The concept of environmental comfort in workplace performance

O conceito de conforto ambiental no desempenho do ambiente de trabalho

Jacqueline C. Vischer

Abstract

The concept of workplace performance is applied to workspace design whose explicit objective is to support the performance of work. In this article, we argue that there are a variety of approaches to defining worker productivity in relation to the buildings they occupy. As a result of the growing knowledge in this area of study, more is understood about how workspace affects building occupants and their work. The concept of environmental comfort is presented as a useful way of organizing and exploring the knowledge we are acquiring in this area. Environmental comfort is composed of three types of comfort, each of which can be measured and which together determine occupant morale and well-being as well as task performance and effectiveness. The theory of environmental comfort considers situations where comfort is lacking, as stressful. An important ingredient of this approach is developing ways of measuring stress at work due to an inappropriate environment. In the second part of the article, data are presented from workers in a large Canadian insurance company, which were analysed to test specific hypotheses pertaining of the different categories of environmental comfort. The results indicate that while a convincing case can be made for the three categories of environmental comfort, more research is needed to test the usefulness of this theoretical approach.

Keywords: environmental comfort; workplace performance; worker productivity.

Resumo

O conceito de desempenho do ambiente de trabalho é aplicável no projeto do espaço de trabalho cujo objetivo explícito é apoiar o desempenho no trabalho. Neste artigo, argumentamos que existe uma variedade de abordagens para definir a produtividade do trabalhador em relação aos edifícios que eles ocupam. Como resultado do aumento de conhecimento sobre esta área de estudo, mais se conhece sobre como o ambiente de trabalho afeta os usuários dos edifícios e o trabalho destes. O conceito de conforto ambiental é apresentado como uma forma eficaz de organizar e explorar o conhecimento sobre esta área. O conforto ambiental é constituído de três tipos de conforto, cada qual passível de medição, sendo que os três juntos determinam a moral e o bem-estar dos usuários, assim como o seu desempenho e eficácia na realização de tarefas. A teoria do conforto ambiental considera como estressantes situações nas quais o conforto é inadequado. Um importante ingrediente desta abordagem é desenvolver procedimentos para medição do estresse no trabalho por conta do ambiente inadequado. Na segunda parte do artigo, são apresentados dados obtidos de funcionários de uma grande empresa canadense na área de seguros. Estes dados foram analisados para testar a pertinência de hipóteses específicas de diferentes categorias de conforto ambiental. Os resultados indicam que, embora se tenha um caso convincente sobre a influência das três categorias de conforto, mais pesquisas são necessárias para testar a utilidade desta abordagem teórica.

Jacqueline C. Visher
Interior Design program
School of Industrial Design
Faculté de l'aménagement
University of Montreal
Montreal - Canada
Tel.: 514-343-6684
Fax.: 514-343-5694
E-mail: jacqueline.vischer@umontreal.ca

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Performance and productivity

The concept of 'workplace performance' is applied to workspace design whose explicit objective is to support the performance of work. Workplace performance aims to optimise worker productivity. Several studies have aimed to measure the effects on worker productivity of physical features of the environments in which people work (VAN DER VOORDT, 2003). A useful way of organising this knowledge is to define workspace at different environmental scales, depending on the type of worker productivity that is being measured. Elsewhere, we have proposed that individual, group and organisational productivity be defined and measured separately, according to variation in scale of environmental influence (VISCHER, 2007).

A number of studies have demonstrated a measurable link between human productivity and office design. The BOSTI-Westinghouse study of the impact of a major office move on employees' attitudes and activities used employee self-reports of environmental impacts on productivity to measure the impact of features like open office design on task performance, and it assessed the effects on productivity in terms of employees' salaries (BRILL et al., 1984). 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, reminiscent of the changes in task performance found in the 1940's in the famous Hawthorne studies of lighting in factories (SPRINGER, 1986). Several recent studies conclude that workspace design can be supportive (have positive effects on work) or non-supportive (have negative effects on work), (for exemple, STALLWORTH; KLEINER, 1996), as well as affecting organizational performance (for exemple ILOZOR; LOVE; TRELOAR, 2002; DAVENPORT; BRUCE, 2002).

Lacking an integrative theoretical model of the environmental psychology of workspace, many studies rely on employees' self-reported satisfaction as a measure of productivity. They make the link between building users' satisfaction ratings at work and their job satisfaction, inferring that job performance is directly affected by job satisfaction. In these studies, deductive logic supplants empirical proof: they argue that if people express satisfaction, they work better, i.e. they are more productive. Occupational psychology research into job strain and productivity, however, indicates that this is not necessarily the case. While employee satisfaction is an important metric to include, no direct evidence of more or better work performance as satisfaction increases has been found (KARASEK; THEORELL, 1990).

Some studies have linked low satisfaction ratings with the presence of stress (for example, EVANS; JOHANSSEN; CARRERE, 1994; WILEY; OOI; GOH, 1997). One study found links between positive satisfaction ratings and positive affective evaluation of the work environment were stronger than links between positive satisfaction ratings and objective building characteristics; in other words, how people feel about the building they work in has a stronger influence on their assessments than physical characteristics of the building (RODRIGUEZ GONZALEZ; FERNANDEZ; SABUCEDO CAMESELLE, 1997). More recent research looks at more diversified outcomes. One study found that worker absenteeism in a number of office buildings varied according to the amount of fresh air admitted into the ventilation system, with more absent days occurring when percentage of fresh air was reduced. (MILTON; GLENCROSS; WALTERS, 2000). Another demonstrated that improved thermal comfort, perceived indoor air quality and occupant satisfaction was associated with underfloor task ventilation in offices (HEDGE; MICHAEL; PARMELEE, 1993). Several studies indicate positive (i.e. stress-relieving) effects on workers of plants in offices (for example, LARSEN et al., 1998). Varying window size in rooms, different colors on office walls, and the positive effects of daylighting in offices show less clear-cut effects on productivity, but variations clearly affect employee morale (HEDGE, 2000; VEITCH; NEWSHAM, 2000; CAPELUTO, 2003). Finally, studies of noise in offices indicate important differences in workers' reactions depending on sound source, and on other features of office environmental design (AYR; CIRILLO; MARTELLOTTA, 2001; CHARLES; VEITCH, 2002). Office workers report higher levels of distraction from noise in open plan settings, and this is linked with reduced satisfaction, especially for people with hearing impairments. (COHEN et al., 1987).

Some studies have addressed the psychosocial dimensions of the work environment in terms of human territoriality. This approach is characterized by two types of outcome: first, the psychological value represented by space for work and corresponding to place in the organization; and second, human interaction with the environmental milieu (FISCHER, 1983). Underlying these two approaches is a human behavioral schema that

expresses itself in the personalization and appropriation of space: marking territory and constructing boundaries are also expressions of territoriality (SUNDSTROM et al., 1982). More recent studies have investigated the impacts of denser and more open office configurations on workspace personalization and other space-appropriation behaviors; (SOMMER; STEINER, 1988; RISHI; SINHA; DUBEY, 2000; BRENNAN; CHUGH; KLINE, 2002) others have examined personalization as territorial expression (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 configuration (HARRISON, 2002; CASCIO, 1999; LAI et al, 2002).

In sum, a wide range of outcome variables has been studied in terms of the effects of features of the physical environment at work. In addition to simply measuring occupant likes and dislikes (satisfaction), behavior that is susceptible to be affected by workspace include various forms of task performance, lateness and absenteeism, degree of stress, social networks and communication, and worker motivation. To organize this growing body of knowledge into a coherent framework, we propose to develop the concept of environmental comfort, and its obverse, workspace stress.

The concept of comfort

In order to integrate what is known about workplace performance, a more robust outcome measure than individual satisfaction is proposed, that is, environmental comfort. The systematic measurement of comfort can then be applied to understanding workplace performance.

Comfort as a basis for setting environmental standards has developed out of recognition of people's need to be more than simply healthy and safe in the buildings they occupy. Building users need environmental support for the activities they are there to perform, and this state of environmental support is what is meant by comfort. Comfort links the psychological aspects of workers' environmental satisfaction with concrete outcome measures such as improved task performance and with organizational productivity.

Figure 1 diagrams the relationship of three levels of environmental comfort. Each level is measurable separately, although all need to be considered if comfort is to be understood in context. The diagram proposes that basic human needs are considered to be physical comfort and if these are not met, the environment is uninhabitable. At the next level of comfort, users have functional needs related to the performance of their tasks and activities in the workspace provided. The vector points up towards psychological comfort, at the peak of the triangle, indicating that optimal environmental quality is a dynamic condition most likely to occur when resources are invested in all three levels of comfort

We will first examine the meaning of the three levels of environmental comfort, and then discuss the implications of environmental decision-making at each level.

Physical comfort

Physical comfort is what most of us think of as comfort. It is at the base of the triangle and a necessary condition for building habitability. It is assured by responsible building design and operation, as well as by setting and meeting standards of health and safety. Health and safety standards for the work environment mostly address extremes, such as too much heat, cold or noise. They exist to ensure that people at work are not placed under undue stress by having to adapt to extreme environmental conditions. As they are built to modern construction standards and respect building codes, relatively few modern office buildings fail to be physically comfortable. Examples of physically uncomfortable workplace occurred for example, during the indoor air quality crisis of the 1980's, when older buildings with undersized ventilation systems failed to exhaust enough heat or to bring in enough fresh air, and people reported illness and fatigue. Another example occurred when the incidence of repetitive strain injuries (RSI) such as carpal tunnel syndrome increased after the large-scale introduction of computer screens and keyboards without adapting furniture, lighting or the way tasks were performed. Extensive and vociferous complaints from building occupants drew attention to these physical comfort problems. They are less evident in more recent office buildings, although they still occur: the disagreeable odor in the air that cannot be traced; unexpected loud noise from the air handling systems; the increasing number of screen-based workers needing corrective lenses.

In terms of its effects on worker performance, users' physical comfort must be assured. As well as the impact on occupants of interior office conditions, interruptions or deficiencies in basic building services, such as elevators, bathrooms, parking, and cleaning and maintenance, also affect workers negatively. In previous work I have characterized this basic level of building

habitability as "building convenience" (VISCHER, 1996; FISCHER; VISCHER, 1998). Our research indicates that a building that scores low on building convenience is not physically comfortable and therefore not likely to be acceptable at other levels of comfort. When workers identify a physical comfort problem, it tends to have a negative effect on their judgment of other aspects of the work environment.

Psychological comfort

At the top of the pyramid – hardest to identify, measure and control – is psychological comfort. In spite of the influence of industrial and occupational psychology, psychological comfort is only beginning to be measured in the office environment (VISCHER et al., 2003). However, as indicated above, several studies have shown that psychosocial aspects – such as the scale and structure of social networks at work, employer-employee relations, the demandingness of the job, and the type and extent of rewards and recognition for work performed – have an important effect on environmental perception and user assessment of workspace. Psychological comfort links psychosocial aspects with the environmental design and management of workspace through the concepts of territoriality, privacy and control.

According to our model, the primary component of psychological comfort is sense of territory, both individual territory (office, workstation) and group territory (team workspace). The concept of territory can be applied equally to individuals and groups, in that both individual territory and group territory are viable concepts. Sense of privacy, sense of status and sense of control are fundamental components of territoriality, and most people perceive and judge workspace, in part, according to these criteria (for example, SUNDSTROM; SUNDSTROM, 1986; BECKER, 1981; STEELE, 1986). 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. 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. Studying a company where three levels of employee – professional, technical and support staff – had been moved into open workstations, we found a significant relationship between territorial definition and job rank, with more negative assessments of privacy, status and control by professionals who, unlike the other two groups, had moved out of private enclosed offices (VISCHER, et al, 2003) This relationship seems to be independent of the actual physical features of the workspace, such as furniture configuration and partition height. In other research, careful interviewing and observation of professionals at work yielded the finding that the demands of the job were more important than individual privacy (KUPRITZ, 1998). These studies and others like them indicate the psychological nature of workers' attitudes towards privacy.

Recent accounts of major office redesign and renovation projects that have attempted to replace traditional enclosed office concepts with more 'dynamic' open environments indicate slow acceptance by workers, and in some cases, outright rejection, (for example, NIEMELA ET AL., 2003; OLDHAM, 1988; BRENNAN, CHUGH AND KLINE, 2002). This may be due to lack of psychological comfort rather than to environmental factors. Studies of job-strain indicate the importance of balancing employees' decision latitude with their 'psychological control' in order for them to feel challenged but not overwhelmed by the demands of their jobs. In many companies, employees have little say in decisions about the design and management of their workspace, and they often feel they have no control over environmental conditions.

Experimental efforts to increase environmental control have often resulted in evidence of beneficial effects on workers, including one experimental design that found a clear association between participation in decision-making and degree of workplace satisfaction following a move to a new facility (ILOZOR; LOVE; TRELOAR,. 2002). Providing opportunities for employees to participate in workspace decision-making is a form of environmental control that may be a constructive response to the need for psychological comfort. More control is positive in several ways: it helps people cope with environmental demands, and it encourages people to find new ways of solving problems, so that users increase their learning and knowledge about their building and workspace. The environmental comfort model calls this 'environmental empowerment'; it means keeping people informed about workspace-related decisions, providing opportunities for participation in decisions about their own space, and giving them some say in how they define their territory.

Functional comfort

Mid-way between the basic needs of physical comfort and the opportunities for increasing psychological comfort is the notion of functional comfort. The concept has been discussed at length elsewhere (VISCHER, 1989; VISCHER, 1996;

FISCHER; VISCHER, 1998). It addresses how effective workspace is in helping users perform their tasks rather than how satisfied they are, although the two concepts overlap. Functional comfort focuses on the generic human requirements for tools to perform specific tasks; it defines workspace as a tool for getting work done. It speaks to the need to invest in good workspace design and management in order to add value to the work performed by workers. As the range and types of tasks performed in offices grow and become more complex, so the concept of functional comfort becomes more important. Today's workspace has to facilitate a wider variety of tasks at an ever-increasing rate of change without becoming even more complex and costly to build. As a result, users' assessment of their functional comfort provides an important indicator to managers and designers of how well workers feel workspace is functioning, and whether or not improvements need to be made to help people perform their tasks better and more quickly.

Feedback from building users is a key measuring tool for assessing whether workspace meets functional comfort criteria, and to help identify ways to design more supportive workspace. Workers can, when asked appropriately, define features that are or are not comfortable related to individual task performance as well as to teamwork. For example, a task performed on an oversized computer screen requiring excellent visual conditions for colours and graphics will have precise environmental requirements – such as lighting, work-surface dimensions, contrast conditions – no matter who is using the computer, but only the users of that computer are in a position to judge whether optimal conditions for task performance are being met. Thus the 'subjective' perspective, which makes satisfaction alone an imprecise outcome measure, is turned to advantage when workers are asked to draw on their own experience of comfort in order to judge the degree to which task performance is supported by the environment.

Figure 2 shows how a task-supportive ('comfortable') workspace boosts the energy of the worker, who can focus her energy on performing her work. Her workspace provides, for example, low background light levels and good task lighting for screen-based work, a choice of small informal places close-by where she can meet co-workers for collaborative work, and some enclosed rooms for her work-group where she can go when she needs to concentrate. This is environment as a tool for her work.

The figure also shows that workspace that is inimical to task performance ('uncomfortable') draws energy out of the worker, as he grapples with environmental barriers in order to perform his work, and therefore has less energy to expend on his tasks. He may have to leave his team workspace and even his floor to find a place to sit and work with members of his team, he finds the air stuffy in his cubicle in the afternoon and feels slowed down by fatigue, and he has to go to another floor to access the large color printer he needs on a regular basis, stopping to greet and talk to co-workers on the way each time he makes the trip. These may only be minor annoyances were they to occur only on rare occasions, but when these extra efforts are built into an individual's or team's daily work schedule, they consume time and energy that is drawn away from work.

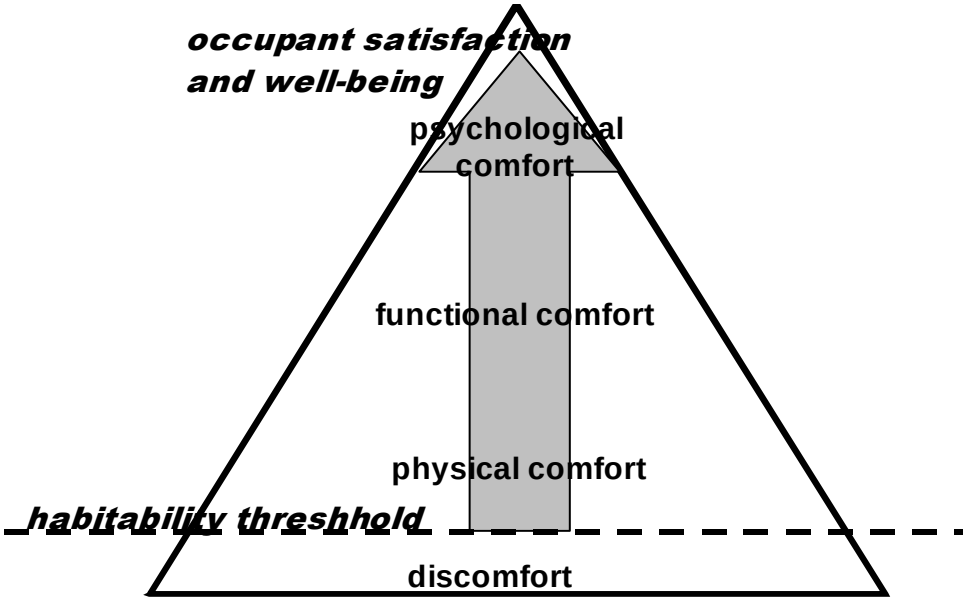

Diagram reproduced from: VISCHER, J. C. **Space Meets Status:** designing workplace performance. London: Taylor & Francis/Routledge, 2005.

Figure 1 - **Ranges of environmental comfort, from basic habitability to optimal well-being**

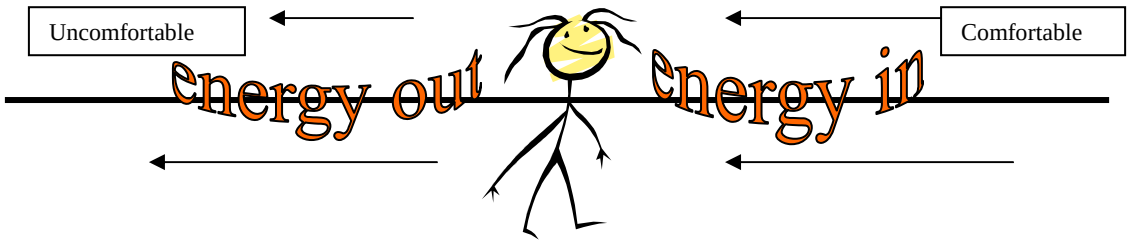

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Figure 2 - **Functional comfort model of user-space interaction**

As was pointed out in our discussion of the stress model, sustained situations in which the demands on users outweigh the amount of control they have over decision-making create stress and impose a strain on workers. In situations where functional comfort feedback indicates that there is little support for task performance, the workspace, or some characteristic of it, is judged to be uncomfortable, indicating stress. Strain occurs in part because users cannot control those environmental features that are uncomfortable: the temperatures are too cold but there is no thermostat, or it does not work; the noise generated by people moving past my desk is distracting, but I feel cannot ask them to stop talking; the light levels are low to facilitate screen-based work but too low to permit easy reading of documents placed next to the computer. Discomfort in any of these situations would be eased if workers had some temperature control, could ask people to talk softly when they walk around, and had a desk-lamp on the worksurface. Not all uncomfortable conditions are solved by increasing users' environmental control; indeed, many situations are not amenable or inaccessible to user control – for example, the level of contaminants in indoor air. On these occasions, the facilities management team tries to improve conditions for users, based on the feedback they have received.

The model posits that sustained discomfort over time generates fatigue and stress, which can eventually affect worker health. A list of typical workspace problems that have been studied to date

for their likely effects on worker health is shown in Figure 3.

Thus the uncomfortable end of the functional comfort continuum can lead directly not only to stress and fatigue at work, but also to health problems for workers. Ill-health affects organizational productivity through employee absenteeism, lateness, increasing health insurance premiums and, through burnout, increased employee turnover. Functionally comfortable workspace is another term for workplace performance, that is, workspace that, by all measures used, supports the efficient and effective performance of work.

To summarize, the integrated model of environmental effects on productivity at work is based on the concept of environmental comfort and workspace stress. Based on the notion of environment as a tool for the performance of work, the concept of environmental comfort is an approach to assessing whether or not workers in given situations have the environmental tools necessary for the performance of their work, regardless of their individual preferences. Environmental comfort is made up of combined physical, psychological and functional comfort. Environment is more than a simple determinant of people's behavior: psychosocial aspects increase the complexity of worker-workspace interaction and have a legitimate role to play in terms of managing the balance between environmental demands and degree of control experienced by building users.

Environments that fail to respond to users' needs at one or more level of comfort risk creating a stressful situation that may have long-term negative consequences. Non-supportive workspace increases job strain, whether this is at a physical, functional or psychological level. Sustained stress leads to health problems, absenteeism and employee turnover. Comfort and stress are at the extreme opposite ends of the functional comfort continuum along which almost any workspace can be placed at a given period of time – more stress in some cases, more comfort in others (VISCHER, 2007).

In the study described below, hypotheses pertaining to physical, psychological and functional comfort were tested, and some empirical support found for the environmental comfort framework.

Assessing comfort in a universal plan office

In 2001, a major Canadian insurance company launched a 3-year study of its new 'universal footprint' approach to office planning (Vischer, 2003). The new workstation replaced older furniture that was in various configurations of 2.4m by 2.4m and 2.4m by 3m, with a single 2.1m by 2.1m footprint that was rolled out sequentially in all the company's buildings, for a total of approximately 3000 new workstations. The company realized important real estate savings, using less space to accommodate a growing number of employees; they also reduced churn costs. The study was designed to determine the impact of the workspace change on employees, both from a comfort (functionality) viewpoint and a satisfaction (well-being) perspective.

The universal workstation has U-shaped worksurfaces varying between 53 cms and 1m in depth. Above the worksurface 2 fluorescent desk-lamps can be controlled by local switches. The workstation partitions vary between 1.4m and 1.7m in height and are 10 cms thick. They stand on feet that are 6.4 cm off the floor. The higher partitions support two binder bins above the worksurfaces. The furniture is of light pastel colors characterized by pink and beige. Workers could request additional features for individual workstations, such as glazing in the partitions, wider openings, counters, and keyboard drawers. In addition, a telephone tray, and document and pencil trays, could be attached to the partitions. The chairs were ergonomically designed and a deep red color. None of the furniture in private offices was changed or affected by the transformation to universal layouts. Typical workstation configurations are shown in Figure 4.

The change-over to the new layouts meant workspace reductions for professional employees (about 25% of employees) as well as for technical employees (about 20% of employees). For the remainder (clerical employees) about half had their workspace reduced and about half had an increase. No private enclosed offices or meeting-room spaces were affected by the universal footprint approach, but 17% of the company's square footage allocated to open plan layouts was recuperated

The study took place in three phases. In phase 1, the space planners and design team were interviewed singly and in groups to record their experiences with implementing the change, their views of effects on users of the new workspace, and their opinions of the positive and negative effects of the design. The issues raised in these

meetings formed the basis for development of a semi-directed interview schedule employed in the next phase of work. In this second phase, a sample of 32 individuals was selected from each of the 7 buildings affected. Each respondent was interviewed privately at their workstation. Responses to detailed questions concerning how each occupant used the space and features of the workstation were recorded and a photographic record was made. The most and least useful and the most and least liked features were identified. The summary of these findings formed the basis of a follow-up series of focus groups, in which participants were encouraged to express their views not only of the workstation furniture, but also of the overall team and departmental layouts, and the features of the buildings within which they worked.

Out of this phase, a third phase comprising a questionnaire survey to a stratified random sample of occupants of all the buildings was developed. A series of testable hypotheses were identified pertaining to physical, functional and psychological comfort. These are listed below.

■Wrong lighting/Glare	⇨Eyestrain, headaches
■No windows	⇨Depression, low morale
■Uncomfortable furniture	⇨Neck, shoulder, back pain
■Intrusive noise levels	⇨Fatigue, poor concentration
■Changing temperatures	⇨Colds, upper respiratory problems
■Nowhere to work together	⇨Frustration, demoralized employees
■Inadequate ventilation	⇨Headaches, nausea

Figure 3 - **Office environmental impacts on health**

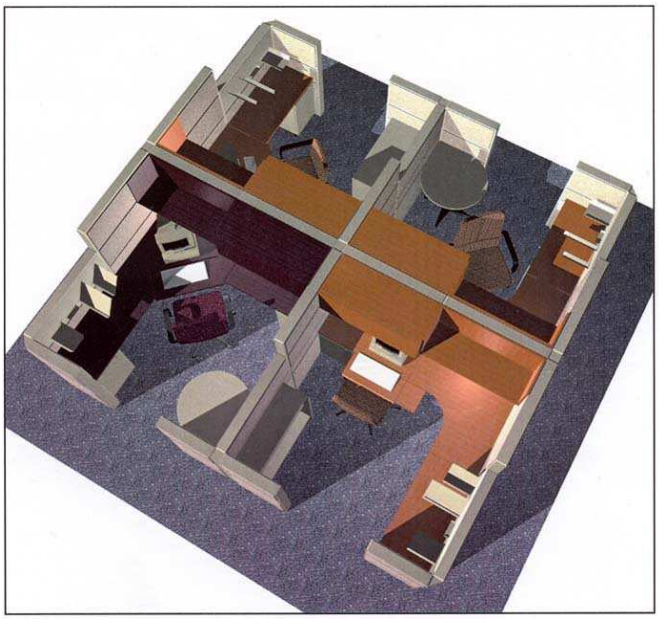

Figure 4 - **Universal workstation, typical configurations**

Physical comfort

(a) Small-scale modifications to the design of the workstation solve problems with knees and eyes and improve users' moral and performance;

(b) Overall people are more aware of what does not work than what does work and therefore provide more data on the former than on the latter;

(c) The acceptability of new workspace by users is affected by physical features of the building in which they work, by the way in which the prospective changes are presented to them, as well as by the physical characteristics of the new workstation;

(d) Users' comfort levels are affected by the physical characteristics of the building, the type of work they do, how long they have occupied their workstation, the years they have worked in the company, the distance to windows, the amount of information received prior to moving, and features of the previously occupied workstation.

Psychological comfort

(a) Occupants of the universal plan learn to recognize and respect each team's territorial limits using features of the physical environment;

(b) The work people do and where they and their co-workers are located affects how and how much occupants use physical features to identify group or team territories;

(c) Space appropriation and territoriality are expressed through the number and type of personal objects found in individual workstations;

(d) The number and type of personal objects in each workstation varies according to the type of work and number of years in the company;

(e) Workspace territoriality is a function of feelings of environmental control, protection of individual privacy, and sense of status in the organization;

(f) The more satisfaction occupants feel towards their workspace, the more they take ownership and express their territoriality, thus increasing comfort and improving performance.

Functional comfort

(a) Significant functional comfort differences exist among the buildings studied, indicating varying degrees of environmental support for the work being performed;

(b) Functional comfort ratings are affected by building differences, as well as by the type of work people do, and where their workstation is located on the floor;

(c) The significant dimensions of functional comfort in this company's buildings do not differ from those found in other buildings occupied by large private companies and government;

(d) Group and individual productivity, and user satisfaction, are influenced by noise levels, lighting quality, thermal comfort and ergonomic conditions.

In order to test the hypotheses, a questionnaire was designed, which also collected data on demographic characteristics and work patterns. The questionnaire was administered by a team of trained interviewers to a representative sample of 520 employees of the company (23%) in 5 buildings. The questionnaire comprised questions on age, sex, job rank, and length of time in the company, and questions regarding type of task and how employees worked, as well as on their experiences of privacy and territoriality. In addition, the questionnaire presented 54 questions on environmental comfort in the form of a 5-point scale, where 1 is uncomfortable and 5 is comfortable. The questionnaire data were entered into SPSS for Windows and tested using bi-variate tests such as Chi-square and Spearman correlation coefficients to measure association between variables, as well as Principal Component Factor Analysis to identify significant dimensions of functional comfort from the scores on the 5-point environmental comfort scales. A summary of the results is presented below.

Summary of results

Of the 520 respondents. 34.3% were support staff, 41% were technicians and the remaining 24.7% were professionals. 78% of respondents were women. A surprising 32.2% had been working there for more than 12 years, and over 50% for more than 7 years. Only 18% had worked there less than 2 years. In terms of the work patterns, some 76% of respondents estimated that they spent 75-100% of their time working at their workstation, rather than in meetings or outside the building. Most respondents indicated they were members of a team or workgroup, and that they were seated reasonably close to other members of their team. However, 68% indicated that they spent less than 25% of their time actively collaborating with co-workers, and only 9.4% spent more than half their time in collaborative work.

Environmentally, about half the sample was located within 15 feet of windows and the other half was further away. Most respondents (65.6 %) had previously occupied another type of open workstation, but 9.3 % had moved into the

universal workstation from a private enclosed office. These respondents were all in the professional category. Overall, respondents were positive about the new workstation, with 47% indicating they felt comfortable more than 80% of the time and 33% feeling comfortable between 60 and 80% of the time.

Regarding the physical comfort hypotheses, small-scale modifications were made after the first round of interviews and problems with knees when seated or with eyes while using the task lighting were alleviated. The interview results indicated a larger number of negative than of positive comments, but the degree of detail differed between the two categories. People tended to make more global positive judgments ("I am comfortable here") and more specific negative comments ("I can hear my neighbor when she is on the telephone"). Therefore the fact that the list of negatives is longer than the list of positives does not mean that there is more of a negative than a positive weighting given by respondents.

Variation among the buildings regarding the overall comfort of the new workstations indicates that building configuration and scale may affect acceptability. As the tasks carried out in each building were largely the same, it appeared that factors such as proximity to windows, overall floor size and how the teams were distributed in the building were variables affecting acceptability. Furthermore, occupants of the different buildings reported receiving different amounts of information prior to moving into the new layouts. In two of the buildings, respondents indicated that had received no information but had learned about the proposed new layouts when these were implemented on other floors. In two other buildings in another city, occupants indicated they had read and heard about the new layouts and had in addition visited a mock-up workstation prior to implementation. The respondents in these latter buildings rated the workstations as slightly more comfortable than those in the buildings where no information was received.

The results indicated that how long respondents had occupied the workstation and the years they had worked with the company had no significant effect on their overall comfort ratings of the universal workstation. However, as indicated above, features of the building, the category of work they perform (support staff, technician or professional), the type of office or workstation previously occupied, and distance to windows from present location were all significantly associated with overall comfort ratings.

Testing of the psychological comfort hypotheses indicated active definition and recognition of territory. Respondents used an average of 2-3 features of the physical environment out of a list of 10 possible features to identify territorial limits. Territorial size varied significantly with work category, with professionals having larger territories than either technicians or support staff. On the other hand, professionals expressed lower satisfaction levels with privacy and sense of status than either technicians or support staff. Most common physical features used to define territorial limits were workstation layout (52.8%) and walls and doors (33.4%) followed by floor-space (30.4%) and walkways (30.3%).

The study yielded significant amounts of personalization behavior, with as many as 56 personal objects being counted in one workstation. The types of objects listed include photos (69%), toys and personal items (50%) and posters (43%). There is no difference between women and men having up to 6 personal objects, although significantly more women than men have more than 6 personal objects, suggesting that while men and women both personalize workspace, women tend to use more personal objects than men. The amount of personalization increases with both time in the company and time respondents have occupied their workstation. However, no significant relationship was found between amount of satisfaction, overall comfort, or degree of functionality of workstation and amount of personalization. In addition, a significant relationship was found between amount of personalization and the number of territorial boundaries that were identified, suggesting that people who personalize more are perhaps more territorially aware or possessive than those who personalize less.

In order to understand more about satisfaction, respondents were asked a series of questions about the relative similarities and differences between the current workstation and their previous office. The pattern of response showed that being able to hear their neighbors, or feel they were being overheard, were important courses of dissatisfaction, both in previously occupied space as well as in the new, universal plan. Levels of dissatisfaction varied according to job-rank, with professionals being less satisfied than either technicians or support staff.

Finally, factor analysis applied to the 54 environmental rating scales revealed 13 functional comfort dimensions in these buildings. Their names and their scores on the 1-5 scale are provided in the table below.

	FUNCTIONAL COMFORT DIMENSION	Score
1.	Workstation comfort	3,64
2.	Thermal comfort	3,23
3.	Air quality	3,11
4.	Privacy	2,77
5	Lighting Quality	3,94
6.	Acoustic comfort	2,85
7.	Spatial comfort	4,20
8.	Teamwork	3,49
9.	Natural light	3,01
10.	Safety and security	4,27
11.	Building appearance	4,25
12.	Visual comfort	4,12
13.	Building and remote noise control	4,28

Table 1 - **Dimensions of functional comfort**

The ratings on each of these 13 dimensions were calculated and examined according to the variables identified in our hypotheses.

The study found significant functional comfort differences among the buildings studied, reflecting not so much variation in type of task as variation in building conditions. Variables differing most significantly among buildings include glare from windows, level of maintenance and cleaning, personal storage and worksurface dimensions, building hygiene, draftiness, noise from ventilation systems and access to natural light. Only one of these concerns the universal workstation, however, and this is workstation surfaces.

Respondents' functional comfort ratings vary significantly according to job rank. The support staff are most positive about the workstation layout, acoustics and furniture, followed by the technicians. The professionals are the least positive about these aspects, and about their degree of privacy. However, professionals tend to be more positive about ventilation and temperature conditions than either technicians or support staff. Type of work thus has an important effect on functional comfort differences, as one would expect. The location of respondents' workstations however, had little effect on functional comfort ratings, with no significant differences between workstations placed close to the perimeter and those further into the interior of floors identified except in regard to amount of natural light.

A multivariate model was constructed in which the 13 functional comfort dimensions predicted overall levels of occupant satisfaction and the perceived functionality of their environment. When tested using regression analysis, the results showed that workstation comfort, privacy, spatial comfort, teamwork, air quality, building appearance, thermal comfort, acoustic comfort, natural light and safety and security are the dimensions having the greatest influence both on perceived functionality of their work environment (60% of variance explained) and on overall satisfaction with the workspace (54% of variance explained).

Overall, the identification of 13 functional comfort dimensions represents an updating of the original seven dimensions uncovered in previous studies (VISCHER, 1989; VISCHER, 1996; FISCHER; VISCHER, 1998), paralleling perhaps the growing complexity and variety of office work and workspace. Whereas the original database indicated a preoccupation with ventilation and thermal comfort conditions, these more recent results show the increasing importance of ergonomics and workstation design. The prevalence of computer equipment and the need for ergonomic support to perform desk-based tasks, as well as concerns about security and worker health, are trends affecting changes in the functional comfort of modern office buildings.

Discussion and conclusions

In order to organize our growing knowledge about the effects of office building design on occupants and thereby to identify key elements of performing workspace, we outlined the concept of environmental comfort. The three categories of environmental comfort are physical, psychological and functional comfort. Situations characterized by a lack of comfort – insufficient support for the performance of work – are considered stressful to building occupants.

Data from a study of occupants in five buildings operated by a major Canadian insurance company were analyzed in order to find empirical support for the tri-partite comfort model. Hypotheses pertaining to physical, psychological and functional comfort were identified, and data from individual, semi-directed interviews and from a questionnaire survey administrated to a stratified random sample of the company's employees were submitted to testing. Test results indicate some support for the three comfort categories.

Physically, respondents indicated they were comfortable with most aspects of the new workstation, in spite of its small size and limited storage. Many compared it to a nest or a cocoon within which everything was in easy reach. However, certain physical comfort problems were uncovered, such as glare from task lights inappropriately situated above the worksurface and causing glare when users were working on their computers. In other situations, the placement of the lateral filing cabinet caused occupants to bang their knees when they turned in their chairs. Once these problems were identified they were rapidly corrected, as were a number of small additional ergonomic misfits that occupants had not reported.

The concepts of territoriality and personalization were measured in order to test psychological comfort. Occupants also provided data on their feelings of privacy, whether or not they felt in control, and on spatial features as symbols of their status in the organization. Results confirm that occupants are aware of and can define territorial boundaries using features of the building to do so. Their notions of territory are related to their job-rank and to type of work. Feelings about privacy and control were linked to satisfaction ratings, and seem to affect psychological comfort more than actual work performance.

Personalizing their space was an important aspect of psychological comfort in this company, with only 3% of respondents having no personal objects. While the number of objects varied with sex of respondent and length of time in the company, this did not seem to be linked to overall feelings of comfort and ability to perform work. However, a relationship was found between number of physical features used to define territorial boundaries and number of personal objects in the office, suggesting that office territoriality is a viable and important concept that merits further study.

Finally, functional comfort was analyzed through responses on 53 environmental scales in which 5 indicated comfortable and 1 indicates uncomfortable. Occupants' responses indicate that they are mostly comfortable with these environmental features, with the exception of acoustic conditions and privacy. Occupants' responses were affected by the building they worked in, the type of work they do and the location of their workstation.

Analysis of the 53 scales yielded 13 factors, or dimensions of functional comfort. This is considerably more than those identified in previous studies of functional comfort. The new list breaks out functional comfort into a finer grain of occupant experiences, where workstation comfort is distinct from the comfort or functionality of the layout and access to other resources, lighting comfort is broken out into daylighting and electrical lighting quality, and features pertaining to collaborative or teamwork emerge as significant. Only 5 of the 13 functional comfort dimensions vary according to the different buildings in which the survey was carried out, indicating their validity across the population sampled.

The relatively high scores on the 13 functional comfort dimensions indicate that workers are overall well supported in their performance of work, and are not subject to workspace stress except in regards to their sense of privacy (2.77) and their acoustic comfort (2.85). Noise from neighbors and lack of voice privacy may be slowing down task performance, and thereby affecting overall productivity. To sum up, results indicate that the 13 factors have an important effect on both occupants' satisfaction, and their ability or not to do their work.

More empirical research is needed to further define and refine the concept of environmental comfort and its three categories. In addition, ways of measuring workspace stress must be identified in order to understand more about how productivity is lost through poor or inappropriate workspace design. By understanding more about physical and psychological as well as functional comfort, planners and designers will be better placed to respond to users' needs in ways that enhance task performance and therefore the productivity of the organization. Although convincing information already exists demonstrating that companies can enhance employee performance through design decisions about the buildings they occupy, the overall framework provided by the concept of environmental comfort is a potentially a useful tool both for presenting this information and for framing future research that will add to it.

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