Environmental factors affecting office worker performance: A review of evidence

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Of the UK's workforce over 50%, equivalent to over 10 million people now work in offices, compared with 20% in 1911[1] and forecasts of 80% by the year 2000[2]. As a consequence there has been a dramatic increase in office space, for example 40% per person in London over the last 20 years. Furthermore, the life cycle of an office building is around 20 to 50 years, and typically a building lasts 40 years. Buildings are therefore both a substantial investment and potentially a long-term commitment. From the occupiers' point of view, building costs are the second-largest cost after staff and are typically 8 to 30% of the total revenue, accounting for the initial cost over life-cycle, or rent, and running costs (see Section 3.3). To maximise on return and encourage sustainable development (e.g. ensure the building is always occupied) it is therefore imperative that the office building is designed and functions in a way appropriate to support the activities that take place within it. Occupiers expect the office to provide a satisfactory and productive working environment to maximise the return on their costs (building and staff). What, then, constitutes a productive workplace and what are the key elements to designing it? Indeed, does the design actually affect productivity?

As a first step, this report aims to present a state-of-the-art review of literature which provides evidence of how the physical environment affects productivity in the work-place, in particular white-collar (knowledge-based) workers in offices. This review presents the results of scientific research and is not intended to provide practical guidance on how to create a productive workplace (this will be provided by a subsequent publication of the Office Productivity Initiative). The review includes only documented, rather than anecdotal, evidence or that obtained through on-going discussion with end-users and practitioners.

There are many sources of written information, which can be grouped in terms of: (a) early industrial fieldwork; (b) laboratory studies of performance tasks; (c) field surveys and experiments conducted in offices; (d) case studies; (e) design guidance; and (f) previous reviews. All these sources of information have merits but they also have problems associated with them when one is interpreting their relevance to the impact of the environment in modern office environments. For example, early industrial fieldwork provided easily quantifiable measures of productivity but the research was mostly conducted, in the early part of the century, in factories in which repetitive physical labour was carried out. The relevance to modern-day office work is therefore questionable. Laboratory studies of performance tasks also allow quantifiable productivity data to be obtained but have many shortcomings associated with them, mostly because the subjects cannot interact with the environment, are placed in unnatural environments and are asked to carry out simple performance tasks (see Section 5.1). Office surveys tend to be conducted by psychologists interested in the effect of environmental and/or organisational factors on productivity. Most of the environmental studies are cross-sectional surveys, rather than full experiments (e.g. involving an intervention, and control groups), and they mostly depend on self-ratings of performance rather than objective measures of productivity. The organisational studies are better but depend on a barrage of long-term measurements which include a subjective element. Case studies provide a valuable insight into the benefits of office improvements but the effects of environmental and organisational change tend to be confounded. Design guidance tends to be based on the practical experience of design consultants rather than being supported by scientific evidence.

It is acknowledged that the effect of the environment upon productivity has been examined in many other literature reviews . For example, Auliciems[3], Lorsch and Abdou[4], McIntyre[5], Parsons[6], Ramsay and Kwon[7] and Wing[8] reviewed the effects of temperature, Abdou and Lorsch[9] discussed the role of air quality, and Davies and Jones[10] and Kryter[11] adequately covered the effects of noise. In addition, Croome and Baizhan[12], Jokl[13], Lorsch and Abdou[14], Oseland[15], Oseland and Williams[16], Sundstrom[17], Whitley[18] and Wyon[19] have all provided general reviews covering most aspects of the physical environment. This report is justified because, firstly, it provides an update to these reviews and, secondly, most of these reviews have concentrated on the physical rather than the non-physical environmental factors that affect productivity.

2 Definition of productivity

Productivity is generally expressed in terms of efficiency, e.g. as the ratio of output to input. Lorsch and Abdou[14] express productivity as 'a measure of what can be achieved by human beings with the least effort' and they also state that 'productivity is the ratio of output to input'. Guzzo and Bondy[20] agree that productivity is the ratio of output to input and add that the productivity of a company is determined by the technology to transform the input to output and the performance of the workers. Similarly, Misterek, et al[21] propose that 'productivity may be defined as simply the relationship between what goes into the system and what is produced, or more simply the ratio of output to input'. Pritchard et al[22] conclude that 'one area where most authors do agree is that productivity is not synonymous with aggregated individual performance. Individual performance is typically output such as number of pieces finished or output relative to an evaluation system such as ratings performance. Pro-ductivity includes the idea of output relative to inputs, or outputs relative to objectives or goals.'

Environmental factors affecting office worker performance: A review of evidence

1 Scope of review and types of supporting evidence

Of the UK's workforce over 50%, equivalent to over 10 million people now work in offices, compared with 20% in 1911[1] and forecasts of 80% by the year 2000[2]. As a consequence there has been a dramatic increase in office space, for example 40% per person in London over the last 20 years. Furthermore, the life cycle of an office building is around 20 to 50 years, and typically a building lasts 40 years. Buildings are therefore both a substantial investment and potentially a long-term commitment. From the occupiers' point of view, building costs are the second-largest cost after staff and are typically 8 to 30% of the total revenue, accounting for the initial cost over life-cycle, or rent, and running costs (see Section 3.3). To maximise on return and encourage sustainable development (e.g. ensure the building is always occupied) it is therefore imperative that the office building is designed and functions in a way appropriate to support the activities that take place within it. Occupiers expect the office to provide a satisfactory and productive working environment to maximise the return on their costs (building and staff). What, then, constitutes a productive workplace and what are the key elements to designing it? Indeed, does the design actually affect productivity?

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The next question, then, is what are the input and output variables? Dorgan Associates[23] provide examples in their definition of productivity, which is 'the increase in the amount of time when work is being done with a decrease in absenteeism, a decrease in employees leaving work early, a reduction of extra long lunches, and the increase in quantity and quality while at work from improved air quality'. Lorsch and Abdou consider that the output achievement may be expressed in terms of quantity and/or quality and the input effort may be the amount of time and money required rather than physical effort. Misterek et al[21] distinguish between partial productivity, which involves measuring a portion of the inputs (e.g. labour costs), and total productivity, which compares all inputs and outputs (e.g. materials, labour, capital) which tend to be quantified using a common denominator such as cost. Jurison[24] says that output can be defined in terms of 'gross' or 'value added', where gross output is the total production and the value added output includes the company's own efforts only and excludes intermediate goods and services purchased outside. He continues that total productivity should include labour, capital, raw material and other relevant costs. Wineman[25] also acknowledges that productivity measures should include employee work performance and associated organisational costs including turnover, absenteeism, tardiness, overtime, vandalism, grievances and mental and physical health. She notes that organisational costs (productivity) are easier to measure than individual worker performance.

Jurison[24] points out that as 'productivity measures the relationship between products and services produced and the resources to create them', then 'productivity is increased by producing more with the same amount of resources or producing the same amount with fewer resources.' Misterek and colleagues provide examples of increased productivity. They term greater output and greater input (with the increase in output greatest) as managed growth; greater output and no change in input as working smarter; greater output and less input as the ideal; no change in output but less input as greater efficiency; and less output and less input (but a smaller decrease in output) as managed decline.

Sundstrom[17] suggests that the environment can be studied at three different levels of analysis: individual workers; teams or units; or the corporation. Similarly performance can be measured at these three levels, for example output per hour, project deadlines, and company profit respectively. The 11 indicators of increased productivity listed by the National Electrical Manufacturers Association (NEMA)[26] all relate to individual performance (Table 1). Sink[27] identified seven distinct measures of 'organisational performance': effectiveness (quality, quantity, meeting targets); efficiency (ratio of expected resources to those used); quality (subjectively or objectively assessed quality attributes); profitability (ratio of total revenues to total costs); productivity (ratio of quantity of output to input in terms of value/cost); quality of work life (psycho-social aspects and social response to company); and innovation (applied creativity).

Table 1 Indicators of increased productivity[26]

1	Performing tasks more accurately
2	Performing faster without loss of accuracy
3	Capability to perform longer without tiring
4	Learning more effectively
5	Being more creative
6	Sustaining stress more effectively
7	Working together more harmoniously
8	Being more able to cope with unforeseen circumstances
9	Feeling healthier and so spending more time at work
10	Accepting more responsibility
11	Responding more positively to requests

There is therefore the potential for confusing productivity terms and Pritchard et al[22] warn us that psychologists often equate performance with productivity. Of course, if an increase in performance is produced without any extra input resources then the increased performance is equivalent to productivity. However, most of the increases in performance shown in the literature are an outcome of some additional cost to the company, as either time and/or money (e.g. refurbishment, energy, training, management), which tends not to be included in the productivity equation. To prevent further confusion, in this review the term 'environment' refers to the general workplace environment. This includes both physical conditions (e.g. temperature, noise, space and layout) and other workplace factors (e.g. company policy, organisational structure, type of work, reward system).

3 Measuring productivity

3.1 Performance measures

The Sumerians kept records of each individual worker's performance more than 7000 years ago. Presumably, the work was simple, repetitive and easily measured. In today's modern office measuring performance and productivity is not so straightforward. For example, following their survey of 70 companies, Brill et al[28] report that 'no organisation in our survey has available any in-place work measuring system for measuring job performance'. Table 1 shows NEMA's list of indicators of increased productivity[26]. The first three items on the list are more conducive to measurement than the other indicators, e.g. creativity is difficult to define, let alone quantify. Traditionally, psychologists have studied the impact of the environment upon performance under controlled laboratory conditions using a series of simple psychometric tasks which were mainly based on examining speed, accuracy and fatigue, i.e. NEMA's first three indicators. These simple psychometric tasks reflect the skills and actions required for the more repetitive type of work, e.g. vigilance tasks directly reflect air traffic control skills. However, with the change in modern office work from simple, menial and repetitive tasks to more complex, creative and demanding ones, items 4 to 11 in NEMA's list are perhaps better indicators of increased performance.

In addition to NEMA's indicators being quite difficult to quantify, it is not clear how to combine them to represent the multi-tasking required in office work or how to account for other important skills such as decision making. Aronoff and Kaplan[2] propose that the greater the knowledge component of the work, the more difficult it is to develop reliable measures of productivity and, furthermore, they note that if the range of input and output factors is too narrowly defined then the resulting information tends to be unreliable and misleading.

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Table 2 Proposed measures of productivity[29]

1	Absence from work or from work-station; unavailability on telephone
2	Health costs including sick leave, accidents, injuries
3	Observed downtime, interruptions
4	Controlled independent judgements of work quality, mood etc.
5	Self-assessments of productivity
6	Component skills, task measures such as speed, slips, accuracy
7	Output from pre-existing work-groups
8	Total unit cost per product or service
9	Output change in response to graded reward
10	Voluntary overtime or extra work
11	Cycle time from initiation to completion of discrete process
12	Multiple measures at all organisational levels
13	Individual measures of performance, health, well-being at work
14	Time course of measures and rates of change

workshop to discuss how productivity could be assessed in the workplace. A list of 14 potential measures of productivity was produced (see Table 2). Unfortunately, many of the methods have practical problems associated with them. For example, it is easier to observe the time performing a task than to measure the efficiency at a particular task, so records of absenteeism and time at work may provide quantitative and unobtrusive means of assessing productivity. Nevertheless, observing down-time may be misleading as people could be away from work or their work-station simply because they are working elsewhere and behaviour such as staring out of the window for several minutes cannot always be considered wasted time as it may provide a sufficient break to allow a problem to be solved. Wyon[19] notes that 'most of them (ASHRAE's measures) have never been used as the dependent measure in controlled experiments on indoor climate, whether in the field or in the laboratory'. Furthermore, the definition of productivity established in the previous section shows that many of the measures on the list are actually performance indicators rather than measures of productivity.

ASHRAE does not specifically mention using objective, quantitative and unobtrusive measures of work output. These measures provide the most reliable source of data but only some types of work are suitable for providing such data. Examples are the number of insurance claims processed or enquiry queuing times, the number of contacts in telesales, key presses in word-processing pools, or the number of components produced in manufacturing companies. Researchers (e.g. Vernon[30]) have for some time used quantitative measures when examining factories and more recently several studies have been conducted in the offices of American insurance companies who had in-house objective measures of productivity, e.g. the number of insurance claims processed per day (see References 31–34).

Reducing staff turnover by incentives, such as a good working environment or career prospects, may be considered an improvement in productivity if the costs of recruiting and training new staff are higher than those of the incentives required to keep existing staff. For example, the MCG 1997 survey of private and public sector organisations[35] reports that the average recruitment cost is £775 per person but suggests that training costs in blue chip companies can be as high as one year's salary per recruit. In contrast, it has been suggested that increased staff turnover may improve productivity by stimulating the production of new ideas (innovation).

Guzzo and Bondy[20] suggest that 'there is no common, widely shared definition of productivity, consequently, there is no one best way of measuring a rise or fall in productivity'. In their review of 104 studies, and in Katzell et al's review[36] of 103 studies examining organisational issues, many different productivity measurements were made: sick pay, safety and accident records, disciplinary actions, backlogs, number of transactions, units serviced, monthly applications processed, key stroke rates, on-time completion of work, pass rate of exams, supervisor ratings, performance ratings, client complaints, peer ratings, personal appearance, idle time, hours per day performing required task, observed required behaviour, work load, cost savings, profit, overtime costs, operating expenses, sales figures, volume of business, interest on accounts and turnover. Guzzo and colleagues categorised these measures as those concerned with: (a) output including quantity/rate, quality/accuracy, costs/efficiency; (b) with-drawal including turnover, absenteeism and tardiness; and (c) disruption including accidents/safety, strikes, slow-downs and grievances. These measures are mostly performance indicators and tend not to be converted into financial savings to the company.

Jurison[24] argues that defining meaningful outputs is difficult for knowledge workers but nevertheless the outcome of the service offered could be measured. For example, the quantity of output or desired results, such as the number of products produced, number of reports prepared, number of contracts negotiated or number of customers visited, could be computed. These measures can then be compared with the input or resources, e.g. labour hours, capital equipment, supplies, materials. He finishes by suggesting accounting for quality by defining output in terms of products meeting quality standards.

Similarly, Ghobadian and Ashworth[37] found that the output of service sector organisations is intangible, heterogeneous, ill-defined and subject to a wide band of quality variations. They studied three separate organisations and for each one measured the input (resources), output (service produced) and the impact (what is achieved) by producing a set of performance indicators for each. They comment that the precise measurement technique was different in each organisation but nevertheless it was possible to develop a set of performance measures. Ghobadian and Ashworth also distinguish between efficiency (the ratio of input to output) and effectiveness (the impact) and note that companies may be interested in only one or both of these measures of productivity. Salemme,[38] too, emphasises the need to shift from measuring output to impact of output, e.g. customer satisfaction. He also encourages using a family of performance indicators e.g. errors, rework, usefulness to customer.

Pritchard et al[22] describe the development of their productivity measurement and enhancement system (ProMES). The system involves establishing the level of performance expected to meet the job duties (outputs) and then weighting the job duties for importance; these weightings are termed contingencies. So they do not just measure the product/output, but develop objective indicators of how well each output is accomplished. The stages of the system are to (a) identify salient products, (b) develop performance indicators of these products, (c) establish contingencies (weightings) and (d) put the