loadings	Average variance extracted (AVE)	Composite reliability (CR)
<b>Negative work wellbeing (Cronbach's alpha .81, 4 items)</b>		0.54	0.82
SW12. How much stress do you have at work?	.87		
SW20. Are you anxious or depressed because of work?	.77		
SW14. How physically or mentally tired do you get at work?	.67		
SW18. Do you find your job interferes with your life outside work or your life outside of work interferes with your job?	.63		
<b>Positive work wellbeing (Cronbach's alpha .79, 3 items)</b>		0.60	0.81
SW19. Are you happy at work?	.87		
SW13. Are you satisfied with your job?	.87		
SW17. How efficiently do you carry out your work?	.55		

### 5.3.3 Structural equation models

SEM was conducted using AMOS 25 with MLE. Refer to Table 5.4 for a summary of the models' fit indices. Fit indices' recommended values were based on several sources (Byrne, 2010; Hair et al., 2018; Hooper, Coughlan, & Mullen, 2008; Hu & Bentler, 1999; Kline, 2011; Schreiber, Nora, Stage, Barlow, & King, 2006). There was multivariate non-normality of the data in the measurement models and Models 1 - 3, as indicated by a critical ratio of multivariate kurtosis level  $> 5$  (Bentler, 2005, as cited in Byrne, 2010). The use of MLE requires data to be multivariate normal, and when data are non-normally distributed, one option is to report a non-MLE  $p$  value, such as Bollen-Stine (T. Morrison, Morrison, & McCutcheon, 2017). Bollen-Stine bootstrap tests of significance have been reported, in addition to bootstrap confidence intervals (Table 5.4). To test mediation and confidence intervals, bootstrapping was conducted in AMOS using 500 samples, with bias-corrected confidence intervals at the 95% confidence level. The significance of indirect effects was tested using an AMOS plugin (Gaskin, n.d.-a).

Table 5.4. *Goodness of Fit Indices*

	$p$	Bollen-Stine $p$	CMIN/DF	SRMR	GFI	AGFI	CFI	RMSEA	PCLOSE
<b>Recommended values</b>	$> .05$	$> .05$	$< 3$	$< .08$	$> .95$	$> .90$	$> .95$	$< .08$	$> .05$
<b>Wellbeing CFA 1 (no correlated errors)</b>	$< .001$	.004	3.773	.063	.943	.877	.940	.114	.001
<b>Wellbeing CFA 2 (with two item factor)</b>	.092	.148	1.891	.045	.983	.949	.989	.065	.292
<b>Model 1<sup>a</sup> (no correlated errors)</b>	$< .001$	.002	2.884	.059	.934	.869	.945	.094	.002
<b>Model 2 (two indicator negative wellbeing construct)</b>	.058	.224	1.681	.051	.976	.935	.988	.056	.357
<b>Model 3<sup>b</sup> (stress predicting anxiety/depression)</b>	.267	.515	1.201	.044	.982	.953	.996	.031	.708
<b>Model 4<sup>ab</sup> (productivity/job satisfaction)</b>	.690	.737	.159	.006	1.00	.996	1.00	.000	.760

<sup>a</sup> hypothesised model <sup>b</sup> final model

### 5.3.3.1 *Confirmatory factor analysis of wellbeing outcomes*

Initially, positive and negative wellbeing outcomes were entered into AMOS, to test the model fit of the latent structures identified by EFA (CFA 1). The paths from negative wellbeing to work-life balance, and positive wellbeing to happiness at work, were fixed to 1. The measurement model had unacceptable goodness of fit (see Figure 5.3 and Table 5.4). Inspection of the modification indices in AMOS showed that the negative wellbeing indicator error terms were related. In order to improve model fit, it is possible to add correlations to the error terms guided by AMOS modification indices. When error terms are not correlated in an SEM model, the assumption is that measurement error is random (Brown, 2015). There can be arguments for correlating error terms, for example, when using similarly worded or reverse-worded items in a questionnaire (Brown, 2015). When errors are correlated for a valid reason, e.g. reverse coded items, it is advised that this should be done consistently.

Some authors caution against correlating error terms to improve model fit (e.g. Hermida, 2015) and suggest that the model should be respecified instead. In order to rectify the problem with correlated errors in the negative wellbeing construct, a possible solution was to delete one of the indicators. This was attempted, but a negative wellbeing construct with three indicators did not achieve a good fit. A two-item negative wellbeing construct consisting of anxiety/depression and stress at work achieved an acceptable model fit (CFA 2; Figure 5.4 and Table 5.4). In CFA 2, the pathways from the indicators to negative wellbeing were constrained to be equal, and the variance of negative wellbeing was set to 1. It is considered preferable to have a minimum of three indicators per construct (Brown, 2015), and in the case of these two indicators, wellbeing theory suggests that stress at work predicts anxiety/depression (DRIVE model; Mark & Smith, 2008). The two-item construct was discarded in favour of a model whereby stress at work predicted anxiety/depression (Figure 5.7).

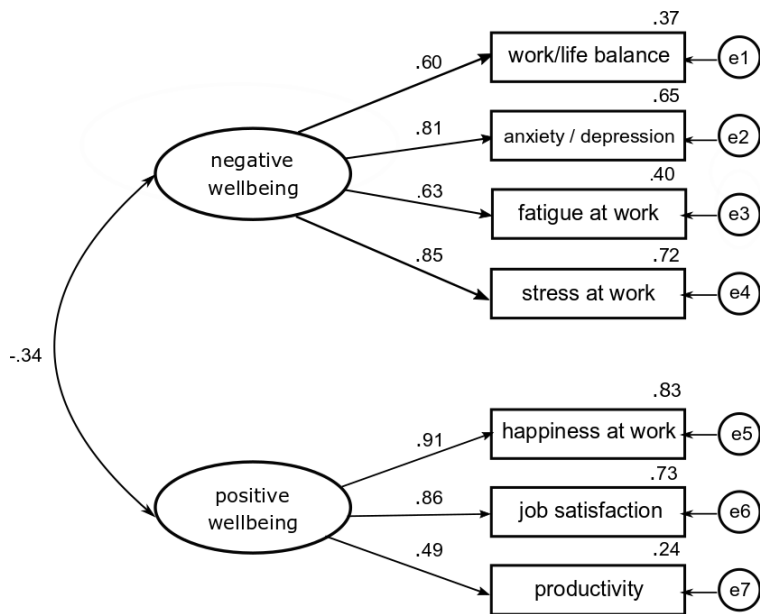


Figure 5.3. Wellbeing outcomes CFA 1 (without correlated errors).

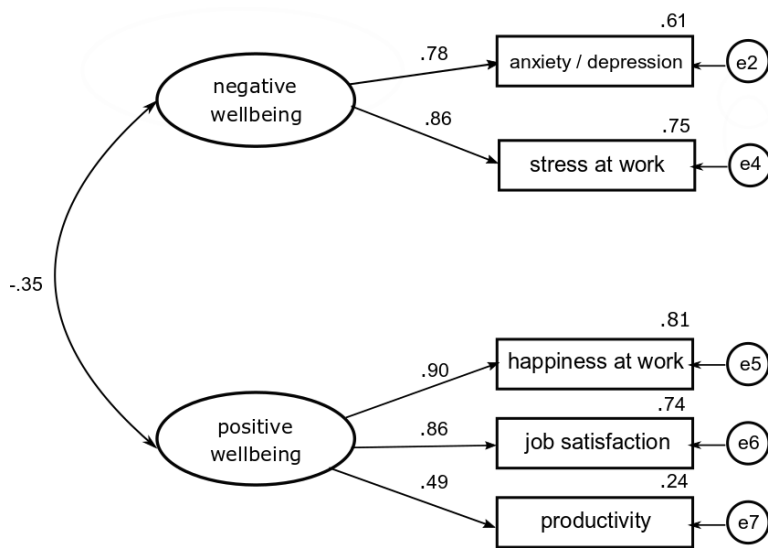


Figure 5.4. Wellbeing outcomes CFA 2 (two-item negative wellbeing construct).

### 5.3.3.2 Models 1 - 3: Environmental satisfaction, wellbeing predictors, and wellbeing outcomes

The conceptual model (Model 1) is illustrated in Figure 5.5. As discussed above, negative wellbeing indicators' error terms were related in the measurement model. The hypothesised model fit was unacceptable without correlating these error terms (Table 5.4). Acceptable fit was achieved using a two-item negative wellbeing construct (see Model 2, illustrated in Figure 5.6). In Model 2, the pathways to the indicator variables from negative wellbeing could not be equal as in the measurement model, and the pathway to anxiety/depression was set to 1. On further consideration of the negative wellbeing construct and referring to existing wellbeing process theory (DRIVE model; Mark & Smith, 2008), it was decided that stress at work predicting anxiety/depression would be more consistent with theory. An alternative model (Model 3) was tested whereby anxiety/depression (an indicator of negative wellbeing) was predicted by stress at work (Figure 5.7). The latter model achieved a better fit than the previous two and was chosen as the final model. Path analysis results are reported for Model 3 in Table 5.5.

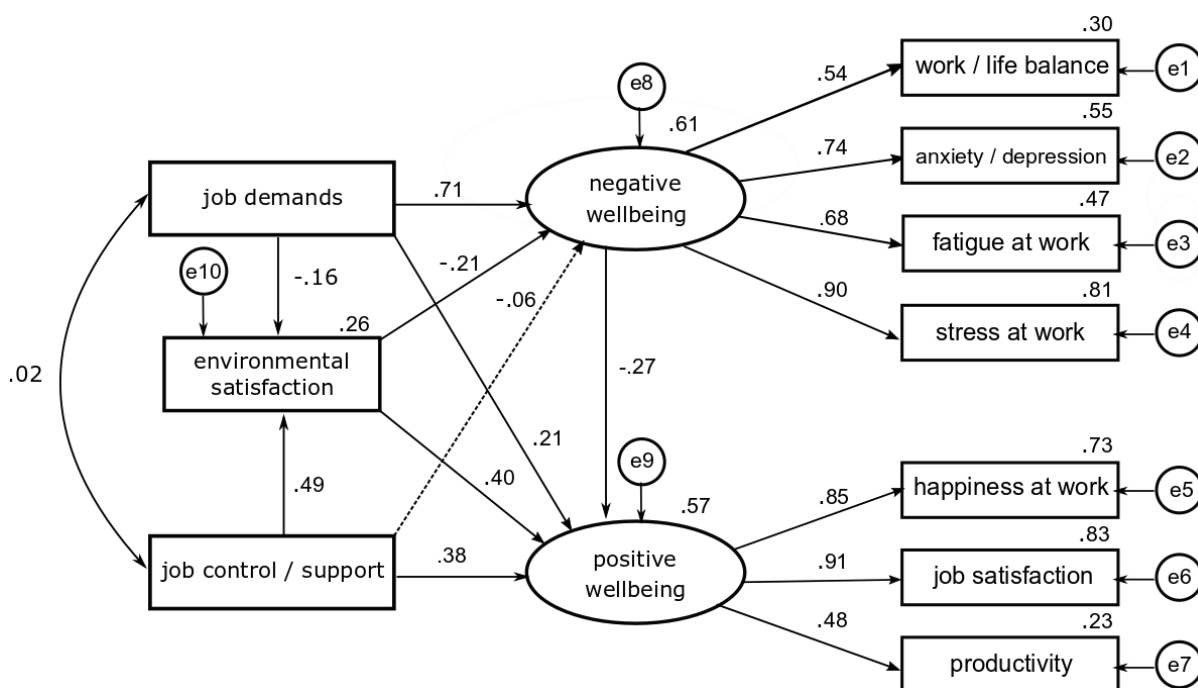


Figure 5.5. Environmental Satisfaction and Wellbeing Model (Model 1).

Note. A dotted line indicates a non-significant pathway.



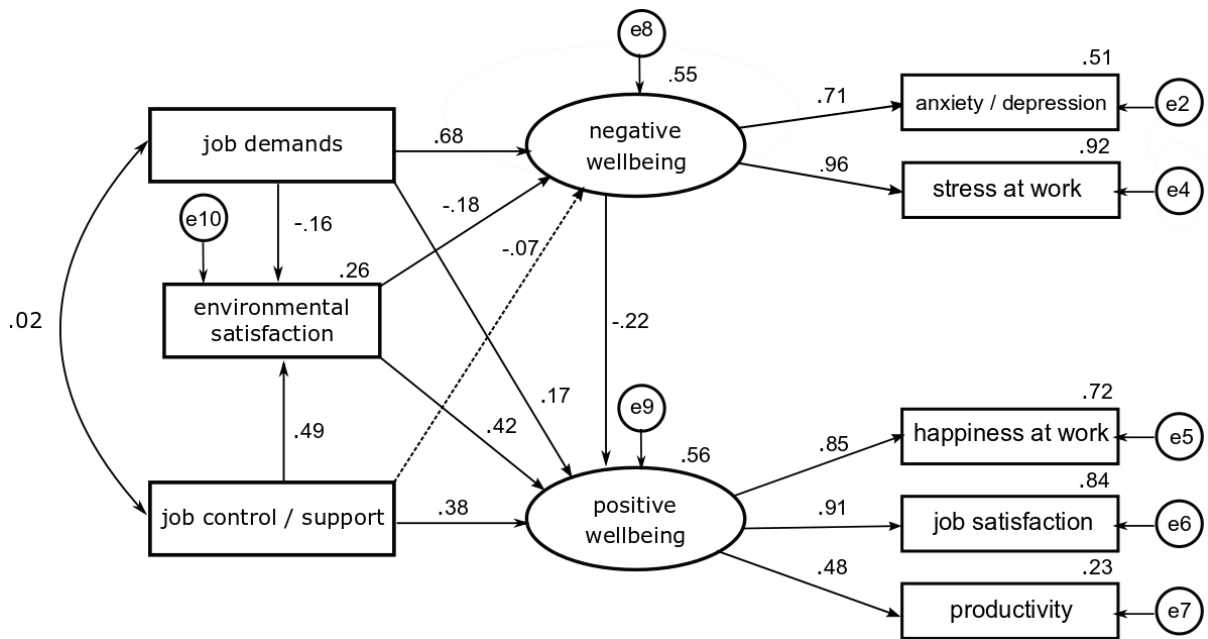


Figure 5.6. Environmental Satisfaction and Wellbeing Model (Model 2; two-indicator negative wellbeing construct).

Note. A dotted line indicates a non-significant pathway.

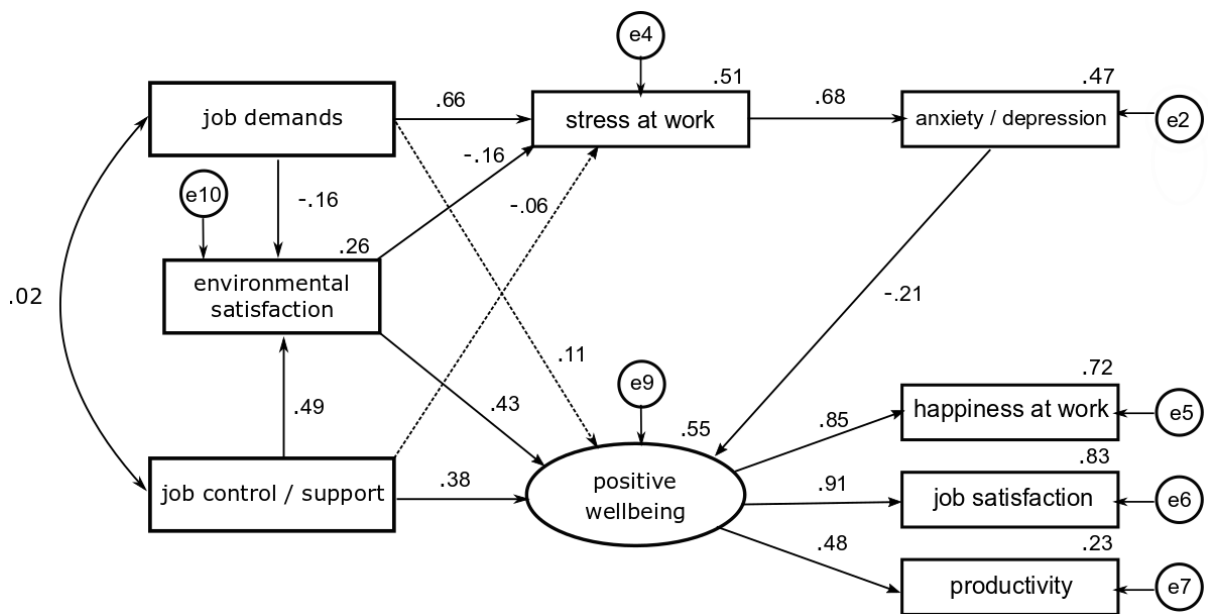


Figure 5.7. Environmental Satisfaction and Wellbeing Model (Model 3; removed negative wellbeing construct).

Note. A dotted line indicates a non-significant pathway.

## 5.3.3.2.1 Model 3 direct effects

As can be seen in Table 5.5, environmental satisfaction significantly predicted higher positive wellbeing ( $\beta = .43$ ), and to a lesser degree, but still significant, lower stress at work ( $\beta = -.16$ ). Job demands significantly predicted lower environmental satisfaction ( $\beta = -.16$ ) and higher stress at work ( $\beta = .66$ ). Job demands was not a significant predictor of positive wellbeing in Model 3, in contrast to Models 1 and 2. Job control/support significantly predicted higher environmental satisfaction ( $\beta = .49$ ) and higher positive wellbeing ( $\beta = .38$ ). Job control/support was not a significant predictor of stress at work. Bootstrap confidence intervals and significance levels were inspected for the pathways. All pathways had significant bootstrap  $p$  values apart from job demands to positive wellbeing, and job control/support to stress at work.

Table 5.5. *Results of Path Analysis for Environmental Satisfaction and Wellbeing Outcomes/Predictors in Model 3*

			<i>B</i>	<i>SE B</i>	<i>95% CI<sup>a</sup></i>	<i>CR</i>	<i>p</i>	$\beta$	<i>95% CI<sup>a</sup></i>
<b>job control/ support</b>	→	environmental satisfaction	3.59	.43	(2.56, 4.45)	8.28	< .001	.49	(0.36, 0.58)
<b>job demands</b>	→	environmental satisfaction	-1.09	.39	(-2.03, -0.17)	-2.77	.006	-.16	(-0.30, -0.02)
<b>job demands</b>	→	stress at work	0.66	.05	(0.56, 0.76)	13.63	< .001	.66	(0.56, 0.76)
<b>environmental satisfaction</b>	→	stress at work	-0.02	.01	(-0.04, -0.01)	-2.91	.004	-.16	(-0.29, -0.04)
<b>job control/ support</b>	→	stress at work	-0.06	.06	(-0.18, 0.07)	-1.02	.306	-.06	(-0.16, 0.07)
<b>stress at work</b>	→	work anxiety/ depression	0.78	.06	(0.67, 0.92)	13.68	< .001	.68	(0.58, 0.76)
<b>environmental satisfaction</b>	→	positive wellbeing	0.05	.01	(0.03, 0.07)	6.72	< .001	.43	(0.28, 0.55)
<b>job control/ support</b>	→	positive wellbeing	0.33	.05	(0.19, 0.45)	6.12	< .001	.38	(0.23, 0.50)
<b>work anxiety/ depression</b>	→	positive wellbeing	-0.15	.04	(-0.26, -0.03)	-3.54	< .001	-.21	(-0.38, -0.04)
<b>job demands</b>	→	positive wellbeing	0.09	.05	(-0.03, 0.20)	1.83	.067	.11	(-0.05, 0.25)

<sup>a</sup> Bootstrap sample of 500, bias-corrected.

### 5.3.3.2.2 Model 3 indirect effects

The fourth hypothesis of this study predicted that environmental satisfaction mediates the relationship between work wellbeing predictors and outcomes. There was a significant ( $p = .002$ ) indirect effect of job control/support on positive wellbeing through environmental satisfaction,  $B = 0.181$ , 95% BCa CI [0.119, 0.246]. See Figure 5.8.

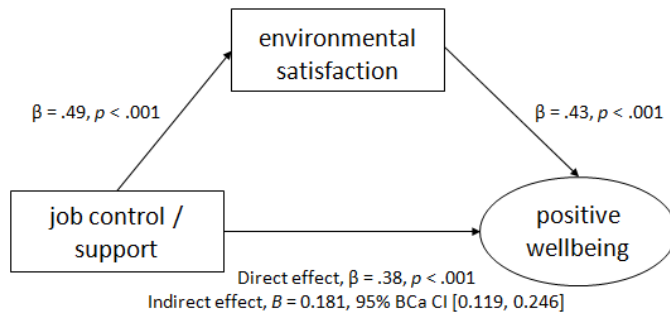


Figure 5.8. Regression coefficients showing the relationship between job control/support, environmental satisfaction, and positive wellbeing.

There was a significant ( $p = .024$ ) indirect effect of job demands on stress at work through environmental satisfaction,  $B = 0.026$ , 95% BCa CI [0.003, 0.065]. See Figure 5.9.

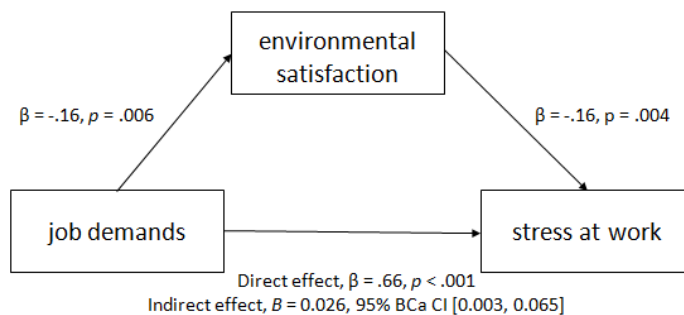


Figure 5.9. Regression coefficients showing the relationship between job demands, environmental satisfaction, and stress at work.

### 5.3.3.3 Model 4: Environmental satisfaction, job satisfaction, and productivity.

Finally, a model was tested to assess the relationship between environmental satisfaction, job satisfaction, and productivity (see Model 4, Figure 5.10). In Model 3, job satisfaction and productivity were indicators of a positive wellbeing construct. In Model 4, environmental satisfaction was not a significant predictor of productivity; however, it was a significant predictor of job satisfaction, which in turn predicted productivity. Job control/support predicted higher levels of environmental satisfaction and job satisfaction (Table 5.6).

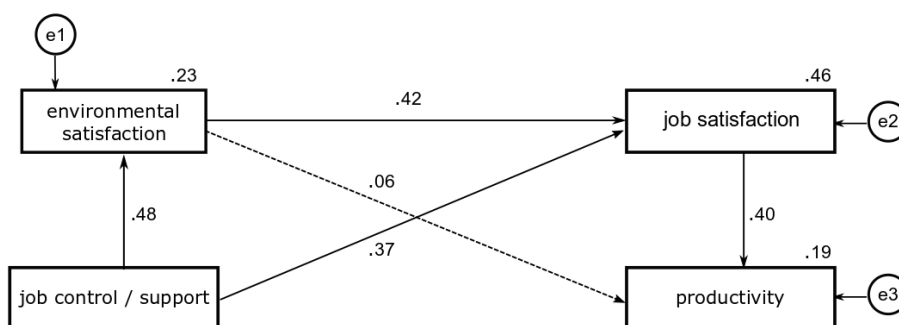


Figure 5.10. Environmental satisfaction, Job Satisfaction, and Productivity (Model 4).

Note. A dotted line indicates a non-significant pathway.

Table 5.6. Results of Path Analysis for Environmental Satisfaction and Wellbeing Outcomes/Predictors in Model 4

			<i>B</i>	<i>SE B</i>	95% <i>CI</i> <sup>a</sup>	<i>CR</i>	<i>p</i>	$\beta$	95% <i>CI</i> <sup>a</sup>
<b>job control/support</b>	→	environmental satisfaction	3.56	.44	(2.43, 4.43)	8.07	< .001	.48	(0.34, 0.58)
<b>job control/support</b>	→	job satisfaction	0.39	.06	(0.23, 0.54)	6.44	< .001	.37	(0.22, 0.48)
<b>environmental satisfaction</b>	→	job satisfaction	0.06	.01	(0.04, 0.08)	7.32	< .001	.42	(0.29, 0.53)
<b>job satisfaction</b>	→	productivity	0.33	.07	(0.18, 0.51)	5.13	< .001	.40	(0.23, 0.55)
<b>environmental satisfaction</b>	→	productivity	0.01	.01	(-0.01, 0.02)	0.75	.454	.06	(-0.08, 0.20)

<sup>a</sup> Bootstrap sample of 500, bias-corrected.

## 5.3.3.3.1 Model 4 indirect effect

There was a significant ( $p = .002$ ) indirect effect of job control/support on job satisfaction through environmental satisfaction,  $B = 0.216$ , 95% BCa CI [0.146, 0.301]. See Figure 5.11.

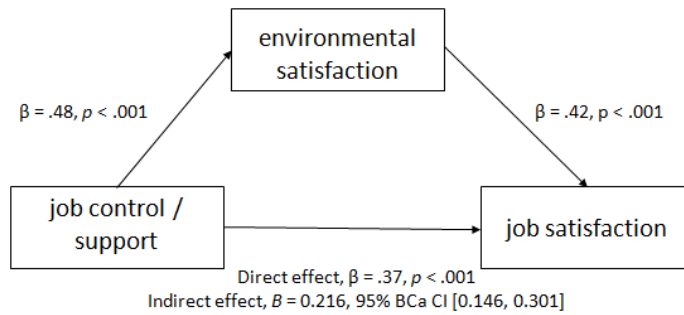


Figure 5.11. Regression coefficients showing the relationship between job control/support, environmental satisfaction, and job satisfaction.

## 5.4 Discussion

Two conceptual structural equation models were constructed to test the study's hypotheses. The first conceptual model (Environmental Satisfaction and Wellbeing Model) underwent three iterations, and the final model, Model 3, achieved acceptable goodness of fit. Model 3 provided support for Hypotheses 1, 3, and 4; and partial support for Hypothesis 2. A second conceptual model (Model 4; Environmental Satisfaction, Job Satisfaction, and Productivity Model) tested the relationship between environmental satisfaction, job control/support, job satisfaction, and productivity. This model achieved acceptable goodness of fit, and provided support for Hypotheses 6 and 7, and partial support for Hypothesis 5. The results showed that environmental satisfaction predicted positive and negative wellbeing in a model that contained other established wellbeing predictors (job demands, job control/support).

Table 5.7. *Summary of Hypotheses*

Hypothesis	Result
Hypothesis 1. Office environmental satisfaction predicts greater levels of positive wellbeing outcomes and lower levels of negative wellbeing outcomes.	supported
Hypothesis 2. Positive wellbeing predictors predicts higher positive, and lower negative, wellbeing outcomes; and negative wellbeing predictors predicts higher negative, and lower positive, wellbeing outcomes.	partially supported
Hypothesis 3. Negative wellbeing outcomes are linked with lower positive wellbeing outcomes.	supported
Hypothesis 4. Environmental satisfaction mediates the relationships between wellbeing predictors and outcomes.	supported
Hypothesis 5. Environmental satisfaction predicts greater job satisfaction and productivity.	partially supported
Hypothesis 6. Job control/support predicts greater job satisfaction.	supported
Hypothesis 7. Job satisfaction predicts higher productivity.	supported

Relationships between mental wellbeing and environmental satisfaction were shown in Model 3. Environmental satisfaction predicted less stress at work, which then predicted less anxiety/depression. Environmental satisfaction also mediated the effect of job demands on stress at work, with job demands predicting lower environmental satisfaction and higher stress at work. Environmental satisfaction was linked with higher Positive Work Wellbeing, a construct that consisted of happiness at work, as well as job satisfaction, and productivity. Environmental satisfaction significantly mediated the relationship between job control/support and positive wellbeing outcomes. The association between environmental satisfaction and mental wellbeing has also been found in other studies (e.g., Herbig et al., 2016; Klitzman & Stellman, 1989; Lütke Lanfer et

al., 2021). This analysis offers a novel insight into how the environment affects occupants, as anxiety and depression are not common outcomes measured in the office design literature.

It has been noted that previous studies which have found a link between wellbeing and office design do not account for other predictors of wellbeing. The models in the present analysis included other wellbeing predictors in addition to environmental satisfaction. In Model 3, job demands (a negative wellbeing predictor) significantly predicted higher stress at work (a negative wellbeing outcome) but was not a significant predictor of lower positive wellbeing. In fact, job demands significantly predicted higher positive wellbeing in two of the models that were discarded (Models 1 and 2). In the retained model (Model 3), there was a non-significant trend for higher job demands predicting higher positive wellbeing. This may reflect a relationship between more challenging jobs and higher positive wellbeing. Job control/support (a positive wellbeing predictor) significantly predicted higher positive wellbeing but was not a significant predictor of stress at work. This analysis found that wellbeing predictors, other than environmental satisfaction, did predict wellbeing outcomes. Therefore, other studies should endeavour to include wellbeing predictors when investigating the relationship between office satisfaction and occupant wellbeing.

In Model 4, the relationships between environmental satisfaction, job satisfaction, and productivity were investigated. Job satisfaction and productivity were included in one construct in Model 3, whereas Model 4 tested their individual relationships with environmental satisfaction. The results showed that environmental satisfaction predicts positive and negative wellbeing in a model that contains other established wellbeing predictors (job demands, job control/support). It was hypothesised that environmental satisfaction predicts greater job satisfaction and productivity (Hypothesis 5). This hypothesis was partially supported, as environmental satisfaction predicted higher job satisfaction, which in turn predicted productivity. The finding that job satisfaction predicted productivity provides support for Hypothesis 7, and also further evidence to show a relationship between these factors. Environmental satisfaction did not have a direct impact on productivity, contrary to the study's prediction and the results of previous studies. The relationship found between environmental satisfaction and job satisfaction has been found in other research (Carlopio, 1996; Newsham et al., 2009; Veitch et al., 2007; Wells, 2000); however, some studies have not found a significant relationship (P. J. Lee et al., 2016; Y. S. Lee & Brand, 2005). Job control/support also significantly predicted job satisfaction (Hypothesis 6), lending additional support to the theory that positive wellbeing predictors are linked with positive wellbeing outcomes.

#### 5.4.1 Wellbeing predictors and outcomes

In the present study, wellbeing was measured using the SWELL (Smith & Smith, 2017), which measures both positive and negative wellbeing predictors and outcomes. Smith and Smith (2017) have explored the relationship between SWELL wellbeing outcomes and predictors, and the results of this study are similar to their findings. To simplify the models in the present study, only variables that were directly work-related were included. The SWELL also includes variables that relate to individual appraisals of wellbeing, and general wellbeing, which were not examined.

In Model 3, job demands was a significant predictor of stress at work, which was also found in Smith and Smith's (2017) study. Smith and Smith found that low job control/support was a predictor of stress at work, although the present study did not replicate this finding. They discovered that high job control/support was associated with job satisfaction, which was the key predictor of happiness at work. In the main model used in the present study (Model 3), positive wellbeing outcomes (job satisfaction, happiness at work, productivity) were included as one latent construct, which was predicted significantly by job control/support. To explore the relationship further, an additional model was examined (Model 4). In Model 4, the direct relationships between environmental satisfaction, job control/support, productivity, and job satisfaction, were investigated. In the model, job control/support predicted job satisfaction, as found by Smith and Smith.

In conclusion, the relationships between the wellbeing predictors and outcomes used mainly agreed with the results from Smith and Smith (2017). The difference found in the relationship between job control/support and stress at work could be explained by statistical techniques used in the two studies, as variables were dichotomised into high and low for analysis in the latter study, while they were not in the present study.

#### 5.4.2 Support from colleagues in open-plan offices

The participants in this study were predominantly open-plan office workers (82%). Due to the small number of participants in private or shared offices, a multi-group analysis was not performed to test group differences in the model. Previous research has shown that collaboration, teamwork, and communication may be worse in open-plan offices (Brennan et al., 2002; R. L. Morrison & Macky, 2017; Otterbring et al., 2018; Parkin et al., 2011). Otterbring et al. (2018) found that employee job satisfaction, ease of interaction, and subjective wellbeing were lower in small and medium open-plan offices as compared to private and shared offices. They demonstrated that the association between open-plan offices and lower job satisfaction was mediated by ease of interaction and



subjective wellbeing. In the present study's Model 3, environmental satisfaction significantly mediated the relationship between job control/support and positive wellbeing outcomes. Satisfaction with interaction was not measured; however, job control/support may be indicative of better interaction with colleagues. Job control/support was measured in the present study by a single item, "Do you feel you have control over your job and support from fellow workers?" In future studies, it may be useful to ask about job control and support from colleagues separately, to ascertain their individual relationships with environmental satisfaction and wellbeing.

#### 5.4.3 Implications for models of work wellbeing

The present SEM results provide some support for other models discussed at the beginning of this chapter. The current findings agree with the theory that an unsupportive environment could be demanding for occupants (Vischer, 2005), as lower ratings of environmental satisfaction predicted more stress at work. Vischer's demand-control model of workspace productivity (2005) proposed that an unsupportive environment, and less control over the design of the environment, could lead to decreased productivity. While environmental satisfaction significantly predicted positive wellbeing outcomes (Model 3), no direct link was shown with productivity (Model 4). Control over the environment has been associated with increased job satisfaction, environmental satisfaction, and perceived productivity (Huang et al., 2004; Y. S. Lee & Brand, 2005; Y. S. Lee & Brand, 2010). In the present study, occupants' environmental control was not included as a separate variable, although the environmental satisfaction manifest variable included questions about control. Participants in the current study were asked about control over their job. Personal control is a feature of many wellbeing models, such as the demand-control model (Karasek, 1979; Karasek & Theorell, 1990). The DRIVE model (Mark & Smith, 2008) theorises that work demands and resources affect wellbeing outcomes, which was supported by this study. The DRIVE model also includes individual characteristics (e.g. optimism), and personal resources and demands, which were not added to the models in the current study to simplify the models and reduce parameters.

#### 5.4.4 Conclusion

The structural equation models in this chapter show that both environmental satisfaction and wellbeing predictors (job demands and job control/support) are associated with wellbeing outcomes. Environmental satisfaction acted as a mediating variable in the relationship between wellbeing predictors and outcomes in this study. Including other wellbeing predictors, as well as environmental satisfaction, demonstrates that the relationship between the office environment and occupant wellbeing cannot be explained entirely by psychosocial working conditions. Theories about

wellbeing in work should also consider the effect of the physical environment on occupants' wellbeing. Further research investigating models of wellbeing and the physical environment, and longitudinal designs, may help to improve our understanding of the influence of wellbeing predictors and environmental satisfaction on wellbeing outcomes. The next chapters will focus on office design intervention and wellbeing. In Chapter 6, the development of a wellbeing and office satisfaction questionnaire will be reported.

#### 5.4.5 Industrial partner summary

- Environmental satisfaction predicted positive and negative wellbeing in a model that contained other wellbeing predictors (job demands, job control/support).
- Job demands and job control/support were also important for occupant wellbeing.
- Environmental satisfaction mediated the relationships between wellbeing predictors and wellbeing outcomes.
- Environmental satisfaction predicted higher job satisfaction, which in turn predicted productivity.

## 6 Well Office Questionnaire (WOQ) development

### 6.1 Introduction

In the preceding chapters, the relationship between the physical office environment and occupant wellbeing was examined. Considering the impact of environmental satisfaction on employees, measurement of occupant wellbeing outcomes should be an important part of evaluating office design. Using occupant surveys is an inexpensive and useful way of gaining feedback about indoor environmental quality (Peretti & Schiavon, 2011), and there is an increasing interest in the occupant survey in post-occupancy evaluation studies (Li, Froese, & Brager, 2018). This chapter will discuss the development of a short questionnaire to measure wellbeing and satisfaction with the office environment, which may be used in the context of office design evaluations.

#### 6.1.1 Current measurement of wellbeing and environmental satisfaction

In a journal article published over ten years ago, Veitch et al. (2007) commented that there is slow research progress on the topic of the physical environment's impact on organisational outcomes, such as productivity and absenteeism. They suggested that a reason for this could be a lack of commonly-used, reliable, and standardised measurement tools to assess the physical environment. Reviews of post-occupancy surveys detail several questionnaires used to evaluate buildings (Dykes & Baird, 2013; Galatioto, Leone, Milone, Pitruzzella, & Franzitta, 2013; Li et al., 2018; Peretti & Schiavon, 2011). At present, there are some commercially available post-occupancy surveys that have been used widely, for example, the Center for the Built Environment (CBE) IEQ satisfaction survey, and the Building Use Studies (BUS) survey; however, items used to measure wellbeing in the context of office design studies vary considerably in the literature. In a review of indoor environmental quality surveys (Dykes & Baird, 2013), the authors recommended that questionnaire-based methods need to be standardised to create benchmarks for companies from the data, as small changes in questionnaires can result in different outcomes. Certainly, in regard to wellbeing outcomes in indoor environment evaluation, the plethora of questions used to measure wellbeing in the literature causes difficulty in comparing results and making conclusions about how office design affects wellbeing.

Measuring wellbeing is a difficult task, as it is a concept that is subjective and multi-dimensional. Definitions of wellbeing include various factors such as physical health, mental wellbeing, satisfaction with life, comfort, and happiness (Diener et al., 1999; NICE, 2015). Furthermore, it has been suggested that increased productivity may result from greater wellbeing (Tehrani et al., 2007), and measures of productivity are sometimes used to indicate wellbeing. Often researchers are interested in a particular aspect of wellbeing, and use outcome measures to reflect this, rather than using a broader approach. Given the multi-dimensional aspect of wellbeing, the wide array of wellbeing measures used in the office design literature is easy to understand.

One of the criticisms of indoor environmental quality measurement has been directed at the inaccessibility of the information to people who would most benefit from the results, e.g. office designers and facility managers. Office designers and facility managers may seek evidence that the physical environment impacts organisational outcomes, and historically, the question has not been settled with sufficient rigour (Veitch et al., 2007). In a review of existing occupant surveys, Dykes and Baird (2013) expressed that results need to be communicated effectively to the appropriate people for workplaces to improve. The authors highlighted areas needing improvement, and ways that this can be achieved, need to be understood. Li et al. (2018) also reviewed post-occupancy surveys and recommended that industry should play a greater role in the development and use of post-occupancy evaluation, as academic researchers are currently the primary developers and users. Harnessing the combined efforts of industry and academia in collaborative efforts may assist in developing and using tools to improve the workplace for greater occupant wellbeing.

#### 6.1.2 Aim of Well Office Questionnaire (WOQ) development

The current chapter describes the development of a short questionnaire, the Well Office Questionnaire (WOQ), which measures occupant wellbeing and environmental satisfaction. The researcher's industrial partner, an office furniture design and manufacturing company, required a measurement tool to use when evaluating client office designs. The measurement tool needed to be easy to administer, quick to complete, and measure both occupant wellbeing and office environmental satisfaction. In order to develop the questionnaire, all environmental satisfaction questions, and selected wellbeing questions, from Study 1 were used. These questions were grouped by themes identified in the literature reviews, and the Study 1 results were used in Principal Components Analysis (PCA) to identify any items which could be combined or eliminated. The author is unaware of any short, non-commercial surveys that measure both environmental satisfaction and

occupant wellbeing. The developed questionnaire could fill this gap by providing a free-to-use, quick measure of wellbeing and environmental satisfaction.

## 6.2 Method

The questionnaire development consisted of three phases: the initial construction of the questionnaire, psychometric evaluation of environmental satisfaction and wellbeing items, and regression analyses to determine individual environmental satisfaction items' ability to predict wellbeing outcomes. Validity of the wellbeing items was assessed using Spearman's correlations with different wellbeing scales. An approach to combine or eliminate some items using literature review themes and PCA was used to reduce the initial questionnaire to a shorter version. Some additional items were added by the researcher to address important missing factors identified in the literature. Finally, regression analyses were conducted to determine whether environmental satisfaction items predicted negative and positive wellbeing outcomes.

### 6.2.1 Phase 1: Initial questionnaire construction

The original questionnaire is shown in Appendix B, Table 12.3. Items in the initial questionnaire were in three categories. Firstly, some demographic, office type, and ways of working items were included to provide more information about the participant sample and their office environments. Secondly, environmental satisfaction items were mainly derived from the literature, with some from Veitch et al. (2007), and others developed from review of literature and discussion with the researcher's industrial partner. Finally, wellbeing was measured with the Smith Wellbeing Questionnaire (SWELL; Smith & Smith, 2017), and other wellbeing scales were used to check the validity of this scale. The questionnaire was used in Study 1, described in Chapter 4. In Study 1, an online sample of 215 UK office workers, recruited by Qualtrics panel, completed this questionnaire. The data from this study was used in regression analyses in Chapter 4, to show the relationship between wellbeing and environmental satisfaction, when controlling for other wellbeing predictors. In Chapter 5, a structural equation model of environmental satisfaction and wellbeing was tested using the data.

#### 6.2.1.1 *Demographics, office type, and ways of working*

Three demographic questions (age, gender, occupation), and 11 questions about the participants' office and way of working were included (e.g., hours worked per week, home working).

#### 6.2.1.2 *Environmental satisfaction*

Twenty-nine environmental satisfaction questions were included and are described in Chapter 4.

### 6.2.1.3 *Wellbeing*

The main measure of wellbeing was the SWELL, a 21-item wellbeing questionnaire that measures both positive and negative aspects of wellbeing. One general health question was added from the RAND 36-Item Short Form Survey Instrument (SF-36). The five-item WHO-5 Wellbeing index (World Health Organization, 1998), a questionnaire popularly used to measure psychological wellbeing (Topp, Østergaard, Søndergaard, & Bech, 2015), was included. A modified version of the Nordic Musculoskeletal Questionnaire (NMQ; Kuorinka et al., 1987) was used to measure the presence and symptom severity of musculoskeletal disorders (MSDs). Sick Building Syndrome (SBS) symptoms were measured using questions modified from the Glostrup Questionnaire (Brauer, 2005; see also Pejtersen et al., 2006).

### 6.2.1.4 *Belief of a positive effect of workplace on wellbeing*

Four items modified from a single question in Agha-Hosseini et al. (2013) assessed participants' belief in the effect of the workplace on wellbeing. These items were not used in the WOQ development.

## 6.2.2 Phase 2: Psychometric evaluation of environmental satisfaction and wellbeing items

The evaluation of the initial questionnaire uses data from Study 1. The participants were 215 office employees recruited by Qualtrics panel (for sample descriptives, see Table 4.1).

In order to assess the validity of using SWELL as a wellbeing measure in the context of office design evaluation, Spearman's correlations were conducted with several other wellbeing scales (WHO-5, Sick Building Syndrome [SBS], and musculoskeletal disorders [MSD] scales; and the RAND general health question). Missing data were not imputed, and the method used was pairwise deletion. The wellbeing scales used were ones that were identified as important in office environments (e.g., MSDs, symptoms of SBS). An assumption was made that if SWELL correlated highly with other scales used to measure aspects of wellbeing in the office design literature, then it would be a valid approach to use SWELL wellbeing items in the final questionnaire. Spearman's correlation coefficient is a non-parametric statistic using ranked data and may be useful when data is not normally distributed (Field, 2013). Two of the scales were negatively skewed, and so a non-parametric statistic was chosen. For this analysis, the SWELL total percentage was calculated using all items, apart from the last item (*SW21. Sickness absence days*). All measures were scored so that higher numbers indicated greater positive wellbeing or less negative wellbeing. Percentage scores were calculated from the total scores of the other wellbeing scales and were used in the correlations.

The SWELL includes items that are predictors of wellbeing (e.g., work demands, support from colleagues), and others that are wellbeing outcomes (e.g., happiness, stress). For the purpose of creating the final questionnaire, the main interest was measuring wellbeing outcomes, and so wellbeing predictors were not included in the PCA. One item was excluded, which asked about sickness absence days, as the questionnaire was aimed at measuring wellbeing over a relatively shorter timeframe (1 month) than the SWELL (6 months).

Descriptive characteristics for the environmental satisfaction and selected SWELL items were calculated. Items were examined for skew, kurtosis, and outliers prior to analysis. Missing values were dealt with using pairwise deletion. A shorter questionnaire was developed using a combination of grouping items by literature review themes and PCA, to identify any items that could be combined or deleted. PCA is a technique that identifies clusters of variables and may be used in questionnaire development (Field, 2013). PCA seeks to account for the maximum amount of total variance in a correlation matrix by converting variables into linear components (Field, 2013). When establishing the adequacy of data for PCA, it is important to consider sample size and the strength of the relationship among items (Pallant, 2016). There are various guidelines about sample size required for PCA, and some 'rules of thumb' such as a minimum of 300 participants (Field, 2013), or 10 times as many participants per variable (Nunnally, 1978). One study has provided evidence to show that both greater sample size and the ratio of participants to variables are important (Osborne & Costello, 2004). Judging by sample size guidelines, the present study's sample size was on the small side. Using ratios of participants to items, the sample size was sufficient in the case of the wellbeing items, but small for the environmental satisfaction items. Separate correlation matrices were examined for environmental satisfaction and wellbeing items to determine the strength of the relationships between items. To assess the appropriateness of the data for PCA, Kaiser-Meyer-Olkin measure of sampling adequacy (KMO; Kaiser, 1974) values of 0.6 or greater were used (Tabachnick & Fidell, 2013), and significant Bartlett's Test of Sphericity (Bartlett, 1954).

Using polychoric correlations for factor analysis of ordinal variables is considered to provide a more accurate reflection of the measure used (Holgado-Tello, Chacón-Moscoso, Barbero-García, & Vila-Abad, 2010); however, when most variables show kurtosis and skewness absolute values < 1.0 these methods may not be necessary (Muthén & Kaplan, 1985). As most environmental satisfaction and wellbeing variables were below this value of kurtosis and skewness, PCA using Pearson's correlations was used. PCA was conducted in SPSS 25 using direct oblimin rotation and pairwise deletion, with a loading cutoff of .30. Direct oblimin rotation is a type of oblique rotation that allows factors to



correlate and is recommended when factors are expected to relate to each other, as often is the case with psychological constructs (Field, 2013). To decide how many factors to include, Kaiser's criterion was used, whereby all factors with eigenvalues of 1 or greater were extracted (Kaiser, 1960). Cattell's scree tests (Cattell, 1966) were used to visualise the factors, but final decisions about the inclusion of factors were not based on the scree tests, but rather on eigenvalues and importance of factors in the literature. Parallel analysis (Horn, 1965) was conducted using the nScree function from the nFactors package (Raiche, 2010) in R for Statistics software version 3.6.1, and the results are reported to support the number of factors extracted.

The selection of items for the final questionnaire was a process involving the combination of items when appropriate, and some inclusion of items based on review of the literature and results from the structural equation modelling (SEM) analysis of the same data in Chapter 5.

### 6.2.3 Phase 3: Environmental satisfaction items and prediction of wellbeing outcomes

In the final phase of the questionnaire development, multiple linear regression analyses were conducted to determine whether the environmental satisfaction items used in the initial questionnaire predicted negative and positive wellbeing outcomes. As described in Chapter 4, positive and negative wellbeing outcomes were the sum of two SWELL items each. The positive outcomes variable was the sum of SWELL items *SW13. Job satisfaction* and *SW19. Happiness at work*. The negative outcomes variable was the sum of *SW12. Stress at work* and *SW20. Anxiety/depression at work*. Positive and negative wellbeing predictors were controlled for in the regressions as per a previous study (Smith & Smith, 2017). The same positive wellbeing predictors (*SW1. Healthy lifestyle*, *SW2. Optimism*, and *SW11. Job control/support*) and negative wellbeing predictors (*SW8. Noise at work* and *SW10. Job demands*) were also used from Chapter 4. Occupation type was included as a wellbeing predictor, as in Chapter 4, it was shown to have a relationship to environmental satisfaction and wellbeing outcomes.

Standard linear multiple regressions were used to consider the contribution of independent variables (IVs; predictors) to the dependent variables (DVs; positive and negative wellbeing outcomes). It is important with this type of regression to examine correlations of IVs with the DVs, as an IV could have a small unique contribution and yet be highly correlated with the DV, as its contribution may be shared with other IVs (Tabachnick & Fidell, 2013). Prior to regression analysis, correlations between wellbeing outcomes and environmental satisfaction items were examined (Table 12.4). The correlations between other wellbeing predictors and wellbeing outcomes were

previously detailed in Chapter 4 (Table 4.4). In standard multiple regression, there should be some correlation between the IVs and the DV, preferably above .3 and below .7 (Pallant, 2016). The correlated values between the environmental satisfaction items and positive wellbeing were mainly in the acceptable range, with none at .7 or higher (Table 12.4). The environmental satisfaction items did not correlate as strongly with negative wellbeing outcomes; the majority correlated below the .3 value, and none were at a .7 value or higher.

Regression analyses were conducted firstly with positive wellbeing outcomes as the DV, and all environmental satisfaction items from the original questionnaire as IVs, or predictors. Significant predictors were then entered into another regression that included other wellbeing predictors, to investigate the unique contribution of the environmental satisfaction items. This procedure was repeated with negative wellbeing outcomes as the DV.

## 6.3 Results

### 6.3.1 Phase 2: Psychometric evaluation of environmental satisfaction items

#### 6.3.1.1 *Environmental satisfaction item descriptives*

Initially, the questionnaire consisted of 29 environmental satisfaction questions. The questions were ordinal, 7-point Likert scale data. Table 6.1 shows skewness and kurtosis values. Shapiro-Wilk tests were significant for all items ( $p < .001$ ), suggesting the possibility of abnormal distribution, although visual inspection of the data distribution indicated the data was approximately normally distributed. In addition, there were no outliers identified. Most variables had kurtosis and skewness absolute values  $< 1.0$ , indicating that PCA using Pearson's correlations was an acceptable method.

Table 6.1. *Environmental Satisfaction Item Descriptives*

Item		<i>N</i>		<i>M</i>	<i>Mdn</i>	<i>SD</i>	Skewness	Kurtosis
What is your degree of satisfaction with the following:	Valid	Missing						
<b>ES1</b> Your work area (workstation) overall	215	0	4.66	5	1.37	-0.52	-0.16	
<b>ES2</b> Your workplace (the office that you work in) overall	213	2	4.79	5	1.33	-0.60	0.04	
<b>ES3</b> Areas in your workplace for meetings.	214	1	4.82	5	1.42	-0.54	-0.28	
<b>ES4</b> Areas in your workplace for doing work that requires focus and concentration.	215	0	4.55	5	1.51	-0.48	-0.29	
<b>ES5</b> Areas in your workplace for relaxing and taking breaks.	214	1	4.21	4	1.75	-0.22	-0.85	
<b>ES6</b> Your ability to adjust or control your work area to suit your needs and preferences.	211	4	4.45	5	1.50	-0.30	-0.50	
<b>ES7</b> Visual appearance of your workplace.	212	3	4.81	5	1.38	-0.50	0.02	
<b>ES8</b> Overall air quality in your work area.	213	2	4.53	5	1.53	-0.43	-0.45	
<b>ES9</b> Temperature in your work area.	214	1	4.36	4	1.60	-0.13	-1.02	
<b>ES10</b> Amount of noise in your work area.	214	1	4.62	5	1.48	-0.28	-0.78	
<b>ES11</b> Amount of noise from other people's conversations while you are at your work area.	212	3	4.46	4.5	1.61	-0.31	-0.68	
<b>ES12</b> Your ability to have a private conversation in your workplace.	214	1	4.36	4	1.69	-0.29	-0.82	
<b>ES13</b> Visual privacy in your work area.	214	1	4.06	4	1.67	-0.03	-0.82	

Note. Scale from 1 (*very unsatisfactory*) – 7 (*very satisfactory*).

Table 6.1. (continued)

Item		N		M	Mdn	SD	Skewness	Kurtosis
		Valid	Missing					
<b>ES14</b>	Frequency of distractions from other people.	213	2	4.14	4	1.52	-0.07	-0.74
<b>ES15</b>	The amount of storage in your work area.	214	1	4.37	5	1.63	-0.28	-0.82
<b>ES16</b>	Cleanliness and tidiness of your workplace.	214	1	4.73	5	1.42	-0.52	-0.29
<b>ES17</b>	Comfort of furniture in your workplace.	213	2	4.62	5	1.44	-0.40	-0.42
<b>ES18</b>	Quality and visual appearance of furniture in your workplace.	210	5	4.65	5	1.48	-0.48	-0.22
<b>ES19</b>	Quality of lighting in your work area.	211	4	4.86	5	1.45	-0.59	-0.20
<b>ES20</b>	Natural light (sunlight) in your workplace.	213	2	4.59	5	1.68	-0.64	-0.41
<b>ES21</b>	Outside view from where you sit.	211	4	4.24	4	1.91	-0.24	-1.07
<b>ES22</b>	Amount of plants in your workplace.	214	1	3.69	4	1.92	0.05	-1.20
<b>ES23</b>	Wall decoration including paint colour and art.	213	2	3.97	4	1.64	-0.22	-0.61
<b>ES24</b>	Ability to choose where to work in your workplace (options to work away from the desk).	214	1	3.70	4	1.79	0.03	-1.00
<b>ES25</b>	Ability to move around at your workplace.	212	3	4.92	5	1.56	-0.70	-0.09
<b>ES26</b>	Size of your desk.	215	0	5.10	5	1.42	-0.92	0.41
<b>ES27</b>	Distance between you and other people you work with.	214	1	4.81	5	1.51	-0.76	0.09
<b>ES28</b>	Amount of space in your workplace.	214	1	4.91	5	1.48	-0.66	-0.23
<b>ES29</b>	Your ability to personalise your work area.	214	1	4.60	5	1.61	-0.55	-0.39

Note. Scale from 1 (*very unsatisfactory*) – 7 (*very satisfactory*).

### 6.3.1.2 *Environmental satisfaction item themes*

The 29 environmental satisfaction items were grouped into themes that were identified in the Chapter 2 literature review (Table 6.2).

Table 6.2. *Environmental Satisfaction grouped by Literature Review Themes*

<b>General satisfaction <sup>a</sup></b>	
<b>ES1</b>	Your work area (workstation) overall
<b>ES2</b>	Your workplace (the office that you work in) overall
<b>Ambient conditions</b>	
<b>ES8</b>	Overall air quality in your work area.
<b>ES9</b>	Temperature in your work area.
<b>ES19</b>	Quality of lighting in your work area.
<b>Office layout/ways of working</b>	
<b>ES3</b>	Areas in your workplace for meetings.
<b>ES4</b>	Areas in your workplace for doing work that requires focus and concentration.
<b>ES5</b>	Areas in your workplace for relaxing and taking breaks.
<b>ES24</b>	Ability to choose where to work in your workplace (options to work away from the desk).
<b>ES25</b>	Ability to move around at your workplace.
<b>Privacy and noise</b>	
<b>ES10</b>	Amount of noise in your work area.
<b>ES11</b>	Amount of noise from other people's conversations while you are at your work area.
<b>ES12</b>	Your ability to have a private conversation in your workplace.
<b>ES13</b>	Visual privacy in your work area.
<b>ES14</b>	Frequency of distractions from other people.
<b>Environmental control</b>	
<b>ES6</b>	Your ability to adjust or control your work area to suit your needs and preferences.
<b>ES29</b>	Your ability to personalise your work area.
<b>Density</b>	
<b>ES26</b>	Size of your desk.
<b>ES27</b>	Distance between you and other people you work with.
<b>ES28</b>	Amount of space in your workplace.
<b>ES15</b>	The amount of storage in your work area.
<b>Biophilia, windows, and views</b>	
<b>ES20</b>	Natural light (sunlight) in your workplace.
<b>ES21</b>	Outside view from where you sit.
<b>ES22</b>	Amount of plants in your workplace.
<b>Furnishings and décor</b>	
<b>ES7</b>	Visual appearance of your workplace.
<b>ES17</b>	Comfort of furniture in your workplace.
<b>ES18</b>	Quality and visual appearance of furniture in your workplace.
<b>ES23</b>	Wall decoration including paint colour and art.
<b>ES16</b>	Cleanliness and tidiness of your workplace.

<sup>a</sup> General satisfaction was not a literature review theme.

### 6.3.1.3 *PCA of environmental satisfaction items*

PCA was conducted to identify the component structure of the environmental satisfaction items. A Pearson's correlation matrix of the original environmental satisfaction items was produced using pairwise deletion. In the matrix (Table 6.3), most of the correlations were above .30, indicating that the data was appropriately related for PCA. The KMO measure was .94, and Bartlett's test was statistically significant ( $p < 0.001$ ). It was decided that the data was acceptable for continuing with PCA. Five components with an eigenvalue of greater than 1.0 were found, explaining 49%, 5%, 4%, 4%, and 4% of the variance, respectively, with a total of 66% explained variance. The components were named General Satisfaction, Aesthetics, Noise and Privacy, Density of Workplace, and Windows/Natural Light (Table 6.4). A scree plot revealed an elbow at the second component (Figure 6.1), but inclusion of the remaining components was more appropriate, due to their importance in the office design and wellbeing literature. Parallel analysis conducted in R, using the nScree function, confirmed that five components should be extracted.

Some of the components found by PCA were similar to the themes identified in the literature review. Noise and Privacy, Density of Workplace, and Windows/Natural Light had some items in common with the literature review themes named privacy and noise; density; and biophilia, windows, and views. General Satisfaction and Aesthetics consisted mainly of items from the literature review themes referred to as ambient conditions, office layout/ways of working, environmental control, and furnishings and décor. Measures of global environmental satisfaction, *ES1* and *ES2*, loaded on the component General Satisfaction.

Table 6.3. *Environmental Satisfaction Pearson's Correlation Matrix*

What is your degree of satisfaction with the following:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1. ES1 - Your work area (workstation) overall	-																											
2. ES2 - Your workplace (the office that you work in) overall	.66	-																										
3. ES3 - Areas in your workplace for meetings.	.49	.63	-																									
4. ES4 - Areas in your workplace for doing work that requires focus and concentration.	.57	.59	.52	-																								
5. ES5 - Areas in your workplace for relaxing and taking breaks.	.48	.55	.49	.49	-																							
6. ES6 - Your ability to adjust or control your work area to suit your needs and preferences.	.48	.63	.51	.62	.70	-																						
7. ES7 - Visual appearance of your workplace.	.54	.71	.55	.55	.55	.62	-																					
8. ES8 - Overall air quality in your work area.	.45	.55	.41	.46	.47	.47	.59	-																				
9. ES9 - Temperature in your work area.	.31	.50	.44	.50	.49	.57	.54	.67	-																			
10. ES10 - Amount of noise in your work area.	.38	.53	.40	.61	.40	.47	.49	.45	.49	-																		
11. ES11 - Amount of noise from other people's conversations while you are at your work area.	.37	.43	.32	.62	.45	.43	.51	.52	.49	.74	-																	
12. ES12 - Your ability to have a private conversation in your workplace.	.32	.57	.53	.55	.53	.52	.55	.49	.53	.62	.61	-																
13. ES13 - Visual privacy in your work area.	.28	.40	.40	.55	.53	.56	.40	.40	.53	.48	.51	.62	-															
14. ES14 - Frequency of distractions from other people.	.39	.55	.38	.56	.49	.55	.48	.44	.50	.56	.58	.58	.63	-														
15. ES15 - The amount of storage in your work area.	.35	.44	.38	.42	.43	.44	.40	.32	.44	.45	.44	.48	.57	.55	-													
16. ES16 - Cleanliness and tidiness of your workplace.	.44	.52	.38	.45	.48	.49	.61	.53	.53	.43	.39	.46	.43	.44	.46	-												

Note.  $N = 206 - 215$ .



Table 6.3. (continued)

What is your degree of satisfaction with the following:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
17. ES17 - Comfort of furniture in your workplace.	.45	.55	.48	.48	.60	.56	.52	.54	.56	.49	.48	.56	.48	.56	.44	.57	-											
18. ES18 - Quality and visual appearance of furniture in your workplace.	.41	.58	.40	.48	.47	.60	.62	.54	.48	.49	.48	.57	.52	.58	.44	.63	.75	-										
19. ES19 - Quality of lighting in your work area.	.37	.51	.39	.51	.43	.51	.54	.56	.56	.50	.55	.55	.43	.47	.45	.50	.59	.58	-									
20. ES20 - Natural light (sunlight) in your workplace.	.31	.46	.29	.41	.35	.41	.48	.51	.53	.47	.48	.46	.38	.44	.36	.40	.47	.50	.52	-								
21. ES21 - Outside view from where you sit.	.24	.43	.26	.34	.43	.42	.50	.45	.43	.36	.39	.40	.38	.41	.30	.40	.46	.47	.40	.71	-							
22. ES22 - Amount of plants in your workplace.	.19	.35	.27	.31	.44	.41	.39	.49	.53	.32	.38	.40	.42	.43	.35	.40	.42	.49	.38	.44	.50	-						
23. ES23 - Wall decoration including paint colour and art.	.35	.46	.35	.42	.47	.39	.51	.51	.48	.39	.40	.45	.43	.51	.34	.44	.49	.58	.43	.51	.52	.63	-					
24. ES24 - Ability to choose where to work in your workplace (options to work away from the desk).	.28	.42	.34	.43	.56	.50	.45	.44	.48	.38	.45	.49	.49	.52	.43	.45	.42	.42	.44	.37	.46	.59	.57	-				
25. ES25 - Ability to move around at your workplace.	.33	.44	.43	.41	.47	.43	.45	.41	.45	.37	.36	.53	.41	.38	.40	.41	.50	.44	.45	.46	.53	.36	.43	.45	-			
26. ES26 - Size of your desk.	.37	.50	.38	.38	.45	.49	.49	.39	.46	.38	.34	.41	.43	.45	.53	.48	.54	.48	.43	.38	.39	.38	.41	.41	.55	-		
27. ES27 - Distance between you and other people you work with.	.41	.43	.42	.52	.42	.44	.45	.48	.49	.51	.52	.49	.48	.44	.51	.47	.46	.46	.44	.45	.41	.32	.42	.43	.45	.51	-	
28. ES28 - Amount of space in your workplace.	.36	.51	.43	.45	.44	.52	.48	.48	.47	.50	.41	.54	.49	.45	.51	.50	.49	.52	.44	.48	.43	.31	.43	.46	.68	.66	.65	-
29. ES29 - Your ability to personalise your work area.	.31	.46	.38	.38	.38	.46	.44	.47	.47	.41	.36	.52	.49	.46	.48	.40	.40	.47	.31	.34	.30	.45	.41	.36	.39	.45	.54	.56

Note.  $N = 206 - 215$ .

Table 6.4. *Environmental Satisfaction Components found by Principal Components Analysis (PCA)*

Item		Component				
		1. General Satisfaction	2. Aesthetics	3. Noise and Privacy	4. Density of Workplace	5. Windows/ Natural Light
ES1	Your work area (workstation) overall	.87				
ES2	Your workplace (the office that you work in) overall	.76				
ES3	Areas in your workplace for meetings.	.69				
ES7	Visual appearance of your workplace.	.65				
ES6	Your ability to adjust or control your work area to suit your needs and preferences.	.56				
ES5	Areas in your workplace for relaxing and taking breaks.	.52	.44			
ES16	Cleanliness and tidiness of your workplace.	.41				
ES17	Comfort of furniture in your workplace.	.40				
ES18	Quality and visual appearance of furniture in your workplace.	.34	.31			
ES8	Overall air quality in your work area.	.34				-.31
ES22	Amount of plants in your workplace.		.89			
ES24	Ability to choose where to work in your workplace (options to work away from the desk).		.70			
ES23	Wall decoration including paint colour and art.		.66			
ES9	Temperature in your work area.		.37			
ES11	Amount of noise from other people's conversations while you are at your work area.			.89		
ES10	Amount of noise in your work area.			.81		
ES4	Areas in your workplace for doing work that requires focus and concentration.	.46		.54		
ES12	Your ability to have a private conversation in your workplace.			.51		
ES14	Frequency of distractions from other people.		.34	.48		
ES13	Visual privacy in your work area.		.37	.42		.33
ES19	Quality of lighting in your work area.			.41		
ES28	Amount of space in your workplace.				.91	
ES26	Size of your desk.				.77	
ES25	Ability to move around at your workplace.				.72	
ES27	Distance between you and other people you work with.			.31	.64	
ES29	Your ability to personalise your work area.				.56	
ES15	The amount of storage in your work area.				.56	
ES20	Natural light (sunlight) in your workplace.			.32		-.58
ES21	Outside view from where you sit.		.40			-.51
<b>Cronbach's alpha</b>		.92	.83	.90	.87	.83
<b>Number of items</b>		10	4	7	6	2
<b>Variance explained</b>		49%	5%	4%	4%	4%

Note. Factor loading cutoff = .30.

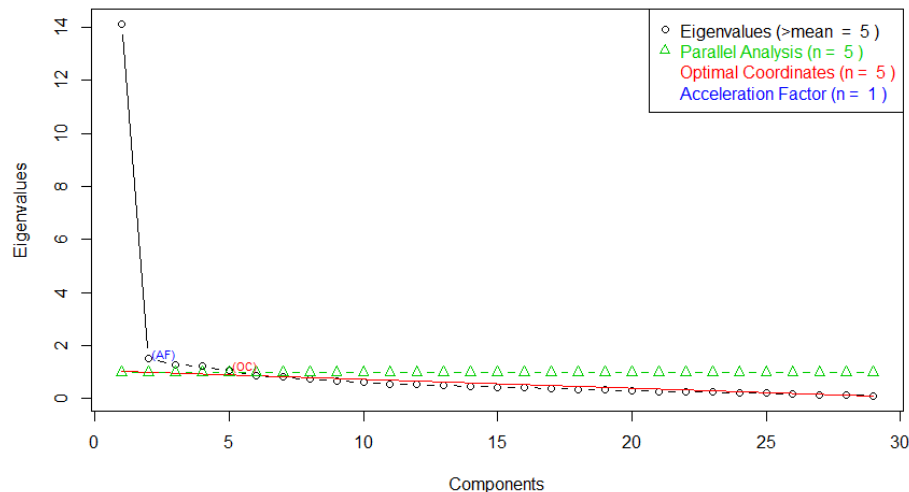


Figure 6.1. Scree plot of environmental satisfaction items.

#### 6.3.1.4 *Environmental satisfaction items retained*

A common method used to reduce questionnaires involves the deletion of items that load less highly on components. Initially, a loading cutoff of .30 was used, which is a criterion used by some researchers (Field, 2013). Stevens (2002, as cited in Field, 2013) recommends interpreting factor loadings with an absolute value of greater than .40, which explains 16% of the variance in the variable. If a higher loading cutoff had been used (e.g. absolute value of less than .40), some items that were identified in the literature as important for wellbeing (e.g., air quality, temperature) would be excluded. It has also been recommended that items that load highly on more than one component (cross-loading) should have a difference in loading of .20 or greater (Gaskin, n.d.-b). While some items had cross-loadings with less difference than .20, these items were not deleted. The decision was made not to delete high cross-loading items as environmental satisfaction items were expected to overlap components. For example, windows may create a pleasant visual appearance in a workplace but can also affect temperature and lighting. Therefore, to reduce the questionnaire, items were combined if they satisfied three conditions: 1) were deemed to have similar content by the researcher, 2) were in the same theme identified by the Chapter 2 literature review, and 3) loaded on the same component in the PCA. Combined items are listed in Table 6.5. After items were combined, there were 25 environmental satisfaction items in total, which were included in the final questionnaire.

Table 6.5. *Combined Environmental Satisfaction Items*

<b>Original Item</b>	<b>New Item</b>
ES10. Amount of noise in your work area. ES11. Amount of noise from other people's conversations while you are at your work area.	ES30. Amount of noise in your work area (e.g. from conversations).
ES12. Your ability to have a private conversation in your workplace. ES13. Visual privacy in your work area.	ES31. Privacy in your workplace (e.g., your ability to have a private conversation, visual privacy).
ES17. Comfort of furniture in your workplace. ES18. Quality and visual appearance of furniture in your workplace.	ES32. Furniture in your workplace (e.g., comfort, quality, appearance).
ES27. Distance between you and other people you work with. ES28. Amount of space in your workplace.	ES33. Amount of space in your workplace (e.g. distance between you and other people you work with).

### 6.3.2 Phase 2: Psychometric evaluation of wellbeing items

#### 6.3.2.1 Validity of wellbeing measures

There were significant correlations between SWELL and other measures that are relevant to wellbeing in office environments (Table 6.6), suggesting SWELL was a valid measure to use in the questionnaire development.

Table 6.6. Spearman Correlations among Wellbeing Outcomes using Different Scales

	<i>M</i>	<i>SD</i>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>1. SWELL total %</b>	59.68	12.47	-			
<b>2. WHO-5 total %<sup>a</sup></b>	49.50	21.71	.53**	-		
			<i>N</i> = 179	-		
<b>3. SBS Total %<sup>b</sup></b>	74.63	14.68	.48**	.23**	-	
			<i>N</i> = 175	<i>N</i> = 196	-	
<b>4. MSD total % reverse coded<sup>c</sup></b>	88.62	12.20	.36**	.24**	.44**	-
			<i>N</i> = 177	<i>N</i> = 197	<i>N</i> = 197	-
<b>5. RAND General Health % reverse coded<sup>d</sup></b>	64.37	20.59	.38**	.54**	.26**	.21**
			<i>N</i> = 185	<i>N</i> = 205	<i>N</i> = 205	<i>N</i> = 206

<sup>a</sup> WHO-5 items were on a scale from 1 to 5 (5 indicating greater positive mental wellbeing).

<sup>b</sup> SBS items were on a scale from 1 to 5 (from 1 – *always* to 5 – *never*).

<sup>c</sup> MSD items were reverse coded from 1 to 5 (1 – *very severe symptoms*, 2 – *severe symptoms*, 3 – *moderate symptoms*, 4 – *mild symptoms*, 5 – *no symptoms*).

<sup>d</sup> RAND general health item was reverse coded from 1 to 5 (1 – *poor* to 5 – *excellent*).

\*\*  $p < .01$ , two-tailed

#### 6.3.2.2 Wellbeing item descriptives

The SWELL items were ordinal, Likert scale data with responses from 1 to 10. The SWELL consists of wellbeing outcomes and predictors, some of which are related to general wellbeing, while others are work-specific. For the purposes of questionnaire development, 10 wellbeing outcomes were selected from the questionnaire. There were nine work-specific wellbeing outcomes, and one non-work-specific outcome chosen. The non-work-specific item (*SW7. Musculoskeletal disorders*) was included as MSD complaints could be an important consideration when designing an office or evaluating the effect of an office redesign. Table 6.7 shows skewness and kurtosis values. As discussed in Chapter 5, some items were not normally distributed, and there were outliers present in two items (*SW14* and *SW17*). Visual inspection of the data distribution suggested that the outliers were genuine responses and therefore were not excluded. PCA using Pearson's correlations was considered acceptable, as most items had kurtosis and skewness absolute values < 1.0.

Table 6.7. SWELL Wellbeing Outcome Item Descriptives

Item		N		M	Mdn	SD	Skewness	Kurtosis
		Valid	Missing					
<b>SW7</b>	Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)? <i>reverse coded</i>	215	0	7.04	8	3.06	-0.62	-1.07
<b>SW12</b>	How much stress do you have at work? <i>reverse coded</i>	214	1	4.99	5	2.29	0.25	-0.58
<b>SW13</b>	Are you satisfied with your job?	213	2	5.98	6	2.23	-0.48	-0.28
<b>SW14</b>	How physically or mentally tired do you get at work? <i>reverse coded</i>	212	3	4.43	4	2.21	0.63	-0.03
<b>SW15</b>	Have you had an illness (either physical or mental) caused or made worse by work? <i>bivariate</i>	210	5	7.73	10	3.92	-1.15	-0.69
<b>SW16</b>	Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to? <i>bivariate</i>	211	4	4.41	1	4.38	0.50	-1.77
<b>SW17</b>	How efficiently do you carry out your work?	211	4	7.37	8	1.89	-1.07	1.06
<b>SW18</b>	Do you find your job interferes with your life outside work or your life outside of work interferes with your job? <i>reverse coded</i>	210	5	5.76	6	2.51	-0.08	-0.97
<b>SW19</b>	Are you happy at work?	212	3	5.98	6	2.18	-0.36	-0.52
<b>SW20</b>	Are you anxious or depressed because of work? <i>reverse coded</i>	213	2	6.20	6	2.63	-0.23	-1.09

Note. On a scale from 1 to 10, with 10 indicating higher positive wellbeing, or lower negative wellbeing.

### 6.3.2.3 Wellbeing outcome item themes

The 10 retained wellbeing outcomes were grouped into themes identified in the Chapter 3 literature review (see Table 6.8).

Table 6.8. *Wellbeing Outcomes grouped by Literature Review Themes*

<b>Comfort</b>	
-	
<b>Environmental and job satisfaction</b>	
<b>SW13</b>	Are you satisfied with your job?
<b>Mental wellbeing</b>	
<b>SW12</b>	How much stress do you have at work? <i>reverse coded</i>
<b>SW19</b>	Are you happy at work?
<b>SW20</b>	Are you anxious or depressed because of work? <i>reverse coded</i>
<b>SW18</b>	Do you find your job interferes with your life outside work or your life outside of work interferes with your job? <i>reverse coded</i>
<b>Health and sickness absence</b>	
<b>SW7</b>	Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)? <i>reverse coded</i>
<b>SW15</b>	Have you had an illness (either physical or mental) caused or made worse by work? <i>bivariate</i>
<b>Productivity</b>	
<b>SW14</b>	How physically or mentally tired do you get at work? <i>reverse coded</i>
<b>SW16</b>	Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to? <i>bivariate</i>
<b>SW17</b>	How efficiently do you carry out your work?
<b>Collaboration</b>	
-	
<b>Cognitive functioning</b>	
-	

### 6.3.2.4 PCA of SWELL wellbeing outcomes items

The selected wellbeing items from the SWELL were analysed by PCA with direct oblimin rotation and pairwise deletion. Inspection of the Pearson's correlation matrix (Table 6.9) revealed some correlations above .30, indicating that PCA was appropriate. One item measuring MSDs (SW7) had no correlations with other items above .30 but was retained as it had some correlations close to .30. KMO was .73, and Bartlett's was  $p < .001$ , indicating acceptability for PCA. Two components with an eigenvalue of greater than 1.0 were found, explaining 34% and 19% of the variance, respectively, and 54% total. The components were named Negative Wellbeing and Positive Wellbeing (see Table 6.10). An inspection of the scree plot revealed an elbow at the third component (Figure 6.2). Parallel analysis confirmed that two components should be extracted.

The components contained items that were grouped into the literature review themes job satisfaction, mental wellbeing, health and sickness absence, and productivity.

Table 6.9. *SWELL Wellbeing Outcome Item Pearson's Correlation Matrix*

	1	2	3	4	5	6	7	8	9	10
1. SW7 - Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)? <i>reverse coded</i>	-									
2. SW12 - How much stress do you have at work? <i>reverse coded</i>	.18	-								
3. SW13 - Are you satisfied with your job?	-.09	.23	-							
4. SW14 - How physically or mentally tired do you get at work? <i>reverse coded</i>	.17	.61	.14	-						
5. SW15 - Have you had an illness (either physical or mental) caused or made worse by work? <i>bivariate</i>	.13	.29	.18	.30	-					
6. SW16 - Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to? <i>bivariate</i>	.11	.33	.15	.31	.30	-				
7. SW17 - How efficiently do you carry out your work?	.00	.04	.43	-.11	.06	-.01	-			
8. SW18 - Do you find your job interferes with your life outside work or your life outside of work interferes with your job? <i>reverse coded</i>	.24	.46	.09	.40	.37	.26	.01	-		
9. SW19 - Are you happy at work?	-.09	.24	.79	.19	.28	.08	.45	.14	-	
10. SW20 - Are you anxious or depressed because of work? <i>reverse coded</i>	.26	.69	.32	.43	.35	.21	.10	.57	.33	-

Note. *N* = 205 – 215.



Table 6.10. SWELL Wellbeing Outcomes Components found by Principal Components Analysis (PCA)

Item		Component	
		1. Negative Wellbeing	2. Positive Wellbeing
<b>SW12</b>	How much stress do you have at work? <i>reverse coded</i>	.81	
<b>SW20</b>	Are you anxious or depressed because of work? <i>reverse coded</i>	.77	
<b>SW18</b>	Do you find your job interferes with your life outside work or your life outside of work interferes with your job? <i>reverse coded</i>	.74	
<b>SW14</b>	How physically or mentally tired do you get at work? <i>reverse coded</i>	.74	
<b>SW15</b>	Have you had an illness (either physical or mental) caused or made worse by work? <i>bivariate</i>	.54	
<b>SW16</b>	Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to? <i>bivariate</i>	.51	
<b>SW7</b>	Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)? <i>reverse coded</i>	.42	
<b>SW19</b>	Are you happy at work?		.88
<b>SW13</b>	Are you satisfied with your job?		.87
<b>SW17</b>	How efficiently do you carry out your work?		.72
<b>Cronbach's alpha</b>		.73	.79
<b>Number of items</b>		7	3
<b>Variance explained</b>		34%	19%

Note. Factor loading cutoff = .30.

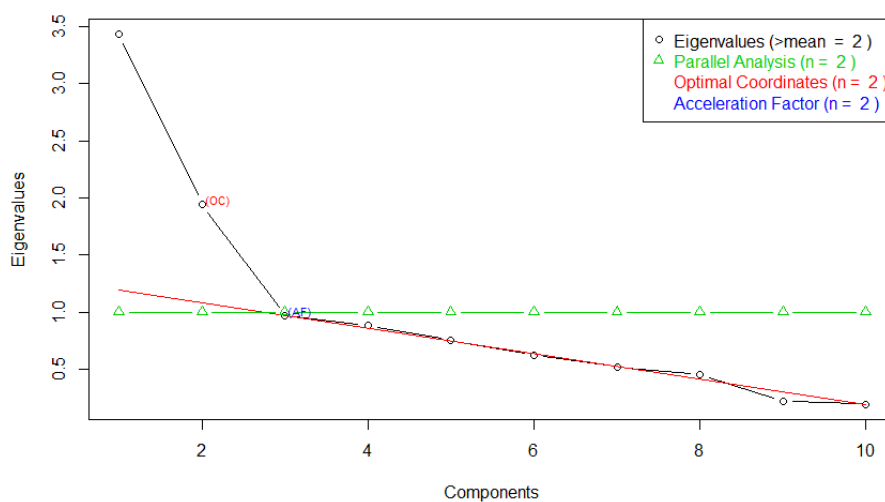


Figure 6.2. Scree plot of SWELL wellbeing outcome items.

### 6.3.2.5 SWELL wellbeing outcome items retained

As there were no items that the researcher judged to be sufficiently similar to combine, all 10 wellbeing outcomes were retained in the final questionnaire, although some minor changes were made. Wording was modified for two items (SW15 and SW16) to use the same scale as the rest of the items. The wording of one item (SW18) was changed slightly to be more work-specific. The modified items are listed in Table 6.11. The SWELL asks participants to reflect on the past 6 months when answering some of the items (“Thinking about the last 6 months”), and a shorter timescale is used in the final questionnaire (“Thinking about the past month”) in order to allow for its use in repeated measure designs, and more immediate feedback from office redesigns.

Table 6.11. SWELL Wellbeing Outcome Modified Items

Modified Item	Dimension
SW15 (modified). Do you suffer from illness (either physical or mental) caused or made worse by work?	sickness attributed to work
SW16 (modified). Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to?	presenteeism
SW18 (modified). Do you find your job interferes with your life outside work?	mental wellbeing

### 6.3.2.6 *Additional productivity outcomes*

After consideration of the literature and the aims of the questionnaire, it was decided that two items should be added addressing collaboration and teamwork.

Collaboration:

*How well do people collaborate in your workplace?*

Teamwork:

*How would you rate teamwork in your workplace?*

### 6.3.2.7 *Inclusion of wellbeing predictors*

In Chapter 5, two SWELL wellbeing predictors were identified that were important in the relationship between wellbeing and environmental satisfaction. These items are included in the questionnaire as optional items. One SWELL item (SW11) was modified to form two questions.

Job demands:

*SW10. How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)?*

Personal control:

*SW11 (modified). Do you feel you have control over your job?*

Support from colleagues:

*SW11 (modified). Do you feel you have support from fellow workers?*

### 6.3.3 Final Well Office Questionnaire (WOQ)

The final questionnaire (see Table 6.12) includes 25 environmental satisfaction items and 15 items measuring wellbeing, productivity, and collaboration.

Table 6.12. *Well Office Questionnaire (WOQ)*

WOQ Item	Dimension	Scale
Environmental satisfaction items		
<i>What is your degree of satisfaction with the following:</i>		1 – very unsatisfactory, 2 – unsatisfactory, 3 – somewhat satisfactory, 4 – neutral, 5 – somewhat satisfactory, 6 – satisfactory, 7 – very satisfactory
1. Your work area (workstation) overall	general satisfaction	
2. Your workplace (the office that you work in) overall	general satisfaction	
3. Areas in your workplace for meetings.	workplace areas	
4. Areas in your workplace for doing work that requires focus and concentration.	workplace areas	
5. Areas in your workplace for relaxing and taking breaks.	workplace areas	
6. Your ability to adjust or control your work area to suit your needs and preferences.	environmental control	
7. Visual appearance of your workplace.	aesthetics	
8. Overall air quality in your work area.	ambient conditions	
9. Temperature in your work area.	ambient conditions	
10. Frequency of distractions from other people.	noise and privacy	
11. The amount of storage in your work area.	storage	
12. Cleanliness and tidiness of your workplace.	cleanliness of workplace	
13. Quality of lighting in your work area.	ambient conditions	
14. Natural light (sunlight) in your workplace.	natural light/windows	
15. Outside view from where you sit.	natural light/windows	
16. Amount of plants in your workplace.	plants	
17. Wall decoration including paint colour and art.	aesthetics	
18. Ability to choose where to work in your workplace (options to work away from the desk).	ABW/environmental control	
19. Ability to move around at your workplace.	ABW/ environmental control	
20. Size of your desk.	desk	
21. Your ability to personalise your work area.	environmental control	
22. Amount of noise in your work area (e.g. from conversations).	noise and privacy	
23. Privacy in your workplace (e.g. your ability to have a private conversation, visual privacy).	noise and privacy	
24. Furniture in your workplace (e.g. comfort, quality, appearance).	furniture	
25. Amount of space in your workplace (e.g. distance between you and other people you work with).	density of workplace	

Table 6.12. (continued)

WOQ item	Dimension	Scale
<i>Wellbeing items</i>		
<i>Thinking about the past month:</i>		
1. Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)? <i>reverse coded</i>	MSDs	(1-10) not at all - very much so
2. How much stress do you have at work? <i>reverse coded</i>	stress	(1-10) very little - a great deal
3. Are you satisfied with your job?	job satisfaction	(1-10) not at all - very much so
4. How physically or mentally tired do you get at work? <i>reverse coded</i>	productivity	(1-10) not at all tired - very tired
5. Do you suffer from illness (either physical or mental) caused or made worse by work? <i>reverse coded</i>	sickness attributed to work	(1-10) never - very often
6. Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to? <i>reverse coded</i>	presenteeism	(1-10) never - very often
7. How efficiently do you carry out your work?	productivity	(1-10) not very efficiently - very efficiently
8. Do you find your job interferes with your life outside work? <i>reverse coded</i>	mental wellbeing	(1-10) never - very often
9. Are you happy at work?	happiness	(1-10) never - very often
10. Are you anxious or depressed because of work? <i>reverse coded</i>	anxiety, depression	(1-10) not at all - very much so
11. How well do people collaborate in your workplace?	collaboration	(1-10) not very well - very well
12. How would you rate teamwork in your workplace?	teamwork	(1-10) very poor - very good
13. How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)? <sup>a</sup>	wellbeing predictor (job demands)	(1-10) not at all demanding - very demanding
14. Do you feel you have control over your job? <sup>a</sup>	wellbeing predictor (job control)	(1-10) not at all - very much so
15. Do you feel you have support from fellow workers? <sup>a</sup>	wellbeing predictor (support from colleagues)	(1-10) not at all - very much so

<sup>a</sup> Optional wellbeing predictor items.

#### 6.3.4 Phase 3: Environmental satisfaction items as predictors of wellbeing outcomes

In Phase 3, regression analyses were conducted to examine environmental satisfaction items in the original questionnaire as predictors of positive and negative wellbeing outcomes. This step was taken to determine specific environmental satisfaction items that were significant predictors of positive or negative wellbeing, to ensure that these items were not removed from the final questionnaire.

##### 6.3.4.1 *Environmental satisfaction and positive wellbeing outcomes (job satisfaction, happiness at work)*

Environmental satisfaction items were entered into a multiple linear regression with positive wellbeing outcomes. The total variance explained by the model was 48%, and the regression equation was significant,  $F(29, 175) = 5.64, p < .001$ . Higher ratings of *ES2. Your workplace overall* and *ES4. Areas in your workplace for doing work that requires focus and concentration* significantly predicted higher positive wellbeing outcomes (Table 6.13). Higher ratings of *ES19. Quality of lighting* significantly predicted lower positive wellbeing outcomes.

The significant environmental satisfaction predictors were entered into another multiple linear regression, alongside other wellbeing predictors. By including other wellbeing predictors, the relationships between satisfaction with the environmental satisfaction items and positive/negative wellbeing outcomes could be measured, while controlling for the effects of other variables, which may have a confounding effect. The wellbeing predictors controlled for were occupation, healthy lifestyle, positive personality, noise exposure, job demands, and job control/support. The total variance explained by the model was 56%, and the regression equation was significant,  $F(9, 196) = 27.75, p < .001$ . When the other wellbeing predictors were included, *ES19. Quality of lighting* was no longer a significant predictor (Table 6.15). *ES2. Your workplace overall* and *ES4. Areas in your workplace for doing work that requires focus and concentration* remained significant after other wellbeing predictors were included. *ES2. Your workplace overall* ( $\beta = .33$ ) was a stronger predictor than *ES4. Areas in your workplace for doing work that requires focus and concentration* ( $\beta = .18$ ).

When two or more predictors are strongly correlated, there may be concern about multicollinearity (Field, 2013). There were no problems with multicollinearity observed in either of the multiple linear regressions. Concerns for multicollinearity may be indicated with tolerance values of less than .10, or variance inflation factor (VIF) values of above 10 (Pallant, 2016). Tolerance values were .23 or greater, and VIF values were 4.36 or less. Inspection of the probability plot (P-P) and scatterplot of

the regression standardised residuals showed that assumptions of normality, linearity, and homoscedasticity between predicted DV scores and errors of prediction were met in both regression models (Pallant, 2016; Tabachnick & Fidell, 2013). There were no outliers identified in the first regression. One outlier was identified in the second regression, with a standardised residual value of  $-3.86$ , which was above the acceptable value of around  $\pm 3.3$  (Tabachnick & Fidell, 2013). When an outlier is found, a maximum Cook's Distance of 1 or greater indicates the case may be a problem for the regression model (Pallant, 2016). This unusual case did not affect the model, as observed by a maximum Cook's Distance of .10, a value less than 1.

#### 6.3.4.2 *Environmental satisfaction and negative wellbeing outcomes (stress, anxiety/depression)*

Environmental satisfaction items were entered into a multiple linear regression with negative wellbeing outcomes. The total variance explained by the model was 27%, and the regression equation was significant,  $F(29, 176) = 2.24, p = .001$ . Higher ratings of *ES6. Ability to adjust work area* and *ES27. Distance between colleagues* significantly predicted lower negative wellbeing outcomes (Table 6.14). Higher ratings of *ES19. Quality of lighting* and *ES21. Outside view* predicted higher negative wellbeing outcomes.

The significant environmental satisfaction predictors were entered into another multiple linear regression, alongside other wellbeing predictors. The total variance explained by the model was 52%, and the regression equation was significant,  $F(10, 196) = 20.98, p < .001$ . When the other wellbeing predictors were included, *ES19. Quality of lighting* was no longer a significant predictor (Table 6.16). Higher ratings of *ES6. Ability to adjust work area* and *ES27. Distance between colleagues* remained significant predictors ( $\beta = -.15$  and  $\beta = -.19$ , respectively) of lower negative wellbeing outcomes after other wellbeing predictors were included. Higher ratings of *ES21. Outside view* remained a predictor of higher negative wellbeing outcomes ( $\beta = .12$ ).

There were no problems with multicollinearity observed in either of the multiple linear regressions. Tolerance values were .23 or greater, and VIF values were 4.36 or less. Inspection of the probability plot (P-P) and a scatterplot of the regression standardised residuals showed that assumptions of normality, linearity, and homoscedasticity between predicted DV scores and errors of prediction were met in both regression models. There were no outliers identified in either regression models, and all standardised residuals were above the acceptable value of approximately  $\pm 3.3$  (Tabachnick & Fidell, 2013).

Table 6.13. *Regression Analysis for Environmental Satisfaction Items' Prediction of Positive Wellbeing Outcomes.*

	<b>B</b>	<b>SE B</b>	<b>β</b>	<b>t</b>	<b>p</b>
(Constant)	1.36	1.15		1.19	.237
ES1. Your work area (workstation) overall	-0.28	0.26	-.09	-1.08	.283
ES2. Your workplace (the office that you work in) overall	0.98	0.33	.31	2.99	.003**
ES3. Areas in your workplace for meetings.	0.29	0.24	.10	1.22	.224
ES4. Areas in your workplace for doing work that requires focus and concentration.	0.55	0.26	.20	2.16	.032*
ES5. Areas in your workplace for relaxing and taking breaks.	-0.09	0.23	-.04	-0.40	.693
ES6. Your ability to adjust or control your work area to suit your needs and preferences.	0.33	0.29	.12	1.16	.247
ES7. Visual appearance of your workplace.	-0.04	0.30	-.01	-0.14	.890
ES8. Overall air quality in your work area.	0.17	0.25	.06	0.69	.492
ES9. Temperature in your work area.	-0.17	0.24	-.07	-0.71	.476
ES10. Amount of noise in your work area.	-0.04	0.26	-.01	-0.14	.885
ES11. Amount of noise from other people's conversations while you are at your work area.	-0.10	0.26	-.04	-0.39	.699
ES12. Your ability to have a private conversation in your workplace.	0.31	0.24	.13	1.32	.189
ES13. Visual privacy in your work area.	-0.01	0.22	.00	-0.05	.964
ES14. Frequency of distractions from other people.	-0.17	0.24	-.06	-0.71	.479
ES15. The amount of storage in your work area.	0.34	0.21	.13	1.63	.104
ES16. Cleanliness and tidiness of your workplace.	0.26	0.24	.09	1.09	.278
ES17. Comfort of furniture in your workplace.	-0.05	0.31	-.02	-0.17	.863
ES18. Quality and visual appearance of furniture in your workplace.	0.20	0.32	.07	0.63	.531
ES19. Quality of lighting in your work area.	-0.52	0.24	-.18	-2.16	.032*
ES20. Natural light (sunlight) in your workplace.	0.16	0.22	.06	0.71	.476
ES21. Outside view from where you sit.	-0.17	0.20	-.08	-0.84	.403
ES22. Amount of plants in your workplace.	-0.06	0.19	-.03	-0.31	.755
ES23. Wall decoration including paint colour and art.	0.18	0.22	.07	0.82	.413
ES24. Ability to choose where to work in your workplace (options to work away from the desk).	0.13	0.20	.06	0.68	.499
ES25. Ability to move around at your workplace.	0.22	0.23	.08	0.96	.339
ES26. Size of your desk.	-0.30	0.25	-.10	-1.21	.229
ES27. Distance between you and other people you work with.	0.30	0.23	.11	1.30	.195
ES28. Amount of space in your workplace.	0.02	0.30	.01	0.07	.941
ES29. Your ability to personalise your work area.	-0.15	0.21	-.06	-0.72	.469

\*  $p < .05$ \*\*  $p < .01$ \*\*\*  $p < .001$



Table 6.14. *Regression Analysis for Environmental Satisfaction Items' Prediction of Negative Wellbeing Outcomes.*

	<b>B</b>	<b>SE B</b>	<b>β</b>	<b>t</b>	<b>p</b>
<b>Constant</b>	17.29	1.47		11.74	< .001***
<b>ES1. Your work area (workstation) overall</b>	-0.06	0.33	-.02	-0.18	.857
<b>ES2. Your workplace (the office that you work in) overall</b>	0.35	0.42	.10	0.82	.412
<b>ES3. Areas in your workplace for meetings.</b>	-0.11	0.30	-.03	-0.35	.724
<b>ES4. Areas in your workplace for doing work that requires focus and concentration.</b>	-0.47	0.33	-.16	-1.45	.150
<b>ES5. Areas in your workplace for relaxing and taking breaks.</b>	0.32	0.29	.12	1.08	.280
<b>ES6. Your ability to adjust or control your work area to suit your needs and preferences.</b>	-0.77	0.37	-.26	-2.09	.038*
<b>ES7. Visual appearance of your workplace.</b>	-0.29	0.39	-.09	-0.75	.455
<b>ES8. Overall air quality in your work area.</b>	-0.14	0.32	-.05	-0.44	.660
<b>ES9. Temperature in your work area.</b>	0.35	0.31	.12	1.13	.262
<b>ES10. Amount of noise in your work area.</b>	0.23	0.34	.08	0.69	.492
<b>ES11. Amount of noise from other people's conversations while you are at your work area.</b>	0.13	0.34	.05	0.38	.704
<b>ES12. Your ability to have a private conversation in your workplace.</b>	-0.52	0.30	-.20	-1.72	.087
<b>ES13. Visual privacy in your work area.</b>	0.48	0.29	.18	1.66	.099
<b>ES14. Frequency of distractions from other people.</b>	-0.29	0.31	-.10	-0.93	.353
<b>ES15. The amount of storage in your work area.</b>	-0.30	0.26	-.11	-1.15	.253
<b>ES16. Cleanliness and tidiness of your workplace.</b>	0.36	0.31	.11	1.17	.245
<b>ES17. Comfort of furniture in your workplace.</b>	0.00	0.39	.00	0.01	.990
<b>ES18. Quality and visual appearance of furniture in your workplace.</b>	-0.45	0.41	-.15	-1.09	.277
<b>ES19. Quality of lighting in your work area.</b>	0.63	0.31	.20	2.05	.041*
<b>ES20. Natural light (sunlight) in your workplace.</b>	-0.29	0.29	-.11	-1.00	.319
<b>ES21. Outside view from where you sit.</b>	0.61	0.26	.26	2.35	.020*
<b>ES22. Amount of plants in your workplace.</b>	-0.04	0.24	-.02	-0.18	.860
<b>ES23. Wall decoration including paint colour and art.</b>	-0.20	0.28	-.07	-0.71	.476
<b>ES24. Ability to choose where to work in your workplace (options to work away from the desk).</b>	0.04	0.25	.02	0.17	.866
<b>ES25. Ability to move around at your workplace.</b>	-0.21	0.30	-.07	-0.70	.483
<b>ES26. Size of your desk.</b>	-0.10	0.32	-.03	-0.31	.758
<b>ES27. Distance between you and other people you work with.</b>	-0.79	0.30	-.27	-2.65	.009**
<b>ES28. Amount of space in your workplace.</b>	-0.11	0.38	-.04	-0.29	.774
<b>ES29. Your ability to personalise your work area.</b>	0.30	0.27	.11	1.14	.257

\*  $p < .05$ \*\*  $p < .01$ \*\*\*  $p < .001$

Table 6.15. *Regression Analysis for Wellbeing Predictors' and Selected Environmental Satisfaction Items' Prediction of Positive Wellbeing Outcomes.*

	<b>B</b>	<b>SE B</b>	<b>β</b>	<b>t</b>	<b>p</b>
<b>(Constant)</b>	-1.43	1.16		-1.23	.219
<b>ES2. Workplace overall</b>	1.05	0.20	.33	5.24	< .001***
<b>ES4. Areas for doing work requiring focus and concentration</b>	0.51	0.18	.18	2.83	.005**
<b>ES19. Quality of lighting</b>	-0.17	0.17	-.06	-1.02	.310
<b>Occupation</b>	-0.14	0.18	-.04	-0.78	.434
<b>SW1. Healthy lifestyle</b>	0.17	0.11	.09	1.56	.121
<b>SW2. Optimism</b>	0.29	0.11	.15	2.54	.012*
<b>SW8. Noise at work</b>	0.07	0.09	.04	0.77	.440
<b>SW10. Job demands</b>	0.03	0.09	.01	0.29	.771
<b>SW11. Job control/support</b>	0.65	0.11	.33	5.79	< .001***

\*  $p < .05$ \*\*  $p < .01$ \*\*\*  $p < .001$ Table 6.16. *Regression Analysis for Wellbeing Predictors' and Selected Environmental Satisfaction Items' Prediction of Negative Wellbeing Outcomes.*

	<b>B</b>	<b>SE B</b>	<b>β</b>	<b>t</b>	<b>p</b>
<b>(Constant)</b>	8.19	1.32		6.23	<.001***
<b>ES6. Ability to adjust work area</b>	-0.47	0.19	-.15	-2.41	.017*
<b>ES19. Quality of lighting</b>	0.06	0.19	.02	0.30	.768
<b>ES21. Outside view</b>	0.29	0.14	.12	2.06	.041*
<b>ES27. Distance between colleagues</b>	-0.56	0.18	-.19	-3.10	.002**
<b>Occupation</b>	0.26	0.21	.07	1.28	.201
<b>SW1. Healthy lifestyle</b>	0.10	0.13	.05	0.81	.419
<b>SW2. Optimism</b>	-0.25	0.13	-.12	-1.96	.052
<b>SW8. Noise at work</b>	0.34	0.10	.18	3.43	.001**
<b>SW10. Job demands</b>	1.01	0.10	.51	9.72	<.001***
<b>SW11. Job control/support</b>	-0.22	0.12	-.10	-1.75	.081

\*  $p < .05$ \*\*  $p < .01$ \*\*\*  $p < .001$

## 6.4 Discussion

Studies have found that features of office design affect occupants' wellbeing; however, a wide variety of methods are used to measure wellbeing, resulting in difficulty making conclusions about the relationship between wellbeing and office design characteristics. It has been recognised that there needs to be a more integrated approach to the investigation of occupant outcomes and satisfaction with the physical environment. This chapter details the development of a short wellbeing and office design questionnaire, the WOQ, by using combination and modification of environmental satisfaction and wellbeing items from a UK office employee study. Environmental satisfaction items were initially derived from the office design literature and discussion with the researcher's industrial partner. Wellbeing items were sourced from the SWELL questionnaire, with some minor modifications. The final questionnaire consists of a total of 40 items: 25 environmental satisfaction items and 15 items measuring wellbeing, productivity, and collaboration. The questionnaire is provided in Table 6.12 and is free to use. The WOQ can be used to assess change in occupants when used as a baseline and post-occupancy measure. Alternatively, it can be used as a single post-occupancy measure to evaluate employee wellbeing and satisfaction with the office environment.

There were 29 environmental satisfaction items in the original questionnaire, and PCA was used to identify which items clustered together. The components were labelled General Satisfaction, Aesthetics, Noise and Privacy, Density of Workplace, and Windows/Natural Light. The latter three components were similar to environmental satisfaction themes identified in the Chapter 2 literature review. General Satisfaction and Aesthetics were less clearly defined and consisted of items from a few literature review themes (ambient conditions, office layout/ways of working, environmental control, furnishings and décor). Some questionnaire items were combined, and this resulted in a final total of 25 environmental satisfaction items. The original questionnaire included some questions used by Veitch et al. (2007), which were modified from Stokols and Scharf (1990). Veitch et al. (2007) found three components identified as satisfaction with Privacy/Acoustics, Ventilation/Temperature, and Lighting. In the environmental satisfaction PCA detailed in the present chapter, differences with the components found by Veitch et al. (2007) reflect less focus in the present questionnaire on ambient conditions. The present study's General Satisfaction component included items about workplace areas, which were not present in the latter study, but were used to reflect modern trends in the workplace for choosing where to work (Wohlers & Hertel, 2017), and emerging evidence that shared areas for breaks and meetings may affect occupant wellbeing and collaboration (Hua et al., 2011; J. Kim et al., 2016). The present study's Noise and Privacy component

was similar to the Privacy/Acoustics component in Veitch et al. (2007). The Density of Workplace component had items relating to the amount of space in the office (e.g., storage, desk size). Previous research has found an association of decreased satisfaction with privacy and lower wellbeing in offices with higher density (Herbig et al., 2016; Oldham, 1988), and open-plan layouts are associated with dissatisfaction with noise and privacy (De Croon et al., 2005). It seems likely that personal space is important for privacy, and therefore, occupant wellbeing and environmental satisfaction in an open-plan office. Another component identified in the present study's PCA was Windows/Natural Light, and the link between windows and wellbeing has been identified (Aries et al., 2010). The environmental satisfaction components in the present study had some similarities to a previous environmental satisfaction scale factor analysis (Veitch et al., 2007), and differences are likely due to the additional items in the present study's original questionnaire. Furthermore, the environmental satisfaction components in the current study are representative of the office design and wellbeing literature themes identified in Chapter 2.

The wellbeing section of the WOQ was developed using selected work-specific SWELL items. The participants' SWELL responses correlated well with their responses to other wellbeing measures (health, psychological wellbeing, SBS symptoms, and MSDs). A PCA with 10 wellbeing outcomes from the SWELL resulted in two components, which were named Negative Wellbeing and Positive Wellbeing. The finding of positive and negative wellbeing components agrees with previous research indicating that these are separate entities (Smith et al., 2011). As the selected items were deemed by the researcher to be too dissimilar to combine or eliminate, all questions were retained, with some minor modifications. The SWELL items selected represented most of the themes identified by the Chapter 3 literature review. A further two items were added to measure collaboration and teamwork. Collaboration may be related to productivity in offices with knowledge workers where information sharing is important, and previous research has found that open-plan offices may have a detrimental impact on collaboration, teamwork, and communication (Brennan et al., 2002; R. L. Morrison & Macky, 2017; Parkin et al., 2011). An optional three wellbeing predictors were included. The wellbeing predictors were identified in a previous study (see Chapter 5) as being important for the relationship between environmental satisfaction and wellbeing. The wellbeing outcome questions measure psychological wellbeing, physical health, job satisfaction, presenteeism, productivity, collaboration, and teamwork.

Lastly, the relationships between environmental satisfaction items used in the initial questionnaire, and positive and negative wellbeing outcomes were examined. Following the same procedure as

Chapter 4, other predictors of wellbeing were controlled for in the analyses. For positive wellbeing, the strongest environmental satisfaction item predictor was *ES2. Your workplace overall*. This would suggest that a global positive evaluation of the workplace environment is more related to positive wellbeing than satisfaction with specific aspects of the environment. The second strongest predictor was *ES4. Areas in your workplace for doing work that requires focus and concentration*. The majority of the sample were open-plan office occupants, and this office type is frequently associated with dissatisfaction with noise and lack of privacy (De Croon et al., 2005; Kaarlela-Tuomaala et al., 2009). Thus, it is logical that occupants who had areas to do focused work also had higher positive wellbeing outcomes. Negative wellbeing was not as strongly associated with the environmental satisfaction individual items. After controlling for other wellbeing predictors, there were lower negative wellbeing outcomes among participants who had higher satisfaction with *ES6. Ability to adjust work area* and *ES27. Distance between colleagues*. These results provide further support for the importance of environmental control (e.g. Y. S. Lee & Brand, 2005) and density (e.g. Herbig et al., 2016) when designing offices for better occupant wellbeing. An interesting result was that higher ratings of *ES21. Outside view* was a predictor of greater negative wellbeing. While this may seem at odds with biophilia research which has shown wellbeing is associated with views of nature and plants (Grinde & Patil, 2009), proximity to a window could result in problems with glare or thermal issues (Aries et al., 2010).

This questionnaire was designed to be an accessible tool for industry and academia, offering an easy-to-use and free option for evaluating occupant wellbeing and satisfaction with the physical office environment. While the questionnaire has been designed to be used in totality, it is possible to shorten it by using only items that are relevant to a particular office environment. In addition, some further items could be removed due to redundancy. The questionnaire examines satisfaction with various aspects of the office environment; however, if a single global satisfaction measure was required, the item *ES2. Your workplace overall* could be used. The latter question was the strongest environmental satisfaction item predictor for positive wellbeing.

#### 6.4.1 Conclusion

The wellbeing and office design literature reveals that studies have used a selection of items to measure wellbeing, and it is difficult to compare wellbeing outcomes from studies as a result. Development of a 40-item questionnaire, the Well Office Questionnaire (WOQ), which measures occupant wellbeing and satisfaction with the office environment, was discussed in this chapter. The WOQ is the result of reduction of a larger questionnaire guided by Chapter 2 and 3 literature review

themes, and PCA of the questionnaire results from a sample of 215 UK office workers. The questionnaire should be used in future studies, to ascertain acceptability to participants and companies, and usefulness as a tool to measure occupant outcomes in office design evaluations.

It is important to assess occupant outcomes in the context of office design or relocation. In the next chapter, Study 2, a longitudinal office design evaluation study, will be described. Chapter 7 will include quantitative comparisons of occupant wellbeing and satisfaction before and after an office redesign, while Chapter 8 will discuss qualitative data exploring how the office environment affects employees' wellbeing.

#### 6.4.2 Industrial partner summary

- The Well Office Questionnaire (WOQ) uses 40 items to measure occupant wellbeing and satisfaction with the office environment.
- The WOQ is free to use and may be adapted to suit (e.g. by removing unnecessary items).

## 7 Occupant wellbeing in an open-plan office: Impact of an office redesign, Part 1

### 7.1 Introduction

In Chapter 5, the relationship between environmental satisfaction and occupant wellbeing was illustrated using a structural equation modelling approach with cross-sectional data. A longitudinal or experimental design would provide a more convincing test of the impact of office design on employee wellbeing. The importance of evaluating occupant outcomes in the context of office design was further discussed in Chapter 6. Chapters 7 and 8 describe Study 2, a longitudinal mixed-methods study investigating environmental satisfaction and wellbeing pre- and post- office redesign. The present chapter contains the Introduction and Method sections, and results from the quantitative data. The qualitative data results and the Discussion section are included in Chapter 8.

This PhD research was conducted in partnership with an industrial partner, an office design and furniture manufacturing company. The present study was based at one of the industrial partner's open-plan offices in the United Kingdom, where activity-based working (ABW) was promoted. The next section provides a brief summary of the relationship between open-plan offices, ABW, and wellbeing.

#### 7.1.1 Open-plan offices and wellbeing

The relationship between negative wellbeing outcomes and open-plan offices was highlighted in Chapter 2. Literature reviews have found this layout is linked with reduced privacy and job satisfaction (De Croon et al., 2005), and consistent negative impacts on employee health, wellbeing, and productivity (A. Richardson et al., 2017). While wellbeing outcomes are generally poorer in open-plan offices, the layout is popular due to reduced costs of remodelling and occupancy (De Croon et al., 2005; Hedge, 1982; Vischer, 2008). Facilitation of collaboration is another perceived benefit of open-plan offices (J. Kim & de Dear, 2013; Pejtersen et al., 2006); however, Chapters 2 and 3 discussed studies which show that they may have a negative effect on collaboration, teamwork, and communication (Brennan et al., 2002; Kaarlela-Tuomaala et al., 2009; R. L. Morrison & Macky, 2017; Otterbring et al., 2018; Parkin et al., 2011). One study found no evidence to indicate that social support and feedback were related to the number of occupants in an office (Pejtersen et al., 2006).

### 7.1.2 Activity-based flexible offices

In activity-based flexible offices, workers can choose different areas to work depending on their task and are not given allocated desks (Wohlers & Hertel, 2017). Evidence suggests ABW, also referred to as agile working, may have a positive impact on interaction, communication, environmental satisfaction, and personal control; however, it may be detrimental for concentration and privacy (Engelen et al., 2018). Personal control over the environment may improve environmental and job satisfaction (Y. S. Lee & Brand, 2005), and ABW may afford occupants more choice and control in open-plan environments. For example, occupants may move to sit in an area of the office where the lighting or temperature is most suited to their preferences. ABW may also encourage physical activity by moving to different areas of the office to work.

### 7.1.3 Open-plan office longitudinal studies

Few studies have investigated the effect of changing office design on occupant wellbeing, and the majority of office design and wellbeing literature is based on cross-sectional methods. For example, several studies compare wellbeing outcomes in occupants of private offices vs open-plan offices. Measuring change in individuals after an alteration to the physical environment results in a stronger design than cross-sectional methods, as differences such as personality and job type are controlled. Some longitudinal studies have shown a decline in wellbeing outcomes and environmental satisfaction after employees have moved from private offices to open-plan offices (Bergström et al., 2015; Brennan et al., 2002; Kaarlela-Tuomaala et al., 2009). Furthermore, the negative impacts persisted over time in subsequent follow-ups (Bergström et al., 2015; Brennan et al., 2002). Although the evidence is limited, the few studies that observe individual changes in wellbeing outcomes after relocation to an open-plan environment indicate poorer outcomes.

Although the literature on open-plan offices and employee wellbeing outcomes is mainly negative, arguably, office environments are variable, and so comparisons are difficult (Hongisto et al., 2016). Some studies have shown improvements in occupant wellbeing outcomes and environmental satisfaction following refurbishment of open-plan offices, or relocation to a more modern open-plan environment (Agha-Hosseini et al., 2013; Hongisto et al., 2016). When evaluating the results of previous studies, it is necessary to consider the features of the open-plan office environments being studied, as there is much difference between a well-designed open-plan layout and a poorly designed one. Since open-plan layouts are a popular choice for companies and considered to be cost-efficient, there is value in exploring what features affect occupant wellbeing, and whether



outcomes can be improved by design that addresses some of the common problems associated with these environments.

#### 7.1.4 Qualitative and mixed-method studies

Qualitative or mixed-methods studies are relatively scarce in the office design and wellbeing literature. Mixed-methods studies include both quantitative and qualitative data to explore a topic (Creswell, 2014; Tashakkori, Teddlie, & Johnson, 2015). Generally, the literature consists predominantly of quantitative analyses of data, and examination of how occupants are affected by office design is currently lacking. Studies in the literature using qualitative data have covered aspects of wellbeing outcomes (e.g., wellbeing, productivity, health, collaboration, privacy) in different office environments (e.g., ABW offices, energy-efficient buildings, open-plan offices) or ways of working such as flexi-desking (Cobaleda Cordero, Babapour, & Karlsson, 2020; Colenberg, Appel-Meulenbroek, et al., 2021; J. Kim et al., 2016; Lansdale et al., 2011; R. L. Morrison & Smollan, 2020; Ornetzeder, Wicher, & Suschek-Berger, 2016; Rolfö et al., 2018). These studies have used qualitative data (e.g., interviews, focus groups, open-ended comments) to provide more information about how occupants experience their physical environments. Collection of qualitative data may allow industry and researchers to have a deeper understanding of participants' satisfaction with the physical environment. In regard to environmental satisfaction, it is important for office designers and facility managers to discover why occupants have unsatisfactory or satisfactory perceptions of office features. Little is known about how physical features of the office affect wellbeing, and an exploratory approach is appropriate to investigate the topic further.

One recent case study has explored wellbeing in 16 university employees after relocation to a combi-office which had shared office seating and alternative working areas (Cobaleda Cordero et al., 2020). The researchers used semi-structured interviews to explore the employees' perceptions of their new office and any effects on wellbeing. Positive impacts on wellbeing were reported from a variety of office features: exposure to daylight, accessibility to colleagues, meeting rooms, spaces for breaks, aesthetics, and spatial diversity. Features of the office having a negative impact were exposure to visual distractions, exposure to sun glare, indoor navigation, separate coffee areas, and power outlets. Occupants had conflicting views on other features of the new office, such as temperature, noise, and personal storage. Some of the issues mentioned in this study have been mentioned in the literature; however, qualitative data can ensure a more in-depth understanding of the mechanisms involved in the impact on wellbeing. For example, the comments from participants highlighted differences in perceptions of noise and privacy in the open-plan environment, and how

occupants felt they were affected by these office characteristics. In-depth evaluations such as this are important in understanding how to design offices to improve occupant wellbeing. While the results from this study may not be directly transferrable to other office environments and participant samples, as different participants in another office may provide other feedback, more qualitative research of this nature is needed to gain a better awareness of how people are affected by their office environment.

In the present study, a convergent parallel mixed-methods approach was taken to explore the topic in more depth and aid in understanding (Creswell, 2014). In parallel mixed-methods designs, the researcher collects both qualitative and quantitative data, usually at the same time, and interprets both types of data in discussion of the results. An important characteristic of parallel mixed-methods research is that the qualitative and quantitative data collection and analysis strands are independent of each other. This differentiates it from other mixed-methods designs where one strand is dependent on outcomes of the other. Using this method enables integration of different strands of data to provide a more comprehensive answer to multifaceted research questions (Tashakkori et al., 2015).

#### 7.1.5 Study 2

The present study was a longitudinal, mixed-methods study assessing the impact of an office redesign on the self-rated environmental satisfaction, wellbeing, productivity, and teamwork of employees in the industrial partner's agile-working, open-plan office. Participants' beliefs about the effect of office design on their wellbeing, productivity, and teamwork were also explored. The study was conducted from 2017 – 2018 in South Wales, United Kingdom. The company wanted to redesign their office to improve employees' wellbeing and teamwork, and to increase the aesthetic appeal to visiting clients. The company had previously identified some office design issues. As a result of rapid company expansion, some employees working on the same project were not seated adjacent to one another. The company hoped to facilitate collaboration and teamwork by incorporating *hubs*, circular arrangement of desks, consisting of employees working on the same project. Feedback was solicited from the employees prior to the redesign, and there was some dissatisfaction about mess and storage, and noise and distractions. Employees in this office needed to collaborate on projects frequently, and also do individual focused work. Their jobs were creative and technical, mainly consisting of computer work (e.g. Computer-Aided Design), with some hands-on work (e.g. building prototypes). The company used a *hybrid* version of ABW, which involves the use of allocated

workstations and additional spaces that support different activities (Engelen et al., 2018), such as areas for focused work and informal meetings.

#### 7.1.5.1 *Aims*

The aims of the research were:

1. Investigate employees' changes in self-assessed environmental satisfaction, wellbeing, productivity, and teamwork after an office redesign.
2. Explore employees' perceptions of any impact of office design on wellbeing, productivity, and teamwork.

## 7.2 Method

### 7.2.1 Setting

The original workspace was a large, open-plan area that contained allocated workstations and two meeting areas. The employees were encouraged to use ABW practices, whereby employees could choose where to work and were not restricted to their workstations. Some of the workstations were sit-stand desks, and others were fixed height desks. The office had windows along two walls, with pleasant views of the surrounding hillside. The workspace was accessed from the other side of the building via two entrances: an open walkway and a double doorway. Kitchen facilities, a canteen, bookable meeting rooms, and soft areas for impromptu meetings were located in other parts of the building, outside the redesigned area.

### 7.2.2 Office redesign

Several changes were made during the redesign (Table 7.1), with the main difference being the workstation desks and their arrangement. The workstation desks were replaced with adjustable height (sit-stand), smaller desks (upcycled from the previous desks) with light blue or green partitioning. The partitioning measured 81 cm in height and wrapped around the desk, screening the whole length of the desk and part of the sides. Project team members were seated together with workstations in circular arrangements, referred to as hubs. Their workstations faced outwards and in the middle of hubs, a table was provided for collaboration and additional storage.

Several office areas were added: a library area, an area to share visual information about colleagues and the company, and another workshop area. The library area had sound panelling, dimmed lighting, and a large projector screen for presentations and displaying background nature videos. Staff were encouraged to work in the library area on laptops if they wished to work without disruption. The additional workshop area provided an area for employees to do hands-on work and display items on the wall to encourage knowledge sharing. Changes were made to storage provision in response to the previous complaints about mess and inadequate storage. Plants were added, with some large floor plants, and some smaller plants attached to partitions. Larch panels were added to one of the doorways to reduce noise and improve privacy. No changes were made to ambient conditions, such as air quality and lighting, or other décor, such as wall paint and carpet.

Table 7.1. *Description of Office Design Changes*

<b>Original Design (Baseline)</b>	<b>Redesign</b>
Layout - linear desk arrangement	Layout - circular hubs desk arrangement
Proximity - some people working on the same projects not seated next to each other	Proximity - people working on the same projects seated next to each other
Desks - large desks, no partitioning, some desks adjustable height (sit-stand)	Desks - smaller desks, partial partition surrounds, all desks adjustable height (sit-stand)
Storage – personal storage at workstation	Storage – personal periphery storage and shared storage in hubs
Areas for focused work – none	Areas for focused work - library area added
No visual information about colleagues	Area added to share information about colleagues, the company, and projects
Meeting areas - two	Meeting areas - no change
Workshop area – one	Workshop areas – two
Entrances - one with doors, one open	Entrances - open doorway partially obscured to reduce noise and increase privacy
Plants – none	Plants - 13 large plants, 42 small plants

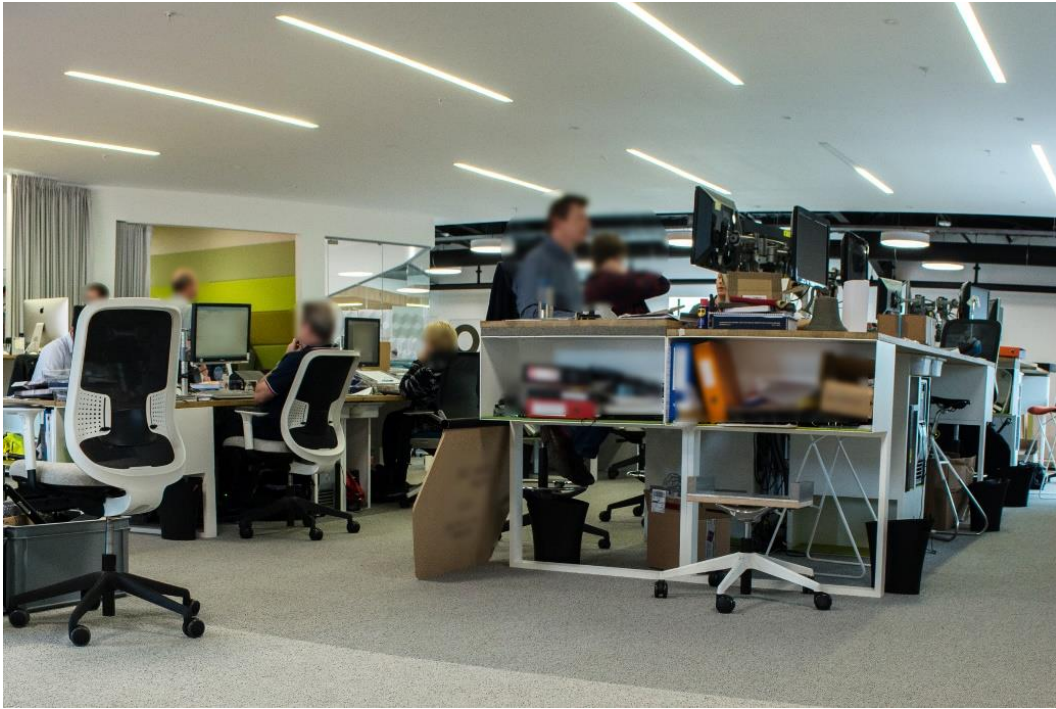


Figure 7.1. Image of office at baseline (pre redesign).



Figure 7.2. Image of office at T1 (post redesign).

### 7.2.3 Questionnaire

#### 7.2.3.1 *Participants*

The participants were office employees working in the redesign area (Table 7.2). The employees consisted of design, engineering, and marketing staff and performed tasks that were creative and technical. At baseline, immediately before the office redesign, there were 30 people, including two managers. There were three exclusions made (reasons for exclusion: holiday, maternity leave, involvement in the research design), which left a potential sample of 27 participants. At T1, one month after the redesign, there were 34 employees. Since the previous measurement, seven new employees had joined the office, three employees had left the company, and one had returned from maternity leave. One exclusion was made for an employee involved in the research design. In total, there were 33 potential participants at T1. At T2, nine months after the redesign, 36 employees were working in the office. A further three employees had joined the company, and one had left the company. Two exclusions were made (one employee involved in the research design, one on sabbatical). In total, there were a possible 34 participants at T2. There were 19 pre-post group participants who completed both baseline and T1 questionnaires. Twelve participants completed baseline, T1, and T2 questionnaires, and formed the longitudinal group.

Participation rates and demographic characteristics of questionnaire participants are shown in Table 7.2. The employees were a predominately male group of professional office workers.

Table 7.2. *Participants at each Measurement Period*

<b>Participants</b>	<b><i>N</i></b>	<b>Response Rate %</b>	<b>Female/Male %</b>	<b>Median Age</b>
<b>Questionnaire baseline</b>	23	85	17/83	30 – 39
<b>Questionnaire T1</b>	28	85	21/79	30 – 39
<b>Questionnaire T2</b>	23	68	17/83	30 – 39
<b>Pre-post group (baseline and T1)</b>	19	-	21/79	30 – 39
<b>Longitudinal group (baseline, T1 and T2)</b>	12	-	17/83	30 - 39/40 – 49
<b>Interview baseline</b>	14	93	29/71	30 – 39
<b>Interview T1</b>	13	93	23/77	30 – 39
<b>Interview T2</b>	13	93	23/77	30 – 39

*Note.* Participants may have completed both questionnaires and interviews.

### 7.2.3.2 *Materials*

The questionnaire (see Table 12.5, Appendix C) consisted of items relating to occupant environmental satisfaction, wellbeing, productivity, and teamwork. Environmental satisfaction was measured with 11 questions, three from a questionnaire used by Veitch et al. (2007), and eight others modified or developed for the study. Participants were asked to rate satisfaction with office features on a scale from 1 (*very unsatisfactory*) to 7 (*very satisfactory*), e.g. "What is your degree of satisfaction with the following: your workstation design overall." In order to measure wellbeing, nine questions were included from the Smith Wellbeing Questionnaire (SWELL; Smith & Smith, 2017). The original SWELL uses a prompt: "Thinking about the last 6 months", which was excluded for the present study, due to the timeframe of the measures. An example question is, "Are you happy at work?" rated on a scale of 0 (*never*) to 10 (*very often*). In addition to the SWELL, eight items developed for the study were used to assess participants' wellbeing, productivity, and teamwork. For example, "Thinking about the last 2 weeks, please rate the following: your productivity at work." rated on a scale from 1 (*extremely good*) to 7 (*extremely bad*). Participants' beliefs about the impact of their workplace on wellbeing, productivity, and teamwork, were assessed by five questions developed through modification of a question used by Agha-Hosseini et al. (2013). Participants were asked to rate the statements on a scale from 1 (*strongly agree*) to 7 (*strongly disagree*), e.g. "My current workplace has a positive effect on: my productivity." The questionnaire included 15 open-ended items asking participants about their satisfaction with the office, wellbeing, productivity, and teamwork. At T2, an additional four questions were used to check whether there were any office design or job changes since the previous time.

### 7.2.3.3 *Procedure*

This study was conducted over a one-year period. Measurement periods were baseline (immediately prior to the office redesign), T1 (one month after office redesign), and T2 (nine months after office redesign). Ethical approval was granted by the School Research Ethics Committee (SREC) of the School of Psychology, Cardiff University.

The researcher visited the company and gave information sheets and consent forms to the participants. Signed consent forms were stored securely at Cardiff University. At each measurement, participants were emailed a link to the online survey, which they were allowed to complete during work time, or at home. Email reminders were also sent to participants. An electronic debrief was included at the end of the online survey.



## 7.2.4 Interview

### 7.2.4.1 *Participants*

At baseline, a random sample of 15 employees was invited for interviews. The sample was created by first grouping participants by their teams, and then generating random lists using Excel. The teams were uneven in number so more participants were chosen from the larger team, engineering. In total, four participants were selected from the marketing and design teams, and seven were selected from the engineering team. Fourteen employees agreed to take part in the interviews at baseline measurement. At T1 and T2, the same 14 participants from the baseline measure were invited to participate in further interviews (see Table 7.2).

### 7.2.4.2 *Materials*

The interview (Appendix C) consisted of nine questions relating to occupants' environmental satisfaction, wellbeing, productivity, and teamwork. At T2, an additional two questions were used to check whether any office design or job changes had occurred since the interviews at T1.

### 7.2.4.3 *Procedure*

A random sample of employees was invited to participate in interviews. Interviews took place in an enclosed meeting room in the company's building, away from the redesign area. The researcher conducted all of the interviews, and they varied from approximately 15 minutes to 1 ½ hours in duration. Before the interview, participants were given an information sheet and consent form. Confidentiality was explained to interviewees, and any questions were answered. Interviews were audio-recorded after participants gave permission and later transcribed by the researcher or a transcription service. Transcripts were stored securely and electronically, with only participant user IDs attached and no identifying information. Signed consent forms were stored securely at Cardiff University.

### 7.2.5 Analysis

Quantitative data was analysed using IBM SPSS Statistics 25. Individual changes were compared in the pre-post comparison group between baseline and T1 using dependent *t*-tests, or Wilcoxon Signed Rank Tests for variables that did not show normality of distribution of differences. One-way repeated measures ANOVAs and Friedman tests were conducted to compare individual changes in the longitudinal group. Holm-Bonferroni corrections (Holm, 1979) were used where there were several tests conducted.

Thematic analysis of interview and questionnaire qualitative data was conducted using NVivo 12 Pro. In thematic analysis, the categorisation of data is rarely completely inductive or deductive, and main themes may be derived from the research question (Kuckartz, 2014). Initially, participants' responses to interviews and questionnaires were grouped by question in NVivo 11 Pro (later updated to NVivo 12 Pro). Content for each question were coded into positive, negative, and neutral comments. Then the positive and negative comments were coded into themes. These themes were developed inductively, using the data directly rather than based on theories, hypotheses, or existing thematic structures (Kuckartz, 2014). Due to the nature of the investigation, the initial themes were office design features. The themes for each question were then grouped under the following main themes: wellbeing, productivity, and teamwork. The latter main themes were largely pre-determined by the research aims of the study, and the design of the interview and questionnaire. In some cases, themes were modified or combined after they were grouped under a main theme. For example, a final wellbeing theme, "physical activity/ABW", consisted of comments relating to several office design features (e.g., sit-stand desks, working away from the desk). The analysis in NVivo was conducted twice to check theme coding.

## 7.3 Results

### 7.3.1 Mean questionnaire scale percentages at baseline, T1, and T2

The quantitative questionnaire results for the entire sample are displayed in Table 7.3. All scale means increased at T1, apart from the SWELL, which declined. At T2, the scale means all declined; however, they were all higher than baseline measures apart from the SWELL. Statistical analyses were conducted using pre-post and longitudinal participant groups and are described in the next sections.

Table 7.3. Mean Questionnaire Scale Percentage Scores at Baseline, T1, and T2

Measure	Baseline		T1 (1 Month Post Office Design)		T2 (9 Months Post Office Design)	
	Mean percentage	<i>N</i>	Mean percentage	<i>N</i>	Mean percentage	<i>N</i>
<b>Environmental satisfaction</b>	56.41 ( <i>SD</i> = 14.08)	23	74.30 ( <i>SD</i> = 12.76)	28	68.94 ( <i>SD</i> = 13.06)	23
<b>Smith Wellbeing questionnaire (SWELL)</b>	61.21 ( <i>SD</i> = 10.40)	23	57.90 ( <i>SD</i> = 11.82)	27	54.01 ( <i>SD</i> = 13.42)	23
<b>Belief of a positive effect of workplace</b>	63.98 ( <i>SD</i> = 14.86)	23	72.49 ( <i>SD</i> = 14.27)	27	67.08 ( <i>SD</i> = 17.82)	23
<b>Past 2 weeks: wellbeing, productivity and teamwork</b>	69.64 ( <i>SD</i> = 12.72)	23	74.94 ( <i>SD</i> = 15.34)	28	71.27 ( <i>SD</i> = 15.16)	23

### 7.3.2 Pre-post group

Mean scale percentages for the pre-post group are shown in Table 7.4. All of the scale means increased at T1, apart from SWELL, which decreased.

Table 7.4. Mean Questionnaire Scale Percentages in the Pre-Post Comparison Group (*N* = 19)

Measure	Baseline	T1 (1 Month Post Office Design)			
	Mean percentage	Mean percentage	<i>statistic</i>	<i>df</i>	<i>p</i>
<b>Environmental satisfaction</b>	54.14 ( <i>SD</i> = 12.21)	71.09 ( <i>SD</i> = 12.53)	<i>Z</i> = -2.853	-	.004*** <sup>a</sup>
<b>Smith Wellbeing questionnaire (SWELL)</b>	62.22( <i>SD</i> = 10.73)	56.73 ( <i>SD</i> = 10.50)	<i>t</i> = 2.676	18	.015* <sup>a</sup>
<b>Belief of a positive effect of workplace</b>	62.56 ( <i>SD</i> = 15.56)	69.32 ( <i>SD</i> = 13.83)	<i>t</i> = -1.966	18	.065
<b>Past 2 weeks: wellbeing, productivity and teamwork</b>	68.33 ( <i>SD</i> = 12.51)	73.40 ( <i>SD</i> = 14.95)	<i>t</i> = -1.855	18	.080

<sup>a</sup> Significant after Holm-Bonferroni correction.

\* *p* < .05

\*\* *p* < .01

### 7.3.2.1 Environmental satisfaction

There was a 31% increase in environmental satisfaction mean ratings from baseline to T1 (Table 7.4). A Wilcoxon Signed Ranks Test indicated that the increase in environmental satisfaction after the office redesign was significant,  $Z = -2.853$ ,  $N - \text{Ties} = 18$ ,  $p = .004$ . After Holm-Bonferroni correction, the  $p$  value remained significant. The environmental satisfaction median score increased from baseline ( $Mdn = 58.44$ ) to T1 ( $Mdn = 72.73$ ). All environmental satisfaction item mean ratings increased at T1, with nine items rated significantly higher (see Table 7.5). Four items with unadjusted  $p$  values of .005 or less remained significant after Holm-Bonferroni correction. These items were overall workplace design, areas in the workplace for doing work requiring focus and concentration, comfort of the workplace, and visual appearance of the workplace.

Table 7.5. Mean Environmental Satisfaction Item Scores at Baseline and T1 in the Pre-Post Sample ( $N = 19$ )

What is your degree of satisfaction with the following:	Baseline $M$	T1 (1 Month Post Office Design) $M$	statistic	$df$	$p$
overall air quality in your work area	4.32 ( $SD = 1.46$ )	5.26 ( $SD = 1.28$ )	$t = -2.673$	18	.016 *
amount of noise from other people's conversations while you are at your workstation	4.00 ( $SD = 1.89$ )	4.53 ( $SD = 1.65$ )	$Z = -1.497$	-	.134
quality of lighting in your work area	4.89 ( $SD = 1.56$ )	5.00 ( $SD = 1.45$ )	$t = -.203$	18	.841
your workstation design overall	3.47 ( $SD = 1.35$ )	4.63 ( $SD = 1.46$ )	$t = -2.752$	18	.013 *
your workplace design overall	3.58 ( $SD = 1.26$ )	5.05 ( $SD = 1.31$ )	$t = -3.684$	18	.002 ** <sup>a</sup>
areas in your workplace for meetings	4.16 ( $SD = 1.50$ )	5.21 ( $SD = 1.27$ )	$Z = -2.246$	-	.025 *
areas in your workplace for doing work that requires focus and concentration	3.21 ( $SD = 1.55$ )	4.47 ( $SD = 1.84$ )	$t = -3.188$	18	.005 ** <sup>a</sup>
comfort of your workplace	3.89 ( $SD = 1.52$ )	5.37 ( $SD = 1.07$ )	$t = -3.904$	18	.001 ** <sup>a</sup>
areas in your workplace for relaxing and taking breaks	4.26 ( $SD = 1.73$ )	5.37 ( $SD = 1.34$ )	$Z = -2.104$	-	.035 *
your ability to adjust or control your work area to suit your needs and preferences	3.16 ( $SD = 1.46$ )	4.68 ( $SD = 1.45$ )	$Z = -2.355$	-	.019 *
visual appearance of your workplace	2.74 ( $SD = 1.48$ )	5.16 ( $SD = 1.57$ )	$Z = -3.133$	-	.002 ** <sup>a</sup>

Note. On a 7-point Likert scale 1 (very unsatisfactory) to 7 (very satisfactory).

<sup>a</sup> Significant after Holm-Bonferroni correction.

\*  $p < .05$

\*\*  $p < .01$

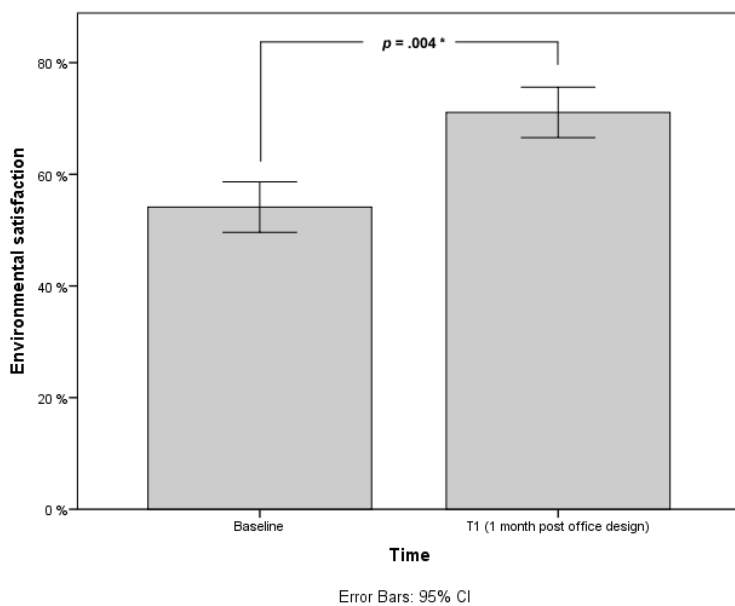


Figure 7.3. Environmental satisfaction mean percentage scores at baseline and T1 (1 month post office design).

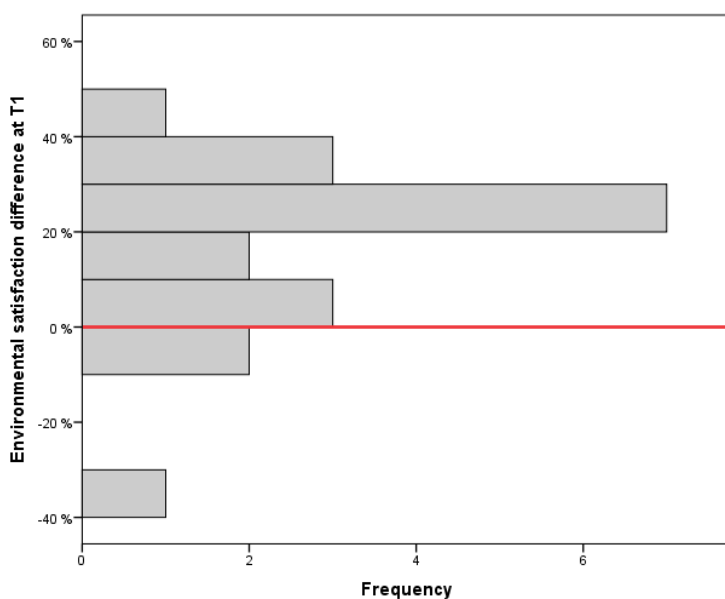


Figure 7.4. Frequencies of difference between T1 (1 month post office design) and baseline environmental satisfaction mean percentage scores.

Note. Positive scores indicate an increase in environmental satisfaction at T1, whereas negative scores indicate a decrease.

### 7.3.2.2 Wellbeing

There was a significant decrease in the mean SWELL percentage scores (indicating poorer wellbeing) from baseline ( $M = 62.22$ ,  $SD = 10.73$ ) to post 1 month ( $M = 56.73$ ,  $SD = 10.50$ );  $t(18) = 2.676$ ,  $p = .015$ ,  $d = .61$  (Table 7.4). The Holm-Bonferroni corrected  $p$  value remained significant, and a medium effect size was indicated by the Cohen's  $d$  value (Cohen, 1992). Table 7.6 shows the SWELL individual

item scores and illustrates that all of the ratings decreased at T1, apart from fatigue at work. At T1, participants reported significantly less control over their job and support from colleagues, and significantly more often feeling anxious or depressed because of work (Table 7.6). The other wellbeing item changes were not significant. After Holm-Bonferroni correction, only the latter result was significant, while the former adjusted  $p$  value was non-significant.

Table 7.6. Mean Smith Wellbeing Questionnaire (SWELL) Item Scores at Baseline and T1 in the Pre-Post Sample ( $N = 19$ )

SWELL item	Baseline $M$	T1 (1 Month Post Office Design) $M$	statistic	$df$	$p$
How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)? <i>reverse coded</i>	3.16 ( $SD = 1.68$ )	2.84 ( $SD = 1.07$ )	$Z = -1.209$	-	.227
Do you feel you have control over your job and support from fellow workers?	7.37 ( $SD = 1.89$ )	6.37 ( $SD = 2.11$ )	$t = 2.312$	18	.033 *
How much stress do you have at work? <i>reverse coded</i>	5.11 ( $SD = 2.47$ )	4.21 ( $SD = 1.18$ )	$t = 1.808$	18	.087
Are you satisfied with your job?	7.05 ( $SD = 2.04$ )	6.68 ( $SD = 2.33$ )	$Z = -1.006$	-	.314
How physically or mentally tired do you get at work? <i>reverse coded</i>	4.58 ( $SD = 1.71$ )	4.74 ( $SD = 1.56$ )	$t = -.470$	18	.644
How efficiently do you carry out your work?	7.00 ( $SD = 1.60$ )	6.84 ( $SD = 1.89$ )	$Z = -.714$	-	.475
Do you find your job interferes with your life outside work or your life outside of work interferes with your job? <i>reverse coded</i>	6.47 ( $SD = 2.39$ )	6.05 ( $SD = 2.25$ )	$t = .954$	18	.353
Are you happy at work?	7.21 ( $SD = 1.84$ )	6.68 ( $SD = 2.03$ )	$Z = -1.365$	-	.172
Are you anxious or depressed because of work? <i>reverse coded</i>	8.05 ( $SD = 1.81$ )	6.63 ( $SD = 1.89$ )	$Z = -2.970$	-	.003 ** <sup>a</sup>

Note. On a scale from 0 to 10. In the SWELL questionnaire, high scores on some items indicated positive wellbeing, whereas others indicated negative wellbeing. The items which indicated negative wellbeing at higher scores were reverse coded in reporting the results.

<sup>a</sup> Significant after Holm-Bonferroni correction.

\*  $p < .05$

\*\*  $p < .01$

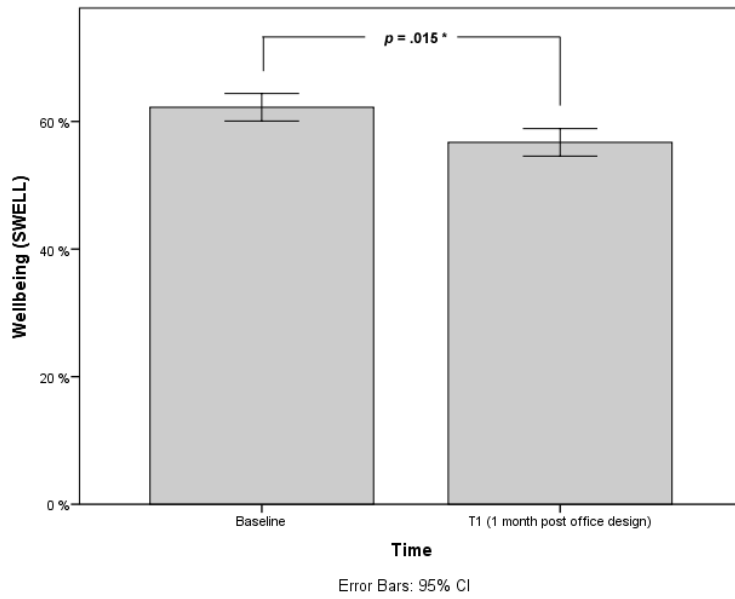


Figure 7.5. Smith Wellbeing Questionnaire (SWELL) mean percentage scores at baseline and T1 (1 month post office design).

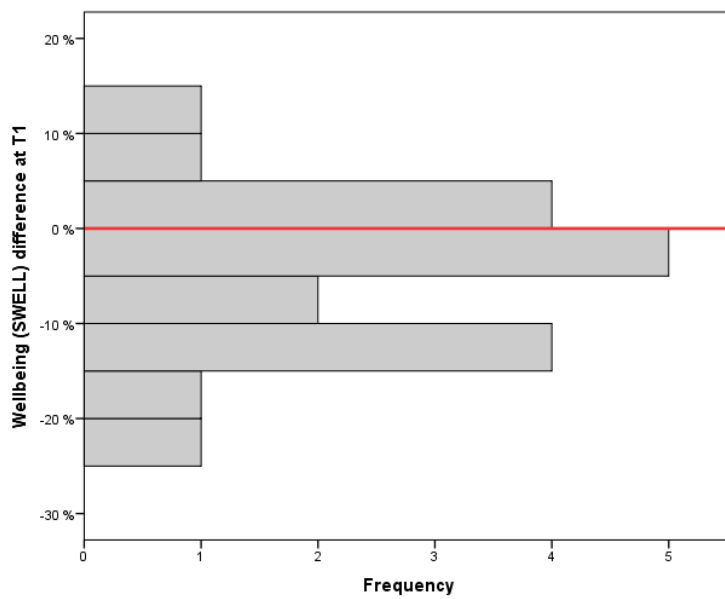


Figure 7.6. Frequencies of differences between T1 (1 month post office design) and baseline Smith Wellbeing Questionnaire (SWELL) mean percentage scores.

Note. Positive scores indicate an increase in wellbeing at T1, whereas negative scores indicate a decrease.

### 7.3.2.3 *Belief of a positive effect of workplace*

Employees' beliefs about the impact of the office on their wellbeing, productivity, and teamwork were measured. There was a non-significant increase in the mean scores for the sum total belief of a positive effect of workplace from baseline ( $M = 62.56$ ,  $SD = 15.56$ ) to T1 ( $M = 69.32$ ,  $SD = 13.83$ );  $t(18) = -1.966$ ,  $p = .065$ . Table 7.7 shows the ratings of items. There was an increase in all ratings at T1, but only the increase in a belief in positive impact of the workplace on health was significant,  $Z = -2.049$ ,  $N - \text{Ties} = 13$ ,  $p = .040$ . This latter result was not significant after Holm-Bonferroni correction.

Table 7.7. *Mean Belief of a Positive Effect of Workplace Item Scores at Baseline and T1 in the Pre-Post Sample (N = 19)*

<b>My current workplace has a positive effect on:</b>	<b>Baseline <i>M</i></b>	<b>T1 (1 month post office design) <i>M</i></b>	<b>statistic</b>	<b><i>df</i></b>	<b><i>p</i></b>
<b>my productivity</b>	4.26 ( <i>SD</i> 1.45)	4.58 ( <i>SD</i> 1.17)	$Z = -.936$	-	.349
<b>my wellbeing (the state of being comfortable, healthy, or happy)</b>	4.37 ( <i>SD</i> 1.34)	4.95 ( <i>SD</i> 1.18)	$Z = -1.556$	-	.120
<b>teamwork</b>	4.58 ( <i>SD</i> 1.22)	5.00 ( <i>SD</i> 1.49)	$Z = -1.634$	-	.102
<b>my mood</b>	4.37 ( <i>SD</i> 1.34)	4.79 ( <i>SD</i> 1.18)	$t = -1.363$	18	.190
<b>my health</b>	4.32 ( <i>SD</i> 1.06)	4.95 ( <i>SD</i> 1.08)	$Z = -2.049$	-	.040 *

Note. On a 7-point Likert scale 1 (*strongly disagree*) to 7 (*strongly agree*).

\*  $p < .05$



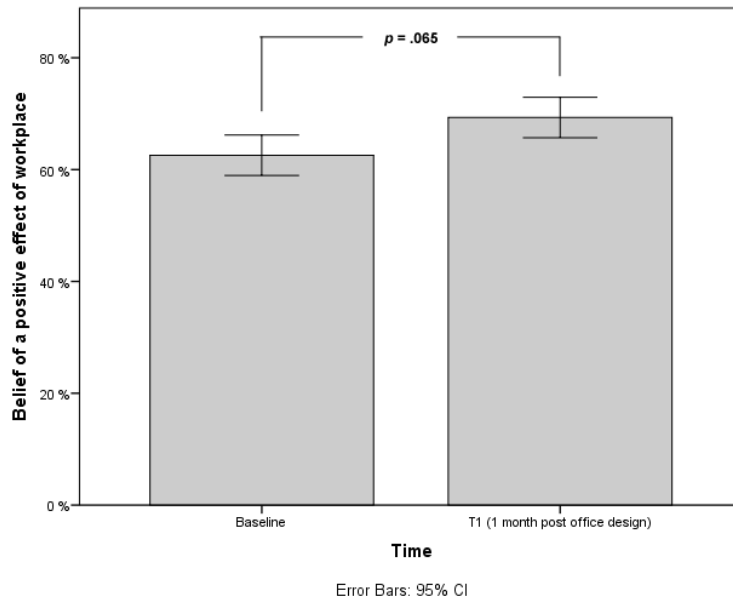


Figure 7.7. Belief of a positive effect of the workplace mean percentage scores at baseline and at T1 (1 month post office design).

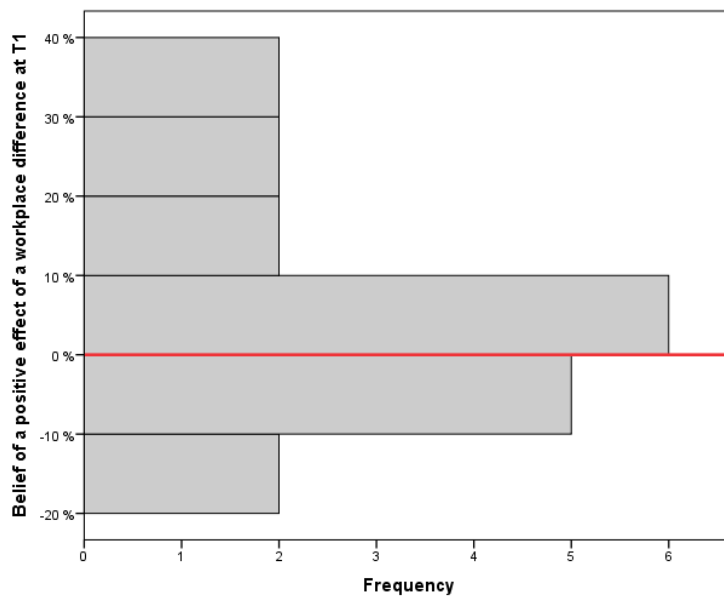


Figure 7.8. Frequencies of differences between T1 (1 month post office design) and baseline belief of a positive effect of the workplace mean percentage scores.

Note. Positive scores indicate an improvement at T1, whereas negative scores indicate a decline.

### 7.3.2.4 Past two weeks: Self-assessed wellbeing, productivity, and teamwork

There was a non-significant increase in the mean scores for the sum total of items assessing self-assessed wellbeing, productivity, and teamwork for the past two weeks, from baseline ( $M = 68.33$ ,  $SD = 12.51$ ) to T1 ( $M = 73.40$ ,  $SD = 14.95$ );  $t(18) = -1.855$ ,  $p = 0.080$ . Table 7.8 shows the differences in ratings of items, with an increase in all ratings at T1, apart from productivity. The only significant difference in items at T1 was rating of comfort,  $t(18) = -3.256$ ,  $p = .004$ ,  $d = -.89$ . This result remained significant after a Holm-Bonferroni correction, and a large effect size was indicated by the Cohen's  $d$  value.

Table 7.8. Mean Scores of Self-assessed Wellbeing, Productivity, and Teamwork for the Past Two Weeks, at Baseline and T1 in the Pre-Post Sample ( $N = 19$ )

Thinking about the last 2 weeks, please rate the following:	Baseline $M$	T1 (1 month post office design) $M$	statistic	$df$	$p$
your productivity at work	5.63 ( $SD = 0.76$ )	5.42 ( $SD = 1.39$ )	$Z = -1.043$	-	.297
your mood at work	5.11 ( $SD = 0.94$ )	5.26 ( $SD = 1.28$ )	$t = -.718$	18	.482
your comfort level at work	4.47 ( $SD = 1.17$ )	5.42 ( $SD = .96$ )	$t = -3.256$	18	.004 <sup>**a</sup>
your wellbeing (the state of being comfortable, healthy, or happy) at work	4.79 ( $SD = 1.18$ )	5.26 ( $SD = 1.28$ )	$t = -1.924$	18	.070
teamwork at your workplace	4.53 ( $SD = 1.26$ )	4.63 ( $SD = 1.64$ )	$Z = -.427$	-	.669
your ability to concentrate and do work that requires focus at your workplace	3.84 ( $SD = 1.26$ )	4.26 ( $SD = 1.56$ )	$t = -1.193$	18	.249
collaboration with others at work	4.58 ( $SD = 1.46$ )	5.16 ( $SD = 1.34$ )	$t = -1.568$	18	.134
your health at work	5.32 ( $SD = 1.06$ )	5.68 ( $SD = 1.25$ )	$Z = -1.259$	-	.208

Note. On a 7-point Likert scale 1 (*extremely bad*) to 7 (*extremely good*).

<sup>a</sup>Significant after Holm-Bonferroni correction.

\*\*  $p < .01$

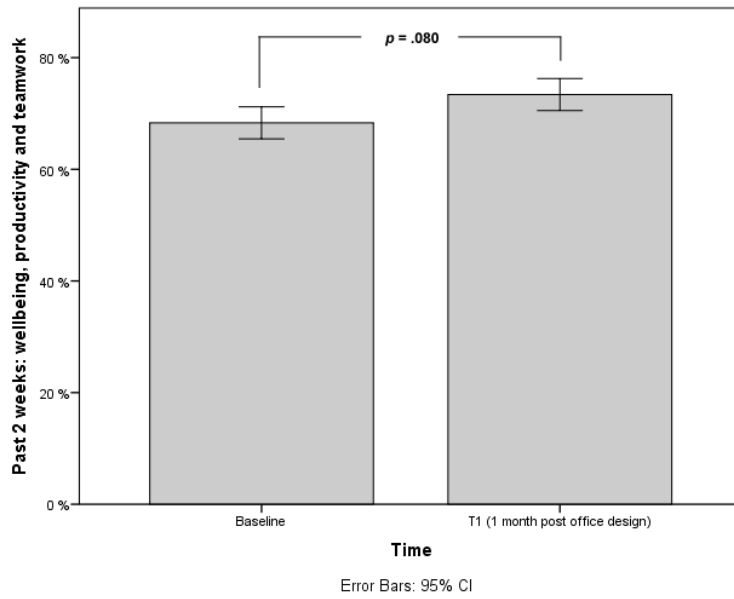


Figure 7.9. Self-assessed wellbeing, productivity, and teamwork for the past two weeks mean percentage scores at baseline and at T1.

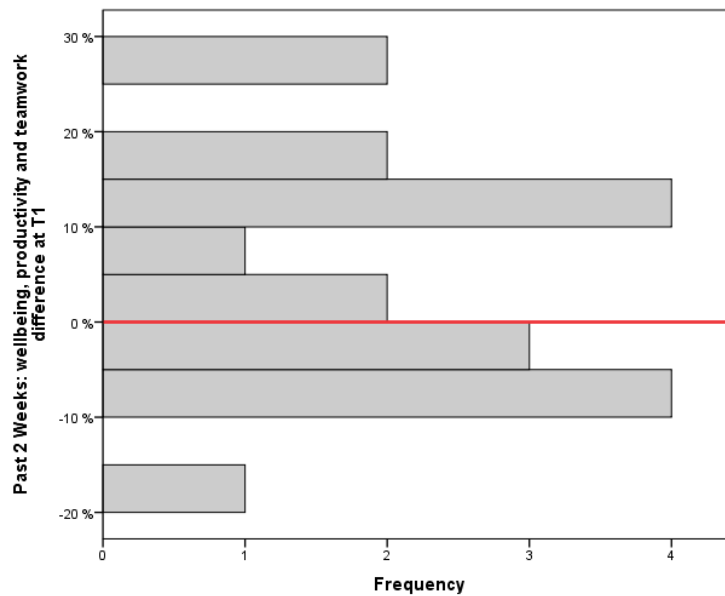


Figure 7.10. Frequencies of differences between T1 (1 month post office design) and baseline self-assessed wellbeing, productivity, and teamwork for the past two weeks mean percentage scores. Note. Positive scores indicate an improvement at T1, whereas negative scores indicate a decline.

### 7.3.3 Longitudinal group

Twelve participants completed all three questionnaires. Table 7.9 shows the results for the longitudinal sample at baseline, T1, and T2. A one-way repeated measures ANOVA was conducted with environmental satisfaction over the three time periods in the longitudinal sample.

Environmental satisfaction showed a significant effect for time,  $F = 9.303 (2, 22)$ ,  $p = .001$ , partial eta squared = .46. Post hoc tests using the Bonferroni correction revealed that the increase in environmental satisfaction from baseline to T1 was significantly different ( $p = .008$ ), and the decrease from T1 to T2 was not statistically significant ( $p = .498$ ). T2 was significantly higher than baseline ( $p = .036$ ). Wellbeing declined over the three time periods, but a Friedman test showed there was no significant effect of time. One-way repeated measures ANOVAs showed there were no significant effects of time for the belief of a positive effect of the workplace; or for wellbeing, productivity, and teamwork for the past two weeks ratings. In order to correct for multiple tests, Holm-Bonferroni corrections were applied, and environmental satisfaction change remained significant.

Table 7.9. Mean Questionnaire Scale Percentages in the Longitudinal Sample at Baseline, T1, and T2 ( $N = 12$ )

Measure	Baseline	T1 (1 Month Post Office Design)	T2 (9 Months Post Office Design)	Statistic	$p$
	Mean ( $SD = 13.51$ )	Mean ( $SD = 9.56$ )	Mean ( $SD = 12.94$ )		
<b>Environmental satisfaction</b>	53.03 ( $SD = 13.51$ )	71.43 ( $SD = 9.56$ )	65.37 ( $SD = 12.94$ )	$F = 9.303 (2, 22)$	.001 <sup>***</sup>
<b>Smith Wellbeing questionnaire (SWELL)</b>	62.31 ( $SD = 13.12$ )	57.69 ( $SD = 9.85$ )	53.89 ( $SD = 15.13$ )	$\chi^2 = 2.478 (2)$	.290
<b>Belief of a positive effect of workplace</b>	61.43 ( $SD = 16.05$ )	68.57 ( $SD = 13.78$ )	64.29 ( $SD = 19.13$ )	$F = 1.381 (2, 22)$	.272
<b>Past 2 weeks: wellbeing, productivity, and teamwork</b>	68.60 ( $SD = 11.53$ )	73.51 ( $SD = 12.92$ )	73.21 ( $SD = 16.42$ )	$F = .888 (2, 22)$	.426

<sup>a</sup> Significant after Holm-Bonferroni correction.

\*\*  $p < .01$

### 7.3.4 Changes reported in the workplace design and jobs at T2

At T2, additional questions were added to the questionnaire and interview schedule to assess whether further changes had occurred in the participants' jobs or the workplace design in the intervening eight months since T1. Only one person in the questionnaire indicated that their job had changed, and this employee commented that they had increased responsibilities. Over half of the

participants (14 participants, 61% of the total) reported that the workplace had changed since the previous questionnaire. The changes reported in the questionnaire were: desks and people moved around, more people in the office, increased noise and distractions, a new chair, and monitors moved back. In the interviews, changes in jobs mentioned by participants mainly related to working on other projects, or different stages of projects, and only three people reported an increase in workload. Interview participants commonly reported changes in the workplace design from T1 to T2, with the most frequently observed change being people and desks moved around. Other changes reported were more people in the office, more plants, quieter, and employees getting used to the new areas and using them more.

### 7.3.5 Conclusion

This chapter outlined the introduction and method of Study 2, as well as quantitative results. The quantitative results indicated that while the office redesign resulted in increased environmental satisfaction, aspects of psychological wellbeing decreased. Furthermore, there were no changes in self-rated teamwork and productivity after the redesign. In the next chapter, the qualitative results and discussion will be presented.

### 7.3.6 Industrial partner summary

- After an office redesign, environmental satisfaction increased; however, aspects of psychological wellbeing declined.
- There were no changes in teamwork or productivity after the office redesign.
- A satisfactory office redesign does not guarantee an increase in employee wellbeing.

## 8 Occupant wellbeing in an open-plan office: Impact of an office redesign, Part 2

The present chapter contains Study 2's qualitative data results and discussion section. The introduction, method, and quantitative data results were presented in Chapter 7.

### 8.1 Results, continued

#### 8.1.1 Qualitative data from interviews and questionnaires

Qualitative data from interviews and questionnaires were gathered at three times (baseline, T1, and T2). The participants reported both negative and positive impacts of the original office design, and the new office design. In general, employees were more positive about the new office design, although there were satisfactory aspects of the original office design that did not change (e.g. windows and views). In both office designs, there were positive and negative impacts of office design features, and these were grouped by themes. Two major differences in the new office design were the hubs arrangement and sit-stand desks for everyone. These differences were commonly discussed by participants in relation to wellbeing, productivity, and teamwork. Participants were very positive about sit-stand desks, while there were more mixed reactions to the hubs. Although there were some important changes in the office design, comments about how other office features (e.g., noise and distractions, temperature, windows and views) impacted occupants' wellbeing remained similar throughout the three data collection points. This is unsurprising, as some aspects of the office were unaltered in the new design, as this was a redesign rather than a relocation. During the study period, there were some staffing and management changes, which were mentioned by some participants. The latter changes were not included in the thematic analysis except in reference to office design (e.g. crowding), as the focus was on the effect of the physical environment, rather than organisational factors. The following sections discuss participants' perceptions of how different features of the office environment impact wellbeing, productivity, and teamwork.

##### 8.1.1.1 *Wellbeing*

The office design features that employees reported affecting their wellbeing were grouped into five themes: physical activity/ABW, comfort, visual appearance/windows and views, noise and distractions, and social interaction/collaboration (Table 8.1). Table 8.2 and Table 8.3 show the number of participants commenting on the positive or negative impact of particular office features.

Table 8.1. Office Design Features Impacting Wellbeing grouped by Themes

<b>Office design features with a positive impact on wellbeing</b>				
<b>physical activity/ABW</b>	<b>comfort</b>	<b>visual appearance/ windows and views</b>	<b>noise and distractions</b>	<b>social interaction/ collaboration</b>
sit-stand desks	ambient conditions (temperature, air quality)	visual appearance of office	partitions (reduce noise)	hub layouts (proximity to colleagues, improve communication within the hub)
office areas (comfortable, places for informal discussions, choice of areas to work)	office furniture	windows/views	quiet/less noise	accessibility to colleagues
working away from the desk/home working (physical activity, variety, focused work)	comfortable workplace	ambient conditions (natural light)		
physical activity encouraged by layout/size of building	ergonomically adjusted workstation	plants		
	space	office furniture		
		clean workplace		
<b>Office design features with a negative impact on wellbeing</b>				
<b>physical activity/ABW</b>	<b>comfort</b>	<b>visual appearance/ windows and views</b>	<b>noise and distractions</b>	<b>social interaction/ collaboration</b>
sedentary/too long at computer or monitor/would like to work away from desk more	ambient conditions (lighting, temperature)	mess/inadequate storage	noise and distractions	hub layouts (isolating, pathways more difficult to colleagues)
sit-stand desks (not having one)	desk too small/monitor too close	windows/views (lack of view)	too quiet	
IT issues (preventing away from desk working)	ergonomics of workstation		lack of areas for focused work/privacy	
	office furniture (uncomfortable)			
	sit-stand desk (uncomfortable)			
	crowded			

#### 8.1.1.1.1 Physical activity/ABW

Office design features relating to physical activity/ABW, such as sit-stand desks and working away from the desk, were viewed as affecting wellbeing positively. Sit-stand desks were popular and received the most comments in relation to wellbeing in the office. At the baseline measure, only some of the employees had sit-stand desks. At T1, everyone had sit-stand desks, which resulted in more positive comments about wellbeing after the office redesign. Some people commented on feeling healthier being able to stand and move around, and some reported feeling better emotionally or more alert.

*"Makes for a better day at work rather than being sat down for eight hours straight and not really getting any movement..." T1 interview participant discussing their sit-stand desk*

At T2, sit-stand desks were still considered to be one of the main office design features that affected wellbeing positively. In this office, the employees were encouraged by management to work away from their desks, and some people commented on the positive impact on their wellbeing due to being able to move around and work in different areas. As much of the employees' work was computer-based, some people commented they felt they were too sedentary in their jobs or would like to work away from their desk more. Some employees were hampered from working away from the desk due to a reliance on their desktop computer for certain tasks. The responses from participants indicated that the positive benefit of sit-stand desks and physical activity in the office may have been related to beliefs about physical health, and also the enjoyment of freedom and variety.

#### 8.1.1.1.2 Comfort

Physical comfort was mentioned in terms of ambient conditions (temperature, air quality, and light), ergonomics of the workstation, and comfort of the workplace (e.g. furniture). Several people commented on ambient conditions, particularly cold and draughty air conditioning, negatively affecting their wellbeing.

*"I always get really cold which annoys me. I find it's always freezing in that room." T1 interview participant*

In open-plan offices, people often have differing opinions of the temperature, and some employees complained it could be too hot. There were no alterations made to lighting or air conditioning during the office design, so no change was expected at T1. In order to change the layout of the office, the



existing desks had been upcycled to create smaller desks in the new office design. The smaller desks caused a reduced distance to the computer monitors, and some employees complained of eye strain. This may have been partially impacted by standing to work, as people tend to move closer to their desk as compared to sitting, and the monitor may need to be moved further away (Bridger, 2020). At T2, the company had reacted to this feedback and was in the process of implementing a design solution to rectify this, although some workstations had not been changed at that time.

#### 8.1.1.1.3 Visual appearance/windows and views

Several participants mentioned the positive impact of the visual appearance of the office, with some comments about the office being light, airy, and modern.

*"...it's light, and it's bright, it's nice materials, nice colours, and it does feel uplifting." T2  
interview participant*

There were no plants in the original office, and after they were introduced in the redesign, employees commented on the positive impact on their wellbeing. The office had a lot of natural light due to the open-plan layout and windows along two of the walls, and some people felt the natural light had a positive effect on their wellbeing.

*"...I feel good in there, it's a vibrant place, lots of windows, which is letting a lot of light in."  
T2 interview participant*

The comments that employees made about the space and natural light suggest that open-plan offices may have some benefit to wellbeing in regard to the visual appearance, feeling of space, and access to windows.

In the original office design, employees had complained about mess and inadequate storage. During the office redesign, efforts were made to remedy this issue by moving private storage to the periphery and providing shared storage in the hubs. Some people commented that mess and inadequate storage affected their wellbeing negatively.

#### 8.1.1.1.4 Noise and distractions

Some employees felt noise and distractions negatively affected their wellbeing. Complaints of noise and distractions were expected to decrease at T1, due to the addition of soft furnishings, partitions,

and plants. After the redesign, some people commented that the new office was quieter or less distracting, attributing the change to partitions and soft furnishings, or the hub layouts. It is possible that the perceived reduction in noise and distractions reported by some employees may have been greater; however, there were additional people in the office at T1 and T2. At T1 and T2, noise and distractions were still one of the main reasons given for a negative impact of the office design on wellbeing. Employees commonly reported a negative impact on their wellbeing from noise and distractions via not being able to concentrate on work. One person felt that the office was too quiet, and this made it uncomfortable.

*“...excessive noise affects my mood/levels of anxiety” Baseline questionnaire participant*

*“...it doesn't really stress me out apart from when I'm really trying to concentrate and I need to get stuff done, then I need to take myself away and sit somewhere else...” T1 interview participant*

#### 8.1.1.1.5 Social interaction/collaboration

Social interaction and collaboration were felt to increase wellbeing. As this analysis focuses on office design, participants' comments about factors unrelated to office design were not included (e.g. friendly colleagues). Office features that were mentioned concerning wellbeing and social interaction/collaboration were hub layouts and accessibility of colleagues. Hub layouts had both positive and negative consequences for interaction. These will be discussed further in relation to teamwork later on in this chapter. Hubs could positively affect wellbeing by allowing proximity and improving communication with colleagues. In contrast to this, hubs also had a negative impact on wellbeing, as they were reported to cause isolation from colleagues in other hubs, and also made the pathways to colleagues more difficult. One person observed that when other hub members worked away from the office, the hub could be very isolating. The desks in the hub layouts faced outwards, and one employee described an uncomfortable feeling when sitting with his/her back to the room. Some participants did not mind facing away from their colleagues; however, for some people, this seating arrangement may cause them to feel overlooked.

Table 8.2. *Office Design Features with a Positive Impact on Wellbeing*

Office design features (positive impact on wellbeing)	Questionnaire <sup>a</sup>			Interview <sup>a</sup>			Total <sup>b</sup>
	Base	T1	T2	Base	T1	T2	
<b>sit-stand desks</b>	2	13	4	5	7	7	38
<b>visual appearance of office</b>	1	3	2	8	4	4	22
<b>ambient conditions (lighting, natural light, air quality, temperature)</b>		1	2	4	1	4	12
<b>windows/views</b>	1	1		3		4	9
<b>plants</b>		3			4	2	9
<b>office areas (comfortable, places for informal discussions, choice of areas to work)</b>		2	1		4	2	9
<b>office furniture</b>		2		3	1	2	8
<b>working away from the desk/home working (physical activity, variety, focused work)</b>	1			2	1	1	5
<b>comfortable workplace</b>		3				1	4
<b>physical activity encouraged by layout/size of building</b>		2	1				3
<b>canteen</b>		1		1	1		3
<b>partitions (reduce noise)</b>		1			1		2
<b>hub layout</b>					1	1	2
<b>ergonomically adjusted workstation</b>	1				1		2
<b>quiet/less noise</b>		1				1	2
<b>clean workplace</b>		1					1
<b>space</b>			1				1
<b>accessibility to colleagues</b>						1	1

<sup>a</sup> Counts are number of participants, not number of comments.

<sup>b</sup> Counts are number of participants per measurement and time totalled.

Table 8.3. *Office Design Features with a Negative Impact on Wellbeing*

Office design features (negative impact on wellbeing)	Questionnaire <sup>a</sup>			Interview <sup>a</sup>			Total <sup>b</sup>
	Base	T1	T2	Base	T1	T2	
ambient conditions (lighting, temperature, air quality)	8	6	5	3	4	3	29
noise and distractions	3	6	6	5	2	4	26
desk too small/monitor too close		5	3		1	3	12
mess/inadequate storage	4	1	2	3		2	12
sedentary/too long at computer or monitor/would like to work away from desk more	2	3		2			7
hub layout (isolating, pathways more difficult to colleagues)		2	1		1	2	6
too quiet	1			1		1	3
ergonomics of workstation		1		2			3
crowded						3	3
sit-stand desks (not having one)	2						2
lack of areas for focused work/privacy	1						1
office furniture (uncomfortable)	1						1
sit-stand desk (uncomfortable)				1			1
IT issues (preventing away from desk working)					1		1
windows/views (seat does not have a view)						1	1

<sup>a</sup> Counts are number of participants, not number of comments.

<sup>b</sup> Counts are number of participants per measurement and time totalled.

### 8.1.1.2 *Productivity*

By far, the most common theme discussed by the employees in regard to productivity was noise and distractions. Other themes mentioned less were collaboration, comfort, and specific job needs.

Table 8.4 and Table 8.5 provide summaries of the number of participants commenting on specific office features in reference to productivity.

#### 8.1.1.2.1 Noise and distractions

The comments from employees highlighted the complexity of dealing with noise and distractions in an open-plan environment. Participants mentioned noise and distractions not just in terms of colleagues' social conversations and work-related discussions, but also interruptions by co-workers asking questions.

*"Sometimes it can have a negative effect, because you get involved in everything else, and not work." T2 Interview participant*

Employees complained that it was hard to focus when frequently being interrupted, and some expressed a need for separate areas to do focused work.

*"...I would like more spaces where we could go to do some quiet concentration work. I don't feel as though I can do that very well at my desk..." T1 Interview participant*

Traffic past desks (e.g. busy pathways behind desks) was another distraction mentioned. Possibly extra activity may have existed in this office due to the encouragement of ABW.

A library area had been added to the new office design prior to T1. After T1, some work booths were added to this area. These areas were considered to be helpful, but there were reports of disruptions in focused areas from colleagues asking questions, or noise and distractions from the open-plan environment. Office etiquette may need to be addressed to tackle noise and distractions, in addition to the office design. After the office redesign, participants still complained of noise and distractions, although some felt the addition of partitions and the hub layouts had helped.

*"...I think there's been a positive impact on general noise levels. It's definitely quieter now."*  
*T2 interview participant*

At T1 and T2, more employees were in the office due to company expansion, and there were some comments about crowding. The additional people in the office may have contributed to ongoing complaints about noise and distractions.

Participants mentioned using headphones, working away from the desk, and home working as coping mechanisms that they used when doing focused work. Commonly, employees felt that they were more productive when working away from their desk, or home working, due to less noise and distractions. Unfortunately, IT issues affected some employees' ability to work away from the desk, or from home, due to a reliance on Computer-Aided Design (CAD) installed at their workplaces and an insufficient number of laptops. After T1, the company responded to feedback about IT issues and made some changes, such as an increased number of more powerful laptops that could operate CAD to enable participants to work away from the desk. Some employees felt that there were insufficient or inadequate areas for focused work.

Although participants generally felt the environment was noisy and distracting at times, a minority of people felt that it was too quiet, making it uncomfortable to communicate with others. One employee mentioned that instead of communicating ad hoc, items were saved to discuss at meetings because of the overly quiet environment. Another participant commented that it would be unpleasant if it was too quiet and that being able to converse socially with colleagues was important for wellbeing.

*“...you don't want to come to work and just sit in silence and go home at the end of the day. It's nice to have that interaction and diversity. I think as long as you've got a balance...where you've got I don't know focused time.” T1 Interview participant*

#### 8.1.1.2.2 Collaboration

The employees had jobs which required collaboration, and several comments were made about the effect of office design on collaboration, and in turn, productivity. Hub layouts were felt to contribute positively to collaboration via proximity to teammates. Accessibility to colleagues in the office was considered to be beneficial and is a positive aspect of open-plan design. Some comments were made about a lack of proximity to teammates affecting productivity negatively, and one person commented that productivity could be adversely impacted when meeting rooms were booked in advance and unavailable.

#### 8.1.1.2.3 Comfort

Employees reported they were more productive when comfortable, with some commenting on comfortable office furniture and ambient conditions.

*“By feeling relaxed and comfortable at work I am not clock watching and am more inclined to work more hours without feeling tired or overworked.” T1 questionnaire participant*

Conversely, uncomfortable office furniture or ambient conditions were felt to contribute to reduced productivity. After the redesign, employees complained of discomfort due to the smaller desk, which had been reduced since baseline.

#### 8.1.1.2.4 Specific job needs

Employees discussed having the tools or facilities required to do their job. Some employees expressed that they had everything they needed for their job, which helped with productivity. There were some comments made about the negative impact of mess and inadequate storage, inadequate workshop areas, and insufficient areas for different types of work (e.g., making phone calls, confidential work). Some comments were made about office etiquette regarding mess and people not tidying after themselves. Mess and inadequate storage were reported to affect productivity as employees had to look for the tools they needed.

*“And then also because of the clutter, you tend to not know where things are. You may put a task off because you're like I need to look for that, I'll look for it later on.” T2 interview participant*

Due to the smaller desk size in the redesigned office, some employees felt they did not have enough storage at their desks for tools, paperwork, and parts.

The employees' jobs required some hands-on work, such as building prototypes. Although they had workshop areas in the office to do this work, some employees preferred to do it at their desk, so they could refer to CAD at the same time. This was difficult after the redesign, as the desks had been reduced in size, and there was less tabletop space to work on. In addition, some employees felt that the workshop area provision was insufficient. As the workshop areas were in the open-plan office, they also contributed to noise and distractions.

## 8.1.1.2.5 Other comments

Some people commented on a positive impact on productivity from sit-stand desks, windows/views, and the visual appearance of the office.

Table 8.4. *Office Design Features with a Positive Impact on Productivity*

Office design features (positive impact on productivity)	Questionnaire <sup>a</sup>			Interview <sup>a</sup>			Total <sup>b</sup>
	Base	T1	T2	Base	T1	T2	
working away from desk/home working/focused work areas	4	5	6	4	8	7	34
hubs (good for interaction/collaboration, reduce noise, accessibility to colleagues)		2	1		4	5	12
quiet/quieter or less distracting than pre office design	1	4			4	1	10
have everything required for job		3	1			2	6
proximity to colleagues/teammates	2		2				4
relaxed/comfortable workplace		3		1			4
sit-stand desks					2	2	4
accessibility to colleagues		2					2
partitions (reduce noise)					2		2
meeting areas		1					1
windows/views		1					1
office furniture				1			1
dual PC monitors					1		1
visual appearance of office						1	1
ambient conditions (lighting)						1	1

<sup>a</sup> Counts are number of participants, not number of comments.

<sup>b</sup> Counts are number of participants per measurement and time totalled.



Table 8.5. *Office Design Features with a Negative Impact on Productivity*

Office design features (negative impact on productivity)	Questionnaire <sup>a</sup>			Interview <sup>a</sup>			Total <sup>b</sup>
	Base	T1	T2	Base	T1	T2	
noise and distractions	13	11	14	8	10	12	68
mess/inadequate storage	3	1	3	4	1	5	17
IT issues (preventing, or affecting speed, of away from desk working or home working; need CAD in workshop area)	1	2		3	4	4	14
desk too small/monitor too close		5			3	4	12
inadequate workshop areas	3		2	2		3	10
insufficient areas for focused work		3	2		3	1	9
too quiet	1		2	2	1	1	7
crowded	1		2			4	6
hubs (isolating, distractions, crowded)		1	1			2	4
sit-stand desks (not having one, uncomfortable)	2			1			3
ambient conditions (temperature, lighting)			2			1	3
office etiquette (noise and mess)						3	3
office areas (insufficient areas for different types of work, e.g. phone calls)	2						2
sedentary/too long at computer or monitor/would like to work away from desk more		2					2
meeting rooms unavailable	1						1
lack of privacy for confidential work				1			1
lack of proximity to teammates				1			1

<sup>a</sup> Counts are number of participants, not number of comments.

<sup>b</sup> Counts are number of participants per measurement and time totalled.

### 8.1.1.3 *Teamwork*

The impact of office design on teamwork was discussed mainly around two themes. The two themes were hubs/proximity and accessibility to colleagues, and meeting areas/collaborative tools. Table 8.6 and Table 8.7 provide summaries of the number of participants commenting on particular office features impacting teamwork.

#### 8.1.1.3.1 Hubs/proximity and accessibility to colleagues

A commonly held belief prior to the redesign was that sitting away from team members working on the same project negatively affected teamwork. The hub layouts introduced in the redesign featured a circular layout with project team members seated together. After the redesign, employees frequently discussed the impact of hub layouts on teamwork. Hub layouts were generally considered to affect teamwork within the hubs in a positive way, by increasing collaboration and accessibility to colleagues. Some people commented on how the hubs had helped collaboration due to the ease of overhearing questions and the group being able to contribute, and also being able to turn around and have a quick discussion with a colleague.

*"I think it's quite easy now, if we overhear things it's quite easy to help each other out, whereas before it was a bit more difficult." T1 Interview participant discussing the hub layout*

Some people felt that there were some drawbacks to the hub layouts, such as people not facing each other, and the pathways to colleagues being more circuitous than before. It was felt by some that the hub layouts negatively affected teamwork between hubs and isolated hub groups. It was noted that while communication improved within each hub, it became more difficult to communicate with people in other hubs.

*"I'd say they're more isolated because of the teams...people just now network within the space that they're sitting..." T2 Interview participant discussing the hub layout*

Over the period of the study, membership in hubs changed, due to employees moving closer to colleagues that they needed to collaborate with on projects. Generally, the hub layouts evolved over the study period, as new employees joined the office, and the hub members adjusted the layouts to suit their needs. At T2, some of the hub layouts were less circular and more ovoid, as hub members had moved workstations to improve pathways.

Employees also commented on proximity and accessibility to their colleagues regarding the open-plan office layout. It was considered beneficial to have the visibility of colleagues and their work, and be able to approach colleagues easily for discussions. A lack of physical barriers was mentioned by some participants as a benefit for approaching colleagues.

#### 8.1.1.3.2 Meeting areas/collaborative tools

Prior to the office redesign, some employees felt that a lack of meeting areas affected teamwork negatively. At T1, several people commented that meeting areas help with teamwork, and the redesign provided a choice of areas to go for different types of meetings (formal and informal). Some people voiced the opinion that the meeting areas allowed for some privacy to discuss matters, which they felt was good for teamwork.

*"...there's lots of places to have informal chats and discussions...depending on varying privacy." T1 interview participant*

Some comments were made about the advantage of having collaborative tools (e.g. whiteboards) to assist with teamwork.

#### 8.1.1.3.3 Other comments

Although the open-plan layout was viewed as being positive for teamwork, due to visibility and accessibility, others commented that the layout negatively affected communication, due to concerns about privacy and disturbing others.

While working away from the desk and home working was commented on positively regarding productivity, some noted that occasionally it was difficult to locate people for meetings or access colleagues on the phone. This difficulty with locating employees working away from the desk may indicate a need for improved communications about employee whereabouts in ABW offices.

Table 8.6. *Office Design Features with a Positive Impact on Teamwork*

Office design features (positive impact on teamwork)	Questionnaire <sup>a</sup>			Interview <sup>a</sup>			Total <sup>b</sup>
	Base	T1	T2	Base	T1	T2	
hubs	1	9	4	3	12	8	37
meeting areas/collaborative tools	2	9	3	4	9	4	31
proximity to colleagues	3	2	3	2	1		11
open-plan layout	1	1		4		1	7
accessibility to colleagues		2					2
office layout			1				1

<sup>a</sup> Counts are number of participants, not number of comments.

<sup>b</sup> Counts are number of participants per measurement and time totalled.

Table 8.7. *Office Design Features with a Negative Impact on Teamwork*

Office design features (negative impact on teamwork)	Questionnaire <sup>a</sup>			Interview <sup>a</sup>			Total <sup>b</sup>
	Base	T1	T2	Base	T1	T2	
hubs		9	3		6	6	24
lack of proximity to colleagues	3			6			9
locating colleagues (people working away from desk/home working)	1		1	2	1	3	8
open-plan layout negatively affects communication	3			3	1		7
insufficient or inadequate meeting areas/collaborative tools	4						4
lack of office etiquette (not tidying after themselves, having meetings at desks)				3	1		4
crowded/more people in office				2		1	3
IT issues		2					2

<sup>a</sup> Counts are number of participants, not number of comments.

<sup>b</sup> Counts are number of participants per measurement and time totalled.

#### 8.1.1.4 *Summary of qualitative data*

In summary, qualitative analysis of the data resulted in several themes relating to the impact of office design on employee wellbeing, productivity, and teamwork (Table 8.8).

The qualitative data revealed how the occupants felt the physical office affects their wellbeing, productivity, and teamwork. Rich data was gathered that may be used to inform future office designs for occupant wellbeing.

Table 8.8. *Summary of Themes*

<b>Main Themes</b>	<b>Themes</b>
<b>Wellbeing</b>	physical activity/ABW comfort visual appearance/windows and views noise and distractions social interaction/collaboration
<b>Productivity</b>	noise and distractions collaboration comfort specific job needs
<b>Teamwork</b>	hubs/proximity and accessibility to colleagues meeting areas/collaborative tools

## 8.2 Discussion

Study 2 aimed to investigate employees' changes in self-assessed environmental satisfaction, wellbeing, productivity, and teamwork after an open-plan office redesign; and also explore their beliefs about any impact of the office design on wellbeing, productivity, and teamwork. Employees reported a significant increase in environmental satisfaction with the office after the redesign; however, measures of wellbeing either declined or did not change. There were non-significant changes in the belief of a positive effect of the workplace, and self-assessment of the past two weeks (wellbeing, productivity, and teamwork), from baseline to T1 (one month post office design). In a small longitudinal sample, it was found that environmental satisfaction was sustained over 8 months, indicating that the increase in environmental satisfaction was not a temporary effect. The change over time in psychological wellbeing in the longitudinal sample was not significant. Employees reported features of the office design that they felt impacted their wellbeing, productivity, and teamwork.

It was anticipated that an increase in environmental satisfaction after the office redesign would result in improved employee outcomes. While open-plan offices are generally linked with poorer wellbeing outcomes (De Croon et al., 2005; A. Richardson et al., 2017), much of the literature consists of comparisons between individuals in different office layouts rather than within-individual changes. Fewer studies investigate the impact of changes in individuals in longitudinal designs involving relocation from private to open-plan offices or improving the design of an open-plan office. Occupant wellbeing outcomes and environmental satisfaction have improved in previous studies after changes to open-plan environments (Agha-Hosseini et al., 2013; Hongisto et al., 2016). The present study did not find this relationship, and aspects of wellbeing decreased, although environmental satisfaction increased.

The decline in psychological wellbeing could have been due to other changes occurring at the time of the study, and a lack of formal change management used in the redesign. In an open-plan office refurbishment study examining individual changes, Hongisto et al. (2016) attributed an increase in job satisfaction with the refurbishment change management. In the present study, there were no formal change management procedures in place, although occupants' opinions of the original office had been sought prior to the redesign, and some participants were involved in the redesign. While Hongisto et al. (2016) found increased job satisfaction and environmental satisfaction in their study, some psychosocial factor ratings, such as stress and social support, did not change significantly.

During the office redesign in the present study, there were other changes taking place due to company expansion. Changes involved the addition of new staff members to the office and some alterations to management staff and practices. The additional new staff in the office at T1 and T2 may have also increased workload and distractions for senior staff who completed baseline measures. Senior employees were required to mentor new employees in addition to their existing workload. Increased distractions may have occurred due to a greater number of occupants in the office, as well as fielding questions from new employees. Office redesigns may occur during periods of expansion and transition in companies, and care should be taken to identify, and minimise, any potential negative impacts on employees from office and company changes. A formal change management procedure, including more open communication during the period of transition, may have resulted in awareness of issues affecting employees' wellbeing that could have been resolved.

An alternative explanation for the lack of increase in wellbeing outcomes is that the difference in office design was not great enough to affect change. The original office design was of a high standard and modern. At the baseline measure, comments from questionnaires and interviews indicated that the office was viewed favourably by some staff. There were positive benefits of the original design that were unchanged during the study (e.g. plenty of windows and natural light). Perhaps there would have been a greater impact on employee outcomes if the redesign involved improvements to an older, low-quality office design. In one study investigating employee outcomes after extensive changes to an open-plan office (conversion to a paperless, ABW office), it was found that there were improvements to some wellbeing outcomes, but other wellbeing outcomes had little or no change (Meijer, et al., 2009). Given the limited changes in wellbeing found in the present study and some previous studies (Hongisto et al., 2016; Meijer et al., 2009), it seems plausible that office redesign and refurbishment may have a subtle impact on wellbeing.

### 8.2.1 Wellbeing

This study used two self-rated measures of wellbeing. There was a reduction in mean SWELL scores one month post office redesign; however, there was no significant change on a single measure of participants' self-rated wellbeing for the past two weeks. This contradiction highlights that results are affected by the type of wellbeing measurement used. Several SWELL items were used, which included questions about work stress and demands, while the other measure used a single item to measure wellbeing, and this may have contributed to the difference. In addition, the single measure used a timescale of two weeks, whereas a timeframe was not specified with the SWELL in this study (modification of the original SWELL). At T1, employees reported significantly less control over their

jobs and support from fellow workers, and significantly more often feeling anxious or depressed because of work. As mentioned previously, several changes occurred following the baseline measure, involving new employees and also changes reported in terms of management initiatives. There were some reports of increased workload due to these changes. The increased number of occupants in the office may have had a negative effect, as increased density has been associated with decreased wellbeing (Aries et al., 2010; Herbig et al., 2016; Oldham, 1988; Oldham & Rotchford, 1983). Questions assessing belief of a positive effect of workplace on wellbeing showed that there were no significant changes in the items relating to wellbeing, apart from a significant increase in a belief in the positive impact of the workplace on health. The impact on health may have been related to the employees' positive reactions to the introduction of sit-stand desks for everyone.

Qualitative data from questionnaires and interviews revealed five main themes concerning office design features that employees felt affected their wellbeing. The themes were physical activity/ABW, comfort, visual appearance/windows and views, noise and distractions, and social interaction/collaboration. Participants reported feeling better emotionally and physically due to being able to stand at their desks, and also move around the office. Physical activity in the office may be something that should be encouraged to improve employees' wellbeing, and sit-stand desks are thought to improve wellbeing by allowing workers to change posture during their workday (MacEwen et al., 2015). Comfort was commented on in regard to aspects of the office, such as ambient conditions and furniture, and was felt to contribute negatively (discomfort) and positively (comfort) to wellbeing. Participants felt that the visual appearance of the workplace (including plants) and windows/views positively affected their wellbeing. The benefits of plants, views, and natural light have been documented in wellbeing literature (e.g., Aries et al., 2010; C. Cooper & Browning, 2015; Grinde & Patil, 2009, Nieuwenhuis et al., 2014). Noise and distractions are commonly complained about in open-plan offices (Kaarlela-Tuomaala et al., 2009; J. Kim & de Dear, 2013; Pejtersen et al., 2006), and employees in this study reported a negative impact on their wellbeing from this problem. Social interaction/collaboration was seen as a positive feature of the office and its impact on wellbeing; however, interaction and collaboration can cause noise and distractions in an open-plan environment. Some of the themes in the current study (e.g. visual appearance of the office) were similar to themes found in a previous mixed-methods study investigating wellbeing and perceptions of the office environment in university employees (Cobaleda Cordero et al., 2020), while other themes were unique to the present study (e.g. physical activity/ABW). The features of the open-plan office design that participants felt affected their



wellbeing agree with the literature and have largely been established previously; however, the popularity of physical activity and sit-stand desks is noteworthy.

### 8.2.2 Productivity

In a previous office relocation study, employees reported increased office satisfaction, as well as increases in their belief of a positive impact of the workplace on their productivity and wellbeing (Agha-Hosseini et al., 2013). The present study did not show an increase in productivity, although environmental satisfaction increased. The qualitative data collected suggests that productivity may have been hindered by the changes relating to company expansion and the continuing, though improved, problem with noise and distractions. To target productivity more effectively, office features that employees feel affect their productivity (e.g. noise) may need to be specifically addressed. While the increased number of occupants in the office may have affected noise levels, participants attributed some design changes (plants, partitions, soft furnishings, hubs) to less noise and distractions. Although ABW offices may have an advantage over traditional open-plan offices by offering additional quiet areas, this study identified that other factors such as office etiquette and IT provision need to be considered for these areas to be effective.

### 8.2.3 Collaboration and teamwork

There were no significant changes in self-reported teamwork following the office redesign. Factors unrelated to office design were not investigated in this study, and teamwork may have been affected by other issues, such as management changes, individual relationships, and staff changes. Office design features which employees felt affected their teamwork included hubs/proximity and accessibility to colleagues, and meeting areas/collaborative tools. The hub layouts were felt generally to be good for teamwork within hubs, although some employees felt that they made teamwork more difficult with people in other hubs. Proximity and accessibility to colleagues, generally attributed to hubs and the open-plan layout, were considered beneficial to teamwork and collaboration. Some employees also commented on the benefit of having visibility of colleagues and their work, and in an open-plan environment, this may be helpful to know when someone can be approached and when they should not be disturbed (Y. S. Lee, 2010). In contrast to this, some people felt that the open-plan layout caused some problems with teamwork such as lack of privacy, and noise and distractions. Employees felt that meeting areas (both formal and informal), and collaborative tools, were helpful for collaborating with colleagues. The present study indicates the importance of proximity and accessibility of colleagues, and also the provision of meeting areas and tools that can be used for formal and informal collaboration, when designing an office space to

improve teamwork. While open-plan layouts may have some negative impacts on teamwork and collaboration, meeting areas may provide solutions to address some of the limitations (e.g., privacy, noise, and distractions).

#### 8.2.4 Conclusion

After a redesign in an open-plan office, environmental satisfaction of occupants significantly increased. There was a decline in aspects of employee psychological wellbeing after the redesign, which could be related to changes occurring in the company at the time of the post measures. In order to have a positive impact on occupant psychological wellbeing, it is important to consider more than just the physical environment. Office design interventions aimed at improving employee wellbeing outcomes should seek to make changes holistically, and address work demands and stressors concurrently. Qualitative data provided insights into the office design features that positively and negatively impacted employees' wellbeing, productivity, and teamwork.

This study involved an office redesign comprised of several changes. In the next chapter, a study investigating one change will be described. Chapter 9 will outline a preliminary study used to test a methodology to evaluate the industrial partner's work booths and any impact on user wellbeing and productivity.

#### 8.2.5 Industrial partner recommendations

- Provide additional areas for focused work away from open-plan areas and investigate IT solutions to allow employees to work productively away from the desk.
- Continue to promote physical activity in the office (sit-stand desks, working away from the desk).
- Consider physical needs of employees (ambient conditions, ergonomics, and comfort of workstations).
- Visual appeal is important for employees' wellbeing.

## 9 A preliminary study of work booths and wellbeing

### 9.1 Introduction

In Chapter 7, an office redesign intervention (Study 2) was described that encompassed several changes. While employees reported an increase in environmental satisfaction from this redesign, there was a decrease in some psychological wellbeing ratings. As the office redesign was comprised of several modifications, it was difficult to make conclusions about the effect of specific changes. In order to test the isolated effect of a single change on wellbeing, a preliminary intervention study (Study 3) was conducted. In Study 3, participants were provided with work booths to conduct focused work. In Study 2, a salient finding was that employees reported their wellbeing and productivity were affected by noise and distractions. The work booths were proposed by the industrial research partner as a partial solution to this problem, which is common in open-plan offices. The present chapter outlines the methodology of this study and discusses the results.

#### 9.1.1 Noise and privacy in open-plan offices

Noise and lack of privacy are frequent sources of dissatisfaction in open-plan offices (e.g., De Croon et al., 2005; Kaarlela-Tuomaala et al., 2009; Pejtersen et al., 2006). Distractions and reductions in productivity are linked to noise (Kaarlela-Tuomaala et al., 2009; Lamb & Kwok, 2016), and it is a major source of discomfort in open-plan office workers (Perrin Jegen & Chevret, 2017). Noise was one of the strongest predictors, and privacy was also a significant predictor, of psychological wellbeing in a previous study (Klitzman & Stellman, 1989). In a study of 128 office workers, Leather et al. (2003) used moderation analysis and discovered that lower levels of ambient noise buffered the negative impacts of psychological job stress on job satisfaction, health, and organisational commitment. There were no direct effects of noise on these outcomes, and the researchers proposed that noise may not be stressful in itself but may impair occupants' ability to cope with job strain. Noise disturbance affected self-rated health, but not job satisfaction, in a structural equation modelling (SEM) study (P. J. Lee et al., 2016). In the latter study, lack of speech privacy was negatively correlated with job satisfaction. In a longitudinal within-subjects study, Lamb and Kwok (2016) used multi-level modelling (MLM) analysis and found that severe noise annoyance significantly reduced self-reported productivity, while both moderate and severe noise annoyance reduced mood. Distractions may be auditory or visual, and it is interesting to note that visual distractions have been largely neglected in research. The literature suggests that noise and privacy

are two factors that should be targeted in interventions to increase occupants' wellbeing in the office.

Individuals vary in noise sensitivity, or annoyance caused by different sources of noise (Smith, 2003). Studies may measure objective acoustic levels and/or occupants' subjective ratings of noise. Noise sensitivity may be related to *negative affectivity*, the extent that an individual views their environment or self negatively (Smith, 2003). Due to the subjective nature of individuals' reactions to noise, it may be more appropriate to use self-rated measures, rather than physical measurements of noise, in studies examining the impact of noise on occupants. It has been previously observed that noise meters may not be the best option for measuring noisiness in different office environments, due to factors such as different room acoustics and relevance of sounds to the participants (Kaarlela-Tuomaala et al., 2009). Furthermore, actual measured noise level generally only accounts for approximately 25% of the variance in ratings of noise annoyance (Oseland & Hodsmann, 2018), and noise sensitivity appears to be an important predictor of acoustic comfort in open-plan offices (Roskams et al., 2019). While subjective assessment of noise may be preferable in assessing noise in office environments, individual differences in noise sensitivity need to be accounted for in studies.

### 9.1.2 The cognitive effect of noise and distractions

The negative impact of noise and distractions on cognitive function is well-documented. Open-plan offices have been linked with greater cognitive stress and distractions than private offices (Seddigh, Berntson, Bodin Danielson, & Westerlund, 2014), although distractions can also occur in private offices (Seddigh, Stenfors, et al., 2015). Generally, the research investigating the impact of noise and distractions in offices is based on lab studies, using tasks to simulate office work rather than field studies with occupants performing their usual duties at their normal workstations. Although lab studies are less ecologically valid than field studies, they provide controlled situations to investigate this topic. Lab studies have shown reductions in memory and task performance when participants are exposed to noise (e.g., Brocolini, Parizet, & Chevret, 2016; Jahncke et al., 2011; Smith-Jackson & Klein, 2009). In addition, working in a high noise environment has been associated with increased fatigue and decreased motivation (Jahncke et al., 2011). There appear to be individual differences in the effect of noise on performance and workload (Brocolini et al., 2016; Smith-Jackson & Klein, 2009). The question of how visual distractions affect concentration has received little attention from researchers, although one study investigated visual distraction using a comparison of static and dynamic lighting conditions (Liebl et al., 2012). Overall, lab studies have shown detrimental impacts of noise and distractions on cognitive functioning tasks.

While many lab studies have been conducted investigating the impact of noise on cognitive function, fewer experimental field studies investigate the impact of noise and distractions on employees' performance. In a field study investigating memory performance in a within-subjects design comparing a quiet baseline condition and usual working conditions, it was found that the performance drop in a noisier condition was greater for larger open-plan and private offices, as compared to smaller open-plan offices (Seddigh, Stenfors, et al., 2015). In the latter study, the researchers proposed that distractions such as phone calls and emails could have affected participants in the private offices. Field studies are important to further knowledge in this area, as they provide greater insight into the real-life impact of noise and distractions under normal working conditions. In lab studies, participants may be instructed to ignore background noises, whereas, in offices, noises could have additional meaning, and employees may be attending to them (Banbury & Berry, 2005). Furthermore, employees are exposed to a multitude of distractions concurrently. These distractions are not just auditory and can be from other factors, such as emails or visual distractions (e.g. from colleagues walking past). The problem of distractions in offices is more complex than in laboratory simulations. In addition, laboratory experiments tend to use short timeframes, and little is known about the long-term impact of working in distracting environments.

### 9.1.3 Partitions and other office design solutions

There is evidence to indicate that wellbeing and productivity improve when measures are taken to reduce noise and distractions or increase privacy in open layouts. Partitions have been used historically to ensure a degree of privacy and fewer distractions in open-plan environments. Panels, bookcases, or *living wall systems* ("walls" made from plants) may also be beneficial in shared office spaces (R. L. Morrison & Macky, 2017). While some studies have found a link between partitions and higher ratings of privacy (Oldham, 1988; Sundstrom et al., 1980), another study found that workers in open-plan offices without partitions had more satisfaction with auditory privacy and noise than those with high partitions (Y. S. Lee, 2010). Individual requirements for privacy and quiet conditions may vary depending on occupants' jobs and need for collaborative and focused work, and the difference found in the latter study could be related to the needs of the occupants in the study. High partitions have been associated with reductions in job satisfaction, and it has been suggested that they may allow for more visual privacy, but not auditory privacy, which may cause problems (Maher & von Hippel, 2005). Possibly, high partitions may reduce job satisfaction via less social interaction or an inability to use visual cues and identify the location of noises (Maher & von Hippel, 2005). In a laboratory study comparing performance on cognitive tasks at workstations with partitions raised vs partitions lowered, perseverance on tasks was shown to increase with partitions raised (Roberts et

al., 2019). Participants' subjective ratings of workload, fatigue, boredom, and negative affect did not change between conditions. Partitions may help improve work performance by decreasing the effort required to perform a task in an open environment (Roberts et al., 2019). Partitions are one solution for increasing privacy and reducing distractions in open-plan offices; however, they should not be considered a panacea for these environments. Height of partitioning is an important design consideration, and it is evident that partitions may decrease, but will not remove, noise disturbance and distractions.

Research studies investigating noise minimisation strategies other than partitions in open-plan offices are limited but show promising results. In a crossover field study using sound-absorbent material in an open-plan office, better acoustic conditions resulted in small improvements in employees' perceptions of disturbances and cognitive stress but no change in professional efficacy (Seddigh, Berntson, et al., 2015). Haapakangas, Hongisto, Varjo, and Lahtinen (2018) compared two groups of participants moving from private to open-plan offices and found both groups had higher distractions after relocation; however, only the group moving to an office with fewer quiet areas had negative effects on environmental satisfaction, perceived collaboration, and stress. Increased distractions mediated the negative effects on collaboration and stress, and distractions may be considered as environmental demands in open-plan offices. Activity-based working (ABW) offices may offer another way of dealing with the open-plan problem of conducting focused work in a noisy, distracting environment (Wohlers & Hertel, 2017). ABW offices provide separate areas that occupants can use for specific types of work, for example, quiet areas for doing concentrated work. A relocation study following people moving from an open-plan office to an ABW office found increased satisfaction with noise and auditory privacy; however, auditory privacy and speech levels were the environmental satisfaction items occupants were most dissatisfied with in the ABW office (Rolfö et al., 2018). Interviewees made comments about issues with noise etiquette, such as teams having meetings in open-plan areas and some teams being noisier than others. The latter study shows that even with provision of quiet areas for open-plan office occupants, issues such as office etiquette are important.

Overall, the studies described in this section suggest that measures can be taken to ensure better working conditions concerning noise in open-plan offices, and these improvements positively impact occupants' wellbeing. Design considerations, such as the provision of quiet areas to work, encouraging working away from the desk practices, use of partitions, and sound absorptive materials, may enable employees in open-plan offices to work with less distractions and noise

disturbances. Acoustic etiquette also should be considered to minimise noise and distractions. Further studies should be conducted in this area, particularly experimental designs, as previous research is limited.

#### 9.1.4 Work booths as a design solution

In Study 2, described in Chapters 7 and 8, open-plan office employees reported that noise and distractions negatively affected their wellbeing and impaired their ability to work productively. Employees commented on feelings of frustration and annoyance stemming from distractions affecting their ability to concentrate. Coping strategies were reported including working away from the desk, home working, and using headphones. The researcher's industrial partner designed a range of work booths, named Coppice, to help with the problem of noise and distractions in open-plan offices. The work booths have partial wrap-around partitioning, which can minimise both visual and auditory distractions. In addition, employees should experience less distraction when they sit at a work booth area, as they are removing themselves from their colleagues, and can signal to others they are doing focused work. To the researcher's knowledge, a longitudinal field study using work booths has not been conducted before. Much of the previous research into using partitions in open-plan offices has focused on partitioning around workstations, whereas work booths do have partitioning, but offer a different experience. When using work booths, employees may work away from their desks for a period to do some focused work. This is a central tenet of ABW, allowing occupants to exercise control and choose an appropriate area to work for their task. As mentioned previously, the provision of quiet areas and ABW have shown some positive results in past studies (Haapakangas, Hongisto, et al., 2018; Rolfö et al., 2018).

#### 9.1.5 Study 3

Study 3 was a preliminary study to trial a methodology which will later be used with a larger participant sample. A randomised crossover design was used, where participants were randomly assigned to one of two conditions, a *Work Booth Condition* and a *Non-work Booth Condition*, and then the participants completed the other condition. In the Work Booth Condition, participants had access to work booths to use whenever they wished for one week, whereas in the Non-work Booth Condition participants were asked not to use the work booths for one week. The industrial partner provided three work booth variants from their product range. Participants were invited to complete daily online questionnaires for two weeks (one week for each condition) at the end of each workday. The questionnaires asked about their use of different areas; and their job satisfaction, self-assessed productivity, satisfaction with noise and privacy, workload, and mood. Average weekly ratings were

calculated for each individual, and repeated measures analyses were conducted to investigate the effect of availability of work booths. At the end of the two weeks, participants were asked to complete a user experience questionnaire, which included questions about their satisfaction with using the work booths. This research should enable a greater understanding of the relationship between wellbeing and work booths, and also explore the use of work booths as a solution for focused work in open-plan environments.

#### 9.1.5.1 *Aim*

The present study aimed to explore participants' use of different areas for activities, including Coppice work booths, in order to understand the impact of work booths and how to implement them successfully in an open-plan office. The hypotheses outlined below were based on the assumption that occupants would have greater productivity and wellbeing during the week when they had access to work booths, as they would be exposed to less noise and distractions.

*Hypothesis 1.* Participants' job satisfaction, self-assessed productivity, and satisfaction with noise and privacy would be higher in the week when work booths were available, as compared to the week when they were not available.

*Hypothesis 2.* Participants' perceived workload would be lower in the week when work booths were available, as compared to the week when they were not available.

*Hypothesis 3.* Participants would have more positive, and less negative, mood states when work booths were available, as compared to the week when they were not available.



## 9.2 Methods

### 9.2.1 Setting

The work booths were placed in open-plan office areas in the industrial partner's headquarters, based in South Wales, United Kingdom. Six booths were located in a newly redesigned open-plan office described in Chapter 7 (the *Design Lab*). This office had 35 occupants at the time of the present study (2019), consisting of designers, engineers, and marketing staff. An additional four booths were located in the corridor of a larger open-plan office area (*main office*), which housed approximately 100 – 140 employees (number dependent on the day) in several occupations: administrative, customer service, IT, HR, management, and business development managers. One booth was situated in a corner of the main office, next to a window with a view of the factory floor below.

### 9.2.2 Participants

The participants were 21 employees working in the industrial partner's head office. There were 12 (57%) male, and nine (43%) female participants, with an age category range of 19 – 29 to 50 – 59 (*Mdn* = 30 – 39). The employees were from the Design Lab and the main office, and several different occupations were represented, from entry-level to management positions. An email was sent to all members of the two open-plan offices, inviting participation in the study. Participants were required to meet the following inclusion criteria: 18 years of age or older, sometimes have a need to do work in a quiet area, have work that could be done away from the desk, and have access to a laptop to use. One employee wished to participate but did not have a laptop, and the company loaned one for the study. The first participants to reply that fit the inclusion criteria were accepted for the study. Participants were randomly assigned to take part in the Work Booth Condition or Non-work Booth Condition first, and then participants completed the other condition. Employees were given £40 as a small token of appreciation for taking part.

### 9.2.3 Materials

The questionnaires were online and used the Qualtrics platform. The Daily Questionnaire and Daily Activity Log were combined and could be accessed with one daily link.

#### 9.2.3.1 *Information about the work booths*

A PowerPoint contained information about the work booths, including suggestions on how to use the work booths and advice not to disturb people working there. The PowerPoint text is listed below:

1. You can use a work booth when you want, and do not need to ask permission.
2. You can use work booths when you need to do focused work in a quiet area (image of a speech bubble with the text 'Shhh!').
3. To do computer work in a work booth area, you will need to use a laptop. Contact Jennifer Langer [langerj3@cardiff.ac.uk](mailto:langerj3@cardiff.ac.uk) if you do not have a laptop to use. You may also use the work booths to do paperwork.
4. Please respect other people when they are working in the work booths, and try not to disturb them unnecessarily.
5. Please remove your belongings when you leave a work booth, so that other people can use it.

The final slide advised participants to contact the researcher if they had any questions.

#### 9.2.3.2 *Questionnaires*

In the Daily Questionnaire (Table 9.1), participants were asked to rate workload, productivity, job satisfaction, noise and distractions/privacy, satisfaction with quiet areas, and mood. Workload was measured using the six-item NASA-TLX (Hart, 2016; Hart & Staveland, 1988; National Aeronautics and Space Administration [NASA], n.d.). The NASA-TLX includes items on mental workload, physical workload, time pressure, performance satisfaction, effort, and frustration, rated on a 20-point scale in this study.

In the Daily Activity Log (Table 9.2), participants were asked to complete a log of locations that they worked at during the day. They were asked about activities they performed, and productivity and distractions while working in these locations. The log included additional questions about the work booths, such as how useful they were.

The Work Booth User Experience (WBUE) questionnaire (Table 9.3) included 10 closed questions, and one open-ended question, asking participants about their satisfaction with working in the work booths. There were two sets of nine questions about mood while working at the Coppice work booth and the desk/workstation.

Table 9.1. *Daily Questionnaire*

Item	Scale	Dimension (source)
Please enter your user ID number below. Please enter the colour/animal combo you were given below.	textbox	user ID
If there are any questions you don't wish to answer, please go on to the next question.		
<b>Q1. Mental Demand</b> How mentally demanding was your work today?	1, very low, to 20, very high	workload (NASA-TLX; Hart & Staveland, 1988)
<b>Q2. Physical Demand</b> How physically demanding was your work today?	1, very low, to 20, very high	
<b>Q3. Temporal Demand</b> How hurried or rushed was the pace of your work today?	1, very low, to 20, very high	
<b>Q4. Performance</b> How successful were you in accomplishing your work today?	1, perfect, to 20, failure	
<b>Q5. Effort</b> How hard did you have to work to accomplish your level of performance today?	1, very low, to 20, very high	
<b>Q6 Frustration</b> How insecure, discouraged, stressed, irritated and annoyed were you today?	1, very low, to 20, very high	
Q7. I would rate my <b>productivity</b> today as:	1, very low, to 10, very high	productivity
Q8. I would rate my <b>job satisfaction</b> today as:	1, very low, to 10, very high	job satisfaction
Q9. I would rate <b>noise and visual distractions</b> (e.g. people walking past) today as:	1, very distracting – 10, not distracting at all	noise and distractions/privacy
Q10. There were suitable <b>quiet areas</b> in my workplace for me to work at today.	1, strongly disagree – 10, strongly agree	satisfaction with quiet areas
Q11. Below is a list of moods and emotions. Please rate your mood <b>today</b> .	Not at all (1), A little (2), Moderately (3), Quite a lot (4), Extremely (5)	mood
Stressed Energetic Isolated/Lonely		

Table 9.2. *Daily Activity Log*

<b>Daily Activity Log</b>
If there are any questions you don't wish to answer, please go on to the next question.
<p>Q1. How many hours did you work today (approximately)?</p> <p>Q1A. Did you sit at a Coppice work booth today? (Yes/No) <i>skipped to next section if "No" selected</i></p> <p>Q1B. How long did you sit at a Coppice work booth today (approximate)?</p> <p>Hours _____</p> <p>Minutes _____</p> <p>Q1C. What activities did you do there? Select all that apply.</p> <ul style="list-style-type: none"> <li>▪ Computer work not requiring much concentration (e.g. short emails)</li> <li>▪ Computer work requiring concentration (e.g. writing reports, longer emails, detailed work)</li> <li>▪ Speaking on the phone</li> <li>▪ Paperwork</li> <li>▪ Meetings</li> <li>▪ Other (please describe) _____</li> </ul> <p>Q1D. Why did you choose to sit at a Coppice work booth today?</p> <p>Q1E. Was sitting at the Coppice work booth today useful? (Yes, No, Undecided/neutral)</p> <p>Q1F. Why was sitting at the Coppice work booth today useful or not useful?</p> <p>Q1G. How productive were you when sitting at the Coppice work booth today? (1, Very unproductive – 10, Very productive)</p> <p>Q1H. How distracted were you (by noise, people walking past, and other distractions) when sitting at the Coppice work booth today? (1, Very distracted – 10, Not distracted at all)</p>
<p>Q2A. Did you sit at a desk/workstation today? (Yes/No) <i>skipped to next section if "No" selected</i></p> <p>Q2B. How long did you sit at a desk/workstation today (approximate)?</p> <p>Hours _____</p> <p>Minutes _____</p> <p>Q2C. What activities did you do there? Select all that apply.</p> <ul style="list-style-type: none"> <li>▪ Computer work not requiring much concentration (e.g. short emails)</li> <li>▪ Computer work requiring concentration (e.g. writing reports, longer emails, detailed work)</li> <li>▪ Speaking on the phone</li> <li>▪ Paperwork</li> <li>▪ Meetings</li> <li>▪ Other (please describe) _____</li> </ul> <p>Q2D. How productive were you when sitting at a desk/workstation today? 1, Very unproductive – 10, Very productive)</p> <p>Q2E. How distracted were you (by noise, people walking past, and other distractions) when sitting at a desk/workstation today? (1, Very distracted – 10, Not distracted at all)</p>
<p>Q3A. Were you in a collaborative/meeting area today? (Yes/No) <i>skipped to next section if "No" selected</i></p> <p>Q3B. How long were you in a collaborative/meeting area today (approximate)?</p> <p>Hours _____</p> <p>Minutes _____</p> <p>Q3C. What activities did you do there? Select all that apply.</p> <ul style="list-style-type: none"> <li>▪ Computer work not requiring much concentration (e.g. short emails)</li> <li>▪ Computer work requiring concentration (e.g. writing reports, longer emails, detailed work)</li> <li>▪ Speaking on the phone</li> <li>▪ Paperwork</li> <li>▪ Meetings</li> <li>▪ Other (please describe) _____</li> </ul> <p>Q3D. How productive were you when you were in the collaborative/meeting area today? (1, Very unproductive – 10, Very productive)</p> <p>Q3E. How distracted were you (by noise, people walking past, and other distractions) when you were in the collaborative/meeting area today? (1, Very distracted – 10, Not distracted at all)</p>

Table 9.2. (continued)

<b>Daily Activity Log</b>
<p>Q4A. Did you sit/work in another area (other than at a desk/workstation, collaborative/meeting area or Coppice work booth) today? (Yes/No) <i>skipped to next section if "No" selected</i></p> <p>Q4A1. What other area did you sit/work in?</p> <p>Q4B. How long did you sit at this other area today (approximate)?</p> <p>Hours _____</p> <p>Minutes _____</p> <p>Q4C. What activities did you do there? Select all that apply.</p> <ul style="list-style-type: none"> <li>▪ Computer work not requiring much concentration (e.g. short emails)</li> <li>▪ Computer work requiring concentration (e.g. writing reports, longer emails, detailed work)</li> <li>▪ Speaking on the phone</li> <li>▪ Paperwork</li> <li>▪ Meetings</li> <li>▪ Other (please describe) _____</li> </ul> <p>Q4D. How productive were you when you were in the other area today? (1, Very unproductive – 10, Very productive)</p> <p>Q4E. How distracted were you (by noise, people walking past, and other distractions) when you were in the other area today? (1, Very distracted – 10, Not distracted at all)</p>
<p>Q5. Did you sit/work in another area (not mentioned above) today? (Yes/No) <i>skipped to next section if "No" selected</i></p> <p>Q5A1. What other area did you sit/work in?</p> <p>Q5B. How long did you sit at this other area today (approximate)?</p> <p>Hours _____</p> <p>Minutes _____</p> <p>Q5C. What activities did you do there? Select all that apply.</p> <ul style="list-style-type: none"> <li>▪ Computer work not requiring much concentration (e.g. short emails)</li> <li>▪ Computer work requiring concentration (e.g. writing reports, longer emails, detailed work)</li> <li>▪ Speaking on the phone</li> <li>▪ Paperwork</li> <li>▪ Meetings</li> <li>▪ Other (please describe) _____</li> </ul> <p>Q5D. How productive were you when you were in the other area today? (1, Very unproductive – 10, Very productive)</p> <p>Q5E. How distracted were you (by noise, people walking past, and other distractions) when you were in the other area today? (1, Very distracted – 10, Not distracted at all)</p>
<p>Q6. If you have any more comments about areas that you have worked at today, please add them below.</p>

Table 9.3. *Work Booth User Experience (WBUE) Questionnaire*

Item	Scale		
In order to be able to link your questionnaires, please provide your user ID and colour/animal combo. Please enter your user ID number below. Please enter the colour/animal combo you were given below.	textbox		
The following questions are about your satisfaction with the Coppice work booth. If there are any questions you don't wish to answer, please go on to the next question.			
Q1. Did you sit at a Coppice work booth at any time during this study?	<i>Yes/No (If no was selected, the survey skipped to the end)</i>		
Q2. How comfortable were you at the work booth?	<i>1, very uncomfortable – 10, very comfortable</i>		
Q3. How would you rate the visual appearance/quality of the work booth?	<i>1, very poor – 10, excellent</i>		
Q4. How useful was the work booth as a place to do quiet, focused work?	<i>1, not useful at all – 10, very useful</i>		
Q5. How easy was it to take your work to the work booth?	<i>1, very difficult – 10, very easy</i>		
Q6. Did you feel you had permission to use the work booth, whenever you wanted?	<i>1, not at all – 10, yes, definitely</i>		
The following questions are asking you to compare your experience working at your usual desk/workstation with working in the Coppice work booth.			
Q7. Compared to working at your usual desk/workstation, <b>how noisy was it</b> when you worked at the work booth?	<i>1, much more noisy in the work booth – 11, much less noisy in the work booth (6 = no difference)</i>		
Q8. Compared to working at your usual desk/workstation, <b>how distracting were conversations and other noises</b> when you worked at the work booth?	<i>1, much more distracting in the work booth – 11, much less distracting in the work booth (6 = no difference)</i>		
Q9. Compared to working at your usual desk/workstation, <b>how distracting were visual distractions (e.g. people walking past)</b> when you worked at the work booth?	<i>1, much more distracting in the work booth – 11, much less distracting in the work booth (6 = no difference)</i>		
Q10. Compared to working at your usual desk/workstation, <b>how would you rate the quantity of work you completed</b> at the work booth?	<i>1, much less in the work booth – 11, much more in the work booth (6 = no difference)</i>		
Q11. Compared to working at your usual desk/workstation, <b>how would you rate the quality of work you completed</b> at the work booth?	<i>1, much lower quality in the work booth – 11, much higher quality in the work booth (6 = no difference)</i>		
The following questions are asking you about your mood while working at your usual desk/workstation, and the Coppice work booth. If there are any questions you don't wish to answer, please go on to the next question.			
Q12. Below is a list of moods and emotions. Please rate your mood while working at the Coppice work booth during the study.	<i>Not at all (1), A little (2), Moderately (3), Quite a lot (4), Extremely (5)</i>		
Stressed Energetic Isolated/Lonely		Irritated/Annoyed Tired Relaxed and calm	Happy Anxious Depressed
Q13. Below is a list of moods and emotions. Please rate your mood while working at a desk/workstation during the study.		<i>Not at all (1), A little (2), Moderately (3), Quite a lot (4), Extremely (5)</i>	
Stressed Energetic Isolated/Lonely	Irritated/Annoyed Tired Relaxed and calm		Happy Anxious Depressed
Q14. Please add any comments about your experience working at the Coppice work booth.	textbox		

### 9.2.3.3 Work booths

There were six booths in the Design Lab and five booths in the main office, provided by the industrial partner. The booths provided by the partner varied slightly in design. The Design Lab booths were Coppice-Library-06, and the main area booths were Coppice-Focus-04 and Coppice-Work-02. The Coppice Library 06 booths were a 6-booth configuration (Figure 9.1), comprising three booths on one side and three on the other, with partitions in the centre and along the sides of each booth. The Coppice-Focus-04 booths (Figure 9.2) had additional partitioning behind the user's seat area. The Coppice-Work-02 booth was a solo booth that was nearly completely enclosed (Figure 9.3).



Figure 9.1. Coppice-Library-06

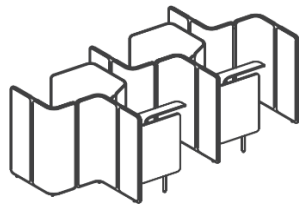


Figure 9.2. Coppice-Focus-04



Figure 9.3. Coppice-Work-02

Figures 9.1 – 9.3 from “Coppice,” by Orangebox, n.d. (<https://orangebox.com/products/coppice>). Copyright by Orangebox. Reprinted with permission.

### 9.2.4 Procedure

Ethical approval for this study was granted by the School Research Ethics Committee (SREC) of the School of Psychology, Cardiff University. The researcher visited the company and gave information sheets and consent forms to the participants. Signed consent forms were stored securely at Cardiff University. Participants were sent an email including a PowerPoint with information about the purpose of the work booths and how to use them. Participants were asked to conduct a daily online questionnaire (including the Daily Activity Log and Daily Questionnaire) at the end of their workday for a week without use of the work booths (Non-work Booth Condition), and for a week with use of the work booths (Work Booth Condition). The links to the daily questionnaires were emailed to participants, along with the following instructions: “Please do not use the work booths this week.” (Non-work Booth Condition), or “You may use the work booths this week, whenever you want.” (Work Booth Condition). There were no guidelines given about how long to work in the booths, and participants were not given tasks to do in the booths. Participants could choose when to use the booths, the duration of time they stayed, and select which work they did there. Therefore, participants had control over their use of the booths. In addition, they were not monitored or observed during the study period. An email was sent to participants with a user ID and also a colour and animal combination so that their anonymous responses could be linked. Each day, participants

were sent an email in the morning with the daily questionnaire link and instructions, and a reminder email in the afternoon. At the end of the two-week study, they were instructed to complete a final questionnaire, the WBUE questionnaire. After completion of the WBUE questionnaire, participants were given remuneration and debriefed by the researcher. Following analysis of the data, participants were invited to a presentation of the results given by the researcher.

#### 9.2.5 Analysis

Quantitative data was analysed using IBM SPSS Statistics 25. In the analysis of the Daily Questionnaire and Daily Activity Log, individual changes were compared using dependent *t*-tests, or Wilcoxon Signed Rank Tests for paired comparisons that did not show normality of distribution of differences. Paired comparisons were undertaken for participants' average weekly ratings in the two conditions, Work Booth Condition and Non-work Booth Condition. Weekly averages for each condition were calculated for participants with a minimum of three daily ratings for that week, and those participants with less than three daily ratings were not included in the pairwise comparisons. To determine whether order of Work Booth and Non-work Booth Condition weeks affected the results, Mixed-design ANOVAs were also conducted for weekly averages, using order of condition as a between factor. In addition, paired comparisons were made between productivity and distraction ratings for the periods of the day that participants worked at the booths vs when they worked at the desks. For this latter comparison, averages were calculated from all ratings for the booths, and for the desks, during the Work Booth Condition week. In the WBUE, differences between ratings of mood when working at the booths vs the desks were also compared using dependent *t*-tests and Wilcoxon Signed Rank Tests. Open-ended comments were entered into NVivo 12 Pro, and the data was analysed using thematic analysis.



## 9.3 Results

### 9.3.1 Daily Activity Log

#### 9.3.1.1 *Activities performed in work booths and different areas*

Participants used the work booths for various tasks (Table 9.4). The task that the work booths were used most for was computer work requiring concentration. During the Work Booth Condition week, the amount of time that participants spent sitting at work booths daily varied from none to 8 hours. Excluding days that participants did not work at booths at all, participants worked at booths for an average of 3 hours and 3 minutes ( $SD = 2$  hours,  $Mdn = 2 \frac{1}{2}$  hours) daily during the Work Booth Condition week.

Table 9.4. *Activities Performed in Different Areas*

Task	Work booth (total = 76)	Desk/ workstation (total = 152)	Meeting / collaborative area (total = 82)	Other area <sup>a</sup> (total = 29)	Other area 2 <sup>a</sup> (total = 12)
<b>Computer work not requiring much concentration (e.g. short emails)</b>	34 (45%)	109 (72%)	5 (6%)	6 (21%)	1 (8%)
<b>Computer work requiring concentration (e.g., writing reports, longer emails, detailed work)</b>	59 (78%)	130 (86%)	18 (22%)	5 (17%)	1 (8%)
<b>Speaking on the phone</b>	13 (17%)	79 (52%)	5 (6%)	5 (17%)	1 (8%)
<b>Paperwork</b>	26 (34%)	84 (55%)	5 (6%)	5 (17%)	2 (17%)
<b>Meetings</b>	2 (3%)	19 (13%)	72 (88%)	11 (38%)	5 (42%)
<b>Research/training</b>	3 (4%)	1 (1%)	1 (1%)	1 (3%)	0 (0%)
<b>Other</b>	3 (4%)	5 (6%)	2 (2%)	9 (31%)	5 (42%)

Note. Number of comments from daily responses not number of participants.

<sup>a</sup> Other area - a variety of places were mentioned (e.g., canteen, soft seating areas, pods, other areas in the office).

### 9.3.1.2 *Reasons given for using the work booths*

Participants were asked why they used a work booth that day. The majority of comments indicated that people used the booths to avoid distractions and noise for concentrated, focused work (Table 9.5). Some comments indicated that people used the booths because they were participating in the study.

Table 9.5. *Reasons Given for Using the Work Booths.*

<b>Reasons given for using the work booths</b>	<b>Number of comments</b>
<b>Avoid distractions, concentrate, quiet place, focused work</b>	42
<b>For the study</b>	17
<b>For a specific task</b>	5
<b>Privacy</b>	4
<b>Break from desk</b>	2
<b>Convenience</b>	2
<b>Be alone</b>	2

*Note.* Number of comments from daily responses not number of participants.

### 9.3.1.3 *Was sitting at a work booth useful?*

Participants were asked if using a work booth was useful. The majority of daily responses were positive, with 52 (68%) “yes” responses. There were only nine (12%) “no” responses and 15 (20%) undecided responses.

### 9.3.1.4 *Why was the work booth useful/not useful?*

The majority of comments made about usefulness of the booths related to the ability to concentrate more, have fewer distractions, and the booths being quieter than the employees’ workstations (Table 9.6).

*"...sitting in the Coppice [helped] me switch off from me chatting and got my head focused."*

*"I found at my desk due to the noise and distractions, made me more [stressed] and anxious, I then moved to the coppice where I felt I could concentrate more and be more productive."*

Several observations were made that the booths were distracting due to people walking past, noise, and interruptions from colleagues.

*"Too many people approached me while i was working in the coppice"*

Some people were dissatisfied with the location of the booths. Negative comments were made about distraction from the corridor in the main office booths and the darkness of the Design Lab booth area. Some other issues mentioned were that participants would prefer to use a PC or dual monitors, and the booths were too small for paperwork or certain tasks. Comments revealed that some participants may have used the work booths inappropriately, concentrating for long periods, instead of using them for shorter periods of focused work.

Table 9.6. *Why the Work Booths were Useful/Not Useful*

Why was the work booth useful/not useful?	Number of comments	Positive/negative
Less distractions	33	+
Concentrate more	18	+
Quieter	18	+
Distracting in booth	11	-
Other	6	+/-
More productive	4	+
IT - prefer PC, more monitors needed, WiFi slower, laptop issues	4	-
Privacy	3	+
Didn't like the location of the booth	3	-
Booth too small	2	-
Didn't stay long enough	1	-
Not used to working in a booth	1	-
Work away from desk	1	+

*Note.* Number of comments from daily responses not number of participants.

### 9.3.1.5 Productivity and distraction ratings when participants worked in different areas

Participants were asked to rate their productivity and level of distraction in different areas they worked at during the day (Table 9.7 and Table 9.8). Daily responses indicated on average higher productivity at the work booths ( $M = 6.86$ ,  $Mdn = 7$ ) than at the desks/workstations ( $M = 6.40$ ,  $Mdn = 6$ ). High productivity ratings were given to other areas (e.g., soft seating areas, pods, canteen). Daily responses showed on average less distraction at the work booths ( $M = 5.38$ ,  $Mdn = 6$ ) than at the desks/workstations ( $M = 6.71$ ,  $Mdn = 7$ ).

Table 9.7. Productivity Ratings in Different Areas

How productive were you when sitting at (area) today?	<i>N</i>	Mean	Median	<i>SD</i>
Work booth	73	6.86	7.00	2.11
Desk/workstation	151	6.40	6.00	1.52
Collaborative/meeting area	82	7.02	7.00	1.60
Other area	28	8.00	8.00	1.78
Other area 2	11	8.00	8.00	1.41

Note. On a scale from 1 (very unproductive) to 10 (very productive).

Table 9.8. Distraction Ratings in Different Areas

How distracted were you (by noise, people walking past, and other distractions) when you were in the (area) today?	<i>N</i>	Mean	Median	<i>SD</i>
Work booth	76	5.38	6.00	2.44
Desk/workstation	152	6.71	7.00	2.24
Collaborative/meeting area	82	3.54	3.00	2.63
Other area	29	4.21	4.00	2.76
Other area 2	11	3.55	3.00	1.97

Note. On a scale from 1 (very distracted) to 10 (not distracted at all), reverse scored.

Average ratings for productivity and distraction in work booths and desks for the Work Booth Condition week, split by day, are illustrated in Figure 9.4 and Figure 9.5. On average there was less distraction during periods when working in the work booths for each day of the week. Productivity was higher during work booth periods each day except Monday. In the study offices, there were generally more meetings on Mondays, so this may explain the difference, or it could have reflected that a period of adjustment was required. Fridays in this office were generally a quieter day, and this could explain the drop in distraction shown in the work booths, or it may have been an effect of adjustment to the booths.

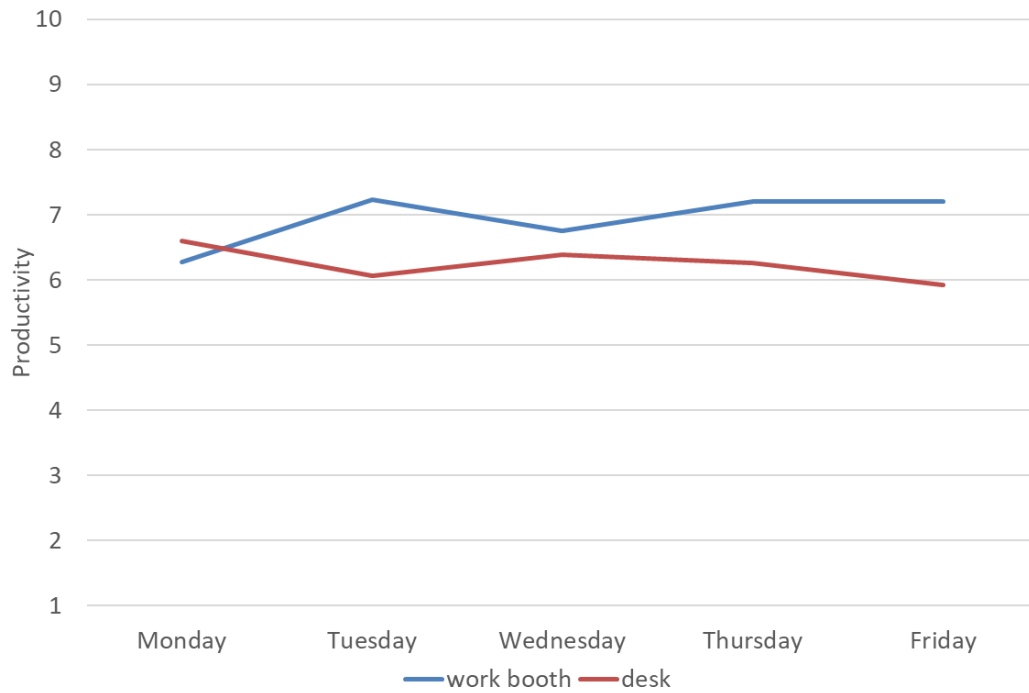


Figure 9.4. Mean productivity ratings for desks and work booths on each day of the week during the Work Booth Condition week.

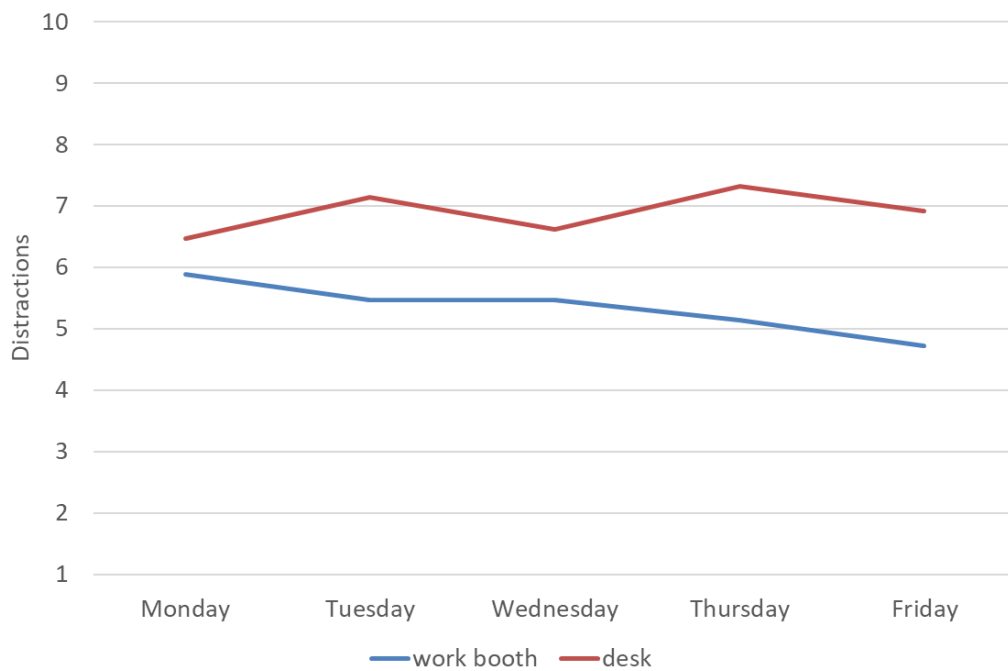


Figure 9.5. Mean distraction ratings for desks and work booths on each day of the week during the Work Booth Condition week.

Note. The distraction ratings are reverse coded (lower values indicate less distraction).

To compare productivity ratings in the daily periods when participants were working at the booths vs the desks, Work Booth Condition week averages were computed for each individual's productivity ratings in the booth, and at the desk. The individuals' average scores for productivity in the two areas were then compared using a Wilcoxon Signed Ranks Test. Ratings for productivity were higher in the booths ( $Mdn = 6.75$ ) vs the desks ( $Mdn = 6$ ) although this difference was not significant,  $Z = -1.69$ ,  $N - \text{Ties} = 19$ ,  $p = .091$  (Figure 9.6).

The same procedure was followed with participants' ratings of distractions. To compare their distraction ratings in the daily periods when they were working at the booths vs the desks, study period averages were computed for each individual's reverse scored distraction ratings in the booth, and at the desk. The average scores for distraction at the two areas for each individual were then compared using a paired-samples  $t$ -test. It was found that participants were significantly less distracted when working in the booths ( $M = 5.57$ ,  $SD = 1.89$ ) as compared to the desks ( $M = 6.93$ ,  $SD = 1.69$ ),  $t(19) = -2.49$ ,  $p = .022$  (Figure 9.7).

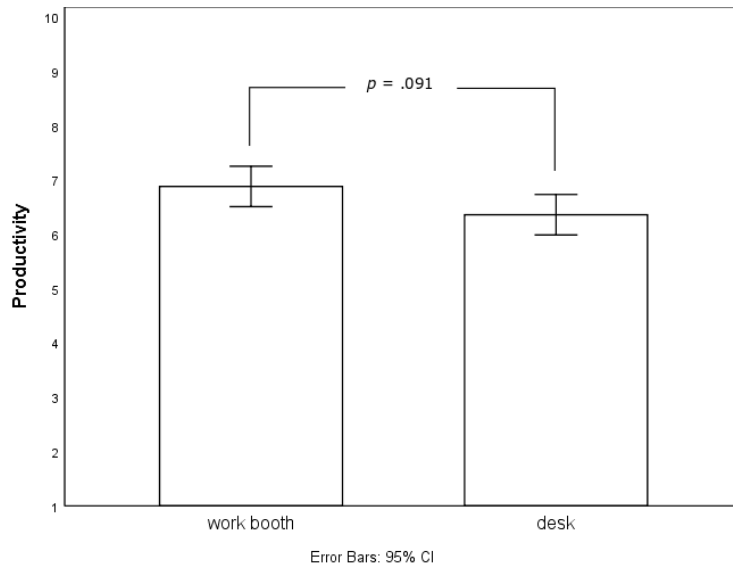


Figure 9.6. Mean ratings of productivity in periods worked at the work booths vs the desk during the Work Booth Condition week in paired sample comparisons.

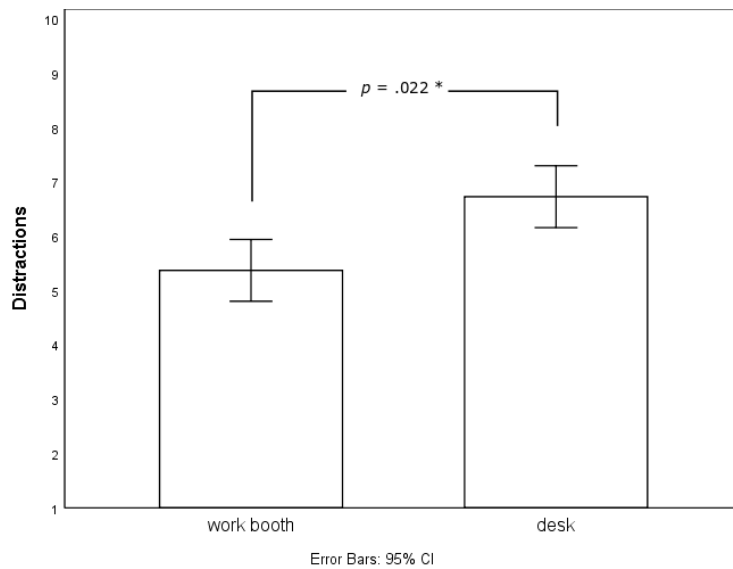


Figure 9.7. Mean ratings of distraction in periods worked at the work booths vs the desk during the Work Booth Condition week in paired sample comparisons.

### 9.3.2 Daily Questionnaire

#### 9.3.2.1 *Differences within individuals (Work Booth Condition vs Non-work Booth Condition weekly averages)*

Within-individual differences (Work Booth Condition vs Non-work Booth Condition weekly averages) were examined for workload, productivity, job satisfaction, noise and distractions/privacy, satisfaction with quiet areas, and mood. Weekly averages were calculated for participants with a minimum of three daily ratings, and those with less were not included in the pairwise comparisons.

The participants' weekly average total perceived workload was calculated using participants' *Raw TLX* scores, the score from added or averaged NASA-TLX items (Hart, 2016). The participants' daily totals were first calculated by adding together all of the NASA-TLX items for each day. Then participants' average weekly workload scores were calculated using the mean of their daily total scores. There was no significant difference between conditions for the average weekly workload percentage scores or the NASA-TLX items (Table 9.9).

There were also no statistical differences between average weekly ratings of productivity, job satisfaction, noise and visual distractions, and satisfaction with quiet areas (Table 9.10).

A total mood score was calculated by adding ratings of positive moods (energetic, relaxed and calm, happy) and reverse scored ratings of negative moods (stressed, isolated/lonely, irritated/annoyed, tired, anxious, depressed). An average weekly mood percentage score was the mean of individuals' total daily mood scores during that week. The average weekly mood percentage scores did not differ significantly between conditions (Table 9.11). Weekly average scores of individual moods were also not significantly different between conditions.

Mixed-design ANOVAs were also conducted on the above analyses using order of condition as a between-subjects factor, and the results were similar to those in Tables 9.9 – 9.11, so they are not described here.



Table 9.9. NASA-TLX Workload Paired Comparisons between Non-work Booth and Work Booth Condition Weeks

NASA-TLX Item	Work Booth Condition Week <i>M</i>	Non-work Booth Condition Week <i>M</i>	statistic	<i>df</i>	<i>p</i>
Mental demand	11.43 ( <i>SD</i> = 3.43)	11.20 ( <i>SD</i> = 2.75)	<i>t</i> = .33	18	.747
Physical demand	4.02 ( <i>SD</i> = 2.77)	4.53 ( <i>SD</i> = 2.73)	<i>t</i> = -1.78	18	.092
Temporal demand	10.14 ( <i>SD</i> = 4.02)	9.77 ( <i>SD</i> = 3.37)	<i>t</i> = .58	18	.567
Performance	9.65 ( <i>SD</i> = 3.65)	9.30 ( <i>SD</i> = 4.05)	<i>Z</i> = -.684	-	.494
Effort	12.21 ( <i>SD</i> = 2.53)	11.58 ( <i>SD</i> = 2.32)	<i>Z</i> = -1.33	-	.185
Frustration	6.72 ( <i>SD</i> = 4.13)	7.23 ( <i>SD</i> = 4.13)	<i>t</i> = -.60	18	.558
Total workload (%)	44.70 ( <i>SD</i> = 11.92)	44.72 ( <i>SD</i> = 10.79)	<i>Z</i> = -.060	-	.952

Note. A 20-point scale was used for NASA-TLX items.

Table 9.10. Daily Questionnaire Paired Comparisons between Non-work Booth and Work Booth Condition Weeks

Daily questionnaire Item	Work Booth Condition Week <i>M</i>	Non-work Booth Condition Week <i>M</i>	statistic	<i>df</i>	<i>p</i>
Productivity <sup>a</sup>	7.03 ( <i>SD</i> = 1.08)	6.93 ( <i>SD</i> = .94)	<i>t</i> = .55	18	.586
Job satisfaction <sup>a</sup>	6.42 ( <i>SD</i> = 1.23)	6.24 ( <i>SD</i> = 1.35)	<i>t</i> = .90	18	.378
Noise and visual distractions <sup>b</sup>	5.22 ( <i>SD</i> = 1.53)	5.48 ( <i>SD</i> = 1.75)	<i>t</i> = -1.12	17	.277
Quiet areas <sup>c</sup>	7.16 ( <i>SD</i> = 1.64)	6.71 ( <i>SD</i> = 2.06)	<i>t</i> = .76	18	.457

<sup>a</sup> On a scale from 1 (*very low*) to 10 (*very high*).

<sup>b</sup> On a scale from 1 (*very distracting*) to 10 (*not distracting at all*).

<sup>c</sup> On a scale from 1 (*strongly disagree*) to 10 (*strongly agree*).

Table 9.11. Daily Questionnaire Mood Paired Comparisons between Non-work Booth and Work Booth Condition Weeks

Daily questionnaire moods	Work Booth Condition Week <i>M</i>	Non-work Booth Condition Week <i>M</i>	statistic	<i>df</i>	<i>p</i>
Stressed	2.10 ( <i>SD</i> = .77)	2.13 ( <i>SD</i> = .85)	<i>t</i> = -.14	18	.891
Energetic	2.75 ( <i>SD</i> = .88)	2.70 ( <i>SD</i> = .79)	<i>t</i> = .39	18	.703
Isolated/lonely	1.58 ( <i>SD</i> = .65)	1.42 ( <i>SD</i> = .54)	<i>t</i> = 1.32	18	.204
Irritated/annoyed	1.82 ( <i>SD</i> = .64)	1.94 ( <i>SD</i> = .52)	<i>t</i> = -.88	18	.388
Tired	2.53 ( <i>SD</i> = .73)	2.39 ( <i>SD</i> = .78)	<i>t</i> = 1.04	18	.312
Relaxed and calm	3.04 ( <i>SD</i> = .86)	2.93 ( <i>SD</i> = .88)	<i>Z</i> = -.85	-	.394
Happy	3.25 ( <i>SD</i> = .78)	3.21 ( <i>SD</i> = .68)	<i>t</i> = .34	18	.738
Anxious	1.64 ( <i>SD</i> = .66)	1.66 ( <i>SD</i> = .74)	<i>Z</i> = -.04	-	.972
Depressed	1.43 ( <i>SD</i> = .65)	1.46 ( <i>SD</i> = .77)	<i>t</i> = -.43	18	.676
Total mood (%)	75.39 ( <i>SD</i> = 10.47)	75.29 ( <i>SD</i> = 11.37)	<i>t</i> = .06	18	.952

Note. Scale is 1 = *Not at all*, 2 = *A little*, 3 = *Moderately*, 4 = *Quite a lot*, 5 = *Extremely*.

### 9.3.3 Work Booth User Experience (WBUE) Questionnaire

In the final user experience questionnaire, average ratings indicated that the work booths were satisfactory to users (Table 9.12 and Table 9.13). Participants felt that the booths were comfortable and useful for conducting focused work. In addition, participants felt they could use the booths whenever they wanted. Participants were asked to rate noise and distractions, and productivity, when working at the booths as compared to working at their desks, and they were more positive about work booths.

Table 9.12. *User Satisfaction with the Work Booths*

Items	N	Mean	Median	SD
How comfortable were you at the work booth?	20	7.05	7	2.04
How would you rate the visual appearance / quality of the work booth?	21	7.05	7	2.04
How useful was the work booth as a place to do quiet, focused work?	21	7.43	8	2.38
How easy was it to take your work to the work booth?	21	6.62	7	2.22
Did you feel you had permission to use the work booth, whenever you wanted?	21	9.19	10	1.70

Note. On a scale from 1 to 10, 10 indicating greatest satisfaction.

Table 9.13. *User Comparison of Working in Booths vs Usual Desk/Workstation*

Items	N	Mean	Median	SD
<b>Compared to working at your usual desk/workstation:</b>				
how noisy was it when you worked at the work booth? (1 much more - 11 much less)	21	8.38	9	2.27
how distracting were conversations and other noises when you worked at the work booth? (1 much more - 11 much less)	21	7.76	9	2.70
how distracting were visual distractions (e.g. people walking past) when you worked at the work booth? (1 much more - 11 much less)	21	7.29	9	3.27
how would you rate the quantity of work you completed at the work booth? (1 much less - 11 much more)	20	7.60	7	2.35
how would you rate the quality of work you completed at the work booth? (1 much lower - 11 much higher)	21	7.86	8	1.96

Note. On a scale from 1 to 11, 11 indicating greatest satisfaction (6 = no difference).

Users rated their moods retrospectively for the periods during the study when they worked at the Coppice work booths, and at their usual desk/workstation. Wilcoxon Signed-Rank Tests and dependent *t*-tests were conducted, and it was found that there were several significant differences within individuals' ratings of mood during these periods (Table 9.14).

An overall mood score was calculated by adding ratings of positive moods (energetic, relaxed and calm, happy) and reverse scored ratings of negative moods (stressed, isolated/lonely, irritated/annoyed, tired, anxious, depressed). A mood percentage score was then calculated. The average total mood score was higher (more positive) for participants' ratings of mood while working at the Coppice booths (*Mdn* = 77.78) as compared to their usual desk/workstation (*Mdn* = 71.11), and this difference was significant,  $Z = -2.95$ ,  $N - \text{Ties} = 19$ ,  $p = .003$ ,  $r = -.46$ .

Participants reported feeling less stressed, energetic, irritated/annoyed, and anxious working in the Coppice booths as compared to working at their usual desk/workstation. They reported feeling more isolated/lonely, and relaxed and calm while working in the Coppice booths as compared to working at their usual desk/workstation. There were no significant differences in tired, happy, and depressed mood ratings between working at the Coppice work booths and working at the usual desk/workstation. After Holm-Bonferroni correction, all of the significant results remained apart from "energetic" and "anxious" moods.

Table 9.14. *User Moods (Retrospective) Working in Booths and at Usual Desk/Workstation (N = 21)*

	Coppice		Workstation		statistic	df	p
	<i>M</i>	<i>Mdn</i>	<i>M</i>	<i>Mdn</i>			
<b>Stressed</b>	1.71	2	2.81	3	$t = -4.42$	20	< .001*** <sup>a</sup>
<b>Energetic</b>	2.38	3	2.90	3	$Z = -2.25$	-	.024*
<b>Isolated/lonely</b>	2.19	2	1.24	1	$t = 3.30$	20	.004*** <sup>a</sup>
<b>Irritated/annoyed</b>	1.43	1	2.71	3	$Z = -3.60$	-	< .001*** <sup>a</sup>
<b>Tired</b>	2.19	2	2.52	2	$Z = -1.54$	-	.124
<b>Relaxed and calm</b>	3.71	4	2.48	3	$Z = -3.60$	-	< .001*** <sup>a</sup>
<b>Happy</b>	3.24	3	3.24	3	$Z = -.05$	-	.963
<b>Anxious</b>	1.38	1	1.95	2	$Z = -2.52$	-	.012*
<b>Depressed</b>	1.33	1	1.48	1	$Z = -1.73$	-	.083
<b>Total mood (%)</b>	77.99	77.78	70.90	71.11	$Z = -2.95$	-	.003*** <sup>a</sup>

Note. Scale is 1 = *Not at all*, 2 = *A little*, 3 = *Moderately*, 4 = *Quite a lot*, 5 = *Extremely*.

<sup>a</sup> Significant after Holm-Bonferroni correction.

\*  $p < .05$

\*\*  $p < .01$

\*\*\*  $p < .001$

#### 9.3.4 User feedback

Participants' feedback was solicited in the Daily Questionnaire and the WBUE Questionnaire. Overall, users were very positive about using the work booths to minimise distractions and complete focused work. Some people felt it was helpful to be able to remove themselves from colleagues in order to concentrate. Comments were made about increased productivity while working in the booths.

*"The coppice was a great tool to move to when you need to complete focused work and remove yourself from any distractions."*

*"I found the work booths environment to help my concentration and improve the quality and quantity of my work. "*

Privacy was also seen by some users as a benefit to using the work booths.

*"...the desk size itself is great and the feeling of privacy is quite high. I will continue to work at the coppice booths now that the study is over."*

Distractions in the booths were mentioned frequently. This may have been partly to do with the location of the study booths. The study booths located in the Design Lab were in a quieter area of the open-plan office, although some participants felt the area was too dark, and one person complained it was untidy. The work booths in the main office were located in a busy corridor. This may have resulted in more distractions, as participants commented that people walking past frequently spoke to them. This finding suggests that employees should be educated not to disturb people unnecessarily while they are working in the booths.

*"...people still came over when you are using the coppice. It may be a good idea to suggest that people in the coppice are not to be approached."*

In addition, people commented that the department next to the main office booths was quite loud, which was distracting. The flooring in the corridor was bare concrete, and this may have contributed to noise disturbance.

*“Unfamiliar location made it hard to adjust to noise & distraction (to which I have learned to ‘zone out’ somewhat when I am at my permanent desk).”*

*“I found the coppice booth ok to work in however the placement of them could be a contributing factor to why I felt more distracted. My normal desk is [away from pathways] so moving to somewhere that has a walk way next to it was unusual for me. Also sound from near by away from the desk areas caused distractions due to the loudness of people in those booths. “*

Several comments provided feedback about the use of work booths for tasks. Some users felt that there was not enough space when they had a laptop and paperwork, and this was an occasional deterrent to use of the booths. Others commented about IT issues relating to use of the booths. The IT issues mentioned were general away from the desk issues rather than related specifically to the work booth design. Comments were made about some tasks requiring dual monitors, working better on a PC vs a laptop, and one person complained that using WiFi meant a task took longer. One issue raised was the time involved bringing work from the workstation to the work booths, and having to organise work to bring to the booths.

*“It wasn’t a conclusive experience to me as this change of habits obliged me to reorganise my job.”*

These latter comments also highlight working away from the desk issues, not problems unique to working in booths.

Some users may have used the booths for longer periods than was beneficial. One person commented on developing a headache after concentrating in the booth for a long time. Another participant remarked that they would not want to spend the entire day in a work booth but would use one for a few hours. The work booths were intended to be used for shorter durations to do work requiring concentration; however, participants may have felt they needed to use them for extended periods to test them properly for the study. This feedback could be used to inform training in the use of work booths, as working away from the desk is a new concept for some office workers and may require some adjustment and education to successfully adopt.

## 9.4 Discussion

A two week randomised crossover work booth preliminary study was conducted with 21 employees at offices in the industrial research partner's headquarters. During one week of the study, participants were invited to use Coppice work booths whenever they wanted (Work Booth Condition), and during the other week, they were asked not to use the booths (Non-work Booth Condition). User responses indicated the Coppice work booths were satisfactory. Participants primarily used the work booths to do focused work in a quieter and less distracting environment. Training needs, ideal placement of booths, and some usability issues were identified. There were no differences in weekly average ratings of workload, productivity, environmental satisfaction, and wellbeing within individuals; however, there were some significant changes when comparing specific periods of the day when participants worked at booths vs desks. In the periods of the day that participants used work booths, there were significantly lower ratings of distraction and differences in retrospective ratings of mood, as compared to periods of the day when they worked at their usual desks.

It was anticipated that in the week when participants had access to work booths, their job satisfaction, self-assessed productivity, and satisfaction with noise and privacy would be higher in comparison to the week when work booths were not available. Open-plan offices are commonly criticised for being noisy, distracting, and lacking in privacy. In fact, there were no significant differences within individuals in these outcomes between the two study conditions. Although there was no difference within individuals' weekly average distraction ratings, there was a significantly lower level of distraction in the periods of the day working at the work booths compared to the desks/workstations. There was higher productivity, although not significant, within individuals in the same periods. The reason for this discrepancy may stem from participants forming a global impression of the day that discounted their decreased distractions for part of the day, or it could be owing to the redundancy of work booths in this office. Participants may have worked in several areas each day, so their overall daily ratings during the Work Booth Condition reflected on time spent in booths and other office locations. In the study offices, participants had several other quiet areas they could use, including the use of private offices when not in use for meetings, and also pods (reconfigurable meeting rooms). Some participants commented during the study debrief that their preference for conducting focused work was the use of a private room or pod if available; however, the work booths were viewed as a good second option. Considering the space and economic difficulty of providing private offices, work booths offer a satisfactory alternative.

Perception of workload was expected to decrease during the Work Booth Condition week vs Non-work Booth Condition week. The researcher presumed participants would accomplish more during the week when work booths were available and, therefore would give lower workload ratings. There were no significant differences found in individuals' NASA-TLX workload ratings between conditions. As mentioned above, this could be explained by participants' retrospective recall of the day and also that they had alternative quiet areas to use. In addition, participants reported being disturbed by colleagues while they worked at the booths, and this may have affected their ability to concentrate on their work. In a previous lab study testing performance on cognitive tasks at a workstation with partitions raised or lowered, the participants also did not report any changes in productivity or workload; however, objective perseverance on tasks increased (Roberts et al., 2019).

In Study 2, discussed in Chapters 7 and 8, noise and distractions affected participants' wellbeing negatively, and some people commented on being irritated or annoyed by these disturbances. In the present study, it was hypothesised that participants would have more positive, and less negative, mood states when work booths were available. There were no significant differences in mood within-individuals when Work Booth Condition vs Non-work Booth Condition weekly average ratings were compared. This agrees with a previous lab study that indicated no difference in mood when participants worked at a desk with partitions raised (Roberts et al., 2019). There were some significant differences in mood within-individuals in the WBUE Questionnaire retrospective ratings. It is possible that users' moods were different in the work booths, but that the transient change in mood state did not impact their impression of their overall daily mood reported in the Daily Questionnaire. There were positive changes in mood states reported in the Coppice work booths in terms of feeling less stressed, irritated/annoyed, and anxious; and more relaxed and calm. Negative mood changes linked with the booths were feeling less energetic and more isolated/lonely. The latter mood changes are perhaps indicative of people's need for social interaction at work and suggest that focused work areas should be used short term, not all day. Thus, moving to work booths for part of the day may be a way for employees to manage mood in the short term, for example, to reduce stress and anxiety.

Comments from the questionnaires indicate that further training in how to use work booths is recommended during implementation. In particular, employees should be educated not to disturb people working in booths and quiet areas. Other comments indicated that placement of the work booths is important. Due to limited available space, some of the booths were located in a busy corridor with bare concrete floors. This resulted in a noisy and distracting environment. Ideally, the

work booths should be located somewhere that is quieter and more private. It can be uncomfortable for some users to have people walking behind their work booth, so it may be better to locate booths away from busy pathways or use configurations incorporating partitioning behind the users' seating area.

Few office design studies mention training occupants in the use of office furniture. In this study, the participants were given a presentation to read that provided training in use of the work booths. In a study investigating the impact of an office ergonomics training program, it was found that environmental satisfaction and control increased after training (Huang et al., 2004). Another study implemented an extensive training program, instructing employees in the use of a new ABW office design (Meijer et al., 2009), and the researchers attributed some of the positive long-term impacts of the redesign on the training and change management. An oversight in the present study was that the training was not extended to everyone in the office, and participants were disturbed in the work booth areas by their colleagues. In addition, the training provided was limited, and possibly further education could have been given to ensure employees understood how to use the work booths. The feedback provided by participants indicated that training in office etiquette, and also the optimal use of work booths, would be beneficial.

#### 9.4.1 Conclusion

Use of work booths in the present study was shown to be acceptable to employees. The employees' comments suggested that the placement of booths is important and further training in use would be beneficial. Comparisons of average weekly ratings between two one-week periods when work booths were available vs unavailable revealed no differences in individuals' workload, productivity, job satisfaction, ratings of noise and distractions/privacy, satisfaction with quiet areas, and mood. There were some significant differences in moods within individuals when they were asked to rate their mood retrospectively during the time spent in work booths vs at their usual desk/workstation. Significantly lower distraction ratings were reported for periods of the day when participants worked at the work booths vs the desks/workstations. Further research should be conducted using single interventions such as this, to evaluate the effect of office design changes in a quasi-experimental fashion. Solutions to the problems facing open-plan workers in regard to noise, distractions, and lack of privacy, need to be designed and tested, to develop design recommendations to improve office occupants' wellbeing and productivity.



This chapter has described the last study in this thesis. In the final chapter, the main findings of the research will be discussed.

#### 9.4.2 Industrial partner recommendations

- Training in use of work booths should educate users about how to use work booths effectively, and not to disturb people working in booths.
- Placement of work booths is important. Booths should be placed in quieter areas and away from busy pathways, if possible. Alternatively, configurations using partitioning behind users' seating areas could be recommended for focused work.

## 10 Discussion

This chapter discusses the main research results, as well as limitations of the research, and suggestions for further investigation. The primary aim of this research was to investigate the relationship between office design and wellbeing. This aim was addressed by a review of the literature and research conducted in Studies 1 to 3, which investigated the relationship using a questionnaire study and two office intervention studies. A secondary aim was to create a tool to measure wellbeing and environmental satisfaction in office occupants. Development of the Well Office Questionnaire (WOQ) was described in Chapter 6 and is summarised in the present chapter. The final aim was to develop office design recommendations to support wellbeing. These recommendations were developed using a literature review and results from the research in this thesis.

In the next section, the relationship between office design and wellbeing is discussed, drawing on the results from the present research. Then a discussion of measurement of wellbeing and environmental satisfaction follows. Finally, office design recommendations are briefly outlined. After the research is discussed, limitations and recommendations for future directions are highlighted.

### 10.1 The relationship between wellbeing and office design

An examination of the relationship between wellbeing and office design was the primary aim of this research. Initially, a literature review was conducted to establish existing knowledge. The literature review outlined in Chapters 2 and 3 indicated aspects of the office environment that have been linked with occupant wellbeing; however, several methodological limitations of the literature were identified. It was noted that comparisons are difficult between studies due to the variety of wellbeing outcomes measured and differences in office environments studied. There has been an emphasis on cross-sectional between-subjects research methods, generally post-occupancy evaluation studies, and there are fewer experimental or field research studies conducted using longitudinal within-subjects designs. Furthermore, few studies control for known wellbeing predictors when investigating the relationship between office satisfaction and wellbeing. The research in this thesis addressed some of these limitations by including predictors of wellbeing and

using longitudinal methods. Qualitative data was used to gain a more in-depth view of how the office environment affects occupants' wellbeing.

Study 1 used a cross-sectional online questionnaire design and measured environmental satisfaction, wellbeing outcomes, and wellbeing predictors. In Chapters 4 and 5, both multiple regression and structural equation modelling (SEM) analyses of Study 1 data showed that the relationship between environmental satisfaction and wellbeing outcomes existed when other wellbeing predictors were included. Studies 2 and 3 used within-subjects office design intervention studies that compared employee outcomes before and after changes had been made to the physical environment. While there were some reductions in psychological wellbeing after a satisfactory office redesign in Study 2, there were some positive outcomes from a more targeted intervention in Study 3. Qualitative data revealed a number of office features that employees felt had a positive and/or negative impact on their wellbeing.

#### 10.1.1 Literature review

A literature review was discussed in two chapters. In Chapter 2, the literature was categorised by office features. The review found that office environment factors associated with poorer wellbeing are open-plan offices, unsatisfactory ambient conditions, lack of privacy and noise dissatisfaction, and increased density. More positive wellbeing outcomes are associated with private offices, presence of environmental control, biophilia (e.g. plants in the office), and windows and views. Some office design features or ways of working, such as sit-stand desks and activity-based working (ABW), require further research to determine their relationship with wellbeing.

In Chapter 3, the literature was grouped by wellbeing outcomes. The review found that features of office design, and satisfaction with the office, may impact occupants' comfort, job satisfaction, physical health, and mental wellbeing. Some associations between the office environment and negative occupant wellbeing were found, such as increased sickness in open-plan offices and negative moods associated with adverse IEQ conditions. Associations between positive wellbeing outcomes and the office environment were also found, such as the link between increased environmental satisfaction and job satisfaction. Measurement of productivity in office workers is difficult; however, the evidence suggests that productivity may be affected by satisfaction with the office environment, and noise is an important issue to consider. Collaboration was included as a wellbeing outcome, as it may be an indicator of social wellbeing and/or productivity. More research is needed to determine how best to facilitate collaboration and focused work in open-plan offices.

### 10.1.2 Inclusion of other wellbeing predictors

In Chapter 4, regression analyses of Study 1 data were used to test the relationship between environmental satisfaction and wellbeing while allowing for the effects of other wellbeing predictors (occupation, healthy lifestyle, optimism, job control/support, noise at work, job demands).

Environmental satisfaction predicted higher positive wellbeing outcomes and lower negative wellbeing outcomes when controlling for other wellbeing predictors. This demonstrated that the effect of environmental satisfaction appears to be separate from the impact of the psychosocial work environment and individual factors. Following on from this, models of the relationship between environmental satisfaction and wellbeing were tested using SEM in Chapter 5.

Environmental satisfaction predicted greater levels of positive wellbeing, and lower levels of negative wellbeing, in a model that included work-related wellbeing predictors (job demands and job control/support). Environmental satisfaction was related to occupant wellbeing both directly and indirectly via job demands and job control/support. The regression and SEM analyses indicated that wellbeing is linked with environmental satisfaction, and this association cannot be attributed entirely to psychosocial and individual factors. Therefore, it is important to consider both the design of the office, and also interventions targeted at improving colleague relationships and reducing job demands, to provide an environment that supports occupant wellbeing.

### 10.1.3 Changes in wellbeing after office design interventions

#### *Study 2*

In Study 2 (Chapters 7 and 8), a field study examining employee wellbeing before and after an office redesign (one month and nine months post-redesign), aspects of psychological wellbeing decreased after an office design that resulted in increased environmental satisfaction. This result contrasts with other office redesign/refurbishment studies that have found improved wellbeing outcomes with increased environmental satisfaction (Agha-Hosseini et al., 2013; Hongisto et al., 2016). The company in the study was undergoing expansion, and other changes which occurred at the same time as the office redesign may have affected the occupants' wellbeing negatively. Change management, user involvement, and open communication are considered important during the office design process (Davis, Leach, & Clegg, 2011; Vischer, 2005) and may be partly responsible for better outcomes in office design/refurbishment studies (Hongisto et al., 2016, Smollan & Morrison, 2019). While the participants in Study 2 were consulted before the office redesign, there were no formal change management procedures in place, and the alterations to staffing and management at the same time could have been unsettling. A possible alternative explanation for the lack of increased wellbeing after the redesign is that the change in design was not sufficiently different to have a major impact on wellbeing. The results from Study 2 suggest it is important to consider more than just the physical environment in designing offices to support wellbeing, and psychosocial and work-related factors should also be addressed.

#### *Study 3*

In Study 2, several changes were made to the office environment. Due to the number of changes, it was not possible to ascertain the individual effect of the office design features. A single intervention was tested in Study 3 (Chapter 9) to assess employee outcomes in a more controlled experiment and target a specific open-plan office problem. This intervention used a two week randomised crossover design, whereby participants had access to work booths for one week of the two-week study (Work Booth Condition) but not the other (Non-work Booth Condition). Participants completed a daily questionnaire during the study period and a final user experience questionnaire at the end of the study.

In Study 3, within-individual comparisons of average weekly ratings in the Work Booth Condition vs the Non-work Booth Condition showed no differences in workload, productivity, environmental satisfaction, and wellbeing. While there were no differences in weekly averages, there were some significant changes when comparing specific periods of the day when participants worked at booths

vs desks. In the periods of the day that participants used work booths, there were significantly lower levels of distraction and differences in retrospective ratings of mood, as compared to periods of the day when they worked at their usual desks. The lack of difference in weekly ratings could have been due to the fact that participants worked in different areas, as well as the booths, during the Work Booth Condition week. The work booths may also have had less impact, as participants already had other quiet areas that they could use, such as unoccupied meeting rooms and pods. In addition, the effectiveness of the intervention may have been affected by distraction at the work booths, caused by the location of the booths and interruptions from colleagues.

Some significant differences were found within individuals' retrospective rating of moods when working at the booths vs their usual desks/workstations. Participants rated mood states when working in booths as less stressed, irritated/annoyed, and anxious; and more relaxed and calm. Some negative mood changes linked with the booths were feeling less energetic and more isolated/lonely. The differences reported in mood states suggest that the booths are useful for concentrated work, but this should be balanced with people's need for social interaction. Therefore, optimal usage of work booths for wellbeing is likely to be for shorter periods of focused work rather than all day. Possibly, work booths may offer potential as a way for employees to self-manage mood, e.g. by using the booths for periods to reduce stress.

The final user experience questionnaire indicated that the participants were satisfied with the experience of working in the booths. Comments from the daily questionnaires revealed that participants generally found the booths to be useful places to do concentrated work. Other comments indicated that placement of the booths was important, and training employees in use of the booths and office acoustic etiquette may be required.

#### **10.1.4 Thematic analysis: How occupants felt the office environment affected their wellbeing**

In Study 2, interviews and open-ended questionnaire items were used to explore how open-plan office occupants felt the physical environment affected their wellbeing, productivity, and teamwork. Thematic analysis of the qualitative data revealed several themes (described in Chapter 8). Themes related to the impact of office design on wellbeing were physical activity/ABW, comfort, visual appearance/windows and views, noise and distractions, and social interaction/collaboration. Concerning the impact of the office environment on productivity, the main theme to emerge was noise and distractions. Lesser mentioned themes were collaboration, comfort, and specific job

needs. The two themes discussed concerning teamwork were hubs/proximity and accessibility to colleagues, and meeting areas/collaborative tools.

A large proportion of the participants commented that physical activity has a positive impact on their wellbeing. Most of the physical activity comments were about the provision of sit-stand desks in the office redesign, and some were about ABW. Physical activity was something that occupants felt improved their physical health and was also beneficial for their mental health. Sedentary working was reported by some to affect their wellbeing negatively.

From a psychological perspective, giving occupants the control to be able to choose where to work (ABW), and which posture to work in (sit-stand desks), may be beneficial for wellbeing. Control is important in wellbeing theories, e.g. the demand-control model (Karasek, 1979; Karasek & Theorell, 1990), although generally, it is conceptualised as the job control an employee has. It is believed that increased environmental control should lead to greater productivity (Vischer, 2005), and there is some evidence to support this theory (Knight & Haslam, 2010). Environmental control has also been linked with environmental and job satisfaction (Y. S. Lee & Brand, 2005). Sit-stand desks have been associated with positive wellbeing outcomes (e.g., Chambers et al., 2019; Edwardson et al., 2018), but some reviews have highlighted the evidence is mixed or insufficient and more research is required (MacEwen et al., 2015; Tew et al., 2015). ABW is a new and promising area, and initial evidence suggests there may be wellbeing benefits to adopting this way of working (Engelen et al., 2018; Rolfö et al., 2018), although negative effects have also been reported, such as issues with concentration and privacy (Engelen et al., 2018). In addition, ABW offices may improve productivity by allowing occupants to choose the most effective place to work (Haapakangas, Hallman, et al., 2018). The mechanism behind improved wellbeing and physical activity may consist of a combination of factors, including impacts on physical health and psychological factors, such as increased environmental control and variety. Increasing physical activity by using ABW design and practices, including the use of sit-stand desks, appears to be a likely intervention to improve occupant wellbeing; however, more research is needed to fully understand the impacts and how to implement these strategies successfully.

A major issue in open-plan offices is the problem of noise and distractions. Related to this issue is a lack of privacy and environmental control allowed by the open environment. Occupants are unable to control their environment as they could in a private office by closing the door. They are bombarded by noise and visual stimuli and cannot limit their accessibility to colleagues. Open-plan

offices are environments where colleagues need to collaborate and conduct individual focused work in the same space. These activities do not work well together, as discussions between colleagues can be noisy and distracting to others who are trying to concentrate on individual work. In Chapter 3, the detrimental effect of noise on cognitive function was discussed. The qualitative data in Study 2, described in Chapter 8, revealed that participants felt noise and distractions negatively affected both their wellbeing and productivity. Few studies in the office design literature place emphasis on qualitative data, and in this study, the comments gathered were invaluable to gaining detailed descriptions of the problems experienced by participants, and an understanding of how participants are affected by noise and distractions. The qualitative data revealed that participants were not only distracted by noise, but also by other distractions, including visual distractions (e.g., colleagues' movements in the office, busy pathways by their desks).

In Study 2, participants used a number of coping strategies to deal with noise and distractions, for example, working away from the desk, home working, and using headphones. Some participants were unable to work away from the desk or at home, due to issues such as a reliance on workstation computer software. Several measures can be taken to reduce the negative effects of noise and distractions in an open-plan area, including provision of quiet areas (Haapakangas, Hongisto, et al., 2018), increased informal meeting areas so that employees may take noisier activities away from the workstations (Hua et al., 2011), acoustic absorption and isolation measures (Hua et al., 2011; Seddigh, Berntson, et al., 2015), and improvement of acoustic office etiquette. Participants in Study 2 frequently voiced the opinion that they were more productive when working away from the desk or working from home. Companies may want to consider possible wellbeing and productivity benefits from allowing employees some flexibility in choosing where to work and providing suitable areas for work requiring concentration.

While the topic of comfort and ambient conditions is popular in the literature, it is notable that in Study 2, occupants mentioned comfort in reference to other factors in addition to ambient conditions. Comfort was mentioned in regard to the furniture and the ergonomics of the workstation. Participants indicated that being comfortable affected their wellbeing positively, while being uncomfortable had a negative influence on their wellbeing. Sit-stand desks had a positive impact as they allowed employees to change posture, but standing may have contributed to reports of discomfort from reduced distance to the monitor. Comfort of furniture and ergonomics are less represented in the research literature and should not be neglected when considering occupant wellbeing.



The qualitative data indicated the positive impacts of visual aesthetics and windows/views on occupant wellbeing. This supports the idea that seemingly small things may be uplifting (Clements-Croome, 2018a), and furthermore, highlights that offices may be salutogenic. Open-plan offices could have an advantage over private offices in regard to aesthetics and windows, due to the open environment and potential for natural light and a feeling of space. The results of the qualitative data are supported by a literature review that found views, plants, and natural light had positive relationships with psychological wellbeing (Colenberg, Jylhä, & Arkesteijn, 2021).

Office design features that enabled social interaction and collaboration were considered by some Study 2 participants to affect wellbeing positively. Office design features affecting collaboration were also discussed by participants in regard to the impact of the office on productivity and teamwork. Some office design features mentioned in relation to collaboration were hub layouts, accessibility to colleagues in the open environment, and meeting areas. When considering office design for wellbeing and productivity, the qualitative data in Study 2 suggests that collaborative spaces and accessibility to colleagues are important, although employees' ability to do focused work needs to be protected (e.g. by providing separate quiet areas).

## 10.2 Measurement of wellbeing and environmental satisfaction

In the literature review described in Chapters 2 and 3, it was observed that comparisons between studies are difficult due to the multitude of measures used, both in assessing wellbeing and environmental satisfaction. Some surveys have been used widely; however, these typically attract a charge. Academic researchers are the primary developers and users of post-occupancy surveys, and it could be advantageous for industry to become more involved in the development and use of post-occupancy evaluation (Li et al., 2018). The collaboration provided by the current PhD research allowed an ideal opportunity for a combination of efforts between academia and industry to produce a measurement tool. The PhD researcher's industrial partner required a short questionnaire that could be used as a tool to evaluate office designs (post-occupancy), and changes in environmental satisfaction and wellbeing after an office design (pre-post measure).

Chapter 6 describes the Well Office Questionnaire (WOQ). The 40-item WOQ was developed with environmental satisfaction questions derived from the research literature and others created for the study, along with wellbeing questions from the Smith Wellbeing questionnaire (SWELL; Smith & Smith, 2017). The final questionnaire was reduced from the larger survey used in Study 1, guided by principal components analysis (PCA) and item grouping by Chapter 2 and 3 literature review themes.

A PCA of the original questionnaire's environmental satisfaction questions resulted in five components: General Satisfaction, Aesthetics, Noise and Privacy, Density of Workplace, and Windows/Natural Light. A second PCA of the work-related wellbeing outcomes in the questionnaire resulted in two components: Negative Wellbeing and Positive Wellbeing. Further studies should be conducted to test the acceptability of the questionnaire to participants and companies, and its utility in measuring occupant outcomes in office design evaluations. This questionnaire is available in Chapter 6 and is free to use.

### **10.3 Design recommendations for occupant wellbeing**

This research was conducted in collaboration with industry, and throughout this thesis, office design affecting occupant wellbeing has been discussed. One of the aims of the research was to develop design recommendations to support occupant wellbeing. A list of recommendations for industry, based on the literature review and research described in this thesis, may be found in Appendix D. Design for wellbeing should aim to minimise noise or limit the impact; increase privacy, environmental control, comfort, and visual appeal; and decrease density. Office design should allow occupants opportunities for social interaction/collaboration and physical activity. Care should be taken to use a holistic approach when implementing office design changes, considering other factors, such as change management, psychosocial factors, work demands, and training needs.

## 10.4 Limitations

Limitations of the present research are discussed below.

### 10.4.1 Study 1

Study 1 data was used in regression analyses (Chapter 4), SEM (Chapter 5), and the development of a questionnaire (Chapter 6).

#### *Cross-sectional design*

In Study 1, an online questionnaire was used, and relationships between environmental satisfaction and wellbeing were examined using multiple regression analyses and SEM. As mentioned in Chapter 2, causality cannot be inferred from examining relationships between data. This limitation was addressed by the use of longitudinal data in Studies 2 and 3.

#### *Participants*

Study 1 participants were recruited using a Qualtrics online survey panel. This method ensured fast and inexpensive recruitment of a large number of participants. While using participants from an online panel may be regarded by some as a limitation, this method of recruitment has been used in previous office design research (R. L. Morrison & Macky, 2017), and data gathered by this kind of recruitment is considered as externally valid as more traditional methods (Brandon, Long, Loraas, Mueller-Phillips, & Vansant, 2014). To ensure the appropriate participants were targeted for this study, several questions were used to filter participants (e.g. country of residence). In addition, Qualtrics used quality checks (e.g. minimum response time) to ensure that low-quality responses were discarded.

#### *SEM analyses*

With SEM analysis, it is possible that an important variable has not been included in the hypothesised model, or that the model could have been specified in a different way. Good model fit does not indicate the extent that a model is plausible, and consideration of theory is important when deciding about the acceptability of a model (Byrne, 2010). The models described in Chapter 5 did not include some variables that could affect work-related wellbeing outcomes, such as opinion of management (Newsham et al., 2009) or individual characteristics (Mark & Smith, 2008). As there were insufficient numbers of occupants in private or shared offices, it was not possible to examine whether the office type may change the relationships in the models. In addition, the Negative

Wellbeing latent construct items had unexplained variance which correlated with each other. The correlated variance may have indicated the existence of another variable not included in the model. Alternatively, the correlated error may have been a method effect owing to wellbeing items consisting of positive and negative items. The revised model included the negative items separately instead of using a latent construct, and wellbeing theory was drawn upon to specify the pathway from stress to anxiety/depression. The results of the models may not generalise to other office populations, and further studies should test the reliability of the models.

### *Questionnaire development*

In Chapter 6, development of the WOQ was described. As the aim was to develop a short questionnaire that measures both wellbeing and office satisfaction, items relating to certain aspects of wellbeing were not included. For example, wellbeing theories include other predictors of wellbeing that were not targeted in the WOQ, such as personality and coping. The wellbeing items included in the WOQ may give an indication of employee wellbeing, and additional employee wellbeing questionnaires may be used if a more in-depth examination of wellbeing is needed. The generalisability of the components discovered by PCA may be limited to the sample used, and Confirmatory Factor Analysis (CFA) was not conducted. In addition, PCA was used with the original questionnaire, and the component structure of the 40-item final questionnaire was not tested. The sample size used was relatively small for PCA, and future studies testing the questionnaire with larger sample sizes would be informative. Further research needs to be conducted to test the utility and usability of this measure.

## **10.4.2 Studies 2 and 3**

### *Participants/Setting*

The present research used two field studies (Studies 2 and 3) which consisted of a small number of participants. Both of the studies did not have sufficient power to detect smaller changes due to the participant numbers. A sample size of 199 pairs would be required to achieve a power of 80% and a significance level of 5% (two-sided) for detecting a small effect size of 0.2 between pairs (Dhand & Khatkar, 2014). To detect a moderate effect size of 0.5, a sample size of 34 pairs would be required, and 16 pairs for a large effect size of 0.8. The topic should be investigated further in studies using larger numbers of participants, and also in different offices with employees performing other job types.

Results of this kind of research may vary depending on the features of the office, participants' job needs, and other factors such as organisational and cultural differences in companies. For example, the participants in Study 2 needed to do work requiring periods of focus, and also collaboration. Some jobs may require less or more independent, focused work and collaboration. Nevertheless, findings from the two field studies presented in this thesis offer qualitative information that can be used by industry and academics to inform design for wellbeing. While some findings may be particular to the offices and participants in the field studies, it is likely that with further research of this type, more patterns will emerge that will further establish best practices in office design for wellbeing. In addition, much of the qualitative results from Studies 2 and 3 were supported by wellbeing and office design literature, lending confidence that the results may be similar in other participant groups.

The participants in Studies 2 and 3 were employees of the research partner and may have been biased towards reporting more favourable impressions of their office environment. While this potential bias is acknowledged, the qualitative data indicated that participants reported both negative and positive opinions about the office design in Study 2, and the work booths in Study 3. In addition, the participant feedback was reflective of the current office design and wellbeing literature. In Study 3, a small financial incentive was given to participants due to the greater time commitment involved. Paying participants may have introduced a bias, whereby participants may have felt compelled to react favourably to the work booths. Providing financial incentives is a common practice in research, and studies requiring more time tend to pay more (Brown et al., 2019).

### *Office design and work booths*

In Studies 2 and 3, the changes to the office environments may not have been great enough to significantly impact occupant wellbeing. As mentioned in Chapter 8, the initial office design in Study 2 was of high quality and generally considered satisfactory to occupants. The redesign resulted in significantly improved environmental satisfaction; however, increased wellbeing did not follow. It is possible that wellbeing may have been improved if the original office was less satisfactory to occupants. The comments from participants suggested that it was more likely that wellbeing had been affected by changes occurring during company expansion. In Study 3, the intervention provided was the addition of work booths as a quiet place to work for one week. The differences may not have been large between conditions, as employees had quiet places to work in both conditions. In fact, the quiet areas that employees already had available to them may have been

superior to the work booths. Employees had the use of unoccupied meeting rooms and pods, which would be quieter areas than work booths in open office areas. The latter study was a preliminary study to test the method for future research, which will be conducted with participants that do not have a variety of additional quiet areas to use. The work booths in Study 3 were three variants, with slightly different configurations. Due to the small sample size in Study 3, reactions to the different variants were not explored; however, participants did not tend to voice a preference for one variant over another but did comment on location.

## 10.5 Future directions

After conducting this research, several issues and directions for future research are apparent. As mentioned previously, use of common measurement tools, multivariate analyses, and more longitudinal and experimental research would be beneficial. With further high-quality research in this area, knowledge could be increased to allow insight into better design practices for wellbeing. Finally, this section outlines some outstanding questions in the area of wellbeing and office design research.

### 10.5.1 Use of common measurement tools

Use of common measurement methods would assist in comparison of studies' outcomes. The literature review described in Chapters 2 and 3 revealed the plethora of measures used in this area of research. This fact is unsurprising, given the complexity of defining wellbeing, and also the number of office features and ways of working that may be potential sources of investigation. Wellbeing is a term that has been used to refer to several employee outcomes, including physical health, mental wellbeing, social wellbeing, job satisfaction, productivity, and comfort. In addition, a myriad of environmental satisfaction issues have been investigated. In recent years, there has been growing interest in post-occupancy surveys, and there are some commercially available questionnaires that have been used widely (Li et al., 2018), which allows easier comparisons between studies using the same surveys. As far as this researcher is aware, there are currently no non-commercial questionnaires that measure both wellbeing and office satisfaction, and this may be partly responsible for the variety of measures that are used in studies. In Chapter 6, the development of a free to use 40-item questionnaire measuring wellbeing outcomes and environmental satisfaction was described. Use of the final questionnaire in a study was not possible given the timeframe of the PhD research; however, this questionnaire may be used in future research studies and further evaluated. Future research into the relationship between office design

and wellbeing outcomes using the same or similar measurement tools would assist in gaining an understanding of the effects.

### 10.5.2 Use of multivariate analyses and models

Multivariate analyses were conducted in Study 1 (see Chapters 4 and 5), using a sample of 215 UK office workers. Wellbeing process theory indicates several variables can impact workers' wellbeing (Mark & Smith, 2008), and larger studies should be conducted to have a sufficient sample size to control for a greater number of wellbeing predictors. As discussed previously, past research has rarely controlled for other wellbeing predictors when measuring links between environmental satisfaction and wellbeing (Herbig et al., 2016). In the regression analyses and SEM analysis of Study 1 data, environmental satisfaction was a predictor of wellbeing when controlling for other predictors, such as job demands and job control/support. It is recognised that other factors could be controlled for, such as satisfaction with management (Newsham et al., 2009). Additional research is necessary to discover whether the models tested in the current research apply to other participant samples. Further research should be conducted investigating models of the pathways by which environmental satisfaction may impact wellbeing. The literature has revealed the complexity of the area, and the typical observation of bivariate relationships only offers a limited view of the impact of the physical environment on wellbeing. Vischer (2007) has previously argued that workspace stress models should include factors from both stress research and environmental psychology, and Study 1 provides support for this position.

### 10.5.3 Longitudinal and experimental research

One of the strengths of the current PhD research was that longitudinal within-subjects designs were used to assess the impact of office design interventions in Studies 2 and 3 (Chapters 7 – 9). More research needs to be conducted in the area of office design and wellbeing, using experimental or longitudinal research methods. Much of the research in this area is cross-sectional, and therefore, does not show that altering the office environment results in wellbeing changes. Some office design intervention studies have shown positive results (Hongisto et al., 2016; Meijer et al., 2009), indicating that employee outcomes can be improved with better design practices. Occupants' wellbeing outcomes in experimental or longitudinal research, alongside detailed descriptions of the office design changes, may clarify office factors that are beneficial or detrimental. More research-based design guidelines are needed to assist in the creation of offices to support or improve occupant wellbeing. Academia and industry could work together in collaboration to address negative aspects of current modern office design and develop recommendations.

#### 10.5.4 Wellbeing design questions

There are some factors that are more established in the office design literature, such as the positive impact of natural light and the negative effects of unsatisfactory ambient conditions. As mentioned in the literature review, there are some features of the office that we know relatively little about regarding the impact on wellbeing, such as the effect of comfort of furniture. In addition to some less researched office design features, there are modern office design issues that require more research. This research was focused on open-plan offices, and there are several design considerations that exist in this layout. A primary issue in open-plan offices is the problem of working in a noisy and distracting environment. While the results from Study 2 suggested that employees found social interaction and collaboration important for wellbeing, these activities in an open-plan office can result in occupants feeling stressed or annoyed. Overheard conversations when occupants are trying to focus can be viewed as noisy and distracting. Therefore, it is essential to consider how to design open-plan offices in ways that both collaboration and focused work may be supported. In addition, there are psychological factors that should be considered in future office design research, such as privacy and environmental control. Open-plan offices reduce opportunities for privacy and environmental control; however, better design and the use of ABW may circumvent these problems. In conclusion, there are some aspects of the influence of office design on wellbeing that require further research, and there are problems in modern office design that need to be solved. With additional studies, gaps in knowledge may be addressed, and translated into practical design recommendations and better offices for occupants.



## 10.6 Conclusion

The research conducted in this PhD has shown that the link between environmental satisfaction and wellbeing exists when the effects of other wellbeing predictors are controlled. A literature review and qualitative data from Study 2 revealed there are a number of office design features that affect employees' wellbeing positively and negatively. Therefore, it is worth considering office design as a tool to support, or improve, employee wellbeing. Sources of dissatisfaction can be addressed by the use of better design practices. In Studies 2 and 3, some issues with the implementation of office design changes were discovered, such as change management, training employees in the use of new furniture/areas, and educating employees about office etiquette (e.g. acoustic etiquette). Further research should be conducted to explore design solutions to improve occupant wellbeing in modern office environments. While the office environment is important for employee wellbeing, psychosocial and work-related factors, such as job demands, job control, and colleague relationships, also have an effect. Office design should be considered as part of a holistic approach to employee wellbeing, which should also include initiatives aimed at addressing psychosocial factors and work-related factors.

## 10.7 Industrial partner summary

- Environmental satisfaction affects wellbeing even when the effects of other wellbeing predictors are included.
- Offices can be designed to support occupant wellbeing and it is worth investing in the physical environment.
- Some implementation issues in office design for wellbeing are change management, training in furniture/office use, and education in office etiquette.
- Office design for wellbeing should be considered part of a holistic intervention and companies should also address psychosocial factors and work-related factors (e.g. work demands).

## 11 References

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## 12 Appendices

## 12.1 Appendix A. Chapter 5 supplementary material

### 12.1.1 Correlation matrices

Table 12.1. *SWELL Positive Work-related Wellbeing Pearson's Correlation Matrix (N = 215, medians imputed)*

	<b>1</b>	<b>2</b>	<b>3</b>
<b>1. SW11. Do you feel you have control over your job and support from fellow workers? (predictor)</b>	-		
<b>2. SW13. Are you satisfied with your job? (outcome)</b>	.57	-	
<b>3. SW17. How efficiently do you carry out your work? (outcome)</b>	.27	.43	-
<b>4. SW19. Are you happy at work? (outcome)</b>	.51	.78	.45

Table 12.2. *SWELL Negative Work-related Wellbeing Pearson's Correlation Matrix (N = 215, medians imputed)*

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
<b>1. SW8. Are you exposed to noise at work? (predictor)</b>	-					
<b>2. SW10. How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)? (predictor)</b>	.22	-				
<b>3. SW12. How much stress do you have at work? (outcome)</b>	.27	.69	-			
<b>4. SW14. How physically or mentally tired do you get at work? (outcome)</b>	.18	.60	.61	-		
<b>5. SW18. Do you find your job interferes with your life outside work or your life outside of work interferes with your job? (outcome)</b>	.26	.35	.46	.40	-	
<b>6. SW20. Are you anxious or depressed because of work? (outcome)</b>	.26	.45	.68	.42	.57	-
<b>7. SW21. Approximately how many days sick leave have you had in the last 12 months? (outcome)</b>	.09	.05	.12	.18	.14	.16

## 12.2 Appendix B. Chapter 6 supplementary material

### 12.2.1 Study 1 questionnaire

Table 12.3. *Study 1 Questionnaire*

Item		Response options
<b>Demographics/screening</b>		
<b>Screening</b>	How old are you?	18 or younger, 19 - 29, 30 - 39, 40 - 49, 50 - 59, 60 - 69, 70 or older
<b>Screening</b>	In which country do you currently reside?	dropdown menu
<b>Screening</b>	Please indicate the amount of time you work at your job on average per week.	35 hours a week or more, less than 35 hours a week, I am not currently employed
<b>Screening</b>	Please select the type of workplace that you work at.	office; retail; hospital, healthcare; factory; restaurant, catering; school, college, education; other
<b>Screening</b>	How long have you worked at this office?	less than 1 month, 1 month to 1 year, 2 years to 5 years, 6 years to 10 years, over 10 years
<b>D2</b>	What is your gender?	female, male, other (describe)
<b>D3</b>	Please select the description that best matches your occupation. If you have more than one, please select the occupation that you do in the office that you spend the most hours in per week, on average.	secretary, clerk, trainee, student; technician, controller, academic, consultant; project leader, senior consultant; director, head of department, manager; other (describe) Source: Pejtersen, Allermann, Kristensen, and Poulsen (2006)
<b>Office type/way of working</b>		
<b>The following questions are about the office that you currently work in. If you work in more than one office, please answer these questions about the office that you work the most hours at per week, on average.</b>		
<b>OT1</b>	How many people work in your office (including you)?	1 person (private office), 2 people, 3 - 6 people, 7 - 28 people, 29 - 50 people, over 50 people Source: modified from Pejtersen et al. (2006)
<b>OT2</b>	Select the option that best describes your desk.	fixed desk - the desk that has been assigned to you is your personal desk, and nobody else uses it flexible desk or hot desk - you do not have a personal desk assigned to you, and use flexible desk space shared by other people in your office
<b>OT3</b>	Please select the items that you have at your usual workstation that are adjustable.	desk height, chair, computer monitor, lighting, temperature, privacy screens (partitions)

Table 12.3 (continued)

Item		Response options
OT4	Please indicate the amount of time you work in your office on average per week.	less than 8 hours, 8 to 15 hours, 16 to 23 hours, 24 to 31 hours, 32 to 40 hours, more than 40 hours
OT5	Please indicate the amount of time you work from home (home working) on average per week.	none, I do not do any home working; 1 to 8 hours; 9 to 15 hours; 16 to 23 hours; 24 to 31 hours; 32 to 40 hours; more than 40 hours
OT6	Please indicate the amount of time you work away from the office (excluding home working) on average per week. For example, you may work on the train or at a client's workplace.	none, 1 to 8 hours, 9 to 15 hours, 16 to 23 hours, 24 to 31 hours, 32 to 40 hours, more than 40 hours
OT7	During the hours that you work at your office, what percentage of time on average would you spend at your desk?	slider
OT8	During the hours that you work at your office, what percentage of time on average would you spend on the following activities? (should total 100)	computer work, formal meetings, informal discussions with colleagues, telephone conversations, breaks, other
<b>SWELL (21 items; Smith &amp; Smith, 2017)</b>		1 to 10
<b>Wellbeing at work</b>		
SW1	A healthy lifestyle involves taking exercise, eating a balanced diet, not smoking, not drinking excessive amounts of alcohol, and not being overweight. To what extent do you have a healthy lifestyle?	1 (not at all) - 10 (very much so)
SW2	People often describe themselves as being positive ("seeing" the glass as half full) or negative ("seeing the glass as half empty"). How would you describe yourself?	1 (very negative) - 10 (very positive)
<b>Thinking about the last 6 months:</b>		
SW3	How satisfied are you with life in general?	1 (not at all) - 10 (very much so)
SW4	How much stress have you had in your life in general? <i>reverse coded</i>	1 (very little) - 10 (a great deal)
SW5	Would you say you are generally happy?	1 (not at all) - 10 (very much so)
SW6	Would you say that you generally feel anxious or depressed? <i>reverse coded</i>	1 (not at all) - 10 (very much so)
SW7	Do you suffer from musculo-skeletal disorders (e.g. arthritis; back pain; sciatica; repetitive strain injury)? <i>reverse coded</i>	1 (not at all) - 10 (very much so)
SW8	Are you exposed to noise at work? <i>reverse coded</i>	1 (not at all) - 10 (very much so)
SW9	Do you work shifts or work at night? <i>bivariate</i>	yes, no
SW10	How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)? <i>reverse coded</i>	1 (not at all demanding) - 10 (very demanding)
SW11	Do you feel you have control over your job and support from fellow workers?	1 (not at all) - 10 (very much so)
SW12	How much stress do you have at work? <i>reverse coded</i>	1 (very little) - 10 (a great deal)
SW13	Are you satisfied with your job?	1 (not at all) - 10 (very much so)
SW14	How physically or mentally tired do you get at work? <i>reverse coded</i>	1 (not at all tired) - 10 (very tired)

Table 12.3 (continued)

Item		Response options
SW15	Have you had an illness (either physical or mental) caused or made worse by work? <i>bivariate</i>	yes, no
SW16	Do you ever come to work when you are feeling ill and knowing you can't do your job as well as you would like to? <i>bivariate</i>	yes, no
SW17	How efficiently do you carry out your work?	1 (not very efficiently) - 10 (very efficiently)
SW18	Do you find your job interferes with your life outside work or your life outside of work interferes with your job? <i>reverse coded</i>	1 (never) - 10 (very often)
SW19	Are you happy at work?	1 (never) - 10 (very often)
SW20	Are you anxious or depressed because of work? <i>reverse coded</i>	1 (never) - 10 (very often)
SW21	Approximately how many days sick leave have you had in the last 12 months?	textbox
<b>General Health (1 item)</b>		
<b>Source: RAND 36-Item Short Form Survey Instrument (SF-36)</b>		
H1	In general, would you say your health is:	1 - excellent, 2 - very good, 3 - good, 4 - fair, 5 - poor
<b>Psychological wellbeing (5 items)</b>		
<b>Source: World Health Organization (1998)</b>		
Please indicate for each of the five statements which is closest to how you have been feeling over the last two weeks.		
WHO5-1	Over the last two weeks: I have felt cheerful and in good spirits	5 - all of the time, 4 - most of the time, 3 - more than half of the time, 2 - less than half of the time, 1 - some of the time, 0 - at no time
WHO5-2	Over the last two weeks: I have felt calm and relaxed	
WHO5-3	Over the last two weeks: I have felt active and vigorous	
WHO5-4	Over the last two weeks: I woke up feeling fresh and rested	
WHO5-5	Over the last two weeks: My daily life has been filled with things that interest me	
<b>Sick Building Syndrome (SBS) symptoms (5 items)</b>		
<b>Source: modified from the Glostrup Questionnaire (Brauer, 2005; see also Pejtersen et al., 2006)</b>		
Please select how often you have experienced the following symptoms in the past four weeks, while working at your office. If you work in more than one office, please answer these questions about the office that you work the most hours at per week, on average.		
SBS-1	eye irritation	1 - always, 2 - most of the time, 3 - about half the time, 4 - sometimes, 5 - never
SBS-2	runny or blocked nose	
SBS-3	irritation of the throat	
SBS-4	fatigue	
SBS-5	headache	

Table 12.3 (continued)

Item	Response options	
<b>Musculoskeletal disorder (MSD) symptoms (5 items)</b>		
<b>Source: modified version of the Nordic Musculoskeletal Questionnaire (NMQ; Kuorinka et al., 1987)</b>		
While working at your office, have you at any time during the past 4 weeks had trouble (such as ache, pain, discomfort, numbness) in your:		
<b>MSD-1</b>	neck	No, Yes. If yes was selected - MSD1A. How severe were the symptoms in your neck? (1 - mild, 2 - moderate, 3 - severe, 4 - very severe)
<b>MSD-2</b>	shoulders	No, Yes. If yes was selected - MSD2A. How severe were the symptoms in your shoulders? (1 - mild, 2 - moderate, 3 - severe, 4 - very severe)
<b>MSD-3</b>	elbows	No, Yes. If yes was selected - MSD3A. How severe were the symptoms in your elbows? (1 - mild, 2 - moderate, 3 - severe, 4 - very severe)
<b>MSD-4</b>	wrists/hands	No, Yes. If yes was selected - MSD4A. How severe were the symptoms in your wrists/hands? (1 - mild, 2 - moderate, 3 - severe, 4 - very severe)
<b>MSD-5</b>	back	No, Yes. If yes was selected - MSD5A. How severe were the symptoms in your back? (1 - mild, 2 - moderate, 3 - severe, 4 - very severe)
<b>Belief of a positive effect of workplace on wellbeing (4 items)</b>		
<b>Source: modified from a single wellbeing belief question in Agha-Hosseini, El-Jouzi, Elmualim, Ellis, and Williams (2013)</b>		
Please indicate your level of agreement with the following. My current workplace has a positive effect on:		
<b>BEW1</b>	my productivity	1 – strongly disagree, 2 – disagree, 3 – somewhat disagree, 4 – neither agree nor disagree, 5 – somewhat agree, 6 – agree, 7 – strongly agree
<b>BEW2</b>	my wellbeing (the state of being comfortable, healthy, or happy)	
<b>BEW3</b>	my mood	
<b>BEW4</b>	my health	
<b>Environmental satisfaction (29 items)</b>		
<b>Source: several items from Veitch et al. (2007) originally modified from Stokols &amp; Scharf (1990); other questions from literature review and discussion with industrial partner</b>		
The following questions are about the office that you currently work in. If you work in more than one office, please answer these questions about the office that you work the most hours at per week, on average.		
What is your degree of satisfaction with the following:		
<b>ES1</b>	Your work area (workstation) overall	1 – very unsatisfactory, 2 – unsatisfactory, 3 – somewhat unsatisfactory, 4 - neutral, 5 – somewhat satisfactory, 6 - satisfactory, 7 – very satisfactory
<b>ES2</b>	Your workplace (the office that you work in) overall	
<b>ES3</b>	Areas in your workplace for meetings.	
<b>ES4</b>	Areas in your workplace for doing work that requires focus and concentration.	
<b>ES5</b>	Areas in your workplace for relaxing and taking breaks.	
<b>ES6</b>	Your ability to adjust or control your work area to suit your needs and preferences.	
<b>ES7</b>	Visual appearance of your workplace. <sup>a</sup>	
<b>ES8</b>	Overall air quality in your work area. <sup>b</sup>	
<b>ES9</b>	Temperature in your work area. <sup>b</sup>	
<b>ES10</b>	Amount of noise in your work area. <sup>a</sup>	

<sup>a</sup> Item modified from Veitch et al. (2007).<sup>b</sup> Item from Veitch et al. (2007).

Table 12.3 (continued)

Item	Response options
ES11	Amount of noise from other people's conversations while you are at your work area. <sup>a</sup>
ES12	Your ability to have a private conversation in your workplace. <sup>a</sup>
ES13	Visual privacy in your work area. <sup>a</sup>
ES14	Frequency of distractions from other people. <sup>b</sup>
ES15	The amount of storage in your work area.
ES16	Cleanliness and tidiness of your workplace.
ES17	Comfort of furniture in your workplace.
ES18	Quality and visual appearance of furniture in your workplace.
ES19	Quality of lighting in your work area. <sup>b</sup>
ES20	Natural light (sunlight) in your workplace.
ES21	Outside view from where you sit. <sup>a</sup>
ES22	Amount of plants in your workplace.
ES23	Wall decoration including paint colour and art.
ES24	Ability to choose where to work in your workplace (options to work away from the desk).
ES25	Ability to move around at your workplace.
ES26	Size of your desk.
ES27	Distance between you and other people you work with. <sup>b</sup>
ES28	Amount of space in your workplace. <sup>a</sup>
ES29	Your ability to personalise your work area. <sup>a</sup>

<sup>a</sup> Item modified from Veitch et al. (2007).

<sup>b</sup> Item from Veitch et al. (2007).

### 12.2.2 Pearson's correlations between positive and negative wellbeing outcomes and environmental satisfaction items

Table 12.4. *Pearson's Correlations between Positive and Negative Wellbeing Outcomes and Environmental Satisfaction Items used in the Initial Questionnaire*

	Positive	Negative
ES1. Your work area (workstation) overall	.41	-.25
ES2. Your workplace (the office that you work in) overall	.59	-.25
ES3. Areas in your workplace for meetings.	.50	-.26
ES4. Areas in your workplace for doing work that requires focus and concentration.	.53	-.33
ES5. Areas in your workplace for relaxing and taking breaks.	.43	-.19
ES6. Your ability to adjust or control your work area to suit your needs and preferences.	.50	-.31
ES7. Visual appearance of your workplace.	.49	-.26
ES8. Overall air quality in your work area.	.40	-.18
ES9. Temperature in your work area.	.39	-.16
ES10. Amount of noise in your work area.	.43	-.22
ES11. Amount of noise from other people's conversations while you are at your work area.	.37	-.21
ES12. Your ability to have a private conversation in your workplace.	.51	-.29
ES13. Visual privacy in your work area.	.42	-.19
ES14. Frequency of distractions from other people.	.42	-.27
ES15. The amount of storage in your work area.	.42	-.25
ES16. Cleanliness and tidiness of your workplace.	.44	-.17
ES17. Comfort of furniture in your workplace.	.41	-.23
ES18. Quality and visual appearance of furniture in your workplace.	.47	-.29
ES19. Quality of lighting in your work area.	.34	-.15
ES20. Natural light (sunlight) in your workplace.	.36	-.17
ES21. Outside view from where you sit.	.32	-.07
ES22. Amount of plants in your workplace.	.29	-.12
ES23. Wall decoration including paint colour and art.	.39	-.21
ES24. Ability to choose where to work in your workplace (options to work away from the desk).	.39	-.17
ES25. Ability to move around at your workplace.	.41	-.23
ES26. Size of your desk.	.34	-.25
ES27. Distance between you and other people you work with.	.44	-.35
ES28. Amount of space in your workplace.	.46	-.30
ES29. Your ability to personalise your work area.	.37	-.22



## 12.3 Appendix C. Chapter 7 supplementary material

### 12.3.1 Study 2 questionnaire

Table 12.5. *Study 2 Questionnaire*

Item	Response options
Demographics (3 questions) Please indicate your department. How old are you?  What is your sex?	text box 18 – 29, 30 – 39, 40 - 49, 50 - 59, 60 – 69, 70+ female, male
The following questions are about your current workplace.	
Environmental satisfaction (11 questions) Source: some items from Veitch et al. (2007) What is your degree of satisfaction with the ... <ul style="list-style-type: none"> <li>▪ overall air quality in your work area</li> <li>▪ amount of noise from other people’s conversations while you are at your workstation</li> <li>▪ quality of lighting in your work area</li> </ul> What is your degree of satisfaction with the following: <ul style="list-style-type: none"> <li>▪ your workstation design overall</li> <li>▪ your workplace design overall</li> <li>▪ areas in your workplace for meetings</li> <li>▪ areas in your workplace for doing work that requires focus and concentration</li> <li>▪ comfort of your workplace</li> <li>▪ areas in your workplace for relaxing and taking breaks</li> <li>▪ your ability to adjust or control your work area to suit your needs and preferences</li> <li>▪ visual appearance of your workplace</li> </ul>	1 – very unsatisfactory, 2 – unsatisfactory, 3 – somewhat satisfactory, 4 - neutral, 5 – somewhat satisfactory, 6 - satisfactory, 7 – very satisfactory  1 – very unsatisfactory, 2 – unsatisfactory, 3 – somewhat satisfactory, 4 - neutral, 5 – somewhat satisfactory, 6 - satisfactory, 7 – very satisfactory
Wellbeing (9 questions) Source: from SWELL (Smith & Smith, 2017)  How demanding do you find your job (e.g. do you have constant pressure, have to work fast, have to put in great effort)?  Do you feel you have control over your job and support from fellow workers? How much stress do you have at work? Are you satisfied with your job?  How physically or mentally tired do you get at work?  How efficiently do you carry out your work?  Do you find your job interferes with your life outside work or your life outside of work interferes with your job? Are you happy at work? Are you anxious or depressed because of work?	0 (not at all demanding) - 10 (very demanding)  0 (not at all) - 10 (very much so) 0 (very little) - 10 (a great deal) 0 (not at all) - 10 (very much so)  0 (not at all tired) - 10 (very tired)  0 (not very efficiently) - 10 (very efficiently)  0 (never) - 10 (very often)  0 (never) - 10 (very often) 0 (never) - 10 (very often)

Table 12.5. (continued)

Item	Response options
<p>Belief of a positive effect of workplace (5 questions)  Source: modified from Agha-Hosseini et al. (2013)  Please indicate your level of agreement with the following. My current workplace has a positive effect on:</p> <ul style="list-style-type: none"> <li>▪ my productivity</li> <li>▪ my wellbeing (the state of being comfortable, healthy, or happy)</li> <li>▪ teamwork</li> <li>▪ my mood</li> <li>▪ my health</li> </ul>	<p>1 – strongly disagree, 2 – disagree, 3 – somewhat disagree, 4 – neither agree nor disagree, 5 – somewhat agree, 6 – agree, 7 – strongly agree</p>
<p>Past 2 weeks: wellbeing, productivity and teamwork (8 questions)  Thinking about the last 2 weeks, please rate the following:</p> <ul style="list-style-type: none"> <li>▪ your productivity at work</li> <li>▪ your mood at work</li> <li>▪ your comfort level at work</li> <li>▪ your wellbeing (the state of being comfortable, healthy, or happy) at work</li> <li>▪ teamwork at your workplace</li> <li>▪ your ability to concentrate and do work that requires focus at your workplace</li> <li>▪ collaboration with others at work</li> <li>▪ your health at work</li> </ul>	<p>1- extremely bad, 2 - moderately bad, 3 - slightly bad, 4 - neither good nor bad, 5 - slightly good, 6 - moderately good, 7 - extremely good</p>
<p>Open ended questions (15 questions baseline and T1, 19 questions T2)</p> <p>The following questions are about your current workplace.</p> <p>How do you like the design of your current workplace?</p> <p>Has anything changed in your workplace since the previous time that you completed this questionnaire? (<i>y/n; additional T2 question</i>)</p> <p>How has your workplace changed? (<i>additional T2 question</i>)</p> <p>Describe any changes you would like to make to your workplace.</p> <p>How easy is to do your job in your current workplace?</p> <p>Has your job changed at all since the previous time that you completed this questionnaire? (<i>y/n; additional T2 question</i>)</p> <p>How has your job changed? (<i>additional T2 question</i>)</p> <p>If any, what effect does your current workplace have on your productivity?</p> <p>If any, what effect does your current workplace have on your wellbeing?</p> <p>How easy is it to adjust or control your work area to suit your needs and preferences?</p> <p>If any, what effect does your current workplace have on your health?</p> <p>If any, what effect does your current workplace have on your mood?</p> <p>How comfortable do you find your current workplace?</p> <p>How visually appealing do you find your current workplace?</p> <p>How easy is it to do work requiring concentration and focus at your current workplace?</p> <p>How is your current workplace for collaboration?</p> <p>How easy is it to interact with colleagues, clients and visitors in your current workplace?</p> <p>If any, what effect does your current workplace have on teamwork?</p> <p>If you have any further comments about wellbeing, teamwork at your workplace, or your workplace design, please add them below.</p>	<p>textbox</p>
<p>Total: 51 questions (55 questions at T2)</p>	

### 12.3.2 Interview

1. Tell me about your workplace.

(Prompt: workplace - where you work, the office that you work in, your workstation.)

1a. Has anything changed in your workplace since last time? If it has, how has it changed? (Prompt: since last time you were interviewed.) *(Additional T2 question)*

2. Tell me about the work that you do.

2a. Has your work changed at all since last time? If it has, how has it changed? (Prompt: change of job role or duties since last time you were interviewed.) *(Additional T2 question)*

3. How do you use your workstation to do your job?

4. How is the experience of working in this office for you?

5. If your workstation or workplace affects your productivity at all, in what way?

6. If your workstation or workplace affects your wellbeing at all, in what way? (Prompt: wellbeing - the state of being comfortable, healthy, or happy.)

7. How is your experience of teamwork in your department?

(Prompt: department – the department that you work in, NOT your project team.)

8. How is your experience of teamwork in your project teams?

(Prompt: project teams – the team working on a project, which consists of people from other departments, NOT just the people in your department.)

9. If your workplace affects teamwork at all, in what way?

## 12.4 Appendix D. Chapter 10 supplementary material

### 12.4.1 Design recommendations for occupant wellbeing

#### **Noise and distractions**

*Noise and distractions may adversely impact wellbeing and productivity.*

Design considerations to decrease noise, or limit impact:

- addition of sound-absorbent materials (e.g., soft furnishings, plants, screens, sound-absorbent panels)
- separate areas for focused work and collaboration
- keep collaborative areas away from quiet areas
- allow employees to work in different ways (e.g., away from the desk, home working)
- office acoustic etiquette rules/training

#### **Privacy**

*Privacy may be important for collaboration and wellbeing.*

Design considerations to improve privacy:

- partitions
- plants (screening)
- careful consideration of pathways (e.g. avoid placement of busy pathways behind employees)
- private offices
- areas for confidential work and conversations

#### **Environmental control**

*Environmental control may increase occupant wellbeing and environmental satisfaction.*

Design considerations to increase environmental control:

- adjustable furniture/ambient conditions
- input into workplace/workstation design
- more choice of where to work and how to work (e.g., ABW, sit-stand desks, home working)

#### **Comfort**

*Comfort is important for occupant wellbeing and productivity.*

Design considerations to improve comfort:

- environmental control of workstation/ambient conditions
- comfort of furniture
- ergonomic assessment

#### **Physical activity**

*Physical activity may improve occupant wellbeing.*

Design considerations to increase physical activity:

- ABW
- sit-stand desks

**Visual appearance**

*A visually appealing office may improve occupant wellbeing.*

Design considerations for aesthetics:

- plants
- open environments, natural light
- access to pleasant views
- furniture, décor

**Social interaction/collaboration**

*Social interaction and collaboration may be important for occupant wellbeing and productivity.*

Design considerations for social interaction/collaboration:

- meeting areas (formal and informal), break areas
- improve privacy

**Density**

*Research suggests that increased density (less space per occupant, more people in an open-plan office) may negatively impact wellbeing.*

Design considerations to decrease density:

- smaller open-plan offices (less occupants per enclosed office)
- increased space per occupant

**Design implementation**

*To impact occupant wellbeing positively, a holistic approach should be taken to design implementation.*

Considerations in implementing office design for wellbeing:

- job needs
- change management
- seeking occupant input into design
- other factors affecting wellbeing (e.g., psychosocial factors, job demands)
- training needs in use of new office furniture/areas and office etiquette
- ergonomic assessment

## 12.5 References (Appendices)

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