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Work Environments

Jennifer A. Veitch

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Abstract and Keywords

Work environment research is a vibrant area not only within environmental psychology, but also in a broad range of building sciences concerned with making buildings work for their inhabitants. Understanding how work environments affect comfort, satisfaction, performance, and health comes through the study of such processes as privacy, attention, stress, affect, and cognition and builds upon the foundation of previous decades. Conversely, the study of workplace behaviors as they affect the environment is comparatively new, with pressing societal questions needing answers. Psychologists together with professionals from fields such as engineering, physics, architecture, and ergonomics have combined roles to play in adding to human knowledge and to design, construct, operate, and inhabit spaces that support the work we do today while sustaining Earth for the future.

Keywords: indoor environment, personal space, satisfaction, thermal comfort, environmental stress, control, positive affect, sustainability, green buildings, workplace

Introduction

Offices are the dominant workplaces in North America, and the proportion of the workforce in these settings is increasing (Woods, 2009). Over half of the workforce is employed in offices, a statistic that does not include the many people for whom an office is part of the work setting rather than its entirety (e.g., nurses, teachers, retail managers). Not surprisingly, offices also predominate among the settings studied by environmental psychologists. For that reason, this chapter focuses primarily on the understanding the effects of the physical environment on people in offices, and secondarily on the environmental effects of people’s working in offices. Offices are major resource users, particularly for energy, as well as major sources of employment.

Understanding the behavior and experiences of people in offices requires a systems approach. One such approach is shown in Figure 14.1. Individuals experience physical, social, and organizational contexts, and bring to work their individual differences and states created by conditions and social roles outside of work. Many internal processes, acting in parallel, take these various influences and result in a variety of outcomes. This figure cannot show all of the possible contextual influences, processes, or outcomes, but does show the structure underlying the chapter. Internal processes are the organizing principle.

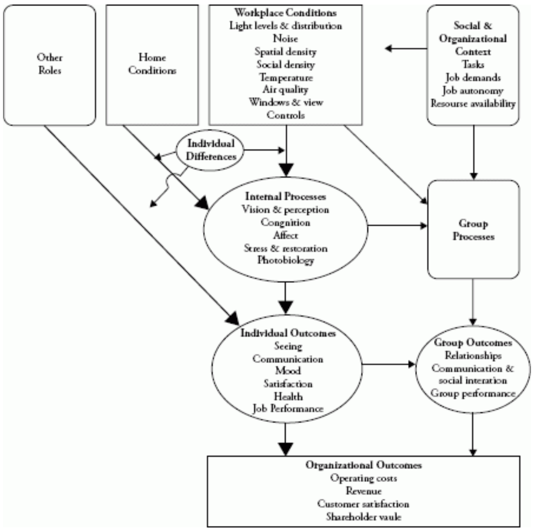

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Figure 14.1 Conceptual Model for Work Environment Effects on Individuals, Groups, and Organizations.

Sundstrom's book (1986) and handbook chapter (1987) on work environments and the BOSTI books (Brill, Margulis, Konar, & BOSTI, 1984) are the classic work environment psychology documents. The past quarter-century has of course brought dramatic change to offices, principally in the rise of information technology. This has changed both the nature of tasks—for example, few employees now need to read soft pencil or handwritten fourth-generation carbon copies—and jobs—for example, (p. 249) no longer is there a typing pool. Consequently, some of the results reported in these classic works do not generalize to present-day offices. This review focuses primarily on papers published since 2002, with the publication of the second *Handbook of Environmental Psychology* and its review of work environments (McCoy, 2002).

Popular media tell us that contemporary ways of working are dramatically different than old ways. This may be true, but many of the fundamental characteristics of people in organizations are unchanged. Moreover, even in organizations that emphasize teamwork, or that use hoteling to manage the assignment of workstations to itinerant employees, there is need for quiet spaces with suitable lighting, temperature, and accommodation while doing individual work (Brill, Weidemann, & BOSTI, 2001).

Employers perennially ask why one might concern oneself with providing superior working conditions. After all, the Hawthorne experiments found contrary results in which performance could be improved even by placebo changes in lighting conditions (Roethlisberger & Dickson, 1939; Snow, 1927). Herzberg (1966) theorized that the physical work environment was a hygiene, rather than a motivating, factor, with increases beyond the baseline of adequacy not providing any substantive return in the form of better job performance. However, several commentators have observed flaws in the design of the Hawthorne illumination experiments (Gifford, 2007; Kompier, 2006), and Herzberg had very limited data to support his theory.

More recent analyses of the costs of employment show the value of a better work environment. Brill and colleagues (2001) calculated that over the life of a building, 82% of the costs are associated with the salary and benefits of those who work in it; 10% of the costs (circa 2000) are for the technology they use; 5% is the initial cost of building and furnishings; and 3% is the cost of operations and maintenance for the building. Small investments in the physical (p. 250) environment can pay off well if they enable the employees to be more effective at work. Moreover, unlike person-centered interventions. such as training, coaching, or immediate rewards, they persist over time and affect new waves of employees as the workforce ebbs and flows. There is no general equation to calculate the return on investment of work environment interventions, although there are methodologies that may be applied to organizations (Linhard, 2005; Neftzger & Walker, 2010).

As these methods underscore, understanding which investments will pay off requires an integrative approach to research, taking together not only human resources management, industrial-organizational psychology, and facilities management (Haynes, 2007), but also engineering and environmental psychology. In some respects, work environment psychology illustrates the identity challenge described by Stokols (1995). Although it seeks to understand the person embedded in a specific context (Craik, 1996), a complete understanding requires truly interdisciplinary investigations.

Behavioral Consequences of Work Environments

This section of the chapter takes the traditional approach of considering the effects of the physical and social environment on employees. Rather than organizing the literature by independent or dependent variables, the focus is on internal processes. Some internal processes—visual perception, for instance—relate more clearly to a specific physical environmental parameter, whereas others, such as cognitive processing, receive influence from several variables (including other processes).

Social Relations and Personal Space

Decisions about the size and arrangement of offices are fundamental to their design, and have financial, functional, style, and practical dimensions. The outcome of these decisions is the creation of the places where people work. Other design decisions have physical ramifications, but these start from the decisions about space. The space decisions influence personal space perceptions, privacy, crowding, and territoriality, processes that themselves form the foundation of environmental psychology (Gifford, 2007).

Office Type

Few issues have created such debate among office workers as has office type; arguably, open-plan office design was the inspiration for the comic strip *Dilbert,* by Scott Adams, and its many panels about life in the “cube farm.” North American offices adopted this arrangement of modular furnishings cubicles in the 1960s (Albrecht & Broikos, 2000). (Note that in Europe, the label “open plan” describes offices in which many individual desks occupy a large area, with no visual barriers between them—what North Americans would call a “bull pen”—and systems of furnishing panels are less common.) One reason for the popularity of the layout is economic: the reduced footprint and ease of rearrangement translates into reduced organizational costs. The other is ideological: the belief that by reducing barriers between individuals, one can increase the opportunities for interaction and communication in ways that will promote teamwork, collaboration, and creative problem-solving. This belief is widespread among designers and has appeared repeatedly in the popular press (Galt, 2002; “Let’s chuck the cubicles!” 2011; Mourtada, 2011). However, the reduced barriers also reduce privacy (Brill et al., 1984), as discussed below.

Broad comparisons between office types reveal many simultaneous processes and, consequently, mixed results. For instance, Sundstrom (1987) observed that field studies reported both favorable and unfavorable outcomes in comparisons of office types: some studies found that satisfaction declined with a shift from an enclosed to an open-plan layout, perhaps because of decreases in privacy and increases in noise and distraction, whereas others found that employees preferred more rather than less exposure to other people. Job category appeared to moderate the relationships, in part because of the use of enclosed offices to provide status markers.

In recent years there have been few investigations that compared office types, probably because of the dominance of the open-plan form (Brill et al., 2001; Haynes, 2008); BOSTI estimated that 71% of American offices fall into this category (Brill et al., 2001). The recent publications demonstrate the complexity of the issues without a clear conclusion about optimal office types.

Brennan, Chugh, and Kline (2002) followed an organization for an extended period before and up to six months following a move from downtown quarters with primarily enclosed offices to a suburban location with open-plan arrangements. The respondents to this longitudinal study reported a decline in privacy and confidentiality in two post-move surveys, as well as persistent declines in environmental satisfaction, job performance, and increases in physical stress. The longitudinal design is a strength (p. 251) of this report, but the authors had no physical measurements of either the pre- or post-move offices and no control group. Moreover, although their questionnaire focused on judgments of the interior of the workplace, the fact that the geographic location had also changed remains a confound. The change in the commute to work might have been stressful, or the new commute itself might be more stressful than the old; commuting stress is known to spill over into other life domains (Novaco & Gonzalez, 2009).

For further consideration of the complexity of the office type issue, consider the results from Danielsson and Bodin (2008), concerning the health status of occupants in various Swedish offices. Classifying offices into seven types differing in both enclosure and the number of occupants, they found that occupants of a medium-size open-plan office (10–24 occupants, with few architectural separations between them) had the highest risk of poor outcomes for physical and emotional health and for aspects of job satisfaction. However, it was not possible from these data to determine precisely which features of this layout were responsible for the increased risk. The large open-plan office, rare in Sweden but more typical in North America, did not show as many increased risks as the smaller version. This is puzzling, as one might expect less privacy and more distraction from the larger number of people.

Privacy

The original BOSTI study of workplace productivity identified visual and acoustic privacy as among the most important design elements for individuals (Brill et al., 1984), and this remains an important issue. Veitch et al. (2003) surveyed more than 770 occupants of cubicles in North America and found that privacy was the second-most-important feature to them among seven ranked features, and the lack of privacy was most likely to be mentioned in open-ended responses as a disliked feature or a feature that the respondent would change.

One way to achieve visual privacy and a degree of acoustic privacy is to provide a higher panel between cubicles. Brill et al. (1984) recommended 65 inches (165 cm) or higher on three sides as a means to provide adequate privacy, but the design trend in recent years has been for panels to be lower than this (“Space planning,” 2003). A field study comparing two Turkish companies found that privacy perceptions were better when panels were 140 cm (~55 in)—high enough to provide visual privacy to the seated occupant—than when they were 120 cm (~47 in) (Yildirim, Akalin-Baskaya, & Celebi, 2007). However, Newsham, Veitch, and Charles (2008), in a reanalysis of the Veitch et al. (2003) data, found no effect of panel height on the risk of dissatisfaction with privacy and acoustics. Workstation size was a significant predictor, with larger workstations reducing the risk of dissatisfaction, probably because of the greater separation between people (and their noise) that larger cubicles provide.

Individual differences and the nature of the work both play a role in employees’ responses to work space design (Maher & Hippel, 2005). Stimulus screening and inhibitory ability, perceived privacy, and task complexity showed interactive effects on job satisfaction in this Australian sample. Higher panels increased perceived privacy. When both perceived privacy and task complexity were high, stimulus screening ability was a significant predictor of job satisfaction. Maher and Hippel suggested that this result revealed a weakness in the use of higher panels to improve perceived privacy, in that they provide more visual privacy than acoustic privacy. Without acoustic privacy, those with poor stimulus screening ability who have complex tasks might experience more distractions than the higher visual privacy would lead them to expect, with concomitant reductions in job satisfaction. These authors suggested that noise is a greater problem for poor stimulus screeners when they lack the visual cues to identify where the noise is coming from.

The seating orientation in the cubicle offers another means to regulate social interaction or to provide privacy. Physical constraints can limit this choice; for example, Sommer and Augustin (2007) found that 97% of users of desktop computers with monitors worked with the primary work space facing into the corner of the cubicle (an arrangement that was common when almost all monitors used cathode-ray tubes, needing a deep desk area for the tube). However, users of laptop computers varied between orienting into the corner (“facing in”) and facing to the side or the entrance (“facing out”). Interviews with employees of both orientations revealed that those who faced out did so to facilitate communication and to avoid being surprised by visitors entering the cubicle; not being startled by people coming up from behind outweighed increased distractions of people passing by. Those who faced in cited fewer distractions and the availability of more desk space on which to spread materials, as well as the physical constraints of the equipment. Personality variables (introversion-extroversion, locus of control, and self-monitoring capacity) did (p. 252) not predict the choice of orientation, although the small sample size and the fact of physical constraints limiting choice might have obscured the relationship. As computer monitors become shallower the physical constraints should decline in the future, making it easier to detect the influence of psychological variables.

The development of Internet-based survey technologies has greatly facilitated the development of large data sets of office employees’ responses to their work environments. Physical measurements lag because they remain timeconsuming and expensive to conduct. The Center for the Built Environment at the University of California, Berkeley, is unusual in having a database comprising more than 50,000 individual responses together with a limited set of physical parameters of each office (Goins, Jellema, & Zhang, 2010). A recent analysis of this data set revealed than the measured height of cubicle enclosures was not as good a predictor of self-rated job performance as was the symbolic character of the office, being viewed as having a home-like atmosphere or being a place to be proud of. The authors suggested that designers seeking to influence organizational outcomes should attend to the symbolic attributes over simple enclosure measures. However, physical attributes matter: the symbolic attributes themselves were influenced by speech privacy, air quality, amount of light, and temperature, all of which are influenced by the physical design of the work space (Newsham et al., 2003).

Communication and Collaboration

The belief that reducing barriers between individuals will create a culture of open communication and information flow began with the landscaped office (*burolandschaft*) movement in the 1950s (Albrecht & Broikos, 2000), and continues today ("Let's chuck," 2011). The reality is more complex than this ideology suggests. There exists a tension between providing opportunities for social interaction and creating conditions that are not conducive to concentration (Heerwagen, Kampschroer, Powell, & Loftness, 2004). Successful workplaces achieve a balance between the two that is appropriate to the organization, or more accurately, to the work unit and the nature of its activities.

Heerwagen et al. (2004) analyzed collaborative knowledge work along three social dimensions: awareness, which concerns knowledge of what is happening in the surroundings; brief interactions, which are short exchanges of fact or personal connections; and collaborations, which may range from a few minutes to several hours in length. Workplace design features affect these dimensions in different ways, and each dimension has different benefits and drawbacks to the organization.

Awareness, for instance, is particularly important in organizations that have high time pressure and require a high degree of coordination between individuals. Proximity to others and high visual access both contribute to awareness. However, they do so at the cost of lost privacy and lost confidentiality (Heerwagen et al., 2004).

Brief interactions also benefit from visual access; people tend to interact with people they can see (Rashid, Kampschroer, Wineman, & Zimring, 2006), and they interact more with people who are nearby. Thus, more open office designs and layouts that place groups in close proximity to one another should prove beneficial (Heerwagen et al., 2004). However, because people tend to meet in individual work spaces rather than in communal spaces, even in offices designed to encourage the use of communal spaces, there is a high risk of distraction in more open spaces (Rashid et al., 2006).

Collaboration, as defined by Heerwagen et al. (2004), encompasses many types of interactions as well as time spent in individual work. Most of the literature in this area comes from studies of group and team work without a specific focus on the physical environment, and yet this category best captures the balancing act between the individual and the group. Various forms of open design for project or team work can facilitate communication among group members, and this coordination can decrease the time required to complete the task; however, for the parts of the task that require individual work, these open areas can be distracting to individuals and can prove stressful (Heerwagen et al., 2004).

Overall, decreasing barriers between individuals appears to increase communication between them, as expected; however, it is less clear that this is, on balance, always a good thing. Not all individuals need to interact with all others all the time. Using physical space to promote social interaction requires a careful consideration of the nature of the work to achieve the appropriate balance given the tasks and needs of the work group. If the balance is wrong, individuals and organizations both lose, as seen in two reports based on data collected 20 years apart. Stokols, Clitheroe, and Zmuidzinas (2002), analyzing data collected in 1987–1988, found evidence for a mediated relationship between environmental distraction, perceived support for creativity, and job satisfaction in which more environmental (p. 253) distraction (more visual access, higher noise levels, more people passing by) decreased perceived support for creativity and this in turn decreased job satisfaction. A longitudinal study of European knowledge workers whose work required little interaction found that cooperation became less pleasant, whereas distractions and difficulty in concentrating increased, after they had moved from private offices to an open-plan space (Kaarlela-Tuomaala, Helenius, Keskinen, & Hongisto, 2009).

Density

Personal space, or the control of it, largely concerns the regulation of our social interactions. The need to do so is partly a function of the density of possible relations. Theorists differentiate between two types of density: “social density” concerns the number of occupants per office, and addresses issues such as the number and complexity of social relationships that an individual must manage. “Spatial density” is the area available to each occupant (e.g., m^2 per person) (Duval, Charles, & Veitch, 2002). For a given office size, the two are clearly related: if social density increases, spatial density will decrease. However, the relationship is not perfect because architectural and interior design choices also play a role; one could reduce social density by providing separation between work groups, even if spatial density stayed constant.

Taken to an extreme, high social or low spatial density could give rise to perceptions of crowding (Stokols, 1972), which can act as a stressor (Sherrod, 1974). At the other extreme, very low social or spatial density could lead to isolation (real or perceived). Present-day office environment research provides little guidance on the effects of density on employees, despite the importance placed on social interaction. In the facilities management and office design literature it seems that real estate costs (“Space planning,” 2003) and the above-mentioned emphasis on visual access, especially for work groups, drive social and spatial density choices.

Duval et al. (2002) surveyed the literature concerning open-plan offices specifically, seeking evidence for recommendations concerning social and spatial density. Many studies were excluded from the review because of insufficiently specific characterization of the density measure. They concluded that overall, both higher social density and lower spatial density had adverse effects on overall environmental satisfaction, but were not able to establish numerical limits. Other data suggested that workstations smaller than 4.5 m^2 (49 sq ft) increase the risk of dissatisfaction with privacy/acoustics and dissatisfaction with lighting (Newsham et al., 2008), but were unable to address social density.

Territoriality

Territoriality is a difficult process to define (Gifford, 2007), but a colloquial definition would hold that it is the process by which people mark space as their own, both to protect belongings and to regulate social interactions. The literature on territoriality in offices is very limited, and focuses primarily on personalization as the means by which individuals mark territories.

Wells has provided valuable insights into the predictors and consequences of office personalization with a series of cross-sectional field investigations. The results are counterintuitive. Although most people believe that the items on display give insight into the personality of the occupant, personality variables as assessed by the Big Five do not predict the nature of the display or the number of items on display (Wells & Thelen, 2002). These personality variables predict the individual’s status in the organization, which in turn does predict personalization: for instance, high-status individuals tend to personalize more. Organizational culture, rather than individual characteristics, is the larger influence on personalization, particularly as it influences the work space design and the explicit policies governing personalization (Wells, Thelen, & Ruark, 2007). Permissive personalization policies are important in that organizations with such policies show a greater degree of personalization, and in turn higher levels of satisfaction with the work environment, job satisfaction, and employee well-being as well as higher organizational well-being (Wells, 2000).

Attention and Distraction

Individual knowledge work remains an important component of work in most organizations: Brill et al. (2001) found that in all job categories, people spent 50% or more of their time in solo activities or on the telephone. For these activities, visual and auditory stimuli from people and equipment are detrimental to concentration and are consistently rated by office occupants as problematic (Banbury & Berry, 2005; Haynes, 2008; Schwede, Davies, & Purdey, 2008; Veitch et al., 2003).

Auditory distraction lends itself well to laboratory investigation, and the work of applied cognitive psychologists studying attention is directly relevant to environmental psychology. It is clear from the literature that irrelevant sound disrupts cognitive (p. 254) performance (Banbury & Berry, 1998; Perham, Banbury, & Jones, 2004; Szalma

& Hancock, 2011). The nature of the sound is more important to the cognitive effects than is its level, at least within the range of commonly encountered sounds, from 48 dB(A) through 80 dB(A) (Banbury, Macken, Tremblay, & Jones, 2001). Sounds that are repeated are less disruptive than are sounds that have acoustic changes in pitch, timbre, or tempo; the changing state attracts attention and disrupts task-related cognitive processing (Banbury et al., 2001).

Individual differences moderate the effects, with those who have smaller working memory capacity being most adversely affected by noise exposure (Sörqvist, Halin, & Hygge, 2010). A different individual difference measure, task absorption, showed complex interaction effects with noise exposure on performance and subjective mental workload ratings (Smith-Jackson & Klein, 2009). Both papers concluded that the role of individual differences is worthy of further investigation.

Although some laboratory studies show that habituation is possible, with the effect being diminished after 20 minutes of exposure to the irrelevant sound (Banbury & Berry, 1998), field studies do not find that the problems disappear with repeated exposure (Banbury & Berry, 2005). This might be explained by the fact that even in offices, exposure to irrelevant sound is not continuous. Banbury and Berry (1998) found that even a short silence after a period of noise exposure was sufficient to reverse the habituation effect. Conversely, Szalma and Hancock (2011) suggested that longer or repeated exposures might permit the development of compensatory or coping mechanisms and identified this as a topic worthy of investigation.

Cognitive performance is not the only problem associated with distraction; there is also an affective component, varyingly operationalized as annoyance, loudness, and distraction ratings, or combined into ratings of acoustic satisfaction (Navai & Veitch, 2003). Acoustic satisfaction diminishes when the ambient sound level rises above 45 dB(A) and when the ambient sound is predominantly of high frequency (Navai & Veitch, 2003).

Speech sounds have the strongest relationship to acoustic satisfaction, and for this reason acousticians have developed a predictive metric based on the physical properties of the acoustic environment. They calculate the speech intelligibility index (SII) to quantify the degree to which speech sounds from outside the target area (a workstation or a room, in the case of offices) are audible against general background noise (Acoustical Society of America, 1997). SII replaces an older quantity known as the articulation index (AI) (American Society for Testing and Materials [ASTM], 1993). Among acousticians, spaces with SII > .20 are thought to be unacceptable.

Adding masking sound to the office environment is one way to improve the SII, because it increases the background level. Masking sound, being a continuous sound with no changing state, should not cause cognitive performance problems. A successful masking sound will be loud enough to cover speech sounds and with enough high-frequency sound to cover most speech sounds, but neither loud enough nor over-weighted in the high frequencies to cause annoyance. Veitch et al. (2002) tested a variety of simulated masking sounds and levels in two experiments, and concluded that spectra that closely match the speech spectrum can be good maskers and provide good acoustic satisfaction, provided that they achieve an SII > .20 and an overall sound pressure level not greater than 45–48 dB(A).

Schlittmeier and Hellbrück (2009) found that a continuous masking sound played over office noise reversed the ill effect of the office noise alone on a serial memory task, but that legato music was rated as a preferable sound when heard in isolation. They observed that masking sounds need to be acceptable to the hearers, adding that taking other processes into account, it would be preferable to add a degree of individual (personal) control to the sound. Interestingly, Lee and Brand (2010) reported that the effect of distraction on self-rated performance in office settings is mediated by the relationship between distraction and perceived control; people who reported higher distraction reported lower perceived control, whereas those with higher perceived control reported higher performance.

Ocular Light-Initiated Processes

Visual Perception

In this section we consider the effects of the work environment as processed by the visual system. We see objects and surfaces around us because they reflect light that the retina detects and the visual cortex processes. The light may come from electric sources, daylight, direct sunlight, or all of these sources. The lit environment will achieve good quality to the extent that the combination of light sources, their location and controls, and the surface properties of the space and objects in it meet functional, cognitive, and emotional needs of the individual occupants of the space in balance with the architectural characteristics of the space and the **(p. 255)** environmental and energy constraints particular to the context (Quality of the Visual Environment Committee, 2009; Rea, 2000).

Lighting requirements for North American workplaces are established by the Illuminating Engineering Society of North America (IES, 2004). Providing an adequate quantity of light[1] to see common office tasks is not difficult because most office workers today use computer monitors, which are self-luminous, and most paper tasks are printed crisply in relatively large type in high contrast (black on white). Under the 300–500 lx that is currently the recommended illuminance for office work (DiLaura, Houser, Mistrick, & Steffy, 2011; IES, 2004), relative visual performance of these tasks will be high (Rea & Ouellette, 1991).

Light distribution is another important dimension of lighting design. Both experimental and field investigations have consistently found that office workers prefer a mixture of direct and indirect lighting with higher proportions of occupants rating such lighting as comfortable, judging spaces lit by direct/indirect systems as more attractive, and reporting higher levels of environmental and job satisfaction after working in spaces lit with direct/indirect systems (Boyce et al., 2006a; Hedge, Sims, & Becker, 1995; Houser, Tiller, Bernecker, & Mistrick, 2002; Veitch & Newsham, 2000a; Veitch, Newsham, Mancini, & Arsenault, 2010).

Most office workers today use computer monitors for much of the day. Display technology has changed in recent years, with flat-panel liquid-crystal displays (commonly known as LCD monitors) having displaced the cathode-ray tube (CRT). The overall effect is beneficial in that LCDs, being flat and having matte surfaces, are less prone to reflection problems than were the spherical (curved), high-gloss surfaces of CRTs. LCDs are also capable of higher luminances than were CRTs, with average luminances of ~300 cd/m^2 for monitors available in 2010 versus 30–35 cd/m^2 being typical in the late 1990s (Veitch & Newsham, 2000b). Existing recommendations call for the ratio of luminances between the task area and the surrounding surfaces to be on the order of 1:3 or 3:1 (IES, 2004), although experiments with both CRTs (30 cd/m^2) and LCDs (91 cd/m^2) have shown that people prefer ratios closer to 1:1 (Sheedy, Smith, & Hayes, 2005; Veitch & Newsham, 2000b). If this is true, it will be more difficult to lower electric light levels as monitor luminances increase.

One obvious way to achieve both higher light levels and reduced energy consumption is to increase the use of daylight. The preference for a window in the office is well established (Collins, 1976; Farley & Veitch, 2001). Successful daylighting, however, requires careful planning so that one delivers the desired light level without causing discomfort. There does not yet exist a widely accepted method to predict visual discomfort from daylight (Osterhaus, 2005), but several methods and metrics have been proposed, such as the daylight glare probability (DGP; Wienold & Christoffersen, 2006) and statistics based on high-dynamic-range images of the office (Osterhaus, 2008; Van Den Wymelenberg, Inanici, & Johnson, 2010). Lindelof and Morel (2008) proposed a Bayesian probability approach in which discomfort is inferred from occupants’ use of lighting and shading controls, and built into the building automation system as an input to creating conditions that provide adequate light levels, limited discomfort, and energy savings.

All of these approaches to understanding discomfort assume that discomfort can be reliably predicted from the physical properties of light in the space. Research in this domain would benefit from improved scales to measure discomfort and more sophisticated research designs to explore the role of individual differences and contextual variables on the experience of discomfort. For instance, discomfort ratings are lower when participants are more involved in their tasks (Osterhaus & Bailey, 1992) and when the source of the glare is a scene judged to be interesting (Tuaycharoen & Tregenza, 2005).

Pressure to reduce lighting energy use is high, which has resulted in many technological developments in lighting equipment, lighting controls, and daylighting systems. Some of the proposed techniques are controversial because of their overall effects on office occupants. Among the most heated debates have occurred over the suggestion that the electric lighting in an office should use a light source that, although still white, has a relatively higher proportion of short-wavelength radiation (i.e., more blue light) so that its correlated color temperature (CCT) will be around 6,500 K. The basis for this argument are findings that show increased depth of field, higher brightness perception, and improved visual acuity for very small, low-contrast targets under this type of light (Berman, 1992);

therefore, the proponents of so-called spectrally enhanced lighting argue that the same level of visual performance could be achieved with lower illuminance levels than would be needed for other light sources.

Although the argument sounds compelling, there is no evidence that the correlated color (p. 256) temperature of a fluorescent lighting system up to 6,500 K influences task performance at light levels typical of office interiors (Boyce, Akashi, Hunter, & Bullough, 2003). In this laboratory experiment, higher CCT reduced pupil size, but the increased depth of field made no difference to the performance of the task. The illuminance (light level) and size of the task did affect both speed and accuracy. There was no interaction of illuminance and CCT, as there would need to be to support the idea of spectrally enhanced lighting. Boyce et al. (2003) concluded that using high CCT light sources would have no practical benefit on task performance.

This issue highlights the importance of considering multiple measures when making decisions about suitable design criteria. Visual performance is only one aspect of office work: we might reduce light levels with a particular light source to maintain visual performance of paper-based tasks, only to find that we have caused a problem with other outcomes, such as aesthetic judgments or visual comfort. Taking a different approach to the question, Akashi and Boyce (2006) examined the acceptability of a reduction in illuminance (from ~575 lx, slightly above the recommended range, to ~450 lx, in the middle of the range) and a change in CCT (from 3,500 K to 6,500 K) in a field setting. They found that office occupants could accept a reduction in ambient illuminance following an adaptation period, that the low-illuminance offices were perceived as brighter under higher-CCT lamps (6500 K), and that visual performance remained at the same level even with the reduction in light level. Some individuals added task lamps to boost their local light levels. However, the 6,500 K lamps were perceived as unattractive when used at higher illuminance. Akashi and Boyce concluded that energy savings are feasible, but do not necessitate the use of a high-CCT lamp.

Environmental psychologists have long sought an understanding of the effects of color on behavior, operationalized either by using colored room surfaces with conventional white light sources (fluorescent or incandescent), or by using colored lights in a white room. Results in recent years do not contradict the conclusions drawn by Beach, Wise, and Wise (1988) in a thorough review over 20 years ago: there are no simple, deterministic effects of color on behavior. Kwallek, Soon, and Lewis (2007) concluded an extensive series of experiments addressing the interactive effects of environmental sensitivity and room color (white, red, or blue-green) on clerical task performance with a week-long test. Taking into account the changing pattern of results for the various tasks over the work week, the three-way interactions had no straightforward interpretation. Hoonhout, Knoop, and Vanpol (2009) used colored lights on white room surfaces to vary the stimulus, but also failed to find straightforward effects of red versus blue light on task performance.

Küller et al. (2006) examined preferences for light and color cross-culturally and across seasons. They found that seasonal differences in mood were more pronounced for people in countries farther from the equator, but overall the main effect held that people preferred offices that they judged to be bright, rather than dim. There was a small effect in which emotional states were more positive for those who judged their offices to be colorful rather than neutral or colorless, but they did not collect data on precisely which colors were present in the offices. A subsequent set of laboratory experiments by part of the team also supported the contention that moderately colorful offices lead to beneficial emotional states that support task performance (Küller, Mikellides, & Janssens, 2009)—but not that any specific color is the ideal color for office decor.

Photobiology

Until 2001, it was thought that the only light-sensitive (photoreceptive) cells in the retina were the rods and cones that process visual signals. In that year we learned that there exist intrinsically photoreceptive retinal ganglion cells (ipRGCs), which transduce information about light and dark but not detailed visual information (Berson, Dunn, & Takao, 2002; Hattar et al., 2002). The ipRGCs have a unique spectral response function that has peak sensitivity in the range from 459 to 483 nm (i.e., in the range of blue light) (Brainard & Provencio, 2006). The information from these cells travels a different pathway from the retina to several higher structures (Commission Internationale de l'Eclairage [CIE], 2009). These structures include the pineal gland, where the information about the presence of light and dark regulates the release of the hormone melatonin, thereby setting the circadian clock (Berson et al., 2002). The ipRGCs also interact with the rods and cones of the visual system and are part of the pupillary light reflex (Gamlin et al., 2007; McDougal & Gamlin, 2010).

This discovery has energized photobiology researchers and has excited the architectural lighting community as well (van Bommel & van den Beld, 2004), although some commentators have cautioned that by placing application ahead of fundamental science, we could do more harm than (p. 257) good (Boyce, 2006; DiLaura, 2005). Those who urge caution point out that those who would make health claims of any kind for any technology require evidence. Changes to workplace lighting based on limited evidence risk causing unintended problems, making early application both an ethical and liability risk to practitioners and industry.

Of the many brain structures linked to the ipRGCs, only the connection to the suprachiasmatic nucleus and on to the pineal gland has been extensively studied (CIE, 2009). This has given us a fair understanding of light's role in circadian regulation but leaves much to be learned about other processes. This understanding has led to one area where applications have been quickly developed: lighting for shift work settings (e.g., Eastman & Martin, 1999; Smith, Fogg, & Eastman, 2009). Judicious use of light exposure during night work and time in darkness at home can aid in maintaining alertness at work and promote better sleep afterward, benefiting the employee, the employer, and society at large (the latter by reducing the risk of accidents both on the job and during the home commute).

The International Commission on Illumination (known by its French acronym, CIE) published a consensus report in 2004 (rereleased in 2009 with an erratum page) that outlined five "Principles of Healthy Lighting" as derived from the literature of the day:

1. The daily light dose received by people in industrialized countries might be too low.
2. Healthy light is inextricably linked to healthy darkness.
3. Light for biological action should be rich in the regions of the spectrum to which the nonvisual system is most sensitive.
4. The important consideration in determining light dose is the light received at the eye, both directly from the light source and reflected off surrounding surfaces.
5. The timing of light exposure influences the effects of the dose. (CIE, 2009)

The most relevant principle for workplace lighting, for both day- and night-shift workers, is the conclusion that most people in industrialized countries would benefit from higher light exposures than they currently experience. This is controversial because it raises the possibility of a demand for higher light level requirements for electric lighting in workplaces, at the same time as energy and environmental concerns are leading to pressure to lower light levels. The suggestion that this light should be rich in the short-wavelength portion of the spectrum has led manufacturers to propose new light sources and to field-test them. Despite these developments, many questions remain unresolved (Brainard & Veitch, 2007). What should the light exposure be? Need it be continuous, all day, or could it be achieved with an appropriately timed exposure?

The sum of knowledge does not yet permit a precise answer to any of these questions, but there are tantalizing hints that light exposure can influence social behavior in the short term and sleep quality later, in addition to measures of well-being cited in the CIE report (CIE, 2009). Using an event-contingent recording method combined with wrist monitors of overall light exposure, aan het Rot, Moskowitz, and Young (2008) found that social interactions that followed exposure to 1,000 lx of white light tended to be less quarrelsome than those following lower light exposures. Participants were exposed to this level for on average 19.6 min per day, a value typical for that latitude and season (Hébert, Dumont, & Paquet, 1998).

Three teams have developed devices to enable improved ecological measurements of daily light dose that take into account its spectral properties (Gordijn, Giménez, & Beersma, 2009; Hubalek, Brink, & Schierz, 2010; Miller et al., 2010). Few studies have as yet been completed with these tools. As would be expected, Miller et al. (2010) found that the daily light exposures of day- and night-shift nurses in the United States are very different and suggested that this tool could be used for further studies of circadian disruption and its effects on health. Hubalek et al. (2010) studied office workers in Germany, collecting both light exposures and questionnaire data concerning mood and sleep quality. Light exposure did not directly predict mood but did influence sleep quality on the following night: sleep quality improved with higher light exposure during the day.

Partly because of the energy implications and partly in recognition of circadian changes in light sensitivity, researchers have begun to explore ways to increase light exposure for shorter periods rather than as continual increases in light levels. The findings are suggestive but not conclusive, partly because of research design issues. Kaida, Takahashi, and Otsuka (2006) exposed Japanese participants to daylight through a window (> 2,000 lx) for

30 min after lunch and found that this improved one positive mood scale and reduced subjective sleepiness relative to a control condition (100 lx electric light, lamp type unspecified); a short nap at the same time (p. 258) on a different day improved three mood scales and reduced subjective sleepiness. Another Japanese team examined the effect of using bright light in the morning and into the early afternoon, in comparison to a constant lower level all day. They interpreted the findings to suggest that the higher light level increased afternoon clerical task performance (Obayashi et al., 2007). Both studies, however, have order effect confounds, and the performance data reported by Obayashi et al. (2007) seem to show a strong effect of practice over the three weeks of the experiment.

de Kort and Smolders (2010) tested a dynamic lighting scheme in which both light level and correlated color temperature varied according to a schedule that was designed to provide more short-wavelength stimulation at times of day when it was thought to be beneficial, and reduced light levels at other times of day to reduce energy use. The experimental condition varied from 700 lx at 4,700 K in the early morning and after lunch, then shifted slowly to 500 lx at 3,000 K in the later morning and late afternoon. This was compared to a static condition of 500 lx at 3,000 K. The field experiment took place in the Netherlands, where the law requires all employees to have a window within 5 meters of the workstation, and this building had very large and unobstructed windows; thus, all participants also experienced high levels of daylight in the workplace (which would not necessarily be the case in North American offices). Daylight-responsive dimming reduced the amount of electric lighting to the extent that daylight provided the required level, and therefore modified the experimental exposures. Although the experimental design itself was strong (an ABA/BAB design over various floors in the building), it is not surprising that most of the outcome measures did not show statistically significant differences. Most interestingly, however, occupants with dynamic lighting did report higher satisfaction with the lighting than when they experienced the static lighting condition.

Another approach to stimulate the ipRGCs has been to use a light source with relatively more light in the short wavelengths to which these cells are more sensitive. The light source that has been tested is nominally white but has a correlated color temperature of 17,000 K. Most people will experience this as much more blue than any commonly used fluorescent lamp (in North America, most lamps are either 3,500 K or 4,100 K, although 5,000 K and 6,500 K lamps are sometimes used, particularly by those who invoke the spectrally enhanced lighting approach described above). Two field trials of the 17,000 K lamp have found that employees in areas with this lamp reported higher alertness and self-reported concentration and performance at work, and reduced fatigue at home in the evening (Mills, Tomkins, & Schlangen, 2007; Viola, James, Schlangen, & Dijk, 2008). These initial positive results merit further investigation and extension to include consideration of the aesthetic judgments of the spaces lit with these lamps. (Anecdotal evidence suggests that some people will strongly dislike the appearance of rooms lit with such an extreme CCT.)

Comfort

Comfort as an outcome receives research attention from human factors researchers, from engineers, and to a lesser extent from psychologists, although each discipline takes its own perspective. Among human factors researchers the focus is largely on physical comfort associated with the musculoskeletal system as influenced by furnishings, equipment, and layout, although thermal conditions and thermal comfort also receive some attention (Brand, 2008). Because Brand extensively reviewed physical comfort and musculoskeletal injury issues associated with workstation design, these are not considered here. Here, we consider the temperature and ventilation conditions that contribute to comfort as being topics less well-known among psychologists.

Thermal Comfort

The engineering community has a long tradition of interest in thermal comfort and perceived air quality (Fanger, 1970), particularly with the aim of setting standards for workplace temperature and ventilation systems (American Society of Heating, Refrigerating, and Air-Conditioning Engineers [ASHRAE], 2001, 2004). Although comfort is entirely a subjective phenomenon, few psychologists have engaged in its study. This is puzzling, as de Dear (2004) has noted.[2]

Among engineers, the dominant model of thermal comfort is Fanger's (1970) Predicted Mean Vote—Predicted Percent Dissatisfied (PMV-PPD) model. Psychophysical experiments in climate chambers established that thermal sensation relates to air temperature, air velocity, radiant temperature, relative humidity, clothing, and activity levels. This model forms the basis of standards for thermal conditions in sealed, air-conditioned buildings (typical in North America), with the target being the achievement of conditions that 80% of the population will find satisfactory (ASHRAE, 2004).

(p. 259) Although this model has dominated North American engineering practice for 40 years, its limitations have long been apparent in the literature. Rohles (1980) reviewed five studies showing that context influences thermal comfort. Newsham and Tiller (1997) found that the Fanger model predicted only 11% of the variance in thermal sensation scores. Humphreys and Hancock (2007) asked respondents both their desired sensation and their thermal sensation. More than half the time, the desired sensation was not “neutral” and there was substantial individual variation in desired sensation.

Elsewhere in the world, natural ventilation (i.e., using windows that open) is more common than it is in North America. In naturally ventilated buildings the PMV-PPD model is not predictive of thermal comfort (de Dear, 2004; Wagner et al., 2007). Better prediction is possible using the adaptive model of thermal comfort, which takes contextual factors into account, such as the individual’s past thermal history, his or her expectations for the thermal environment, and behavioral adjustments he or she makes (Brager & de Dear, 1998).

Ventilation

The North American standard for the supply of fresh air in mechanically ventilated buildings specifies that a volume of 10 L/s/person of outdoor air should be provided (ASHRAE, 2001). The level was set with the aim of providing sufficient outdoor air to remove pollutants (including carbon dioxide created by occupants) to maintain health and comfort, and in parallel to limit energy use. In cold climates the outdoor air must be heated in winter, and in all seasons fans are required to move the air.

The evidence is mounting, however, that this level may be too low. A multidisciplinary panel of European experts (although not including any psychologists) reviewed the literature in 2002 and concluded that as much as 25 L/s/person might be needed for adequate comfort and health (Wargocki et al., 2002). They also noted that many of the initially identified papers had to be excluded because of methodological limitations. Charles and Veitch (2002) made some of the same criticisms; although they did not view the evidence in favor of levels above 10 L/s/person as being clear, they did conclude that levels lower than this are clearly too low.

Many studies are limited to physical data at the building or perhaps the floor level; few have data on local conditions in workstations. Therefore, there is little data on the achievement of the design conditions in the places where people work. Charles et al. (2006) analyzed data from a study of ~770 North American workstations. The dependent variable was a satisfaction with ventilation scale for which ratings of satisfaction with temperature, air movement, and overall air quality were averaged (Veitch, Charles, Farley, & Newsham, 2007). The physical conditions generally met the applicable standards (e.g., the mean carbon dioxide, or CO_2, concentration was 648 ppm [Charles et al., 2006], whereas the standard specifies 1,000 ppm as the upper limit [ASHRAE, 2001]). Satisfaction with ventilation showed the predicted inverse relationship with CO_2, with satisfaction being higher when CO_2 levels were lower.

Newsham et al., (2008) used log-linear models to analyze the risk of dissatisfaction with this data set, and found that people whose local CO_2 levels were above 650 ppm had a three-times-higher risk of dissatisfaction with ventilation. Other risk groups for dissatisfaction with ventilation were those who were either next to, or very far away from, a window; experienced a temperature more than 0.5 degree C away from the calculated neutral temperature; or were female.

Integrated Models of Comfort

Practical separations between building systems and furnishings support the development of separate research lines for thermal comfort, ventilation, acoustic satisfaction, and so on. Understanding how temperature conditions influence comfort can enable engineers to design systems to create those conditions. Nonetheless, researchers have called for integrated systems approaches combining these domains (Bluyssen, Ariës, & van Dommelen, 2011; Brand, 2008; Frontczak & Wargocki, 2011; Vink & Hallbeck, 2011). The approach of studying each physical domain separately (temperature, ventilation, acoustics, lighting) does not allow for the possibility of interactions.

The North American workstation environmental satisfaction project cited earlier explicitly took an integrated approach (Newsham et al., 2008; Veitch et al., 2003). All results and reports from the Cost-effective Open-Plan Environments project are available online at www.nrc-cnrc.gc.ca/eng/projects/irc/cope.html. Its field study led to the development of three separate scales for satisfaction with lighting; privacy and acoustics; and ventilation and indoor air quality. There also was a separate scale for overall environmental satisfaction and one for job satisfaction. Physical conditions in all environmental domains were measured simultaneously with the **(p. 260)** occupant surveys. Domain-specific and general regressions were run. The value of this approach is evident when one considers the different results for different satisfaction domains. For example, satisfaction with lighting was highest for people next to a window, but satisfaction with ventilation and overall environmental satisfaction were better for people in the second row (who benefit from the daylight without potential thermal problems) (Veitch et al., 2003).

Bluyssen et al. (2011) tested regression models for overall comfort on a large European data set for which both summer and winter data were available (*N* > 5,700). The outcome measures were derived from averages of scores for comfort with individual dimensions (e.g., noise, lighting, etc.). The predictors were self-reported adequacy of building conditions (view; environmental controls; and privacy, cleanliness, decor, and layout as one office conditions scale) and office characteristics (cardinal orientation). The models showed strong effects (~25% explained variance) for which the predictors differed in summer and winter. The strongest predictors in both seasons were the reported quality of the view and the overall satisfaction with the office conditions. However, the between-building differences were large enough to lead the authors to suggest that future studies require additional data collection concerning individual and social variables, before the desired practical shortcuts for building design can be developed.

Inadequate data—not enough studies—is a common refrain in this domain. Frontczak and Wargocki (2011) reviewed the literature on workplace comfort, seeking studies that would permit the development of a ranking of the importance of comfort in the domains thermal, lighting, acoustics, and air quality. They observed that such a ranking would permit practical judgments to be made about which condition to address first. It was evident that when such a ranking was possible, thermal comfort was the highest priority for occupants. However, they also noted that there are too few studies to determine whether the importance of the domain is related to the level of satisfaction with it. Some studies have found that when satisfaction with a building condition is high, the importance of that condition is lower (Boubekri & Haghighat, 1993; Veitch et al., 2003). As did Bluyssen et al. (2011), Frontczak and Wargocki (2011) called for more studies, and stronger methodologies, concerning the effects of personal and organizational characteristics on comfort.

Ergonomists have begun to distinguish between comfort and discomfort as separate dimensions (Helander & Zhang, 1997; Zhang, Helander, & Drury, 1996). This approach has had little influence as yet outside the domain of product development. The studies cited here have considered comfort to be a unidimensional concept with a negative state (discomfort) and a positive state (comfort), and largely synonymous with the concept of satisfaction with the physical environment. Vink and Hallbeck (2011) have proposed a new model of comfort that differentiates between comfort, neutral, and discomfort outcomes resulting from individual, environmental, and contextual aspects of exposures. Whether indoor environment researchers (from any discipline) take up and test this model remains to be seen.

Stress and Health

Interest in work environments as contributors to strain through stress processes has a long history, as seen in now-classic articles and chapters (e.g., Wineman, 1982). The early focus was on specific stressors in the work environment, such as noise and temperature; this was followed by studies of sick building syndrome—a particular interest in the indoor air quality and ventilation communities. These studies can contribute to workplace design and engineering choices with the aim of preventing adverse outcomes. Such attention to detail is particularly important given evidence that mild to moderate risk factors act in sum as a cumulative stressor to reduce well-being (Evans Becker, Zahn, Bilotta, & Keesee, 2012; Wellens & Smith, 2006), and chronic exposure to environmental stressors can cause learned helplessness (Evans & Stecker, 2004).

Noise

Noise is among the most-studied stressors. Apart from its effects on hearing, chronically high levels of community noise have detrimental effects on health and well-being, influencing outcomes from annoyance to cardiovascular health (Ising & Kruppa, 2004). This has led the World Health Organization Regional Office for Europe (WHO Europe) to formulate guidelines for urban noise levels (WHO Europe, 2007).

Exposure to very high noise levels is associated with reports of stress-related health problems. Raffaello and Maass (2002) observed a decline in reported stress-related health problems among factory workers whose conditions changed from a range of 78–84 dB(A) to 69–72 dB(A) as a result (p. 261) of a move to a new factory, in comparison to a control group whose conditions stayed in the range of 75–86 dB(A).

Other investigations have found that the effects of workplace noise on health are interactive rather than simple. In an industrial setting in Israel where the mean noise level was 71 dB(A), Melamed, Fried, and Froom (2001) found that the effects of noise exposure on blood pressure and job satisfaction were greater for workers with greater job complexity. Fried, Melamed, and Ben-David (2002) analyzed noise exposure and sickness absence data from white-collar workers in Israel. (Both papers used data collected as part of a larger study in industrial organizations conducted between 1985 and 1987.) The mean noise level was 63 dB(A) for this sample. Sickness absence was, as predicted, a function of both noise exposure and job complexity. Working on cognitively complex jobs in noisy conditions had adverse health consequences, particularly for women (Fried et al., 2002).

Evans and Johnson (2000) found that exposure to simulated office noise played at an average level of 55 dB(A) with peaks to 65 dB(A) in a laboratory setting resulted in increases in epinephrine secretion (but not in cortisol, the “fight or flight” hormone), reduced postural adjustments, and behavioral aftereffects typical of motivational deficits, as compared to the quiet condition of 40 dB(A). A UK field study observed noise conditions in the range 46–63 dB(A), with a mean of 55 dB(A) (Leather, Beale, & Sullivan, 2003). Noise did not exert a main effect on self-reported health symptoms, but did moderate the relationship between job strain and symptom reports. Job strain had no effect on health symptoms for people in low noise, but the combination of high job strain and high noise exposure was associated with increased reporting of symptoms of ill health.

Overall, a workplace noise level of 55 dB(A) or higher may contribute to ill health, particularly for people with complex jobs or who experience high levels of job strain. However, contemporary offices in North America are not typically this noisy. Two field studies of North American open-plan offices found the median background sound level to be 46 dB(A) (Veitch et al., 2003; Warnock & Chu, 2002).

Sick Building Syndrome

Sick building syndrome (SBS), also known as non-specific building-related symptoms (BRS), is among the most frustrating contemporary built-environment problems. As compared to diseases with symptoms that cluster according to known physiological mechanisms, SBS is both difficult to describe and difficult to understand. Identifiable diseases, such as lung cancer or asthma, have reasonably well-understood causes. SBS symptoms include eye, nose, or throat irritation, headache or fatigue, breathing problems, and skin irritation, and generally improve following periods of time away from the target building (Mendell, 2003). Despite the absence of an operational definition of the condition (Hodgson, 2002), several risk factors have been identified. After 20 years of study, it is now known that symptoms are associated with high temperatures, low outdoor air ventilation rates, poorly maintained humidification systems, and microbial contamination (Mendell et al., 2008; Norbäck, 2009; Wargocki et al., 2002). The condition is somewhat more likely in mechanically ventilated than in naturally ventilated buildings (Gomzi et al., 2007).

In addition to these physical factors, research also shows that individual characteristics and working conditions contribute to symptom reports. Women report more SBS symptoms than do men (Brasche et al., 2001; Runeson, Wahlstedt, Wieslander, & Norback, 2006). Personality variables such as neuroticism, somatic anxiety, and psychic anxiety have been associated with higher risks of reporting SBS symptoms (Gomzi et al., 2007; Runeson, Norback, Klinteberg, & Edling, 2004; Runeson et al., 2006). Working conditions also play a role, but in complex ways. High job demands and role overload have been associated with symptom severity, suggesting a role for stress in the development of sick building syndrome (Mendelson, Catano, & Kelloway, 2000; Runeson et al., 2006), but both studies also found more complex interactions of social support than would be predicted by the traditional demand-control-support model of workplace stress (Doef & Maes, 1999). Mendelson et al. concluded that support from the organization and the reduction of role stress might be effective responses to the problem of SBS, whereas interventions designed to increase support from coworkers are less likely to reduce symptom severity.

Control

Classically, stressful conditions are created when environmental stimulation creates demands but one lacks control over the source of stimulation (e.g., Glass & Singer, 1972). In occupational health psychology the dominant model for this is the demand-control model (Karasek & Theorell, 1990). In the absence of control over the job (i.e., when one has (p. 262) little job autonomy), greater demands act as stressors, leading to strain outcomes such as ill health. In work environment psychology, it has long been thought that the provision of individual environmental controls would facilitate stress reduction (Becker, 1985). Specifically, giving people control over the stressor—or the perception that they have the power to control the stressor—would be expected to diminish its physiological and behavioral effects (Averill, 1973; Glass & Singer, 1972).

The demand-control model as understood by occupational health psychologists has been modified to include social support (Doef & Maes, 1999). The availability of social support—for example, friendly relations with coworkers—would be expected to buffer (or prevent) the strain associated with exposure to a stressor, even if the support does not itself confer actual or perceived control over the stressor. In environmental psychology, this concept has an extension in the form of organizational support as evidenced in the work space design, the organization’s responsiveness to reported problems in the physical environment, and the involvement of occupants in design and operation (Becker, 1985; Leaman & Bordass, 2001).

Vischer (2007) integrated negative and positive dimensions of stress in a proposal for a model of what she called “work space stress,” a modification of the demand-control model (Karasek & Theorell, 1990). The key concepts in Vischer’s model are the psychological demands that the work space makes on the occupant, and the decision latitude available to the occupant for responding to the demands. Such a model, she argued, could encompass the conceptual complexity of physical features that simultaneously influence several processes, such as work space separations that create territories, define the boundaries of privacy, enable social interaction, define work groups and social networks, and permit distractions, particularly by focusing on the fit of the environmental characteristics with the needs of the occupant. Decision latitude, according to Vischer, means the degree to which individuals may participate in determining what the work space conditions will be; a higher degree of decision latitude should provide a buffer against the adverse effects of high levels of work space demands.

Most studies in this field examine the effects of *perceived* control (varyingly defined as limited to the physical environment, or incorporating elements of the job, tasks, or “work life”) on outcomes such as environmental satisfaction, job satisfaction, and self-reported job performance. (A few studies have experimentally manipulated providing physical control; see below.) Lee and Brand (2005) found that perceived environmental control was positively related to environmental satisfaction directly, and both directly and indirectly related to job satisfaction, the indirect effect being through an effect on group cohesiveness. Distractions also negatively predicted environmental satisfaction. Later, the team examined the effect of distractions on perceived (environment and job) control and self-rated job performance (Lee & Brand, 2010), finding that perceived control mediated the effect of distractions on performance; that is, where distractions were greater, control was perceived as lower and in turn, self-rated job performance was also lower.

Through the integration of concepts from organizational psychology and environmental psychology comes a more nuanced view of the influence of environmental control on employees. O’Neill (2010) described environmental control as “about giving people the work space design, furnishings, technology and policy tools that provide choice over how to work, as opposed to being controlled by the space and organizational policies” (p. 133). He developed a model of control—actual control, not only the perception of it—at the individual, group, and organizational levels, and identified research directions, pointing out that there is ample evidence for the benefits to individual behavior and performance of adjustability and flexibility in the physical environment, but less evidence for the consequences at the organizational level—that is, the effects on business outcomes that will be used to justify investments.

Knight and Haslam (2010a) conducted two elegant experiments testing hypotheses related to the performance and satisfaction effects of working in offices they characterized as “lean” (without decoration), “enriched” (with plants and art), “empowered” (with plants and art chosen by the participant), and “disempowered” (with plants and art chosen by the participant but then removed by the experimenter). As predicted, permitting people’s input into the office decoration improved performance on clerical tasks and well-being (physical comfort, psychological comfort, and job satisfaction), and removing their choices diminished their performance and well-being.

Knight and Haslam (2010a) did not observe expected effects on organizational identification in these laboratory settings; they had expected that providing autonomy over the environment would lead to increased organizational identification. In (p. 263) two field surveys they did find support for such a model (Knight & Haslam, 2010b). Autonomy over the physical work environment and involvement in it predicted psychological comfort (conceptually related to what other researchers have called environmental satisfaction; Veitch et al., 2007), which in turn predicted organizational identification, and this concept in its turn predicted job satisfaction.

Organizational identification as defined by Knight and Haslam (2010b) has similarities to affective organizational commitment as understood by organizational psychologists (Allen & Meyer, 1996), and in turn managerial control of space is an element of organizational support, along with human resources practice and policies. Organizational support is a predictor of affective organizational commitment (Meyer, Stanley, Herscovitch, & Topolnytsky, 2002). Further exploration of the concepts explored by Knight and Haslam (2010a, 2010b) could provide the needed link to organizational outcomes, by adding office space management concepts to existing models showing that business units with greater average job satisfaction show reduced turnover, higher customer satisfaction, and greater business unit performance (Harter, Schmidt, & Hayes, 2002).

Restoration

In addition to the classical physiological consequences of exposure to stressors (Selye, 1956), contemporary researchers also hypothesize that demanding environmental conditions force the allocation of attentional resources to cope with the threat (Hancock, Ross, & Szalma, 2007; Szalma & Hancock, 2011). Kaplan (1995, 2001) argued that natural environments are inherently rich in the properties required to restore directed attention, such as mystery and coherence. Indeed, environmental psychologists studying homes, workplaces, and recreation settings have found consistently that access to nature can provide opportunities for restoration from stressful experiences. This access to nature can take the form of active presence, such as a wilderness hike (Hartig, Mang, & Evans, 1991) or passive viewing of films (Berman, Jonides, & Kaplan, 2008; Ulrich et al., 1991).

The possibility of restoration might account for the persistent and strong preference for windows in workplaces (Farley & Veitch, 2001; Veitch et al., 2003). Beyond the simple presence of a window, the amount of view provided is a predictor of the judged pleasantness of the office (Cetegen, Veitch, & Newsham, 2008) and of satisfaction with lighting (Newsham, Brand, et al., 2009). The preference for more view seems to cross cultures, as Dogrusoy and Tureyen (2007) found that occupants of offices in Izmir, Turkey, also preferred window shapes providing more extensive views. Similarly, Ozdemir (2010), studying the judgments of office occupants in a building in Ankara, Turkey, found that occupants of offices with more natural views rated their satisfaction with the room more highly. Chang and Chen (2005) found that watching a nature view and being in the presence of indoor plants reduced both anxiety and physiological measures of tension and arousal.

Although most investigations have focused on access to nature, the relationship may be more complex. Ariës, Veitch, and Newsham (2010) obtained independent ratings of the attractiveness of office views, and studied both this variable and the view content (natural vs. urban) as they affected judgments of the room appearance and in relation to physical and psychological comfort at work and sleep quality at home. The data were obtained from Dutch office workers, all of whom are guaranteed window access within 5 m of the desk. Those with more attractive views had more favorable impressions of their offices, better psychological and physical comfort at work, and better sleep quality at home. The views of nature from this set of offices had contrary effects: they directly improved office impressions, thereby indirectly contributing to improved psychological and physical comfort; however, nature views directly reduced comfort, as compared to urban views. The latter finding is very unusual, and the study awaits replication.

Few field studies are able to incorporate detailed physiological measurements together with self-reported data on environmental satisfaction, but Thayer et al. (2010) were able to do so in a pre/post comparison of employees in a building undergoing renovation. Many aspects of the interior design changed in the renovation, making causal attributions difficult; however, the most salient changes according to the environmental satisfaction questionnaire were an increase in daylight availability and access to a view, improved lighting quality, and improved air quality. Overall results of heart-rate variability and cortisol secretion measurements showed lower autonomic activation and lower stress hormonal response in the new space (Thayer et al., 2010). Whether these results relate to the light exposure, the view content, or the air quality—or all three—cannot be determined from these data.

(p. 264) In many North American buildings, the large floor plate precludes providing window access to all employees, whereas in many European countries it is a legal requirement (e.g., Danish Building and Housing Agency, 1995; Government of Norway, 1997). It might be thought that one way to provide a natural element in a windowless space, or in a windowed space without a nature view, would be to provide plants. Two recent reviews have concluded that the literature testing this idea has several methodological weaknesses (Bakker & Voordt, 2010; Bringslimark, Hartig, & Patil, 2009). Both reviews concluded that in general, the presence of indoor plants appears to reduce stress in some fashion, but the precise physiological, affective, or cognitive effects and the mechanism by which they operate is unknown. Bakker and Voordt (2010) further noted that little attention has been paid to the type of plant or to its state of health.

Positive Affect

Individual control allows people to influence stressors at work, but also allows the possibility of obtaining conditions that suit their personal preference. The default conditions might not themselves be stressors—they might be adequate conditions for the work to be done—but they might not be those that the individual prefers. By making it possible for adjustments to be made it becomes possible for individuals to satisfy their desires. In experimental work, this effect is subtle enough that there might be no main effect of individual control, as seen in Veitch and Newsham's (2000a) study of office lighting levels and light distribution, but large individual differences in preferred conditions (Veitch & Newsham, 2000b) and evidence that individuals who work under their preferred conditions experience greater well-being (Newsham & Veitch, 2001).

Positive affect theory is the mechanism by which this effect is thought to operate (Baron, 1994; Isen & Baron, 1991). Regardless of whether one has chosen the conditions or has the power to alter them, working under preferred conditions can create a state of positive affect that in turn leads to benefits in the form of increased cooperation, reduced competition, improved intellectual performance, and increased creativity (Baron, 1990; Baron & Thomley, 1994). Baron's experiments concerned scent. Kuller et al. (2006) conducted a multi-nation survey of office lighting and color conditions and found that when light levels were said to be “just right,” mood measures reached their highest levels.

Most thermal environment research is atheoretical, seeking deterministic relationships between environmental conditions and various experiential and observable outcomes. However, positive affect might be the mechanism behind findings that are used to justify engineering standards. For example, classroom performance on standardized tests improved when temperatures were reduced such that students reported neutral comfort rather than feeling too hot (Wargocki & Wyon, 2007). In the laboratory, when participants work in thermal environmental conditions close to the neutral point of comfort between “too warm” and “too cold,” they show the best performance on neurobehavioral and clerical tasks (Lan, Wargocki, & Lian, 2011).

The benefits of conditions that create positive affect can be used to justify investments in specific design features known to be generally preferred, and particularly to support the implementation of individual environmental controls in offices. Any single design criterion can satisfy only a portion of the population (Newsham & Veitch, 2001), whereas individual control enables a broad range of conditions to be achieved. This was the motivation behind the Light Right Consortium laboratory and field investigations of energy-efficient office lighting featuring workstation-specific, individually controllable direct-indirect lighting as the condition thought to create the best overall environment. Both in the laboratory and in the field, this was the case. In the laboratory, this lighting system was judged to be the most comfortable and the individual control appeared to provide a buffer against the progression of fatigue over the workday (Boyce et al., 2006a). In the field, employees with this lighting installation reported greater satisfaction with lighting, overall environmental satisfaction, job satisfaction, and organizational commitment, and lower intent to turnover (Veitch et al., 2010).

Three studies, with five independent data sets, have supported a theoretical model in which people who report better appraisals of their office lighting show predicted beneficial effects through improved mood. Veitch, Newsham, Boyce, and Jones (2008) used mediated regressions to establish a chain of effects from higher lighting appraisals through improved room appearance judgments to more pleasant mood and on to improved health and well-being in the form of physical and visual comfort reports at the end of the workday and higher end-of-day satisfaction with the environment and their work during the day. Veitch, Stokkermans, and Newsham (in press) found support for a similar (p. 265) model in which improved mood led to stronger work engagement. Data from an organization undergoing an office renovation showed support for a model in which lighting appraisals led to improved room appearance judgments, which in turn led to improved mood; improved mood in turn led to a chain from improved overall environmental satisfaction to reduced intent to turnover and to a separate chain from improved mood to reduced health problems in the form of visual and physical discomfort at work and fewer days absent from work (Veitch et al., 2010). Thus, providing conditions that employees perceive as comfortable or better has benefits for organizations as well as for the individuals themselves.

Famously, Herzberg (1966) concluded that the physical environment is a hygiene factor in work motivation—that if the physical conditions are inadequate (e.g., dark, noisy, badly arranged) then motivation will decline, but that there is no room to improve motivation above the baseline using the work space design or furnishings. Contemporary researchers would beg to differ. Although most of the recent research testing the positive affect theory has focused on lighting systems and their individual control, in principle this model could be applied to study the benefits, to organizations as well as to individuals, of providing environmental conditions that create a state of comfort or satisfaction.

Cognition

A few investigations have examined how cognitive processes influence one's environmental appraisals or judgments about work environments. These investigations, although each taking a different perspective, remind us of moderating effects internal to the observer that influence the processes described above.

Fischer, Tarquinio, and Vischer (2004) examined the influence of the self-schema on environmental appraisals and job satisfaction. The work environments of the participants were broadly comparable, but the perceptions of those environments differed for participants with a success-oriented or a failure-oriented professional self-schema. Those with a success-oriented professional self-schema tended to hold more positive views of their work environments and of their jobs.

For all but the self-employed, the provision of a work environment is management's responsibility. This has a physical and a symbolic aspect, in that organizations implicitly communicate the value of the employees in the office environment provided (Marquardt, Veitch, & Charles, 2002). One would expect this communication function to influence the organizational identification process that Knight and Haslam (2010b) explored, although no studies appear to have tested this notion.

Marquardt et al. (2002) concluded that when individuals' needs are met by the working conditions provided, environmental satisfaction is improved. Expressing the relation in this form, there is no room for a positive increase in environmental satisfaction. Perhaps similarly, Lee (2006) found that when employees' expectations for the office environment are met, satisfaction plateaus; office environments that exceeded expectations did not result in higher environmental satisfaction. This finding merits further examination, in view of the contrast with the positive affect results and those of Goins et al. (2010), both discussed above.

Innovative Work Arrangements

With the advent of the Internet, increasing real estate costs, and the cost and time associated with commuting, we hear much about the "new ways of working," including telework (working electronically from a site that is not the corporate office) and hoteling (working at the corporate office in a workstation assigned temporarily). Although computing and communications technology today makes these practices easier, they are not new concepts (van Meel, 2011). Moreover, the fundamental processes that employees experience are not different for different work arrangements; privacy, distraction, comfort, and so on occur regardless of where one is.

Very few studies have examined the physical work environment aspect of teleworking (Ng, 2010). Ng's review concluded that teleworkers desire in their home office the same qualities they would find in the corporate office, but that there can be challenges to fulfilling these desires. Even for employers with policies that mandate the provision of equipment and furnishings for home-based work, there is no guarantee that the employee’s home will have a suitable space in which to put the office. The health and safety aspects of these issues remain unresolved in both Canada and the United States; as Ng pointed out, there might be hidden costs to organizations associated with moving employees out of the corporate office. This area warrants systematic research.

Communications researchers have begun to examine the social dimension of remote working. They note that the information and communications technologies (ICT) that permit distributed working are paradoxical. Distributed work means (p. 266) less face-to-face communication, which some argue is a fundamental aspect of work life (van Meel, 2011), but also creates an expectation of constant, instant availability. Leonardi, Treem, and Jackson (2010) observed that teleworkers used ICT in covert ways to manage availability so that it appeared that they used time in the same way as they would have had they been in the corporate office. Leonardi et al. also observed that some of the same distractions and interruptions that the teleworkers were trying to control, such as e-mail, also affect workers in the corporate office. Others have found that the reduction in the experience of these stressors explained higher job satisfaction for teleworkers as compared to office workers (Fonner & Roloff, 2010).

Danielsson and Bodin (2008) presented one of the few studies to consider the effects of hoteling in comparison to other office types. The “flex” offices in their sample were assigned on an as-needed, temporary basis, and offered no opportunity for personalization. Based on the previous discussion concerning territoriality, one would predict that such an office would increase the employee’s risk of adverse health and well-being. In this sample, the reverse was true: people in flex offices had a lower risk of ill health. Why this might be so is unclear from the data.

Summary

Overall, research into the effects of work environments on their occupants since the last major handbook chapter (McCoy, 2002) has refined rather than revolutionized our understanding. There is a greater understanding of the influence of the environment on attention processes in particular. Coupled with the increased evidence for the merits of access to nature to promote restoration, we see the importance of understanding the mechanisms of action, as these can lead to innovative or unexpected solutions. For example, if it is not possible to entirely remove the sources of distraction, one might instead seek to provide opportunities for nature restoration.

Environmental Consequences of Workplace Behaviors

In commercial buildings the two largest electricity-consuming functions are lighting (38%) and heating, ventilation, and air-conditioning (HVAC) (30%) (United States Energy Information Administration, 2009). Improvements in technology could reduce the total energy consumed for these functions, but they are also targets for behavior change. Research topics concern the usability of the new technologies—particularly demonstrations that they preserve suitable environmental conditions for work—as well as verification of the intended energy savings. Research into the factors influencing the adoption of the new technologies among organizations is at an early stage.

Individual Resource Use

Despite the long history of environmental psychologists’ interest in using psychological principles to effect change in environmentally relevant behaviors and in resource management (Geller, 1987; Stern & Oskamp, 1987), comparatively little of this attention has focused on work settings. A few studies have examined values and norms and their influence on energy-conserving behaviors in workplaces (Andersson & Bateman, 2000; Scherbaum, Popovich, & Finlinson, 2008), but there is little guidance available for organizations to follow in promoting environmentally responsible actions to employees.

The engineering approach to workplace energy use is technological. Automated lighting controls such as occupancy sensors to turn off lights in unoccupied spaces and daylight harvesting to dim the electric lighting when daylight is available are unquestioned energy savers (Galasiu & Newsham, 2009; Galasiu, Newsham, Suvagau, & Sander, 2007; Jennings, Rubinstein, DiBartolomeo, & Blanc, 2000). It is less well known that individual control can also save energy; where individuals have the opportunity to control the level of their local lighting, on average the lighting energy use is ~10–15% lower than it would be under a fixed level (Galasiu et al., 2007; Jennings et al., 2000; Veitch & Newsham, 2000a). Given the benefits of individual control associated with positive affect, this makes individual control over lighting a benefit to individuals, organizations, and the environment. However, both the size of the energy savings and the possibility for individuals to obtain their preferred conditions will depend on the equipment and the control system parameters, such as the possible range of light levels (Boyce et al., 2006b; Fotios, Logadóttir, Cheal, & Christoffersen, 2011; Newsham, Arsenault, Veitch, Tosco, & Duval, 2005), which leaves room for further research.

As noted above, there is a strong preference for windows in offices and benefits to a view of outside. However, direct sun causes both thermal and visual discomfort, leading people to lower the blinds. When this occurs early in the day the tendency is not to raise them again (Reinhart & Voss, 2003), (p. 267) which can lead to an increase in electric lighting use. The technical solution to this could be to provide automatic blinds, but people dislike fully automated systems, which take away choice (Galasiu & Veitch, 2006). Cultural factors also influence the response to automated building controls (Cole & Brown, 2009). Building automation generally is an area in which psychologists' contributions seem an obvious, but unmet, need, as there appear to be no systematic investigations of the effectiveness or acceptability of these systems for individual occupants or for building operators.

Thermal comfort also offers room for individual action that can reduce energy use, particularly if one adopts the adaptive model. Few North American buildings provide local options to change the ventilation or temperature, so most of the research on adaptive responses comes from other continents. With a push from the adoption of energy codes mandating strict limits on building energy consumption, natural ventilation and passive cooling strategies become more attractive. Such buildings can have wider variation in thermal conditions than occur in mechanically ventilated buildings, to which occupants may respond with adaptive behaviors to maintain thermal comfort, such as adding or removing a layer of clothing, or opening or closing a window (de Dear, 2004). Field surveys reveal that these occupants can perceive these buildings favorably (Barlow & Fiala, 2007; Wagner et al., 2007), but more systematic investigations with more robust measurement tools and statistical analysis would support stronger inferences about the features that work best.

Organizations' Behaviors

Environmental psychologists have paid scant attention to organizational decision-making and its influence on global environmental conditions (Stern, 2011), although a few management and industrial-organizational psychologists have explored these questions (e.g., Bansal & Roth, 2000). Just as individuals choose to ride a bicycle or drive a car, switch lights off or on, or purchase an energy-efficient appliance, organizations also make decisions about their operations, facilities, and policies that influence the state of the environment. The decisions are not based solely on financial considerations of initial costs or simple payback; for example, those who make decisions about lighting systems place a high value on employee satisfaction and want to avoid creating problems that could lead to employee turnover or reduced work output (Light Right Consortium, 2002).

Thus, building practitioners need information about the effects of organizational technology choices on individual employees to demonstrate that environmentally responsible work environment choices will not have unintended consequences. For example, "demand response" describes systems in which large electrical users reduce their electrical loads by allowing temperature to drift upward and by dimming the lighting, both in response to a request from the utility company. The system allows utilities to manage the peak demand (particularly on hot summer afternoons) to maintain the stability of the electrical grid. The electrical user receives an incentive from the utility to reduce demand, but overall savings will result only if the resulting work environment conditions remain adequate for the employees. Laboratory and field investigations of the limits of such systems show that, at least for short periods, people can tolerate these changes provided the change is not too rapid (Akashi & Boyce, 2006; Newsham et al., 2006; Newsham, Mancini, et al., 2009).

Just as for individuals, the provision of space is a substantial investment for an organization. In the architectural and design communities, so-called green buildings are in fashion, with the emphasis being on the design and construction of buildings to meet targets for energy and water use, waste management, and ecologically sound practices. However, this way of building generally comes at an increased cost that the organization must justify.

Various rating schemes exist, including Leadership in Energy and Environmental Design (LEED), Green Globes, and BREEAM (Portalatin, Koepke, Roskoski, & Shouse, 2010). Although they differ in their details, each aims to reduce energy and resource use while providing a better indoor environment for occupants. Heerwagen (2000) concluded that done well, such buildings could result in better well-being for occupants as well as improved organizational performance and reductions in energy and resource use.

Again, this is a domain in which environmental psychologists and their measurement expertise are needed to validate the rating schemes and provide feedback on the elements intended to preserve or improve indoor environmental quality. Evidence that green buildings save energy as intended is mixed (Newsham, Mancini, & Birt, 2009). The limited information available as yet concerning indoor conditions shows that each building has unique features and context that make case study results difficult to generalize (Brown, Cole, Robinson, & Dowlatabadi, 2010), but environmental psychologists with expertise in post-occupancy evaluation have tools to address this. One issue that has emerged is acoustical satisfaction, in that some of the design features favored in green buildings (few interior partitions, to permit daylight penetration, and exposed concrete ceiling slabs, to reduce material use) lead to higher noise levels and reduced acoustic privacy (Zhang & Altan, 2011).

Summary

Engineers and inventors have developed many technologies to improve building energy efficiency, but their adoption has been slower than had been hoped (K. Kampschroer, personal communication, Oct. 26, 2010). A likely reason for this has been the relative absence of psychologists from the development of the technologies and their deployment. The psychological literature is largely silent concerning the barriers to the adoption and use of advanced building technologies and the incentives that might motivate more widespread use. Such research needs to go beyond the general attitude-behavior approach commonly taken in the study of environmentally responsible behavior to focus on specific structural, informational, and practical barriers as experienced by various actors in the decision-making system, from vice presidents responsible for facilities through building engineers who maintain them.

Conclusion

Work environments clearly influence the comfort, satisfaction, mood, performance, and well-being of the people who work in them. Multiple physiological and psychological processes occur simultaneously and interactively, often moderated by other contextual and individual conditions, leading together to the behavior of the person in the space. The march of technology, bringing with it the possibility of working away from the corporate office, does not change fundamental human nature. Many of the physical conditions of an effective office are the same regardless of where the work occurs.

Our understanding of the influences of the environment on people at work, and equally our understanding of the environmental effects of workplace behaviors, is clearly increasing, but is hampered by two problems, one methodological and one interpersonal. The interpersonal problem arises from the inherently interdisciplinary nature of work environment research. Understanding work environments ought not to be a purely intellectual exercise, but one that leads to the design, construction, operation, and occupation of good environments. This requires psychologists to work together with their counterparts in such fields as engineering, architecture, and physics and not only with anthropologists and sociologists (Veitch, 2008). Without this, it will be impossible to solve the other problem, which is methodological.

Many reviewers have noted methodological problems in work environment research (e.g., Bringslimark et al., 2009; Frontczak & Wargocki, 2011; Winkel, Saegert, & Evans, 2009). To the commonly reported issues (monomethod bias, inadequate statistical controls, threats to internal validity, etc.), we can add the tendency to emphasize either the environmental measurements or the behavioral outcomes, each to the detriment of the other. Psychologists can bring the strength of their research methods and statistical training; building scientists with backgrounds in engineering or physics tend to bring expertise in measuring physical quantities with great precision. Absent such a combination, we cannot know exactly which conditions trigger effects or what exactly those effects might be.

Overcoming professional inertia to change our own behavior in this regard will not be easy, but psychologists have the tools for behavior change. Using them, we can reap the rewards of increased influence over the environments we all inhabit (Veitch, 2008).

Future Directions

Key research directions for work environment psychology to address in the near term include:

– What are the space and physical accommodation needs of the increasingly prevalent older office employee? How do they differ from youth entering the workforce—for example, in the experience of and expectation for privacy (cf. Smith, 2008)?
– What are the prospects for an integrated theory of comfort, encompassing the broad variety of indoor conditions and bringing together the work of psychologists, engineers, and ergonomists (cf. Bluyssen et al., 2011; Reffat & Harkness, 2001; Vink & Hallbeck, 2011)?
– What are the balancing points between competing processes? For example, when is the inter-workstation distance sufficient for privacy, and when does isolation begin? When does background sound provide a desirable mask for intrusive speech, and when does it become annoying? How much environmental control enables individualized (p. 269) environments, and when does the abundance of choice become a stressor in itself? Investigations of such questions demand precision about the ranges of the independent variables, and technical knowledge appropriate to the domain.
– What are the costs, and what are the benefits, to individuals and to organizations, of space management policies that include telework, hoteling, and similar practices that eliminate individual territories at the corporate office? What contextual factors contribute to their success, or their failure? - What beliefs, knowledge, attitudes, or other factors have prevented organizations—or key individuals within organizations—from adopting novel environmental technologies? What specific information do decision-makers need to justify the investment?

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Notes:

(1.) The quantity of light falling on a surface is the *illuminance* of the surface. The SI unit for illuminance is lumens/m^2, abbreviated lx. The quantity of light emitted from a surface or a light source is its *luminance.* The SI unit for luminance is the candela/m^2, abbreviated cd/m^2.

(2.) A few psychologists have bridged these communities. Most notably, Frederick Rohles, now an emeritus professor at Kansas State University, has been awarded Fellow status in the American Psychological Association (and its Divisions 21 and 34), the Human Factors and Ergonomics Society, and the American Society for Heating, Refrigerating, and Air-Conditioning Engineers—probably the only person to have been so recognized by these organizations.

Jennifer A. Veitch

Jennifer A. Veitch NRC Construction Ottawa, Ontario, Canada