

Individual Control over Office Lighting: Perceptions, Choices and Energy Savings

by G.R. Newsham and J.A. Veitch

Employees say they want more control over their workplace environment, including lighting. What the benefits of greater control are — to workers, employers, and facilities managers — is a question the Lighting Quality research project conducted by NRC's Institute for Research in Construction tried to answer. This Update reports on an experiment performed as part of this project.

Construction Technology Update No. 10 (1997) described a lighting quality research project underway at NRC's Institute for Research in Construction. This project comprised two experiments. The first, reported in *Update No. 10*, sought to characterize office lighting quality and to relate it to worker satisfaction and performance.

The second experiment, described here, explored the effect of giving individuals control over the lighting in their own work spaces. The questions of interest included:

- What choices do people make?
- How do these choices relate to energy code requirements?
- What is the connection between choices and the characterization of lighting quality developed in the first experiment?
- How does control influence office worker satisfaction and performance?

It is a common belief among designers, researchers and the building services community that it is desirable to give occupants individual control over their own workplace environments. This view is generally supported by surveys of building occupants.

Further, prevailing opinion suggests that a personally tailored environment will produce greater satisfaction with one's job and working environment, resulting in enhanced performance and economic payoffs for the employer.

In spite of the general consensus favouring greater individual control of office environments, there is little empirical proof of tangible benefits. This could explain why office managers seem reluctant to invest in costly individual-level control technologies. In fact, some studies have shown that control can actually be detrimental. In a demanding workplace, individual control could be a source of unwanted additional employee demands. In addition, people will avoid control when they think their choice will risk their achieving a desired goal, or

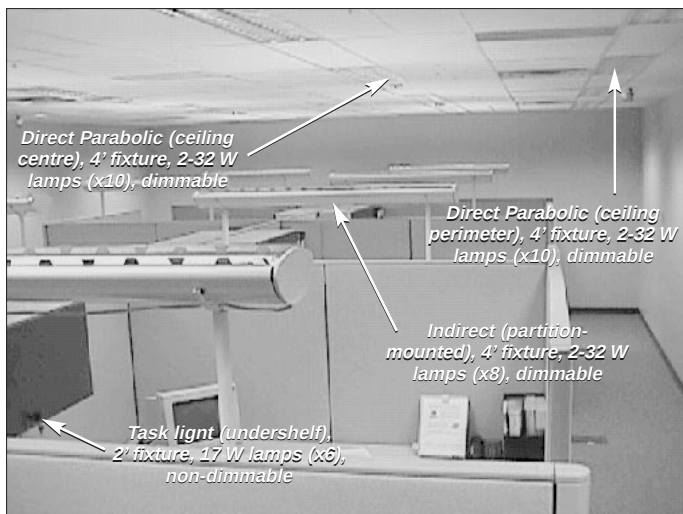


Figure 1. The mock-up office and the four lighting circuits

perceive that they would look foolish by making the wrong choice (Veitch and Gifford, 1996).

The impact on energy costs of giving workers greater control is another point of debate. For example, the conventional approach to lighting an open-plan office is to install ambient lighting in a regular ceiling grid, ensuring a uniform light level over the entire space. Control proponents argue that with greater personal influence over lighting conditions, employees would tend to raise light levels only at their own work stations, allowing managers to provide a much lower level of ambient lighting. Opponents, however, contend that control in the hands of people who are not responsible for the energy bills will lead to excessive light levels and compromised energy efficiency.

The lighting quality experiment described in this Update was designed to examine these issues.

IRC Lighting Quality Research

The Research Set-up

The experiment was performed in a windowless office space mock-up, 83 m² (880 ft²) in size. The open-plan area contained six workstations, arranged as parallel rows of three along a central spine. A single hybrid lighting system was installed on four controllable circuits (see Figure 1). These circuits controlled:

- recessed 300 mm x 1200 mm (1'x 4') deep-cell parabolic louvered luminaires overhead
- recessed 300 mm x 1200 mm (1'x 4') deep-cell parabolic louvered luminaires at the perimeter of the space
- partition-mounted indirect lighting, and
- under-shelf task lighting.

The first three circuits were continuously dimmable while the task lighting had a simple on/off control. All luminaires used electronic ballasts.

The experiment required a total of 120 temporary office workers. On each day, two participants (matched by age and sex) were seated at the two centre work stations. Of each pair, one participant was designated as the lighting controller (LC), while the other was identified as having no control (NC).

At the start of the day the LC participant adjusted the lighting system to his/her preference. The NC participant received the same lighting conditions as the LC, but

was unaware that the LC participant had selected the conditions. The participants then performed a day of computer-based office tasks, and completed a number of questionnaires on their satisfaction with and impressions of various office features. During the day's work, no further adjustments to the lighting were permitted.

At the end of the day, the NC participant was given an opportunity to adjust the lighting according to his/her preferences. The LC participant was asked on a questionnaire to indicate what changes, if any, he/she would, in retrospect, have made to the original lighting set-up.

Photometry

The lit environments the participants chose were recorded in detail. One of the key sets of variables was the fraction of the maximum output for each lighting circuit (which was proportional to the dimmer setting). Spot illuminance and luminance were also measured, and supplemented with digital image analysis of luminance in the field of view.

Results

1. Lighting choices

The lighting conditions created by the LC participants were judged as highly satisfactory by both themselves and their NC counterparts. The mean rating of lighting quality was high for both groups (mean = 4.07 on a scale of 1 to 5). The satisfaction ratings did not differ between the LC and NC groups to a statistically significant degree.

Lighting choices conformed well to the recommendations for luminous environments in North American codes and standards. For example, IESNA Recommended Practice for Office Lighting RP-1 (IESNA, 1993) states that desktop illuminance in spaces with VDTs should be lower than 500 lux. More than 70% of the choices made by participants met this criterion (see Figure 2).

2. Sense of control

LC participants felt in greater control of the lighting, and of the experimental session in general.

3. Impact of control

Despite LC participants' increased perception of control, they demonstrated no statistically significant improvements in task performance, mood, satisfaction or physical sensation when compared to NC participants.

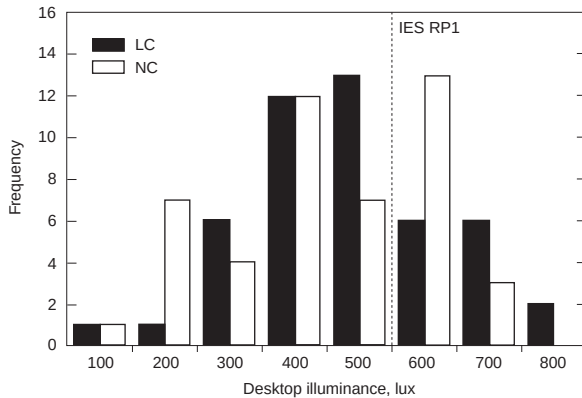


Figure 2. Desktop illuminance choices

However, the results did demonstrate that control is associated with a measurable benefit when it is used to improve environmental conditions. Statistical analysis revealed that when NC participants were handed control of the lighting at the end of the day, they made less use of the perimeter parabolic luminaires than their LC counterparts. This option resulted in measurably lower levels of VDT screen glare and lower lighting power density (LPD); LPD is a measure of power required by the lighting system. Interestingly, this finding was consistent with the responses of LC participants on the exit questionnaire: They reported that they would have reduced screen glare by lowering the output of the perimeter parabolic luminaires, had they had an opportunity to make lighting adjustments during the day.

4. Energy use

The electrical power requirements of the lighting arrangements selected by the LC participants conformed to energy codes and standards. For example, ASHRAE/IESNA 90.1 (1989) and Canada's Model National Energy Code for Buildings (CCBFC, 1997) specify a maximum lighting power density of 19.4 W/m^2 for office lighting. Even though the installation allowed for choices that exceeded code guidelines, more than 80% of the selections had LPDs at or below the recommended level (Figure 3). Moreover, the mean LPD for the sample, at 14.3 W/m^2 , was fully 25% lower than current recommendations.

Discussion:

1. Is Individual Control over Lighting Desirable?

The results of IRC's study suggest the answer to this question is a qualified "Yes."

Study participants reported favouring the ability to individually control their lighting, and this was associated with a greater sense of session control in general. This observation is consistent with the widely expressed views of people who design, operate, study and occupy workplaces.

Moreover, with the power to control their environment, LC participants tended to select lighting arrangements that were good in both objective and subjective terms.

Further, the study data indicate that when subjects perceived a problem with their luminous environment (e.g., glare on the VDT screen), having individual control allowed them to successfully correct the problem.

Finally, the results suggest that individual control over appropriately designed lighting can result in energy savings. The lit environments people selected for themselves had, on average, lower power requirements than the recommendations in existing codes and standards. In other words, giving people control over lighting may result in lower energy consumption than a fixed lighting design with an LPD at the maximum allowed by codes and standards.

However, the data revealed no association — positive or negative — between increased control over lighting and environmental satisfaction or performance.

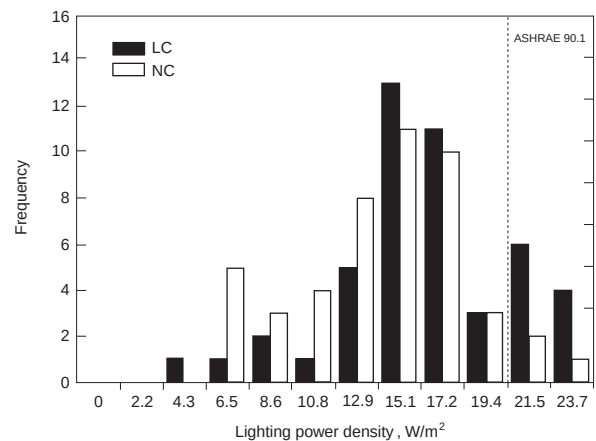


Figure 3. Lighting power density choices

2. The Connection Between Control and Benefits

There are several possible reasons why, in this experiment, no connection was found between increased control and job-related benefits such as improved satisfaction or performance:

- No beneficial effect was measured because there is none. However, the impression that increased control leads to satisfaction and performance benefits is persistent and widespread. To discount it on the basis of one experiment in one office set-up with a particular combination of lighting equipment and control options, would be premature; it would be wiser to consider other explanations first.
- Control may confer benefits only when the uncontrolled conditions are markedly poor. This was not generally true in this experiment. Even though, by day's end, participants of both groups indicated that their lighting preferences had evolved somewhat over the course of the day, they generally expressed a high degree of satisfaction with the lit environments they had experienced.
- It is possible that the experiment did not last long enough to simulate real-world conditions. While the period of exposure to particular lighting arrangements was long for a laboratory experiment, it was brief in comparison to an actual employment situation. The connection between enhanced lighting control and job satisfaction or performance benefits may only manifest itself over prolonged periods.
- Control may provide more benefit when available continuously. This was not the case in this experiment; LC participants made control decisions only once, at the start of the day. Continuous control would allow occupants to respond immediately to changes in lighting preference.

Summary

A lighting quality research project conducted at IRC demonstrated that control over lighting confers some benefits.

- Participants with control created lit environments that were highly satisfactory.
- The chosen lighting conditions were consistent with codes and standards for office lighting.

- The selected lighting conditions required 25% less power than those recommended in codes and standards.
- Participants with lighting control felt more in control of the experimental session in general.

However, the nature of the control offered in this experiment did not result in improved job satisfaction and performance. Further work is required to determine whether this null effect is genuine, or an artefact of the experimental design.

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For more information, please consult:

URL: http://irc.nrc-cnrc.gc.ca/light/lq_project/lqp.html

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