

Invited Review Paper

Towards an Environmental Psychology of Workspace: How People are affected by Environments for Work

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Received 31 March 2008; accepted 29 April 2008

Abstract: Inquiry into how people experience environmental conditions at work is a growing area of study. Until the 1980s, there was insufficient research on 'workspaces' –and on office environments in particular – to warrant review. Since that time, the range and number of studies of workspace have burgeoned. This paper will identify and review the main themes and findings of this area of research with the objective of defining basic parameters and prevailing theories of the environmental psychology of workspace. These will generate questions and directions for future research

Keywords: Ambient environmental conditions, Ergonomics, Functional comfort, Furniture, Health and safety, Office buildings, Office layouts, Productivity, Satisfaction, Territoriality, User participation, Workspace

Introduction

Evidence from commercial leasing agents, office furniture manufacturers the design professions and building contractors indicates that some new knowledge is finding its way into the real estate industry as commercial building owners and tenants demand better quality workspaces for their employees. Until recently, the design of office buildings adhered to a 19th Century model of work (Duffy, 1997). Workers who are asked to perform rather than to think, who are brought together in space and time so that they can be supervised, so that they have access to necessary tools, and so that there is a clear barrier between work and their other activities, occupy standardized and often uniform workspace. Formerly in the form of factories, contemporary workspace is more likely to be in the form of offices, and reducing occupancy costs is a key driver of design decision-making (Vischer, 2007a). With the changes in the 21st Century world of work, few of these conditions are still valid. Tools for work have radically changed, and advances in computers and tele-communications mean that people no longer need to be fixed in space and time to work together. Barriers between work and personal life are breaking down as people seek career opportunities rather than

jobs, work at all hours, make a social life at work, and sleep and eat at work if necessary. What may now be called *workspace*¹ is diversifying, mobile work and non-territorial workspace is increasing, and companies are applying quality as well as cost criteria to workspace design (Becker & Kelley, 2004; Preiser & Vischer, 2005).

As part of these changes, conceptualization of the environments for work is shifting from the notion of workspace as a backdrop – that is, passive setting – for work, to the concept of workspace as an active support to – and tool for – getting work done (Newsham, 1997). One of the results of this shift is the growing interest in how building occupants behave as a function of workspace features. As the research reviewed in this paper suggests, evidence is mounting that employees may waste time and energy trying to cope in poorly designed workspace and that employers are increasingly concerned that their employees invest their energy in work and relationships rather than in coping with adverse or uncomfortable workspace conditions. In reviewing some of the knowledge accrued to date on how workers interact with and are affected by environmental

¹ I have always tried to avoid using "office" or "offices" in titling any of my work, books or articles. I find the word limits the notion of the diversity of work spaces and only inspires yawns. People think of boxes with windows or partitions. "Office" is in my view a dated concept. I use *workspace* because the domain of study includes all types of space in which people do work. While much of the research has in fact been done in office buildings, the broader concept of "workspace" includes places to meet, to use technology, public spaces where work occurs, amenities to support work, and so on, as well as office-type workspace in places like hospitals, universities and numerous other contexts.

features, this paper groups findings from workspace research according to, first, the aspect of workspace studied, and second, to the type of outcome measure or research result identified. Thus, the environmental aspects of workspace include ambient environmental conditions (noise, lighting, air quality, thermal comfort), furniture layout and ergonomics (workstations, offices and shared amenities), and process issues, such as user participation in design, and meeting business and organizational objectives. Behavioral or outcome measures common in work environment research include employee satisfaction, employees' feelings about their work environment as expressed in the sense of territory, ownership and belonging, and employee productivity. Most work environment studies can be organized into the typology identified in Table 1.

Linking the satisfaction and productivity categories is the notion of comfort, specifically functional comfort. A three-way definition of the concept of comfort has been applied to numerous field studies of office buildings; it posits that

people need to be more than simply healthy and safe in the buildings they occupy, they need environmental support for the activities they are there to perform (Vischer, 1996). This notion of functional comfort goes beyond the more traditional concept of comfort based on measurements of users' responses to varying environmental conditions. The latter may focus, for example, on temperature and relative humidity for thermal comfort, air speed and freshness for ventilation comfort, and brightness, contrast conditions and luminance for lighting comfort (Cheng & Ng, 2006; Odemis, Yener & Camgoz, 2004; Ozturk, 2003; Rowe, 2004). The results of many comfort studies, using feedback from occupants as well as sensitive environmental measuring devices, form the basis for environmental standards in public buildings. The concept of functional comfort, however, links the psychological aspects of workers' environmental likes and dislikes with concrete outcome measures such as improved task performance and team effectiveness.

Table 1: Proposed Typology of Research on the Environmental Psychology of Workspace.

	Satisfaction	Territoriality and belonging	Productivity
Ambient environmental conditions	Do people <i>like</i> the lighting, noise levels, IAQ, and thermal comfort.	How do conditions such as daylighting and natural ventilation, as well as local controls over interior conditions affect the way people feel (appropriation, commitment) about their work and workspace?	Do changing environmental conditions help people work better or faster?
Furniture and office layout	Do people <i>like</i> their furniture, location, access to meeting-rooms and on-site services.	How do moves, changes and other reconfigurations of workspace affect people's feelings about territory, their sense of privacy, and their social status?	Does changing furniture, layouts, the location of equipment, meeting-space, bathrooms et cetera help people work better or faster?
Process issues (e.g. user participation)	Do people report more satisfaction with the work environment if they have been involved in space-related decisions?	How does involving workers in making decisions about their workspace affect their feelings of ownership and belonging, and increase employee loyalty?	Do environments designed to meet organizational goals and objectives have a positive impact on the company's 'bottom line'?

How workspace is designed and occupied affects not only how people feel, but also their work performance, their commitment to their employer, and the creation of new knowledge (human capital) in the organization. These are the cornerstones of the domain known as the environmental psychology of workspace (Vischer, 2008). Moreover, measures of user perceptions of environmental conditions can be used to diagnose building performance and the effectiveness of building systems (Vischer & Fischer, 2005). The focus of this paper, then, is on the behaviour of building occupants, behaviour in this context being a broad term covering not only people's actions and responses but also attitudes, feelings, expectations, values and beliefs. In this context, it is useful to think of the user-environment relation as dynamic and interactive: that is to say, that part of the user's environmental experience includes the consequences of any user behaviour that may occur. The user is not a passive receptacle experiencing the built environment statically, as input; the user's experience of the environment is itself transformed by the activities she is performing in that environment: the relationship might better be characterised as transactional (Moore, 1980; Vischer, 2008). This paper will review research results clustered into three broad categories of user satisfaction and functional comfort, territoriality or sense of belonging, and productivity, and will indicate how these results have practical applications to design, construction and management of buildings in which people work.

Satisfaction and Functional Comfort

How satisfied or not users are with the space they are occupying is a notion that has guided environmental evaluation since its earliest efforts (Craik, 1966; Friedman, Zimring & Zube, 1978; Little, 1968). It refers to the processes whereby users know and judge their physical environment. The basic premises state that the processes of environmental knowing and assessing are linked not only to observable physical features, but also to the attitudes individuals have towards a particular space. Evaluation research, such as post-occupancy evaluation, seeks to determine the extent to which certain environmental characteristics affect users' satisfaction or dissatisfaction; they have been carried out in office environments since the 1980s (Marans & Spreckelmeyer, 1981; Ornstein, 1999; Stokols, 1978; Wineman, 1986).

The earliest post-occupancy evaluations of offices used extensive survey questionnaires of building users to identify what what occupants 'like' and 'dislike' about their work environment, on the assumption that measuring users' self-rated satisfaction with individual features helps to understand the effects of the built environment on users. Studies of occupant satisfaction imply that this concept is a *de facto* measure of building quality: users feel positive (satisfied) about good quality built space, whereas if they are 'dissatisfied' the place is not performing or has somehow failed. Studies of users' satisfaction levels in offices have generated extensive knowledge of workers' preferences but relatively little additional understanding of building performance. Most post-occupancy evaluations question occupants on their perceptions and judgments of workspaces in terms of the "perceived qualities" of the place. Evaluation in this sense includes two essential elements: the functional characteristics of the space that lend themselves to measurement, and are considered factors

influencing the performance of workers; and the qualities of a place that cause users to consider it satisfactory or unsatisfactory. Thus, surveys of occupant satisfaction in specific buildings indicate which features are preferred and which are disliked by occupants (Walden, 2005; Windsor, 2005).

One of the most consistent findings from user surveys is that office workers are dissatisfied with the 'open plan' office, whether this is due to noise levels, distractions, lack of privacy or the sameness of 'cubicles' (Churchman, Stokols, Scharf, Nishimoto & Wright, 1990; Hedge, 1986; Oldham, 1988; Sommer & Steiner, 1988; Sundstrom, Herbert & Brown, 1982). However, the prevalence of this finding has not prevented employers from favouring the open plan - in part because it is cheaper to construct and more flexible to reconfigure than a conventional private or cellular office layout, and in part because workstations occupy less square feet than private offices. A more useful question to ask is to what degree are workers supported in the performance of their tasks in open workstations - in other words, to what degree is their ability to work affected? Studies show that, on the positive side, open workstations facilitate communication and enable workers to exchange information rapidly and informally. On the negative side, the open environment can generate distractions that prevent workers from concentrating on their tasks.

A large number of work environment studies have tested users' satisfaction in reference to specific workspace features (Becker, 1981; Brennan, Chugh & Kline, 2002; Hedge, 1991; Humphries, 2005; Veitch, Charles, Newsham, Marquardt & Geerts, 2004). These studies show that people's preferences are affected by, among other things, indirect lighting, mechanical ventilation rates, access to natural light, new furniture, and aspects of the acoustic environment, as well as some degree of participation in decision-making. According to this approach, environmental satisfaction is implicitly a measure not only of workspace effectiveness or success, but also of job satisfaction, in spite of the lack of proven connections between them. As a result, occupant satisfaction has become the main yardstick by which workspace features are evaluated, with many studies falsely assuming a direct link between users' level of job or workspace satisfaction and their effectiveness or productivity (Karasek & Theorell, 1990).

Some studies have gone beyond the simple 'if-then' logic of how satisfaction is affected by physical features to developing an approach to environmental evaluation that is more responsive to the concept of place as an interactive system composed of both physical and social elements. This model posits space as a resource in terms of its inherent potential to make any social system function (Moos, 1973; Perin, 1970; Thiel, 1997). In applying this approach to work environment evaluation, researchers have examined links between workspace design and the organization of work, and attempted to demonstrate ways in which space can be considered an organizational resource (Fischer, 1983; Fischer & Vischer, 1998; Kampschroer & Heerwagen, 2005; Seiler, 1984).

The concept of functional comfort links users' environmental assessments of their environment to the requirements of the tasks they are performing; this goes beyond general findings on what people like and dislike, and towards assessing building performance (Vischer, 1989, 1996, 1999). It was developed

to respond to the limitations of measuring user satisfaction by applying feedback from users to the performance of building systems. While building users' physical comfort refers to meeting the basic human needs, such as safety, hygiene and accessibility, without which a building is uninhabitable, functional comfort is defined as environmental support for users' performance of work-related tasks and activities. Appropriate lighting for screen-based work, ergonomic furniture for computer users, and enclosed rooms available for meetings and collaborative work, for example, help ensure users functional comfort at work.

The difference between a supportive and an unsupportive workspace is the degree to which occupants can conserve their attention and energy for their tasks, as opposed to expending it to cope with adverse environmental conditions. For example, certain variables such as lighting, ventilation and noise can, under certain conditions, generate stress, which, in turn, has a negative effect on productivity (Evans & Cohen, 1987). This is further discussed, below. The obverse of this argument holds that an environment conducive to the performance of work improves performance and morale (Dewulf & Van Meel, 2003).

The functional comfort approach makes human judgements the focus of study, thereby avoiding the temporal and calibration limitations of instrument-based data collection. However, researchers may take measurements of building systems performance as a follow-up procedure to help understand the meaning behind the feedback yielded by users on their perceptions of building conditions. Traditionally human comfort measurements have been linked to individual building systems (lighting, ventilation, temperature) in order to enable standards of comfort and health to be established, and thus to guide the design of buildings. Functional comfort is defined by the degree to which workers can perform their tasks in the place they occupy; it is derived from notions of comfort as defined by environmental standards, with the added precision that users' experience of comfort varies with the requirements of the tasks they have to perform. Therefore, one of the outcome measures of diagnostic evaluation of functional comfort is whether people can perform tasks easily, with difficulty, or not at all in the workspace occupied. The diagnostic approach was designed to learn more about how people work and how space affects work performance, as well as to understand the impact of changing office technologies on the performance of work and on space-use. Data on users' functional comfort provide a diagnostic yardstick for designers, planners and managers; systematic and reliable feedback from occupants takes the form of a simple, accurate profile of user comfort in a given work environment. This approach yields a more precise definition of how workers are affected by their space than users' satisfaction ratings.

Balancing environmental demands with the skills and abilities of users to act on their environment is a way of defining optimal workspace for creativity and flow (Csikszentmihalyi, 2003). The concepts of positive stress (Selye, 1979) and of environmental competence (Lawton, 1980; Sternberg, 2001) are both useful in this context, in that they recognize that some environmental challenge is necessary to ensure active engagement. A workspace cannot be designed to be a one-time, final, and permanent ergonomic support for all office tasks, but rather needs to be

adaptable and 'negotiable' to be most supportive to users. Users need the skills and opportunities to engage with and adjust their environment successfully, over time and with changing task requirements, in order to optimize comfort and manage workspace stress successfully (Vischer, 2007b).

Territoriality and Belonging

Several studies identify a sense of belonging (appropriation), along with loyalty or commitment to the organization and a sense of territory, as outcome measures of environmental studies because a sense of belonging or ownership is a better measure of environmental quality or success than either satisfaction or effective task performance (Fischer, 1983; Sundstrom & Sundstrom, 1986). Unlike user satisfaction, sense of belonging is linked to employee commitment to and retention in the organization – results that have a direct effect on company operations and costs. Territoriality at work goes beyond the physical attributes of spaces occupied by individual workers (Davis & Altman, 1976). The sense of ownership, or occupying territory, is affected by how team and shared workspace is defined, as well as characteristics of individual workspace. It is also affected by participation in design decisions and feeling 'empowered' in regards to environmental decision-making. Users' experience of territoriality, control and appropriation combine as 'psychological comfort': one of three types of environmental comfort according to which the users' experience of workspace can be organized (Vischer, 1996; Vischer, 2005). *Physical comfort* refers to basic human needs such as safety, hygiene and accessibility, which must be assured – usually through applying existing building codes and standards – so that users find their environment habitable. *Functional comfort*, as mentioned previously, refers to the degree to which their environment supports users' tasks. At a more abstract level but equally important to users at work is *psychological comfort*, including feelings of belonging, ownership and control over the workspace (see Figure 1).

Psychological comfort links psychosocial aspects of the worker with the environmental design and management of workspace through territoriality, privacy and environmental control (Vischer, McCuaig, Nadeau, Melillo & Castonguay-Vien, 2003). The primary component of psychological comfort is sense of territory, both individual territory (office, workstation, micro-workspace) and group territory (team, group, midrange workspace). Human territory at work has psychological value that is represented both by space for one's work and by one's place in the organization. Underlying these is a human behavioral schema that expresses itself in terms of the personalization and appropriation of space: marking territory and constructing boundaries of social and environmental control (Fischer, 1989; Sundstrom, Town, Brown, Forman & McGee, 1982). Territorial ownership affects employees' interaction with the environmental milieu (Steele, 1986). Workspace personalization and space appropriation behaviors have become more noticeable in offices where denser and more open office configurations have been installed (Wells & Thelen, 2002). The introduction and use of new technology and better virtual communications tools have also affected workers' perceptions of and attitude towards their physical environment and workspace (Cascio, 2000; Lai, Levas, Chou, Pinhanez &

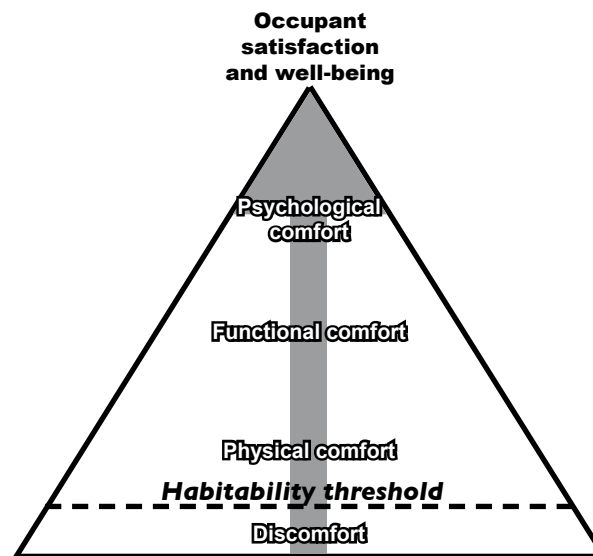


Figure 1: Environmental comfort model of workspace quality.

Viveros, 2002). Territory is not simply made up of the walls and doors that enclose space; territoriality at work is also affected by sense of privacy, social status and perception of control.

Studies have found that people moving out of private enclosed offices into open workstations judge their environment more negatively, citing lack of privacy, acoustic conditions, and confidentiality problems (Brennan, Chugh, & Kline, 2002; Rishi, Sinha & Dubey, 2000). These reasons are given irrespective of whether or not their work is confidential, and whether or not they need to be alone to perform tasks effectively. Complaints about lack of privacy abound in before-and-after studies of workspace change, independent of physical features of the workspace such as furniture configuration and partition height (Wineman, 1986). On the other hand, data collected from professionals in open workstations who were not faced with an imminent or recent move indicated that the demands of the job are more important than individual privacy (Kupritz, 1998). The need for privacy seems to be only indirectly related to workspace design and to depend on psychological factors, such as concerns about status and control.

Environmental control – and users' *perception* of control – affects workers on at least two levels: mechanical or instrumental control, and empowerment (Vischer, 2005). Experimental efforts to increase users' control over environmental conditions provide evidence of beneficial effects on workers, including one experimental design that found a clear association between participation in design decisions and degree of workplace satisfaction following a move to a new facility (Niemala, Rautio, Hannula & Reijula, 2002). Environmental control can be mechanical, such as chairs and worktables that are raised and lowered, shelving and tables on wheels to be moved around, switchable lights, and a door to open and close. Evidence indicates a positive psychological impact from this type of control in situations where employees are informed and even trained to make use of the controls available (Newsham, Veitch, Arsenaault & Duval, 2004; Tu & Loftness, 1998). Another form of environmental control is empowerment: increased opportunities for employees to participate in workspace decision-making. Access to such opportunities increases users'

perceptions of having some control over their environment and is a constructive response to the need for psychological comfort. This helps people cope with environmental demands and encourages workers to find new ways of solving environmental problems, so that they also increase their learning and knowledge about their building and workspace. Empowerment as a form of environmental control increases opportunities for employees to both participate in and be listened to in workspace decision-making, and means they are better informed. Lack of control over workspace has been described as demotivating and leading to 'learned helplessness' (McCoy & Evans, 2005). Several studies demonstrate that psychosocial control by means of user participation in the design process has a positive effect on people's response to and feelings about their workspace (Lee & Brand, 2005; Veitch & Newsham, 2000). Environmental empowerment is directly linked to psychological comfort. People who are informed about workspace-related decisions, and who participate in decisions about their own space, are more likely to feel territorial about their workspace and to have feelings of belonging and ownership (Vischer, 2005).

Thus notions of appropriation and belonging are psychosocial aspects expressed through territoriality at work. A sense of territory is associated with feelings of belonging and ownership, and privacy is best understood as the need to exercise control over one's accessibility to others (Altman, 1975). Finally, some studies have demonstrated a connection between users' psychological traits and their reactions to the built environment at work. In focusing on cognitive processes, this research orientation links up with a well-established paradigm of social psychology, namely Lewin's field theory (1951). It addresses the effects of users' individual differences and how workers' evaluation of their workspace affects their perception of themselves at work (Somat, Tarquinio & Dufresne, 1999). Not only do employees' cognitive and affective processes affect their perception and evaluation of their work environment, but their perception and assessment of their workspace also affect their view of themselves as workers and of their professional effectiveness (Fischer, Tarquinio & Vischer, 2004). A study comparing open with enclosed office users showed that

extraverts respond more positively to more possibilities for communication, and therefore do better in open office settings than workers with more introvert personalities (McCusker, 2002).

Productivity and the Performance of Work

Many studies have sought to make direct links between the environmental design of workspace and worker performance or organizational productivity.² The concept of '*workplace performance*' has come to mean workspace whose explicit objective is to support the performance of work: a performing workplace is designed to optimise worker productivity (Clements-Croome, 2006). The concept of worker productivity tends to be applied to a whole range of desired behavioural outcomes in the context of work. A recent review of studies of the effects of environment on productivity concluded that confusion about what productivity means has made it difficult to identify how environmental conditions affect worker performance (CABE, 2004). Many studies use respondents' own self-reports of 'improved' or 'reduced' productivity as the dependent variable, and studies measuring 'real' or quantifiable output per worker or team are few and far between (Oseland, 1999).

There are at least three types of productivity that are influenced by environmental design, each of them in different ways.³ These three categories are individual, group, and organisational productivity: each category denotes a variation in scale of environmental influence (Vischer, 2006). Individual productivity is typically evaluated at the scale of the individual workspace (desk and office) and on how the micro-environment influences individual task performance, that is to say, how fast and accurately a worker carries out his tasks at work. Individual task performance is affected by environmental conditions such as lighting and visual conditions, variations in temperature and humidity, furniture ergonomics, and, to some degree, acoustics. Positive individual productivity outcomes mean improved speed and accuracy of the tasks performed, whereas negative outcomes might include a higher error rate, slower time for task completion, or adverse health effects on workers, such as sore eyes, fatigue or upper respiratory problems.

The productivity of workgroups sharing workspace, such as a teamwork environment, is typically evaluated in terms of the quality and quantity of group processes. Teamwork is affected by the mid-range environment, that of the work-group or team, and it is measured in tangible terms such as time to market of a new product, or in terms of more qualitative outcomes, such as number of good new ideas or good (i.e. successful) recommendations coming out of effective business processes. Group process is affected by workgroup size and the relative proximity of team members (Leaman & Bordass, 1998). Other

environmental determinants of workgroup effectiveness include the positioning of work areas and shared space, as well as access to shared tools and equipment (Heerwagen, Kampschroer, Powell & Loftness, 2004).

A third level of productivity corresponds to the company or organization's entire workspace or accommodation – the macro-environment. There are many approaches to assessing the degree to which workspace helps (or fails to help) a company meet its business objectives and/or increase its competitive advantage. Organisational effectiveness is affected by locational advantages and ease of access, balancing consolidation under one roof (centralisation) with dispersion of different groups in different facilities over manageable distances, and by building amenities such as fast elevators, convenient bathrooms, adequate parking, and attractive eating areas (Vischer, 2006). Studies have shown that both worker performance and organisational success is compromised "when the physical environment interferes with actions taken towards achievement [of objectives]" (McCoy & Evans, 2005).

Tools exist to measure environmental impacts on productivity in each of the three categories. Individual productivity is the most often measured, using various tools for ergonomic analysis as well as a wide variety of questionnaire surveys that focus on the effects on building users of ambient conditions as lighting, noise levels, furniture comfort, temperature, and indoor air quality. Team effectiveness studies tend to be more dependent on anecdotal data, although indirect measures such as analysis of social networks, 'gaming', and comparing outcomes among comparable workgroups in different environments, have also yielded valuable results (Horgen, Joroff, Porter & Schon, 1999; Stephenson, 1998). A recent review of four of the most popular methods for evaluating organisational effectiveness concluded that none is entirely satisfactory, as this is an elusive concept to define and measure (Bontis, Dragonetti, Jacobsen & Roos, 1999). However, some researchers have been successful adapting the Balanced Scorecard to measure environmental effects on organisational effectiveness (Kampschroer & Heerwagen, 2005).

The BOSTI-Westinghouse study was an important advance, which attempted to link environmental features not just with levels of satisfaction, but also directly with functional support to individual workers (Brill, Margulis & Konar, 1985). This longitudinal study examined employee behaviour before and after an office move and attempted to measure the costs of worker productivity lost through poorly-designed or dysfunctional workspace; it used employee self-reports of productivity to measure the impact of features like open office design on task performance. The results showed, among other things, that employees, especially managers, working in open plan workstations felt they were more productive in enclosed

² The editor has suggested that these relations might best be conceptualised as a model of workplace environmental design factors (eg, ambient environmental conditions, furniture and office layouts) as independent variables, with productivity as the ultimate dependent outcome variable and satisfaction, territoriality and belonging, as mediating variables. This is an interesting line of inquiry that deserves further consideration.

³ There are numerous studies of how age, gender, SES and job-rank affect workers attitudes, performance and effectiveness in the work environment, but very few use the term 'environment' to refer to the physical setting. Consequently, most of this research is published in the industrial and occupational psychology literature and is not included in this review. However, it would make an interesting addition to our research to study this literature and develop some hypotheses of how these function as moderating variables in the user-space relationship at work. See, for example, the review by Gifford (2007) and the role of moderating variables in a different architectural setting.

offices. Subsequent studies have attempted to measure the economic value of workers' productivity increases that are considered to result from environmental improvements, such that the return on investment of an environmental intervention can be calculated (Brill & Weideman, 2001; Sullivan, 1990). At about the same time, an overview of studies measuring the impact of furniture and layout changes on teams working on assembly line-like paper processing tasks in different organizations indicated extraordinary increases in process speed and results (Springer, 1986). These findings are reminiscent of the changes in task performance found in the 1940's in the famous Hawthorne studies of lighting in factories, suggesting that any environmental change improves team performance regardless of its actual effect (Adair, 1984). More judiciously, several studies conclude that workspace design can be supportive (have positive effects on work) or non-supportive (have negative effects on work) as well as affecting organizational performance (Davenport & Bruce, 2002; Ilozor, Love, & Treloar, 2002; Klitzman & Stellman, 1989; Stallworth & Kleiner, 1996). The domain of organizational ecology is a framework for analyzing organizations according to different aspects of their structure and function, including features of the workspace they occupy (Steele, 1973). The systems framework of organizational ecology strengthens the notion that the space it occupies is an integral part of how an organization functions. Later work has built on this concept, producing such ideas as '*workscape*' to indicate an inclusive approach to both the use and the planning and design of the work environment (Becker & Steele, 1994).

An increasing number of ergonomically oriented studies have looked at specific environmental conditions, such as ventilation and indoor air quality, lighting and daylighting, acoustics and noise control, as well as furniture placement and comfort. In these studies, environmental effects on task performance, rates of absenteeism and self-reported productivity are measured rather than users' satisfaction ratings. Lighting research, for example, has tended to distinguish between the effects on building occupants of artificial, interior lighting and of natural light or daylighting from windows. Daylighting research has linked increased comfort and self-reported productivity with window size and proximity, as well as with view out, control over blinds and shielding from glare (Hedge, 2000; Leather, Pyrgas, Beale & Lawrence, 1998; Mallory-Hill, Van der Voost & Van Dortmont, 2005). More significantly, research on daylight and views from hospital rooms has been shown to affect medication requirements and recovery rates (Verderber & Reuman, 1988; Ulrich, 1991). In their recent overview of the effects of different kinds of artificial lighting on task performance and occupant satisfaction in a simulated office environment where workers used controls to exercise their lighting choices, (Boyce, Veitch, Newsham, Myer & Hunter, 2003) concluded that current office lighting standards are preferred by most people carrying out typical individual office tasks, Boyce *et al.* The study results made a distinction between visual comfort – lighting needed to perform well on office tasks – and satisfaction, or lighting judged to be aesthetic.

Current studies of noise in offices have adapted techniques for measuring noise levels in industrial environments. Workers

in open plan workspace tend to judge noise to be a primary source of discomfort and reduced productivity (Stokols & Scharf, 1990; Mital, McGlothlin, Faard, 1992). Acoustic comfort studies have focussed on correlating physical measures, such as signal-to-noise ratios at different densities, background noise levels and intensities, and speech intelligibility under differing physical conditions, with occupant judgements of distraction and annoyance (Ayr, Cirillo & Martellota, 2001; Chu & Warnock, 2002). Efforts to control office noise through more absorbent surfaces, sound-masking systems and behavioural controls have been weakened by increasing office densities and collaborative work in modern workspace.

Studies focussing on floor layouts and furniture suggest these factors influence teamwork effectiveness as well as individual task performance (Vischer, 2006). Studies focus on the height and density of workstation partitions, the amount and accessibility of file and work storage, and furniture dimensions such as work-surfaces. These elements of furniture and spatial layout have a powerful effect not only on the satisfaction of individual workers but also on the performance of teams. One study indicated that the additional investment in ergonomic tables and chairs for workers, as well as ergonomic training, yielded a 5-month payback in terms of increased individual productivity (Miles, 2000). Several studies provide evidence that office workers are uncomfortable in open plan configurations and prefer private enclosed workspace, which may work better for individual tasks but are less successful for teamwork (Hatch, 1987; Fried, Slowik, Ben-David & Tiegs, 2001; Ornstein, Andrade, Coelho & Leite, 2005).

Evidence is mounting that the design of their workspace does make workers more or less effective. However, finding out more about how this relationship works should not lead to 'social engineering' solutions, where employers or building owners apply a recipe for environmental design with a view to guaranteeing maximum performance from their workers. It is preferable for employers and decision-makers to use research evidence to consider environmental design decisions as investments in the work force. Workspace can and should be a tool for performing work, much as investing in computer technology ensures better tools for employees.

Discussion

While much of the research on which norms and standards for user health and comfort at work are based has been carried out in laboratory settings, the most frequent approach to studying how workspace affects users is questioning the latter directly. This may take the form of experimental designs in controlled laboratory settings, where an environmental condition is varied and subjects provide ratings, as well as in quasi-experimental settings, such as controlled field situations where building users' assessments are compared before and after some environmental change. More commonly, survey research is applied in uncontrolled field situations, either in the form of eliciting satisfaction ratings as in a conventional post-occupancy evaluation, or using a standardised survey questionnaire in order to compare the same data from subjects across a number of buildings. A variety of field-tested tools and techniques to study workspace behaviour has been developed in this latter category.

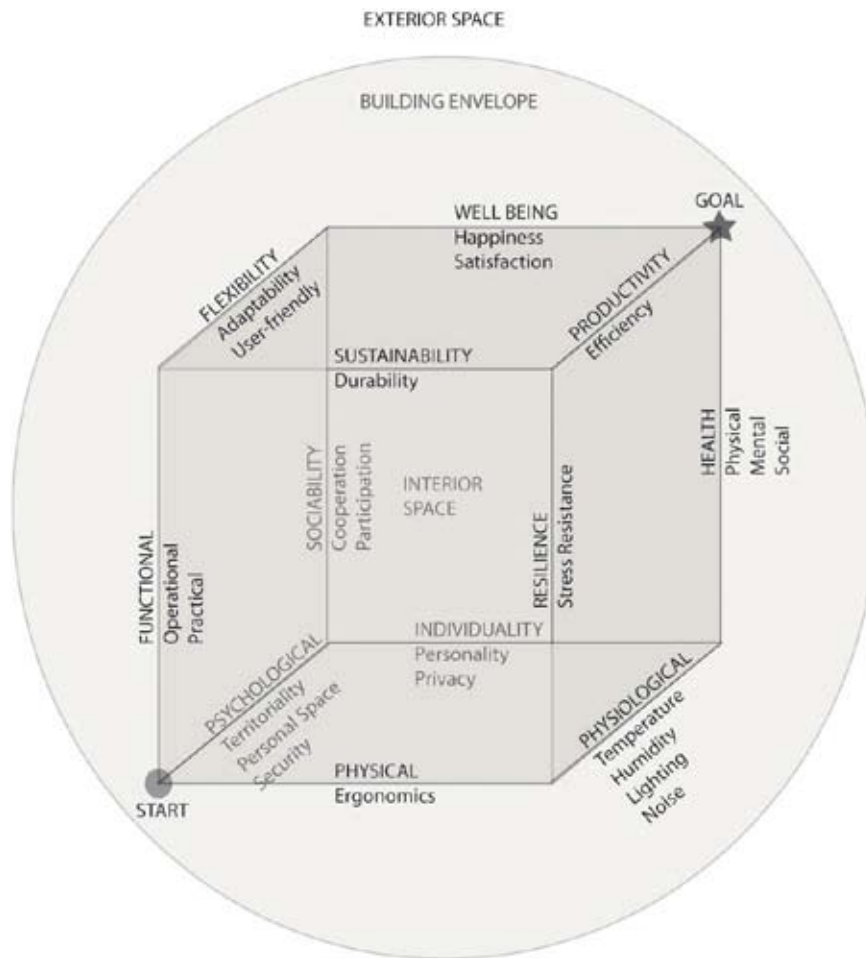


Figure 2: Dimensions of functionally comfortable workspace design.

The structure and form of the way users are approached and the data they are required to yield needs to be precise and standardised to link user feedback with building performance. The results yielded by this approach provide a rich and diverse basis for understanding the user experience (Gann & Whyte, 2003; Leaman & Bordass, 2001; Vischer, 1989, 2005; Zagreus, Huizenga, Arens & Lehrer, 2004). Data yielded by assessment tools, whether in the context of post-occupancy evaluation, design and environmental quality indicators, or building-in-use assessment, can be analysed both for what they tell us about building use as well as about building performance. These field tools are a natural outgrowth of early studies on the sociology of work, of which a few included the physical setting for work. Of these, the most important, and still salient today, is Herzberg’s analysis of factors that influence worker motivation. His research established that several key elements of the work environment influence worker motivation, and they can be negative, positive or neutral (Herzberg, 1966). Among these elements is the physical environment, which can be either a neutral or a negative influence on worker motivation. This implies that if it is supportive of the performance of work, it is not noticed. The ‘threshold effect’ means that those work conditions that affect motivation can be measured in terms of their propensity to move from a neutral, ‘no effect’ category into ‘negative effect’; there is no ‘positive effect’ category.

Building on this theoretical base, and in line with the results of functional comfort studies, researcher attention is being increasingly paid to the concept of workspace stress. Functional comfort links psychosocial aspects, including worker motivation, with workspace elements and thereby with organisational productivity by measuring environmental support for task performance. The notion of support incorporates not just receiving support from, but also being able to act on the environment to achieve a desired, supportive result. The inverse is also true: where workers’ have to struggle to perform their tasks because the built environment is problematic, their situation can be characterised as stressful. In situations where workers do not feel supported, and indeed have to make an extra effort to ‘deal’ with environmental barriers or problems in order to get their work done, they may lose motivation and experience stress. The definition of workspace stress is the degree to which users have to compensate and expend their own energy performing activities in adverse environmental conditions (Vischer, 2007b). All built environments for work can be placed somewhere on the continuum ranging from completely functionally comfortable to completely dysfunctional and stressful, using feedback from users at a given point in time.

In their overview of stress related to the physical work environment, McCoy and Evans (2005) go beyond ergonomics

to characterise as stressful those situations where elements of the physical environment interfere with the attainment of work objectives. Stressors in the work environment affect employee performance adversely when they are high intensity or prolonged; they slow down the individual's ability to process and understand the number and predictability of 'signals', which increase with task complexity. Potential stressors (i.e. elements that interfere with task performance, motivation and social relationships) include "spatial organisation, architectonic details, ambient conditions and resources, and view or visual access from the workspace. As environmental stressors, [these] can influence physiological processes, produce negative affect, limit motivation and performance, and impede social interaction". These physical stressors in the workplace affect workers' sense of control and effectiveness. Physical environmental stressors also affect social relationships, as the negative effects of stressor exposure reduce "cooperative behaviors, such as social support, altruistic behaviors, and teamwork" (Evans & Cohen, 1987).

Thus in addition to satisfaction, comfort and belonging, the environmental psychology of workspace also includes well established concepts such as worker motivation and how it is influenced by the physical setting, and, more recently, the notion that some measurable amount of stress at work can be attributed to the design of the physical environment. A comprehensive environmental comfort model of workspace quality that incorporates these and other factors is shown in Figure 3. More research is needed to link these concepts together and provide a solid theoretical framework for advancing knowledge through future research.

Conclusions and Directions for Future Research

While considerable knowledge has accrued from studying various aspects of the environmental psychology of workspace, important gaps remain. The structure and content of this area of research have given rise to some new and important questions that are fruitful directions for future research. Before exploring these new directions, we will comment on the development of this field of knowledge to date with a view to strengthening the theoretical framework and lending greater coherence to knowledge already acquired.

By comparing research studies looking at different aspects of the work environment, the lack of clarity about outcomes being measured shows that clarification is needed to guide future research. Occupant satisfaction, while offering a broad and comprehensive measure of environmental quality, is not a practical outcome measure for workspace research. While occupants' self-reports provide data on their needs and preferences, such studies generate little information about what supports task completion, what adds value to the organisation, and why owners and managers should invest in workspace improvement. However, much has been learned about what workers like and dislike in their work environment.

Functional comfort, as measured through systematic feedback from users, invites occupants to provide diagnostic feedback on specific features of the work environment based on what environmental supports they need to perform their tasks. Decisions to remove, replace or change workspace features can be based on how well or not they support

occupants' work and thereby affect the productivity of the organisation. Structured feedback on ambient conditions can also be applied to assessing building systems, and subsequently used to diagnose building problems that are amenable to intervention and improvement. However, a clearer distinction needs to be made between measuring user perceptions and judgements, and measuring actual behavioural effects that are attributable to physical features. For example, workers' perceptions of team workspace (e.g. meeting-rooms and worktables) may not be related to whether or not teamwork behaviour occurs.

Productivity has also been measured largely in terms of occupants' self-reports. These are subject to more subjective bias than satisfaction ratings, as respondents are being asked to make an estimate based on their own feelings. However, there are some studies where more objective productivity indicators such as reduced illness rates, increased speed and accuracy of task completion, and even rate of new ideas generation, have been used as measures of environmental effectiveness in terms of productivity outcomes. A new and little explored outcome measure concerns the effect of the work environment on the creation and transmission of knowledge in organisations (Von Krogh, Nonaka & Nishiguchi, 2000). Many companies are interested in understanding how knowledge accrues in their organisations and how this process can be optimized. The concept termed '*ba*' – an environment that supports and encourages knowledge creation, not only through the design of the space but also through the structure and operations of the social and cultural environment – is now a focus of research. To date, human capital researchers have focused on developing a better understanding of *ba*. This offers a new and promising direction for analyzing how features of the work environment add value to an organisation's human capital (Nenonen, 2004). Although the concept of *ba* is only partly definable in physical terms, it would be useful to learn more about how physical settings encourage and support it.

In summary, a rich range of measures of worker productivity is available, and more diversity is needed to advance this line of inquiry. As these new directions for workspace research indicate, worker productivity in the knowledge economy is less a matter of improving speed and accuracy of routine tasks and increasingly a function of generating new ideas, being creative, working effectively in teams, and generating knowledge that adds value to the organisation.

Finally, the feeling of belonging, as might be measured through territoriality and appropriation of space, needs further study owing to the important link with employee retention and reducing costly turnover in organisations. More information about how and why certain environmental features affect employees' sense of belonging and support constructive appropriation behaviours will help organisations determine how and to what degree investment in environmental quality will affect both recruitment and retention of their employees.

In recent years, as the real estate and construction industry shifts its attention to sustainability and the environment, researchers have started to look at the interaction between user comfort at work and the presence or absence of environmentally sustainable features (Heerwagen, 2000; Leaman & Bordass, 2007; Vischer & Prasow, 2008). This direction for future

study has two possible lines of exploration: the effects of sustainable building features, such as natural ventilation, water recycling and passive cooling technology on occupants and their work; and the behaviour and behavioural changes needed and expected from occupants as a result of sustainable design features in office and other buildings.⁴ These might include turning off lights when out of the room, dropping blinds on sunny windows to reduce heat gain, and using public transportation to get to and from work. Anecdotal evidence already exists of buildings supplied with innovative sustainable design features that occupants have either not wanted or not been able to use. There is also some evidence that giving occupants a more active role and responsibility for changing their behaviour in environmentally sustainable buildings is a necessary condition for success.

The environmental psychology of workspace is a rich and diverse field of study that is growing fast. As human beings in all parts of the world spend increasing amounts of time in offices in a wide variety of buildings, the effects of these environments on occupants' performance, health and morale urgently needs to be understood. The knowledge yielded by research in this field will inform employers' decisions as well as corporate investments in the work settings they create, and will assist and improve the building industry as designers, facilities managers, leasing agents and construction professionals acquire it. Business managers also need to understand more about how workspace affects their personnel, as companies need to become more 'agile' and by making ongoing changes to workspace (Joroff, Porter, Feinberg & Kukla, 2003). Finally, all indications are that a better understanding of occupant comfort is a prerequisite for successful sustainability and an effective impact on global warming.

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⁴ I am indebted to Cédéanne Simard, masters student at the University of Montreal, for her insight into these two possible directions for research in this area.

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