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Making the Open-Plan Office a Better Place to Work

By G.R. Newsham

This Update provides guidance on the design of open-plan offices to ensure a more satisfactory workplace environment. It is based on the results of a major consortium research project.

The single most common workplace in North America is the open-plan office. Many people who work in this type of office spend more waking hours in this environment than in any other, and there is abundant evidence that they do not generally consider it to be a satisfactory experience.

Organizations should be concerned about this because research shows that there are significant linkages between the workplace environment and job satisfaction, and between job satisfaction and the corporate bottom-line.[1,2,3] For example, there is a strong correlation between lack of job satisfaction and the intention to leave an organization, with estimates putting the cost of replacing employees at 50–150% of their annual salaries. Nevertheless, there is a recent trend towards making workstations smaller, which is driven primarily by a desire to reduce real-estate costs. But without careful design, reducing the size of workstations is likely to result in an increase in workplace environment problems, such as more noise and less privacy.

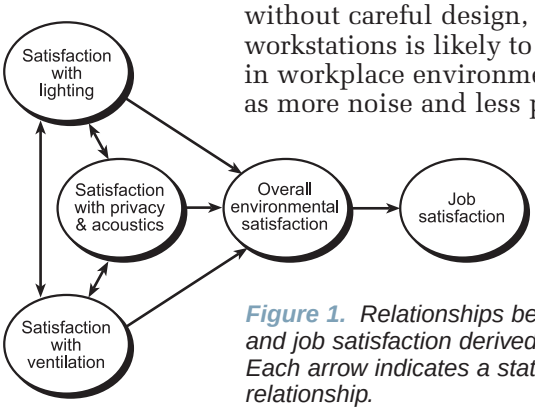

Figure 1. Relationships between environmental and job satisfaction derived from field study data. Each arrow indicates a statistically significant relationship.

With these facts in mind, IRC, with its consortium partners, initiated a comprehensive research project entitled Cost-effective Open-Plan Environments, or COPE, to examine the effect of office design choices on the workplace environment in open-plan offices, and on occupant satisfaction (see sidebar, p. 6). The COPE project combined experiments in mock-up office spaces, a large field study, computer simulations, and extensive reviews of relevant work published by others.

Satisfaction Linkages

As part of the COPE field study, IRC researchers issued a questionnaire to office workers regarding their satisfaction with various aspects of their workplace environment and their job. Responses were received from 779 public- and private-sector employees in nine buildings in Canada and the U.S., establishing the pattern of linkages shown in Figure 1.

As expected, higher levels of job satisfaction were associated with higher levels of satisfaction with the workplace environment. Overall environmental satisfaction had three aspects: satisfaction with lighting, satisfaction with privacy and acoustics, and satisfaction with ventilation. The following sections discuss the findings and design implications for each of these aspects; another section expands on the interrelationships and trade-offs between them.

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Satisfaction with Lighting

Data from the field study showed that proximity to a window had the biggest effect on satisfaction with lighting, due to a combination of higher light levels and the availability of a view to the outside. In addition, people tended to prefer brighter environments, provided that higher light levels did not also cause glare.[4,5] COPE simulation studies demonstrated that reducing partition heights and increasing surface reflectances both acted to increase daylight penetration and light levels (see Figure 2). Although not studied as part of COPE, flicker from fluorescent lights with magnetic ballasts is known to be associated with reduced satisfaction and negative health effects.[6,7] Research also shows that light level preferences vary widely among individuals, and that satisfaction is improved if individuals get the light level they prefer.[8]

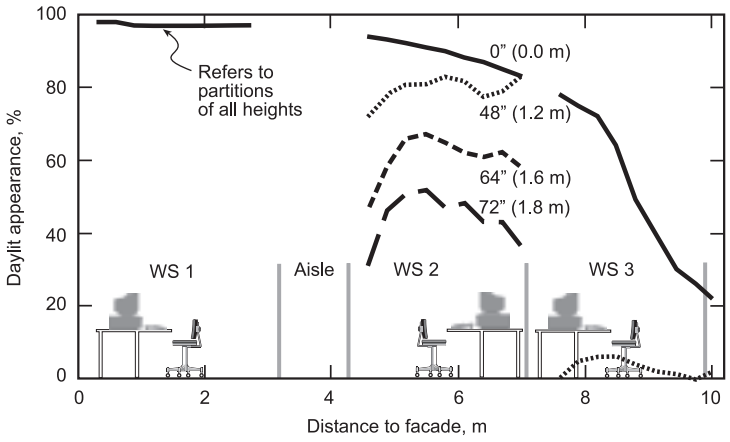

Figure 2. The effect of partition height on daylight availability for workstations, as one moves away from the window. (Each curve represents a specific partition height.) Daylight availability ("daylit appearance") is the percentage of working hours with appreciable daylight (≥150 lux). The workstation next to the window (WS 1) always has lots of daylight; the third workstation never gets any daylight (except when there are no partitions). In this example, workstations are 3.05 m x 3.05 m (10 ft x 10 ft), reflectances are 50% and the perimeter is curtain wall with windows from desktop to ceiling.

Implications for Practice (Lighting)

- Provide as many people as possible with a window, or at least a view of one.
- Reduce partition heights to increase daylight penetration and to increase illuminance and lighting uniformity from electric lights.
- Use lighter-coloured surfaces to increase illuminance and improve lighting uniformity.
- Use luminaires that have low brightness when viewed directly and that do not create reflections on a computer screen; this will reduce glare. Reflected glare is less obvious on a computer screen with a light background and on an LCD screen; anti-glare filters can also be helpful.
- Use electronic ballasts with fluorescent lights to eliminate flicker. Electronic ballasts are also more energy efficient than magnetic ballasts.
- Provide individual dimming control over lights so that occupants can choose their own preferred light level. In the open-plan office, this requires aligning and assigning luminaires to workstations.

Satisfaction with Privacy and Acoustics

A review of prior research shows that noise from the conversations of others is a major irritant for workers, a finding confirmed by the COPE field study data. The primary measure of acoustic privacy is the Speech Intelligibility Index (SII), which is dependent on the ratio of the level of speech sounds to the level of background noise. SII ranges from 0 to 1, where 1 means 100% comprehension of speech from an adjacent workstation and 0 means that no speech can be understood. However, the relationship between SII and speech comprehension is not linear, and only values below 0.2 are generally considered as an acceptable level of speech privacy in an open-plan office. The COPE studies sought to evaluate the linkages between SII and satisfaction, and to develop methods of reducing SII through office design.

Studies in a mock-up office showed that if partitions were already high enough to block the direct sound path from the source (mouth) to the receiver (ears), the next most

important path for speech propagation between workstations is reflection off the ceiling. Therefore, reducing the level of speech sounds requires a high-absorption ceiling. Sound absorption by partitions was of lower importance, while floor type was found to have little effect.

Increasing background noise is another way of improving speech privacy. This usually means installing a dedicated masking-noise system. Masking noise mimics the sound of a ventilation system and is created with loudspeakers above the ceiling tile. A study in a mock-up office demonstrated that reducing SII by increasing masking noise improved satisfaction with acoustics. However, the study also showed that if the masking noise is too loud it can be a source of dissatisfaction itself. The COPE studies indicate that masking noise in the range of 42–48 dBA should be recommended. They also showed that the frequency spectrum of the masking noise influences its effectiveness. A spectrum with more energy in the higher frequencies will mask speech better. This, however, requires careful balancing—too much high-frequency sound, or not enough low-frequency sound, will be unpleasantly "hissy."

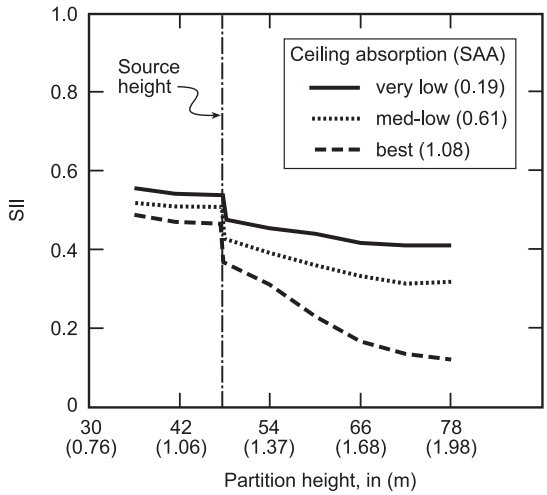

Figure 3. The effect of partition height and ceiling tile absorption on SII. (An SII of 0.2 or lower is considered acceptable in terms of speech privacy.) In this example, workstations are 3.05 m x 3.05 m (10 ft x 10 ft), there is a masking noise of 45 dBA and speech levels are typical of open-plan offices. Note the benefit of using partitions higher than the source: SII drops. Also note the benefit of using the 'best' ceiling tile with the highest absorption. The tile labelled "med-low" is a typical office ceiling.

Implications for Practice (Privacy and Acoustics)

- Specify partitions that are higher than the heads of seated occupants—the higher the better for acoustic privacy (see Figure 3). Partitions that are high enough so that most people standing cannot see someone seated in their workstation are preferable because they also increase visual privacy.
- Choose highly absorbent ceiling tile to reduce the level of reflected speech sounds (see Figure 3). Increasing the absorption of other surfaces also helps.
- Emphasize the importance of office etiquette: ask people to be considerate of others' acoustic privacy when holding conversations.
- Increase the size of workstations; this improves privacy because it increases the distance between neighbours.
- Use a well-designed masking-noise system.
- Locate workstations, particularly entrances to them, away from high-traffic areas to improve both acoustic and visual privacy.

Satisfaction with Ventilation

The COPE studies focused on mechanically ventilated office buildings. In these buildings the operator of the ventilation system can control the amount of outdoor air delivered to provide oxygen for breathing and to dilute pollutants. This outdoor air is usually mixed with re-circulated building air and is heated or cooled, depending on the thermal load in the building.

ASHRAE recommends that outside air be delivered at a rate of 10 L/s/person.[9] A COPE review of the research provided support for this rate, showing that there was often a decline in satisfaction as outdoor air supply rates were reduced. Increasing outdoor air rates, which would require additional heating/cooling energy, did not result in a consistent improvement in occupant satisfaction. Based on what was already known, the focus of the COPE work was then to examine whether office design could affect air quality and thermal comfort even when 10 L/s/person of outdoor air is supplied.

A study conducted in a mock-up office laboratory found that workstation size, partition height and distance from a supply diffuser had little effect on ventilation effectiveness (i.e., the time it takes supply air to reach an occupant). However, the field study suggested that higher partitions reduce satisfaction with ventilation. The laboratory study demonstrated that certain supply-diffuser and occupant geometries can increase the risk of draught. The effect of these geometries can be accentuated in smaller workstations, where there is higher occupant density, where occupants have less flexibility in their positioning and where total air-flow rates are likely to be raised due to increased demand for cooling.

A review of the published research found that satisfaction can be improved by providing occupants with some control over the ventilation in their workstation. The field study data also showed that being seated next to a window can lessen thermal comfort because temperatures there tend to be more extreme than in the rest of the building.

Implications for Practice (Ventilation)

- Ensure that the HVAC system is well maintained, and that it delivers 10 L/s/person of outdoor air.
- Adjust supply-air diffusers to avoid discomfort from localized draughts.
- Avoid very high partitions, which can create an impression of poor air flow.
- Give individuals control over one or more of the following: air-flow rate, direction and temperature.
- Choose windows with high insulation values, provide shading devices, and offer local sources of additional heating or cooling to offset thermal comfort problems near windows.
- Use low-emission materials and ensure regular cleaning of office furniture and carpets to reduce the effect of pollutants.

Figure 4. Is this the perfect partition design? With windows on the right, the use of transparent panels makes the partition low enough for daylighting purposes and also high enough for speech privacy. However, after installation these transparent panels are often covered by posters or coats by occupants seeking visual privacy. Note that to really improve daylight penetration into the second row of workstations from the window (on the left), the upper panels of these partitions should also be transparent.

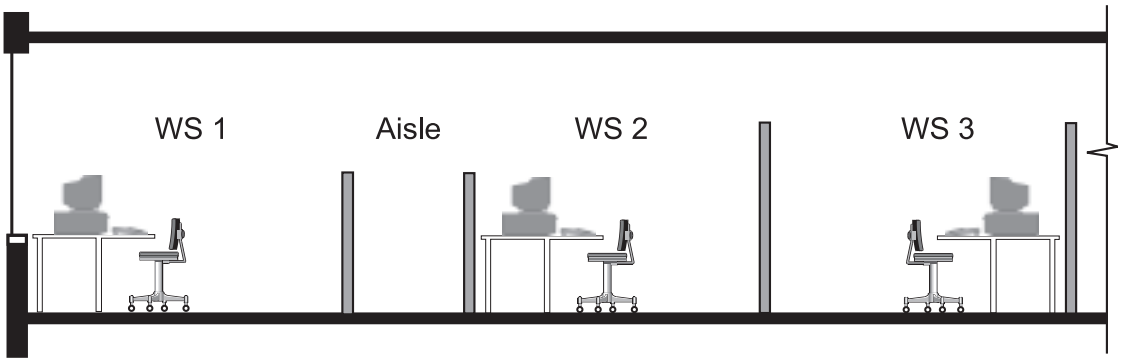

Figure 5. If the needs and preferences of occupants are known, it is easier to choose partitions to meet the conflicting demands of acoustics and daylighting. Occupants who prefer daylight over privacy can be located near the windows, with low partitions (WS 1 and WS 2). Those who prefer acoustic privacy over daylight can be located further from the window, with high partitions (WS 3). Note that the siting of furniture within a workstation can help improve acoustic privacy. The chairs in WS 2 and WS 3 are in opposite corners, maximizing the distance between noise sources and ensuring that speech in one workstation is directed away from the adjacent one.

Interrelationships and Trade-offs Affecting Workplace Satisfaction

Clearly, achieving satisfaction in one area may be incompatible with achieving it in another—the most obvious example is related to partition height. While lower partitions improve daylight penetration, the view to windows, electric light distribution and satisfaction with ventilation, they also increase noise and reduce visual privacy. There is no such thing as a perfect solution (see Figure 4), but full consideration of the most important factors in each situation can improve the chances of a good compromise (see Figure 5).

The choice of ceiling tile will also affect more than one aspect of the office environment. To achieve good daylight penetration, a tile with as high a reflectance as possible is desirable. However, a high-reflectance product should not be selected at the expense of good acoustic absorption, if speech privacy is also an issue.

Implications for Practice (Interrelationships and Trade-offs Affecting Workplace Satisfaction)

- Consult with occupants of the space to discover what tasks they perform and which aspects of the office environment are most critical to this. Consultation should begin as early as possible in the design process.
- Form multi-disciplinary design teams to find appropriate compromises between the various effects of design choices on the workplace environment.

Software Tools

An online software tool (COPE-ODE) can assist in evaluating the effects of various choices to help find designs that are truly cost effective—i.e., likely to create a satisfactory environment at a reasonable cost. The user inputs information about different aspects of the workstation, such as its size, partition height and reflectance, and of the surrounding offices, such as the ceiling tile properties, noise levels, lighting design and presence of lighting and ventilation controls. Users can also input the costs of their choices, indicating first- and life-cycle costs. The software calculates light levels and SII, and then compares them to specified criteria. It also indicates which features of the design might be positive or negative with respect to occupant satisfaction.

A second tool (COPECalc) focuses on acoustic design. It features more detailed input and output, including the ability to "hear" and compare the effects of different design choices on a telephone conversation in a neighbouring workstation.

Acknowledgement

The author was the project manager of COPE. However, much of the research work described in this document was led by other members of the COPE research team. Particular credit goes to Jennifer Veitch, Kate Charles, John Bradley, John Shaw, Dan Sander, and Christoph Reinhart.

The COPE Project

The COPE project grew out of discussions with organizations that provide and manage office space, and with companies that manufacture office products. Both groups were invited to talk about the leading trends in open-plan office accommodation and the workplace environment problems that they encountered. It became clear that addressing these issues through research would require substantial resources. Therefore, in 1999, IRC/NRC created a research consortium to assemble a critical mass of resources and expertise. The consortium partners provided substantial financial and in-kind resources, guidance, access to field study sites, and channels to get the results of the work into practice.

IRC's partners in the COPE consortium were:

- Public Works and Government Services Canada
- Building Technology Transfer Forum
- USG Corporation
- Ontario Realty Corporation
- British Columbia Buildings Corporation
- Steelcase Incorporated
- Natural Resources Canada

More information on the COPE project can be found at http://irc.nrc-cnrc.gc.ca/ie/cope/.

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