



# Lighting, Well-being and Performance at Work

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# Executive Summary

Recent years have witnessed unprecedented changes in the way people work. For most - if not all – workers the need to create a remarkable client experience has led to the intensification of work and the need to cope with continually changing work requirements and a faster pace of work. In this context, the challenge for employers and researchers is to design work environments that can best meet the needs of 21st century workers and ensure maximum levels of well-being and performance.

This report has been undertaken by the Centre for Performance at Work at City University London and reviews existing research on:

1. The impact of lighting on performance and well-being in the workplace.
2. New developments in work practices and their relevance for lighting, well-being and performance in the workplace.
3. Emerging good practice concerning well-being at work.

#### The findings from this review suggest that:

- Existing research documents good evidence of an association between lighting and work performance, mediated by employee well-being.
- Studies suggest that whilst lighting alone is unlikely to have a strong effect on performance, it is one of several factors that combine to create healthy work environments that in turn help promote employee engagement, well-being and productivity.
- There is growing evidence for a link between lighting conditions, shift-work and biological health conditions: an area likely to receive more attention from researchers in future.
- Since 2003, new standards and norms (EN-12464-1) regulate the maximum allowed luminance limits for luminaries, thus limiting some of the risks associated with poor lighting conditions and visual health for high risk worker groups (e.g., employees using VDTs and older workers).

- Worker controlled lighting and lighting solutions tailored to the individual needs of workers have considerable potential for enhancing employees' work satisfaction and enhancing retention. This may be particularly important in the case of professional workers that employers would most like to attract and retain.
- The increasing need for employers to adapt flexibly and proactively to rapidly changing market conditions may constitute an opportunity to look at how adaptable lighting schemes can assist by creating more flexible work environments that contribute to innovation and productivity.
- There is likely to be more interest in the interface between employee and customer satisfaction and well-being, and how lighting can help facilitate this.

#### Based on these findings, and recognising that there is unlikely to be a simple solution, we recommend that:

- Companies should consider the need to invest in workplace lighting as a means to develop work environments that support well-being and performance, and reduce the likelihood of employee stress, absenteeism, and industrial accidents.
- Discussion and decisions about the role of lighting on employee well-being and performance need to be central to strategic decisions about organisational performance, and therefore need to be initiated at the board-level in order to secure the commitment of the senior management team.



“24/7 working, shift-work, office work and different geographical latitudes mean that most employees work in environments where there is a need for artificial lighting for some or all of their work period”

- Companies need to adopt a holistic approach to health and well-being that identifies the needs of different employee groups and addresses them through a combination of company-wide and worker-centred initiatives.
- There is a need for more focus capturing, evaluating, and measuring the impact of lighting on employee well-being and performance, in order to build an evidence base to support workplace interventions. This is likely to require the coordinated efforts of different parts of an organisation, or cross-sector projects.

## Preface

Recent years have witnessed unprecedented changes in the way people work. Not only have these changes impacted on the way individuals experience work, they also imply a need to redesign modern workplaces to develop and sustain healthy, productive workers.

New information and communication technologies (ICTs), a growing emphasis on knowledge intensive work, and rapid increases in globalisation and workplace diversity, have all provided opportunities for companies to achieve accelerated growth and competitive market positions. But the same factors also mean that workers today have to cope with a far greater pace of change, roles that are becoming increasingly ambiguous and complex, with more emphasis on service-oriented and customer-facing work. The challenge for employers and researchers is therefore to design work environments that can best meet the needs of 21st century workers and ensure maximum levels of well-being and performance.

As experts in organisational psychology and work performance, we recognise that many important and interdependent factors can impact on well-being and performance at work. In fact a very extensive academic literature search has documented many different individual and organisational-level factors that can contribute to sustainable healthy productive work environments. Despite evidence that workplace lighting impacts on factors like worker safety, visual acuity and productivity at work, there have been surprisingly few systematic investigations of the impact of lighting on worker well-being and productivity. The limited studies which exist have been undertaken primarily by vision researchers, and as such there has been little attempt so far to link knowledge and practice from the two academic fields of management and vision research.

This report aims to address this important gap in our understanding. It is aimed at chief executives and senior corporate decision-makers, as well as members of the wider research community, who may be looking for ideas and information about the impact of lighting on workplace well-being and performance. We hope it will act as a catalyst for future cross-disciplinary research building on ideas and theories from management and vision research. Our two main objectives in this report have been to (a) consolidate findings from existing studies and evaluate evidence regarding the relationship between lighting and employee well-being and performance, and (b) explore the ways in which work is changing and identify how new developments in the lighting field might help in the design of work environments capable of enhancing organisational well-being and performance. Beginning with a description of the now classic Hawthorne studies and their impact on research in this area, the report goes on to review the evidence base in each of the following three areas:

1. The impact of lighting on performance and well-being in the workplace.
2. New developments in work practices and their relevance for lighting, well-being and performance in the workplace.
3. Emerging good practice concerning well-being at work.

## Our Approach

Our team consisted of Professor Jo Silvester and Dr Efrosyni Konstantinou and we would like to acknowledge the contribution of Kate Shaw who helped undertake these searches and collate material for this report. The Centre for Performance at Work helps organisations in the private, public and third sector achieve their optimal levels of performance and well-being (please visit: [www.city.ac.uk/performanceatwork](http://www.city.ac.uk/performanceatwork)). The Centre draws together experts in Work Psychology, Organisational Behaviour and Human Resource Management in order to conduct research and design practical solutions for today's needs.

We have undertaken extensive literature searches using academic sources including PsychInfo, library searchers and Google Scholar. Beginning with older research and moving to more recent studies we have used key words to identify relevant work and material for each of the sections. A list of search logs and key words can be found in Appendix I.

We would particularly like to thank Professor John Barbur, Director of the "Applied Vision Research Centre" and the "Colour Vision Research Laboratory" at City University London, and Dr Paul Flaxman, Centre for Performance at Work, for their comments and ideas on earlier drafts of this report.



# Lighting, Performance and Well-being at Work

## The Hawthorne Studies

In the early 1920s researchers were in broad agreement that physical conditions in the workplace such as illumination, temperature, noise and humidity had a significant impact on worker productivity. They believed that if workers were provided with optimum environmental conditions, their work rate and performance would inevitably improve. Elton Mayo – an Australian researcher from Harvard Business School – was the first researcher to test these ideas. He pioneered a series of now classic studies that examined the impact of a series of environmental factors like lighting, temperature and humidity on employee productivity by manipulating levels and recording employee output.

The Hawthorne Studies ran for more than 15 years and involved the observation, interviewing and counselling of more than 20,000 workers in factories and other workplaces of the time. The most significant finding of this research – and what is now referred to as ‘the Hawthorne Effect’ – was that regardless of the nature of experimental manipulation employed by the researchers, work performance always increased. No matter what the researchers did, whether they increased or decreased lighting or temperature or humidity, productivity always appeared to improve. The explanation for these findings was that workers were responding to the attention that researchers paid to them, rather than changes to physical conditions in the workplace. The Hawthorne Studies are of particular importance to this report for two reasons.

## Realizing the importance of employee needs

Whilst the studies failed to demonstrate a direct causal relationship between workplace conditions like lighting and worker productivity, they did emphasise the importance of managers paying attention to workers’ needs and the work environment in order to improve performance. In fact, the Hawthorne Studies gave rise to the Human Relations Movement, which still influences management research and practice today. This movement advocates a holistic approach to workplace design, emphasising the importance of a well-designed work environment for employee well-being and performance.

## From lighting and performance to lighting and well-being

The Hawthorne Studies also had an important effect upon subsequent research into lighting and workplace performance. Now cited as the classic example of ‘experimenter effect’ in virtually all management and work psychology text books, the studies probably led to a decline in research investigating the direct impact of lighting on work performance (there are certainly many fewer studies in this area than have looked at other work conditions such as job control and management style). Instead, there was a marked shift towards research looking at how lighting may influence work performance via its impact on worker well-being.

## Building an Evidence Base

In this report we review existing research on the relationships between lighting, well-being and performance, but before doing so it is worth considering how these concepts have been defined and measured by researchers:

### Work performance

Work performance can be defined as the extent to which an employee meets the requirements of their job role. The precise nature of this will vary widely depending on the type of work performed, but researchers have used productivity (e.g., the volume and/or quality of work produced by an employee during a particular time period), problem solving, team performance, relationships with work colleagues, communication style, and customer service as criteria across different types of work. Studies have also included a mix of objective performance measures (e.g., number of products created during a fixed time period) and subjective measures (e.g., managers’ or customers’ judgements and employee self-assessments) to assess performance.

### Employee well-being

Employee well-being is also a broad concept that can incorporate a range of factors from subjective feelings of work satisfaction to clinical measures of employee burn-out and stress. Research into employee well-being has used a similar mix of self-report measures, to assess well-being outcomes like work-related stress, job satisfaction, fatigue, mood, and commitment to work. However, researchers have also used biological and physical measures, such as assessment of musculoskeletal disorders and tests for chemicals associated with stress that are present in employee blood or urine samples.

In general the best research (and that most likely to avoid the problems of experimenter effect identified by the Hawthorne Studies) will normally use a mix of methods, conditions and measures to control for different effects. For example, research might compare results from field studies (where workers are observed in their own workplace) with those from experimental studies (where researchers control different variables and examine the effects). No single study can provide definitive evidence of a causal link making it necessary to build a case based on evidence derived from many studies to demonstrate and explain the impact of lighting on well-being and performance.

As the research literature concerning lighting, performance and well-being is extensive, we have divided studies into those broadly concerned with the impact of different forms of ‘Lighting’ and those concerned with different forms of ‘Work’.





# Lighting

## Natural and Artificial Forms of Lighting

Studies of lighting in the workplace have consistently shown that sunlight has positive effects on workers' subjective well-being; and that employees prefer to work near windows or in workplaces with natural lighting (Leather, Pyrgas, Beale & Lawrence, 1998; Oldham & Fried, 1987; Wang & Boubekri, 2009; Yildirim et al. 2007). However, the nature of modern working means that for many workers access to natural lighting is not always possible. 24/7 working, shift-work, office work and different geographical latitudes mean that most employees work in environments where there is a need for artificial lighting for some or all of their work period. This emphasises a need to understand how the use of artificial lighting impacts directly or indirectly on worker well-being and performance.

Lighting in the workplace may influence employee performance in several ways. It may affect eye strain and visual comfort (van Bommel & van Beld, 2004; Boyce, 2003). Lighting may also influence cognitive performance and problem solving ability by interfering with physiological factors like circadian rhythms (Juslen & Tenner, 2005). Lighting can also impact on mood and interpersonal relationships at work and therefore job satisfaction (Boyce, 2003).

## Lighting and Visual Performance

Researchers have been able to document consistent effects in relation to the impact of lighting on visual performance and health. Poor lighting can result in eye strain, fatigue and aching, which in turn is likely to lead to deterioration in performance, particularly if work relies on visual acuity such as computer-based (VDT) job roles (Parsons, 2000, Nave 1984). As this type of work is now common-place, the importance of lighting for visual health and performance at work is likely to become increasingly important.

However, relationships between lighting, well-being and performance are unlikely to be simple, and employee preference for particular types of lighting may not necessarily impact on their performance. For example, whilst employees clearly prefer indirect to direct lighting (Veitch, 2001), there is little evidence of a direct impact on health, well-being, or cognitive performance of office workers (Fostervold & Nersveen, 2008). That said, many studies have documented significant effects in areas such as visual performance and well-being. Hedge et al. (1995) found that office workers preferred ceiling suspended, lensed-indirect up-lighting to a parabolic down lighting system, and experienced fewer problems of screen glare and tired eyes. Juslen (2007) found that when horizontal luminance was alternated per work shift (between 800 and 1200 lux) the speed of workers in a factory assembling electronic devices increased significantly in the 1200 lux condition; an effect that held for morning and evening shifts in the winter; and during the evening shift in the summer.

Findings are not always consistent, however. Katzev (1992) found that participants in laboratory studies adapted to new lighting systems with little changes in performance or mood, and Knez and Enmarker (1998) found that performance decreased. Therefore, researchers have focused on understanding the mechanisms by which lighting influences worker performance and well-being in different types of work, work environments and lighting conditions.

## Fluorescent Lighting

In recent years, fluorescent lighting has been regulated by norms and European standards, but prior to standardisation, a significant body of research investigated how fluorescent lighting, specifically the luminous flicker produced by such lighting, leads to visual discomfort, deteriorations in visual performance, stress and headaches. Results generally confirmed a detrimental impact on visual performance that also extended to task performance (Wilkins, Nimmo-Smith, Slater, & Bedocs, 1989, Knez, 2001; Kuller & Laike, 1998; Veitch & Newsham, 1998). For example, Kuller and Laike (1998) found that fluorescent light powered by conventional and high frequency ballasts impacted on the well-being, performance and physiological arousal of workers in a laboratory office: when the light was powered by conventional ballasts individuals in the critical flicker fusion frequency (CFF) condition showed increased speed but reduced accuracy in task performance.

## Colour, Mood and Performance

Studies have also found that the colour of lighting can have an effect on a persons' mood and work performance (Kuller, 2006). One experimental study of the effects of lighting, age and gender on mood and cognitive performance, found a gender difference in that younger females experienced positive and negative mood for longer than the males. Older adults showed a negative mood in

cool bluish lighting, whilst younger adults showed a more negative mood in warm, reddish light (Knez & Kers, 2000). Similarly, researchers at the University Medical Centre in Hamburg-Eppendorf, found that children approaching their teens (8-12 years old) were more positively inclined towards a reddish light that made them feel calmer. This study also showed a slight decrease in aggressive behaviour in the same age group and supports the relationship between improved lighting conditions and better well-being and performance. An increase in pro-social behaviour was combined with better reading comprehension by the participating students, as well as greater reading speed and fewer errors.

Another study by Knez (2001) found that although overall participants performed better in the 'warm' than in the 'cool' and artificial 'daylight' white lighting, men performed better than women in the 'warm' and 'cool' white lighting, and women performed better than men in the artificial 'daylight' white lighting. In a prospective controlled intervention study, Mills and Tomkins (2007) found that fluorescent light sources with high correlated colour temperature (17000K) improved concentration, fatigue, alertness, work performance, and mental health.

Viola et al. (2008) compared the impact of exposure to blue-enriched white light (17000K) and white light (4000K) on alertness, performance, and evening fatigue among workers in an office setting during daytime work hours. Using questionnaires to measure employee alertness, mood, sleep quality, performance, mental effort, headache and eye strain, and mood throughout the study, the researchers found that the blue-enriched white light (17000K) improved the subjective measures of alertness, positive mood, fatigue, performance, irritability, concentration and eye discomfort. They also found that daytime sleepiness was reduced, and the quality of subjective nocturnal sleep was improved, by the blue-enriched white light.



Hoffmann et al. (2008) also found that variable light has a potential advantage in indoor office settings with respect to subjective mood. In their experimental study of the effects of variable lighting intensities on sulphatoxymelatonin and subjective mood, they found that variable light increased 'activity' ratings and reduced 'deactivation' and 'fatigue' ratings on two successive days compared with regular illumination.

Although most of these studies have used simulated work settings, Ballal et al. (2006) carried out their research in real work environments in different countries to investigate whether the mood of people working indoors is affected by lighting and its colour. They found that workers displayed a

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low mood when lighting was perceived as being too bright or too dim, but mood improved when the lighting was perceived as being at the right level. They also found that employees located in the countries located far north of the equator showed a significant variation in psychological mood over the year (Ballal et al 2006).

## Employee Controlled Lighting

There has been growing interest in whether employee control (or lack of control) over lighting at work can impact on well-being and performance (Sutter, 2006). Veitch (2000) compared the work performance and satisfaction of 47 office workers who were given choices concerning workplace lighting with another group of workers matched for age and sex, working under identical lighting, but who had no choice over their lighting conditions. They found that although participants with choices over their lighting had greater perceived control, there were no differences in satisfaction, mood, performance or health between the two groups. However, a very recent field study of the behavioural effects of an energy-saving lighting retrofit by Veitch et al. (2010) found that individual control over workstation lighting was perceived as more comfortable than recessed parabolic-louvered luminaires.

## Lighting and Safety at Work

There is an obvious link between lighting and workplace safety: insufficient lighting leads to increased error rates, and in many cases small or significant injuries. A recent report published by the UK Health and Safety Executive identified a number of lighting hazards that may lead to health and safety risks at work. These included insufficient light on the task, uneven lighting, too bright natural/artificial lighting, high reflectance of surfaces, strong shadows, reduced contrast of task due to veiling reflections and flicker. Emergency lighting, standby and escape lighting help to ensure employee safety in emergency conditions and therefore contribute to safer work environments. It is important to note that standards and regulations apply which limit some of the risks identified above. Systematic emphasis on employee well-being and workplace safety requires awareness of the risks, implementation and revision of standards on an on-going basis for their improvement.



# Different Types of Work

The importance of lighting in different types of work and work settings has also attracted considerable interest from researchers. Certain types of work, such as shift-work and night-work, that require employees to work under artificial lighting for considerable periods of time, have been of particular interest to researchers (see Eastman, 1999). Increasingly, however, the impact of lighting in VDT or computer based work has featured as an important area for researchers interested in worker well-being and performance.

## Shift-work and Night-work

As lighting assists in the regulation of circadian rhythms, the reliance of shift-work and night-work on artificial forms of lighting can have a number of effects on well-being and performance (Moore-Ede & Richardson, 1985; Costa, 1997). Most studies have looked at the effect of shift-work on subjective well-being and performance of night-shift workers, such as nurses, with an important stream of research investigating links between shift-work and breast cancer:

Of particular interest to researchers is the possibility that the impact of shift work on circadian rhythms can be mediated by using different lighting conditions. In a series of field and laboratory studies with nurses, Bolvin and James (2002) found that six hours of intermittent bright-light exposure in the workplace delayed circadian rhythms and promoted adaptation to night-shift work. Budnick (1995) also investigated the effectiveness of using scheduled bright light and periods of dark to alter the circadian pacemakers of rotating shift-workers. They found that 50% of their group had a statistically significant circadian change, but whilst a few significant changes were noted concerning reported sleep and alertness, findings concerning self-perceived alertness and performance at work, and sleep patterns were inconsistent. However, Leppamaki (2003) found that repeated, brief exposures to bright light during night shifts over a 2-week period improved the subjective well-being of nurses during and after night-work in summer and in winter, independent of the subject's age.

Iwata's (1997) study of bright artificial light on the subjective mental state of 10 female nurses working shifts found some evidence that the light improved vigour, eagerness, appetite and reduced tension during night, but not evening shifts. Costa (1993) studied nurses in a resuscitation unit on a fast rotating shift schedule who were exposed to short periods (4 x 20 min) of bright light (2350 lx) during night duty to test for a positive effect on tolerance to night work. Two nights with normal lighting (20-380 lx) and two nights with bright light were compared, with the latter indicating signs of better physical fitness, less tiredness and sleepiness, a more balanced sleep pattern, and better performance on a test of cognitive efficiency. Juslén et al.'s (2007) study of localised task lighting installed in addition to general lighting in a food factory found that shift workers liked the new lighting which they felt made them feel less sleepy and able to perform more efficiently. Direct measurements also showed a statistically significant three per cent improvement in performance with higher illuminance.

The detection of a novel photoreceptor cell in the eye in 2002 has led to the discovery that good lighting has beneficial biological effects as well as visual effects. It is now understood that light mediates and controls a large number of biochemical processes in the human body. The most important findings are related to the control of the biological clock and to the regulation of some important hormones, cortisol and melatonin through regular light and dark rhythms. This in turn means that lighting has a large

influence on health, well-being and alertness (see Bommel and Beld, 2004, 2006, Rea, Figueiro, Bullough, 2002). One of the most significant areas of research has investigated whether exposure to light-at-night and disturbance of the circadian rhythm, possibly mediated via the melatonin synthesis and clock genes, is a contributing cause of breast cancer. In a review of previous research, Hansen (2006) found that studies have consistently shown an increase in risk of breast cancer among night and shift workers. For example, in their study of sleep habits and night working Davis et al. (2001) found that breast cancer risk was increased among women who frequently failed to sleep during the period of night when melatonin levels are typically at their highest. The association between shift-work and risk of breast cancer was also stronger with increasing years and with more hours per week of shift work. This constitutes an important area for future studies.

## VDT and Computer Work

Since 2003, new standards and norms (EN-12464-1) regulate the maximum allowed luminance limits for luminaries. These are likely to improve the adversarial consequences of poor lighting conditions for video display terminal (VDT) and computer users. Aaras et al. (2000) identify the main problems reported by VDT workers as visual discomfort and musculoskeletal pain. A considerable amount of research has been carried out into the effects of lighting conditions (e.g., luminance, contrast and glare) on VDT work. For example, Hunting et al. (1981) found that eye impairments and objective symptoms of eye irritation (e.g., use of eye drops) were more frequent in VDT operators, and that these were associated with high luminance contrasts between screen, source document

and the surrounding space, and increased oscillating luminance of screen characters. Gobba et al. (1988) found that when video display terminal (VDT) work stations were provided with adequate levels of illumination employees did not develop deteriorating visual conditions such as asthenopia and myopia. Dainoff et al. (1981) also found a relatively high level of incidence of eye fatigue symptoms, and complaints regarding glare and lighting among office workers whose jobs required the use of video display terminals; although, Houshang (1982) notes the importance of individual differences in preference for screen and workplace lighting adjustment among employees.

Other research has also found a relationship between workplace lighting and reduced visual discomfort (e.g., Bjorset et al. 1998). Investigating the effect of moving from single occupancy offices to a landscape environment, Helland (2008) found that Visual Display Unit (VDU) operators reported significantly worsened condition of lighting and glare and that this was associated with increased visual discomfort. Kamienska-Zyla (1993) noted that the highest percentage of complaints from VDT operators in Poland resulted from discomfort associated with eyesight. In a recent intervention study, Aaras (1998) found that visual discomfort and glare was significantly reduced by using a new lighting system that increased general illuminance levels, luminance of room surfaces and luminance distribution. The intervention groups continued to report significant reduction of visual discomfort after 6 years (Aaras, 2001).

## Open Plan Offices

Research exploring the effects of open plan offices on worker satisfaction and visual comfort has demonstrated a relationship between work satisfaction and satisfaction with the work environment. A field study of 779 people working in open plan offices in nine government and private sector buildings across five large Canadian and US cities, found that workers who were more satisfied with their work environments were also more satisfied with their jobs (Veitch et al. 2007). Two further experiments conducted using a simulated office space where office workers worked for a day under one of six lighting conditions, also found that those who perceived their lighting as being of higher quality rated the space as more attractive, reported improved mood, and demonstrated better well-being at the end of the day (Veitch et al. 2008); lighting that improved visibility also improved task performance. Lee and Guerin (2009) looked at lighting quality in open plan offices with different height partitions, private enclosed and private shared offices, and open plan offices with no partitions. They found that workers reported higher satisfaction and visual comfort in all office types except those with high cubicles.

Yildirim et al. (2007) found that proximity to a window affected employee satisfaction with their work space, particularly when coupled with a 1.40m workstation partition, which gave them a higher level of visual and acoustical privacy, whilst minimizing distractions and interruptions. Newsham et al. (2009) also demonstrated the importance of windows in an open plan office in their study of employees at 95 workstations. They found that window access played an important role in worker satisfaction with lighting.

## Work in Industrial Settings

Industrial settings refer here to manufacturing, production or factory settings and may or may not involve working with machinery. A study by Untimanon et al. (2006) concluded that visual strain problems are most common among vision intensive industrial workers. The study measured the visual performance of electronic and jewellery, manufacturing workers working on tiny visual tasks over near distances. When lighting conditions were improved, short breaks introduced and visual performance problems corrected, they found that performance increased significantly among the electronic but not the jewellery workers. Juslen et al. (2007) measured employee productivity (speed and quality) in a factory electronic assembly line in the Netherlands after changing the horizontal illuminance per work shift between 800 and 1200 lux. Conducting their research in the summer and the winter, they found a significant effect of illuminance, such that, the speed of production in the summer was 2.9% higher in the 1200 lux condition than the 800 lux condition. In the winter it was 3.1% higher. No effect of illuminance on error rate was found.

Juslen et al. (2005) showed that in industrial settings employees will systematically choose different levels of lighting throughout the day in summer and winter. Their research participants exhibited different weekly rhythms in their preferred illuminance, tending to use lower lighting on Fridays than Thursdays during the summer, and the reverse in winter. Overall lower levels of light were preferred in the summer. The researchers also showed that when factory workers could control the level of light their productivity increased by 4.5%. Similar increases in productivity were observed amongst workers on a manual assembly in an electronics factory. Finally, Niemela et al. (2002) concluded that improving thermal climate and lighting conditions, and reducing contaminant concentrations and better lighting conditions for workers in a storage building, could all improve employee productivity.

## Performance in Schools

There is some evidence that lighting in schools can impact on the work performance of teachers and pupils via its effect on learning. Whilst learning is an important feature of all workplaces, it is the central activity in schools. Successful student learning involves acquisition of knowledge, and development of skills, behaviour and attitudes necessary for students to become socially adept and independent. Teacher performance involves supporting student learning.

Most studies involving students have focused on the impact of lighting on school achievement. It is now widely accepted that lighting in the learning environment impacts on students' learning experience and school achievement (Dunn et al., 1985; Schneider, 2002; Heath & Medell, 2002). In a report for the US Department of Education Lyons (2000) reviewed the impact of school facilities on a child's education. The report strongly advocates the case for sufficient and adequate lighting that is diffused throughout the room, while noting that, despite its benefits, daylight may increase glare and be unevenly distributed. Lyons and several other researchers have concluded that improved artificial lighting solutions can improve significantly the learning experience. For example, although daylight is considered important (Heschong et al., 2002; Lyons, 2000), Benya (2001) reviewed the psychological and physiological benefits of both daylight and artificial light, and concluded that a mix of the two can offer a healthy and cost efficient solution to lighting in schools. Dunn et al. (1985) showed that children have strong preferences over the level of lighting. In their study, they built on the premise that eye sensitivity will determine the level and type of lighting that an individual finds

comfortable. They found evidence of individual differences, such that students who could concentrate better under bright light reported feeling lethargic when the light was not bright enough, whereas students who preferred dimmer lighting claimed that bright light made them 'nervous and fidgety'. The study concluded that individual preferences may have a profound influence on student school achievement.

Despite a wealth of studies about how student performance is affected by lighting conditions, relatively little is known about lighting and teacher performance, and there are also very few published studies that have examined the influence of lighting on teacher and student well-being. One exception is work by Buckley et al. (2008), which documents the high turnover rates of school teachers in the US and suggests that the quality of the school facilities (including lighting) can be an important contributory factor in teacher retention levels.



# The Changing Nature of Work

The past few decades have witnessed profound changes to working patterns and work environments resulting from an unprecedented period of innovation in information and communication technologies (ICTs). These changes present opportunities and challenges for workers and their employers. One of the most important is greater flexibility. Work has been stretched in both space and time. It is now possible to work across different countries and time-zones in virtual teams using email, video-links and telephone. For employers, the introduction of e-based human resource systems for areas like recruitment and training has also allowed companies to identify, attract and develop talented workers internationally.

Globalisation, international working, and increasing workplace diversity, together with the rise in knowledge intensive work, all bring significant challenges for companies. Key to meeting these challenges will be the ability to design modern workplaces capable of supporting companies in their efforts to maintain a competitive market position.

The following are just some of the areas likely to be relevant to future workplace design:

1. Service work
2. Knowledge work
3. Virtual working
4. Working across space and time zones
5. Changing demographics

## Service Work

In most developed countries there has been a decline in the number of jobs in traditional manufacturing work and an increase in those based in new service industries. Many service workers work in call-centres, where their work involves the use of computer and telephone-based technologies to distribute incoming calls from customers or clients to available staff (Holman, 2002). Call centres can be thought of as 21st century production lines, where employees produce social or cognitive outputs (service) rather than physical outputs (products). Although they have

been in existence for some time now, they provide a very good illustration of how the workplace has changed for many workers. Faster and cheaper communication and technology mean that service and sales work is now routinely provided via workers in call centre environments, for customers who may live in different countries or time-zones.

The work environment of call-centre workers and other types of service staff is likely to become an increasing focus of interest. This type of work requires workers to demonstrate high levels of concentration and positivity towards customers. Yet the use of electronic performance monitoring and the highly structured nature of this type of work (e.g., there may be a maximum of five minutes permitted per call), can mean that it is highly stressful for employees. Consequently, many researchers have focused on how these environments impact on well-being and performance, and what might be done to improve them. In a work environment, like call centres, performance measures need to be fully embedded in employee schemes aiming to develop employees' skills and abilities and accompanied by a supportive supervisory relationship (e.g., Holman, Chissick & Totterdell, 2002).



## Knowledge Work

The shift towards service and customer-facing work has also meant that workers are more reliant on cognitive and interpersonal skills like communication, negotiation, networking, project management, problem solving and influencing skills, than the physical skills of traditional industry. However, uncertainty and ambiguity characterise knowledge work and the context in which it takes place. Blackler et al., (1993) believe that the wider context in which contemporary organizations operate is characterised by

'economic, ecological, personal, social and cultural uncertainties \*which+ are being experienced on an unprecedented scale' and argue that the focus should be on the circumstances that these uncertainties create for individuals and organizations. Within this changing organizational context the tasks that knowledge workers will undertake are complex, intangible, symbolic in nature and frequently entail the involvement of other individuals (e.g., clients), while the results are equally difficult to assess (Alvesson, 2001, 2004; Newell et al., 2002).





Knowledge work also typifies many of the roles at the higher end of the jobs market (e.g., consultancy, finance, law), where employees are highly paid and work long hours. Employers are particularly keen to retain high performers, and are therefore looking for solutions, like more attractive and comfortable work environments that can help them to do this.

## Virtual Working

Developments in ICT and mobile communication devices mean that employees can be contacted wherever and whenever they are working. They also mean that employees can access up-to-date information about their job without the time or cost associated with returning to their place of work. However, important aspects of work, such as the socialisation process of the virtual worker with the rest of the organisation and the psychological impact of virtual working, may be disrupted under virtual work settings. According to Ward and Shabha (2001), employees who work remotely miss out on everyday office life and may frequently suffer from a lack of face-to-face communication, limited professional support and feelings of isolation. Moreover, virtual workers may find it difficult to internalise

workplace attitudes, values and behaviour that are informally absorbed by office-based employees (Johnson, 1991). In this case remote employees may find it more difficult to form interpersonal relationships and the emphasis has been on helping line managers to socialise remote colleagues in the workplace (Johnson 1991). Similarly, Konstantinou (2002) interviewed 8 line manager-employee pairs and found that, when performance is not easily quantifiable, the line manager may find it difficult to assess productivity and work becomes invisible.

## Working Across Space and Time Zones

International working has meant that, in many cases, employees work across space and time. The organisational benefits of such working patterns include decreased travel costs and greater time efficiencies. Another significant advantage is the development of new knowledge (or innovation) and the improvement of practice as different employees perform the same tasks in different locations. However, the transfer of innovation from one part of the organisation to the next and across boundaries depends on

well-designed and established channels of communication and once again ICTs become important. Young (1995) asked 2,642 employees in a multinational company in Silicon Valley in California how they use ICTs and how these technologies influence the nature of work. The study showed that in many cases ICTs were perceived as more efficient than face-to-face communication, but lagged behind when sensitive/contentious issues needed to be discussed, when technical problems disrupted all communication and in terms of facilitating informal communication (e.g., bumping into someone) that was frequently considered important for maintaining interpersonal relationships.

## Changing Demographics

Over the past twenty five years the number of older people across the world has grown significantly. This population has been growing at a similar rate to the population as a whole. Nevertheless, according to the United Nations in 2050 there will be 379 million people over 80 years old.

Changing demographics mean that there is a growing expectation that people should work for longer, as well as greater recognition that work environments should be designed to take account of the needs of an older workforce. These changes are being experienced internationally, but are likely to be particularly important for companies in the developed world. Governments have begun to introduce legislation to encourage older workers back into work and to guard against potential discrimination in the workplace. For example, many countries are increasing the age at which people can claim their State Pension, increasing the number of older employees in the workplace. Changing demographics are also likely to mean that an increasing proportion of younger workers will have care responsibilities for older relatives.

It is hard to predict the health of older people in employment due to changes in health support and lifestyles. However, in the UK approximately one-fifth of men aged 65-69 and one-third of women aged 60-64 were in employment in 2008. A report by the Office for National statistics (2009) found that as a group they reported relatively high levels of ill-health with heart, blood pressure and circulatory problems being the most common health problems. Back and neck, and hands and feet problems were also frequent. Although visual problems were not cited it seems likely they will become increasingly important given current trends towards more computer-based working, and deteriorations in visual ability with age. There have also been numerous studies demonstrating that cognitive speed decreases with age, although this is frequently compensated for by increased knowledge and experience.

Factors like workplace lighting can play an important role in improving task performance among older workers, something that is likely to be increasingly important when designing work and work environments around the needs of older workers.

# Future Well-being

Researchers are in broad agreement that a combination of equally important inter-dependent factors must be aligned in order to enhance organisational well-being and achieve an engaged, productive workforce.

For most workers, an intensification in work demands over recent decades have been accompanied by the need to cope with continually changing work requirements, on-going learning and a faster pace of work. In many cases these have resulted in increased levels of stress, deterioration in employee well-being, and, by implication, reduced work performance. Work-related stress is important, because it affects not only the sufferer, but also the people who work around them, and the organisation as a whole. Perhaps unsurprisingly a significant literature on well-being at work has therefore evolved aimed at understanding factors that contribute to well-being and performance at work. We have not attempted to review the entire well-being literature in this section, but instead consider factors relevant to lighting solutions, well-being and performance with the aim of supporting future decision-making in this area.

## Work-related causes of employee stress and well-being: An overview

According to the Health and Safety Executive, more than half a million people in the UK experience work-related stress costing industry about £9.6bn every year (HSE, 2005). Workplace stress is certainly not unique to the UK: in fact there is evidence of increased work-related stress across many developed and developing countries due to changes in work design, a faster pace of work and more recent changes in the global economic climate. The well-being literature identifies several factors that induce significant stress levels in companies, all of which are within the power of managers to address (Fincham & Rhodes, 2005; Vischer, 2007), including:

- Poorly designed or managed workload or work design
- Poorly designed physical environment
- Lacking skills necessary to perform a job
- Lack of job control (e.g., authority to make decisions)
- Lack of social and managerial support
- Role-related factors (e.g., increased role ambiguity or no work-life balance);
- Lack of procedures for dealing with conflict (e.g., bullying or harassment)
- Job insecurity
- Long working hours

Of these, 'poorly designed work environment' has most relevance to interventions based on improving lighting and employee control.



## Consequences of work-related stress for employees and employers

Although individual employee responses to stress can vary considerably as a consequence of individual differences like personality (Parsons, 2000), they can be divided broadly into four categories: physiological, emotional, cognitive and behavioural (European Foundation, 2007). Within these categories responses can also vary, ranging from increased absenteeism, reduced motivation and organisational commitment, to heightened blood pressure and sleep disturbances. However, prolonged exposure to stress usually exacerbates the consequences of stress and can lead to workers experiencing chronic fatigue, burnout, musculoskeletal problems and cardiovascular disease.

Whilst acknowledging the importance of individual variation in responses to stress, researchers have also sought to identify generic characteristics or work-related factors that consistently predict well-being and performance, in order to identify ways to mitigate their effects in the workplace. Most researchers agree that stress results from a combination of environmental (work-related) and individual factors and grows gradually over a period of time. There is often insufficient acknowledgement of stress by the employee and the line manager; and poor communication or a lack of trust between employees and line managers can mean that employees are reluctant to discuss their situation. A lack of understanding or awareness on the part of managers can also mean that the causes of stress are not addressed until the symptoms become severe.

Table 1. Individual responses to work-related stress.

Physiological	Emotional	Cognitive	Behavioural
Increase in heart rate	Nervousness	Reduced attention	Aggressiveness
High blood pressure	Irritability	Reduced perception	Impulsive behaviour
Hyperventilation		Forgetfulness	High error rates
Musculoskeletal disorders			Reporting sick
Disturbed metabolism			
Alcohol/Tobacco dependence			

From: European Foundation for the Improvement of Living and Working Conditions (2007)

A recent review by van Erp (2008) underlines the importance of addressing workplace well-being. This found that whilst work-related stress can have significant consequences for employers including increased absenteeism and turnover; and reduced safety and performance at work, 'an increase in psychological and sleep related well-being of employees has a positive influence on their productivity, creativity, absenteeism, and occupational injuries' (pp. 17).

## Enhancing well-being at work

Roelofsen (2002) argues that providing employees with a workplace that allows them to perform their work comfortably is a fundamental human requirement that should be central to organisational strategy aimed at enhancing performance.

There is a substantial body of research concerned with ways in which companies can reduce stress levels, enhance well-being and improve performance. Most studies demonstrate that, to be successful, employee well-being must be systematically and holistically managed within companies. Work-related stress must be acknowledged at a strategic level to avoid stigmatising individuals and to ensure intervention programmes are effective. As with all organisational change initiatives, the role of the CEO in leading and promoting new practice is of key importance to secure organisational commitment at the strategic level.

Recent research by the UK Health and Safety Executive (2007) has also emphasised the need to develop managers' competency to prevent work-related stress. This builds on an extensive HR literature which suggests that responsibility for the well-being of employees should lie primarily with line managers, who provided they have the right tools and training, are likely to be able to take care of most well-being issues. Indeed, Karasek (2004) concludes that open communication between labour and management and worker participation in facilitating a learning approach are important ways of preventing stress at work and increasing productivity.

“There is a substantial body of research concerned with ways in which companies can reduce stress levels, enhance well-being and improve performance. Most studies demonstrate that, to be successful, employee well-being must be systematically and holistically managed within companies”

Factors such as organisational structure and culture, team-building activities, supportive supervision, and the opportunity to participate in decision-making, are now seen as being as important as environmental factors such lighting, humidity and temperature.



## Interventions based on lighting

Well-being interventions designed to have an effect on the entire organisation include company-wide change programmes targeting the culture of a company or the general management style of senior employees (Kelly, 1992; Kopelman, 1985). Alternatively, individual-oriented or worker-centred interventions focus on helping individual employees to develop the skills they need to manage, resist and reduce stress (Ivancevich & Matteson, 1987; McLeroy et al. 1988; Murphy, 1996). However, recent thinking suggests that to be successful, work-related stress interventions need to combine different methods and approaches including company-wide and worker-centred levels, as well as interventions targeting the design of the work environment. For example, Dalke et al. (2006) investigated lighting patterns that could improve the UK National Health System (NHS) environment for patients, staff and visitors. They concluded that lighting design is important in helping to meet important legal requirements such as the use of colour contrast for the visually impaired, as well as improved work conditions for patients and staff. Importantly, the researchers explored the use of lighting to create different kinds of work environment within the same location, in order to meet the varying needs of staff at different times, and in different aspects of their role. They recommended, for example, that staff relaxation rooms should have different colour and lux levels from other work spaces and areas designed for patients awaiting intensive treatment. Whilst lighting design may not cure ill health, the researchers conclude that monotony and poor environmental conditions certainly have a detrimental effect on recovery rates and staff morale. With an increasing focus on work involving customers, there is likely to be a growing need to create environments that can boost morale and therefore the quality of service interactions. Lighting may prove to be an important way of addressing these needs.

Certainly, researchers have advocated the use of lighting-based interventions to enhance worker well-being and performance. For example, Kuller et al. (2006) noted that light and colour should be studied as parts of the more complex system that makes up a healthy building. They also stress the importance of identifying and accommodating individual, task and company-related differences when designing and managing lighting solutions. Following up on this, leading-edge industrial ('The Effect of Lighting on Well-being' by Royal Philips Electronics) and government ('Lighting at Work' by the Health and Safety Executive) reports suggest that, at a strategic level, developing and maintaining lighting solutions requires four steps: (1) Planning: which involves identifying and setting priorities so that the lighting design is suitable and safe for the type of work performed, (2) Organisation: which means ensuring that all staff are aware of their responsibility to report any issues relevant to lighting, and the systematic provision of resources (e.g., staff training in lighting solutions), (3) Control: which involves setting standards and maintaining them, and (4) Monitoring: which involves checking that planning, organisation and control standards have been met. The report also proposes that for lighting solutions to be suitable and sufficient, the following questions need to be considered.

1. Is the design of the lighting solution suitable and sufficient for the type of tasks undertaken in the workplace?
2. What aspects of the work are affected by lighting (i.e. is there a need for detail or an ability to distinguish between colours)?
3. How does the lighting solution complement other aspects of the work environment (e.g., level of natural light, interior design and work conditions)?
4. How can lighting help to support or mediate health aspects of the work, including likelihood of psychological and physiological strain?
5. Can the lighting solution address the requirements and preference of individual workers for different types and levels of lighting?
6. How will on-going lighting maintenance be undertaken, including the availability and monitoring of emergency lighting?

## Worker-centred Interventions

Whilst company-wide initiatives are critical for creating organisational cultures that develop and sustain employee well-being and productivity, these initiatives are much more effective if combined with interventions targeted at the needs of individual workers.

One of the most important factors in worker well-being and performance is 'job control', which is defined as the degree to which an individual perceives him- or her-self to have autonomy or influence over how they perform their role (Hackman & Oldham, 1976). Today, the technology exists to provide workers with more flexible working spaces and many companies choose to enhance employee participation by offering more choice to their employees about how they perform their task. However, another important means of enhancing worker control is by providing employees with the ability to control aspects of their own work environment: this can be achieved through individually-controlled lighting solutions that make it possible to tailor the lighting environment to their personal needs (Juslen, 2005). In many respects technological advances have outpaced research in this area, although increasing diversity in the workplace, particularly in relation to age and visual ability is likely to mean that there will be increasing demand for personalised lighting environments to support worker productivity. This implies a need for more research documenting the impact of personalised lighting solutions on worker well-being and performance in different types of work and industry sectors.





# Recommendations

This report documents the existence of a now substantial body of research concerned with the impact of environmental conditions like lighting on worker well-being and performance. Much of the work on lighting in particular is spread across a variety of academic areas, including ergonomics and health, rather than the mainstream management literature. It would appear that the Hawthorne Studies continue to have a strong, but perhaps unjustified effect on the willingness of management and organisational researchers to explore this area. This is unfortunate, because existing studies suggest that lighting, and particularly recent innovations in worker-controlled lighting, have considerable potential in helping organisations design healthy and productive workplaces.

## We summarise key findings as follows:

- Existing research documents good evidence of an association between lighting and work performance, mediated by employee well-being.
- Lighting is one of several factors that combine to create healthy work environments that in turn help promote employee engagement, well-being and productivity.
- There is growing evidence for a link between lighting conditions, shift-work and biological health conditions: an area likely to receive more attention from researchers in future.
- Standards and norms regulating lighting conditions have increased the focus on the importance of lighting and visual health among workers, particularly those most at risk (e.g., employees using VDTs and older workers).
- Worker controlled lighting and lighting solutions tailored to the individual needs of workers have considerable potential for enhancing employees' work satisfaction and enhancing retention. This may be particularly important in the case of professional workers that employers would most like to attract and retain.
- The increasing need for employers to adapt flexibly and proactively to rapidly changing market conditions may constitute an opportunity to look at how adaptable lighting schemes can assist by creating more flexible work environments that contribute to innovation and productivity.
- There is likely to be more interest in the interface between employee and customer satisfaction and well-being, and how lighting can help facilitate this.

## Based on these findings, and recognising that there is unlikely to be a simple solution, we recommend that:

- Companies should consider the need to invest in workplace lighting as a means to develop work environments that support well-being and performance, and reduce the likelihood of employee stress, absenteeism, and industrial accidents.
- Discussion and decisions about the role of lighting on employee well-being and performance need to be central to strategic decisions about organisational performance, and therefore need to be initiated at the board-level in order to secure the commitment of the senior management team.
- Companies need to adopt a holistic approach to health and well-being that identifies the needs of different employee groups and addresses them through a combination of company-wide and worker-centred initiatives.
- There is a need for more focus capturing, evaluating, and measuring the impact of lighting on employee well-being and performance, in order to build an evidence base to support workplace interventions. This is likely to require the coordinated efforts of different parts of an organisation, or cross-sector projects.

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# Appendix I. Searches

## Health

Lighting AND health at work (Web of Science)  
Lighting AND health at work (Ergonomic Abstracts)  
Lighting AND health at work (Google scholar)  
Lighting AND health (Web of Science)  
Lighting AND health (Ergonomic Abstracts)  
Lighting AND health (Google scholar)

## Performance

Lighting AND performance at work (Web of Science)  
Lighting AND performance at work (Ergonomic Abstracts)  
Lighting AND performance at work (Google scholar)  
Lighting AND performance (Web of Science)  
Lighting AND performance (Ergonomic Abstracts)  
Lighting AND performance (Google scholar)

## Well-being

Lighting AND well-being (Web of Science)  
Lighting AND well-being (Ergonomic Abstracts)  
Lighting AND well-being (Google scholar)  
Lighting AND well-being at work (Web of Science)  
Lighting AND well-being at work (Ergonomic Abstracts)  
Lighting AND well-being at work (Google scholar)

## Productivity

Lighting AND productivity at work (Web of Science)  
Lighting AND productivity at work (Ergonomic Abstracts)  
Lighting AND productivity at work (Google scholar)  
Lighting AND productivity (Web of Science)  
Lighting AND productivity (Ergonomic Abstracts)  
Lighting AND productivity (Google scholar)  
Lighting, Health and Well-being in the Workplace

## Work environment

Work environment AND lighting (Web of Science)  
Work environment AND lighting (Ergonomic Abstracts)  
Work environment AND lighting (Google scholar)

## Human Factors

Human Factors AND lighting (Web of Science)  
Human Factors AND lighting (Ergonomic Abstracts)  
Human Factors AND lighting (Google scholar)

## Ergonomics

Ergonomics AND lighting (Web of Science)  
Ergonomics AND lighting (Ergonomic Abstracts)  
Ergonomics AND lighting (Google scholar)

## Mood

Lighting AND employee mood (Web of Science)  
Lighting AND employee mood (Ergonomic Abstracts)  
Lighting AND employee mood (Google scholar)  
Lighting AND mood at work (Web of Science)  
Lighting AND mood at work (Ergonomic Abstracts)  
Lighting AND mood at work (Google scholar)

## Industrial Settings

Lighting AND health AND industrial work (Web of Science)  
Lighting AND health AND industrial work (Ergonomic Abstracts)  
Lighting AND health AND industrial work (Google scholar)  
Lighting AND well-being AND industrial work (Web of Science)  
Lighting AND well-being AND industrial work (Ergonomic Abstracts)  
Lighting AND well-being AND industrial work (Google scholar)  
Lighting AND performance AND industrial work (Web of Science)  
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Lighting AND Productivity AND industrial work (Google scholar)  
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Lighting AND industrial work (Ergonomic Abstracts)  
Lighting AND industrial work (Google scholar)

## Customer satisfaction

Lighting AND customer satisfaction (Web of Science)  
Lighting AND customer satisfaction (Ergonomic Abstracts)  
Lighting AND customer satisfaction (Google scholar)  
Call centres Lighting AND call centres (Web of Science)  
Lighting AND call centres (Ergonomic Abstracts)  
Lighting AND call centres (Google scholar)

## Open plan offices

Lighting AND open plan offices (Web of Science)  
Lighting AND open plan offices (Ergonomic Abstracts)  
Lighting AND open plan offices (Google scholar)

## Shift work/night work

Lighting AND Shift work (Web of Science)  
Lighting AND Shift work (Ergonomic Abstracts)  
Lighting AND Shift work (Google scholar)  
Lighting AND night working (Web of Science)  
Lighting AND night working (Ergonomic Abstracts)  
Lighting AND night working (Google scholar)

## Lighting and Video Display Terminals/Virtual office work

Lighting AND VDT (Web of Science)  
Lighting AND VDT (Ergonomic Abstracts)  
Lighting AND VDT (Google scholar)  
Lighting and video display terminals (Web of Science)  
Lighting and video display terminals (Ergonomic Abstracts)  
Lighting and video display terminals (Google scholar)  
Lighting AND virtual office work (Web of Science)  
Lighting AND virtual office work (Ergonomic Abstracts)  
Lighting AND virtual office work (Google scholar) Older workers  
Lighting and older workers (Web of Science)  
Lighting and older workers (Ergonomic Abstracts)  
Lighting and older workers (Google scholar)

## Control

Lighting AND control at work (Web of Science)  
Lighting AND control at work (Ergonomic Abstracts)  
Lighting AND control at work (Google scholar)

## Telework

Lighting AND telework (Web of Science)  
Lighting AND telework (Ergonomic Abstracts)  
Lighting AND telework (Google scholar)

## Mobile working

Lighting AND mobile working (Web of Science)  
Lighting AND mobile working (Ergonomic Abstracts)  
Lighting AND mobile working (Google scholar)

## Home working

Lighting AND home working (Web of Science)  
Lighting AND home working (Ergonomic Abstracts)  
Lighting AND home working (Google scholar)  
Lighting AND working at home (Web of Science)  
Lighting AND working at home (Ergonomic Abstracts)  
Lighting AND working at home (Google scholar)

# The Centre for Performance at Work

The Centre for Performance at Work is a new interdisciplinary research centre launched by City University in 2010. We bring together experts in organisational psychology, organisational behaviour and human resource management from Cass Business School and the School of Social Sciences at City University London.

We aim to help organisations achieve optimum levels of performance and well-being through leading-edge research and practice.

## Professor Jo Silvester (Director)

Jo is a Professor in Organisational Psychology and a leading expert in political leadership. She has worked extensively with private, public and government organisations in the fields of leadership development, employee selection and assessment, and organisational change. Her clients include international financial institutions, political parties and leading retail and manufacturing companies. (jo.silvester.1@city.ac.uk).

## Dr Efrosyni Konstantinou

Effie is the Research Fellow of the Centre for Performance at Work. She is an expert in the identity of knowledge workers and knowledge sharing strategies and technologies in multinational organisations. (efrosyni.konstantinou.1@city.ac.uk)

**For more information about the Centre for Performance at Work please visit our website at: [www.city.ac.uk/performanceatwork](http://www.city.ac.uk/performanceatwork)**



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