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by **Jennifer A. Veitch, PhD., Kelly M. J. Farley, and Guy R. Newsham, PhD.**

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Executive Summary

Organisations and their facilities managers are under pressure to reduce the space allocation to individuals in open-plan offices, as a means to reduce costs. The reduced space allocation, however, risks creating an unpleasant working environment, either directly through the creation of adverse physical conditions (e.g., more noise, added obstructions to air circulation), or indirectly through psychological processes such as privacy or stress. As part of a larger project concerning the design and operation of open plan offices, a field study was conducted to determine the effects of open-plan office design (particularly workstation size and partition height) on the indoor environment and on occupant satisfaction with that environment. The study is a pre-post renovation study of government office buildings that will undergo space-saving renovations to smaller cubicle sizes. This paper reports on time 1 data only (time 2 data will not be available until 2003).

Three government office buildings in two cities were surveyed, with a total of 419 employees and their workstations participating. While research staff conducted extensive measurements of ventilation, temperature, noise, lighting, and descriptive characteristics of the workstation, the workstation occupant completed a 27-item questionnaire on a handheld computer. The questionnaire included 18 individual ratings of satisfaction with environmental features, a 2-item index of overall environmental satisfaction, and a 2-item index of job satisfaction.

This paper reports on the methodology and on analyses of the underlying factor structure of the 18 individual environmental features ratings, and of a model incorporating environmental and job satisfaction in relation to these ratings. Relationships between environmental features ratings and characteristics of the workstations, and specific relationships to other physical conditions in the workstation, will follow in subsequent papers.

The sample was divided into two random groups for exploratory and confirmatory factor analysis. Exploratory factor analysis using oblimin rotation revealed three factors, interpreted as Satisfaction with Privacy, Satisfaction with Lighting and Satisfaction with Ventilation. Confirmatory factor analysis using structural equation modelling (on EQS) supported the three-factor model. The variables loading on each latent variable are as follows:

Satisfaction with Privacy: [satisfaction with...] visual privacy, conversational privacy, amount of noise from others' conversations, amount of background noise; amount of distraction, workstation size, degree of enclosure, ability to alter conditions; distance between coworkers; and aesthetic appearance.

Satisfaction with Lighting: [satisfaction with...] lighting quality, quantity of light on the desk, quantity of light for computer work, computer glare, and access to a view.

Satisfaction with Ventilation: [satisfaction with...] air quality, temperature, and air movement.

The entire sample was recombined for analyses of the relationships between satisfaction with aspects of environmental satisfaction, and overall environmental satisfaction and job satisfaction. The model with the best fit showed intercorrelations between the three aspects of environmental satisfaction, direct relationships between them and overall environmental satisfaction, and a direct relationship between overall environmental satisfaction and job satisfaction. Although model fit was modest (e.g., standardised RMR = .06), all paths are statistically significant and the model is consistent with other models in the environmental psychology literature. Future research should seek relationships between these variables and other important job-related outcomes, such as organisational commitment, intent to turnover, absenteeism, and job performance.

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1.0 Introduction

Organisations and their facilities managers are under pressure to reduce the space allocation to individuals in open-plan offices, as a means to reduce costs. The reduced space allocation, however, risks creating an unpleasant working environment, either directly through the creation of adverse physical conditions (e.g., more noise, added obstructions to air circulation), or indirectly through psychological processes such as privacy or stress. Predicting changes to the physical environment associated with workstation design and partition height, and the effects of those physical conditions on environmental satisfaction, is the aim of the Cost-Effective Open-Plan Environments project.

The project design follows two decades of research into relations between the physical work environment and the individual worker, interpersonal relations, and the organisation (e.g., Carlopio, 1996; Oldham & Brass, 1979; Sundstrom, 1987; Sundstrom, Bell, Busby, & Asmus, 1996; Sutton & Rafaeli, 1987). Despite considerable effort, the literature remains scattered and poorly linked to the engineering and design disciplines that might make use of it. Designers and facilities managers have asked for demonstrable proof that the physical environment influences organisational outcomes such as work output, absenteeism, turnover, and, ultimately, productivity. Psychologists, often lacking the expertise to measure or quantify the physical environment, have been unable to provide such direct evidence with scientific rigour (Rubin, 1987; Wyon, 1996).

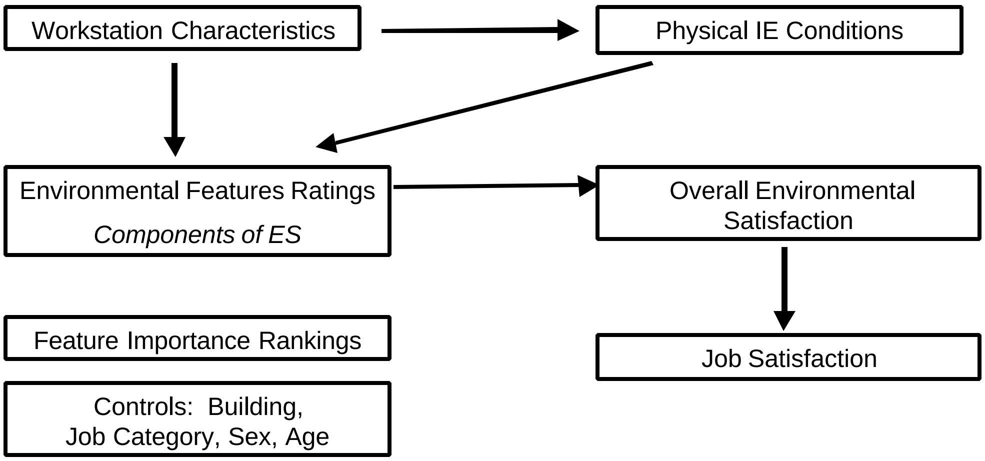
One reason for the slow progress in this area has been the absence of multidisciplinary studies incorporating strong measurement of both the physical environment and the individual or organisational behavioural outcomes. For instance, Sutton and Rafaeli (1987) defined hotness as "the product of an employees judgement as to how often it got too hot at a work station and the [estimated] temperature when it is at it hottest" (p. 264). Conversely, many other investigators have not used standardised tools to measure perceptions of the workplace or behaviours in it (Stokols & Scharf, 1990).

Standardised research instruments addressing the physical work environment should meet certain key requirements (Stokols & Scharf, 1990). First, the questionnaire should be streamlined in length and wording so respondents can complete the protocols in a straightforward manner. Second, the scope of the content should be sufficiently broad to so that important aspects of facility design are not neglected. In addition to characteristics of the physical work environment, other variables that should be included are respondent biographic characteristics, job status or category, and ratings of job or work satisfaction. Finally, survey items should be directly relevant to organisational problem-solving strategies. That is, the findings from research using these instruments should suggest specific organisational and environmental design strategies that can be implemented to resolve problems identified in the research.

With these issues in mind, Stokols and Scharf (1990) developed the Ratings of Environmental Features (REF) questionnaire for use in a variety of office settings. Privacy, air quality and lighting were the major, physical work environment variables included in the REF. The REF contains 27 items for which respondents rate the quality of several physical features (e.g., ‘conversational privacy within your office’ and ‘quality of lighting for the work you do’). Stokols and Scharf reported acceptable internal consistency values (.87 to .94) over five pilot administrations of the REF. Although physical environmental data were also collected, analyses of these data have never been published.

Another example of the development of a standardised tool is Carlopio's (1996) Physical Work Environment Satisfaction Questionnaire (PWESQ) which included the assessment of five general areas (environmental design, facilities, work organisation, equipment and tools, and health and safety). He validated the tool in a field survey involving employees in eight companies ranging from a computer assembly site to durable goods manufacturing warehouses. The PWESQ met criteria for internal consistency and discriminant validity; moreover, across settings, satisfaction with the physical environment and job satisfaction both related to organisational commitment and intent to turnover. This is consistent

Figure 1. *Conceptual model of the COPE field study.*



with existing organisational psychology theory. However, we could find no publications that used the PWESQ for further research into how measured physical conditions relate to satisfaction.

The Cost-Effective Open-Plan Environments (COPE) field study was designed to address this limitation in knowledge, while providing an opportunity to test models based on laboratory, computer simulation, and literature review studies also conducted as part of the overall COPE project. The field study was designed to determine the effects of open-plan office design on the indoor environment and on occupant satisfaction with that environment. It is a pre-post renovation study of office buildings that will undergo space-saving renovations to smaller cubicle sizes.

The COPE study is unique in that it combines extensive local physical measurements paired with simultaneous questionnaire data collection. This report describes the methodology used in the field study and addresses the validation of the satisfaction questionnaire, using time 1 data only (time 2 data will not be available until 2003). Figure 1 shows a conceptual model of the field study. The model posits that workstation characteristics (particularly workstation size and partition height, but not limited to those), determine the physical conditions in the workstation. The physical conditions and the workstation characteristics jointly determine satisfaction with elements of the physical environment, measured using the 18-item Environmental Features Ratings (EFR) [based on Stokols and Scharf's (1990) Ratings of Environmental Features]. The reduction of the 18 EFR items to a smaller number of components, and their relations to overall environmental satisfaction and to job satisfaction, is the topic of this report.

Based on the literature, we hypothesized that the 18-item Environmental Features Ratings would reflect a limited number of underlying latent variables. Based on the literature, we expected that factors for privacy, ventilation and lighting would emerge (Dillon & Vischer, 1987; González, Fernández, & Cameselle, 1997; Stokols & Scharf, 1990). Specifically, we expected that privacy would account for the greatest proportion of the variance observed followed in order by ventilation and lighting. Moreover, we predicted that these latent variables would be directly related to job satisfaction and overall satisfaction with the environment (Dillon & Vischer, 1987; Wells, 2000).

To test these hypotheses, exploratory (EFA) and confirmatory factor analyses (CFA) were conducted. This pair of techniques allows investigators to establish a preliminary model using half of the data set, and then to test whether that model fits the remaining data using the other half. The latent, underlying variables thus established will provide a smaller, manageable, interpretable set of subscales – components of environmental satisfaction – for use in further analyses.

Structural equation modelling was used to test the hypothesized relationships between all variables using the entire data set. We predicted that the of latent variables would relate directly to overall environmental satisfaction, and that overall environmental satisfaction would predict job satisfaction. These procedures have been used to verify the validity of job satisfaction inventories, and such relationships have been observed (Carlopio, 1996; González et al., 1997; Wells, 2000).

2.0 Method

2.1 Sites

Data were collected in three federal government office buildings in large Canadian cities, occupied by various departments. The buildings, and the specific locations within them, were selected because they contained open-plan offices occupied by white-collar workers, were of a suitable size, were slated to undergo renovation in the 12-18 month period following the visit, and because their management was willing to host the visit. The team intends to revisit the sites 6 months post-occupancy, within the same season as the original visit.

Table 1. *Summary of site characteristics.*

Building	**Year Built**	**Visited**	**# Floors**	**Floor plate (sf)**	**Lighting**	**HVAC**	**Windows**	**Sound**
1	1977	Spring 2000	11 (4 visited)	39000 (x 2 towers)	4' coffered prismatic fluorescent	ducted air VAV cooling / perimeter hot-water heating	non-openable	No sound masking
2	1975	Summer 2000	12 (3 visited)	40000	4' recessed parabolic cube	ducted air VAV cooling / perimeter convention heating	non-openable	No sound masking
3	1975	Spring 2000 and Winter 2000	22 (4 visited)	18000	4' recessed prismatic (some parabolic)	ducted air VAV cooling / perimeter hot and chilled water heating & cooling	non-openable	Sound masking in use

2.1.1 Building 1 details. Parts of four floors in the eastern half of this building were visited. Office accommodation at this location was primarily open-plan, with some enclosed offices on the perimeter and at the centre of the floor plan. In the majority of cases, open-plan workstations were formed using free-standing fabric partitions, and free-standing furniture elements. Lighting was provided, almost universally, by surface mounted prismatic fixtures housing a single 4' fluorescent lamp. These fixtures were located at the centre of 5'x5' ceiling coffer elements. Sound masking was not in use at this location. The HVAC system comprised a ducted-air variable air volume (VAV) cooling system, and a perimeter hot-water heating system, both controlled by zone thermostats. Perimeter zones stretched between structural columns along the perimeter (33') to a depth of about 10'; interior zones were up to 30' x 30' in size. The building operators controlled zone thermostats. Thermostats were generally fixed at 22^{o}C, though certain thermostats had been adjusted to accommodate local preferences. The VAV system utilised two compartment fans in each tower of each floor. Each fan served approximately half the floor plate, and was capable of supplying up to 25,500 cfm, with the outside air fraction fixed at 10%. Manual controls ensured that the flow rate to the interior zones never fell below 50% of maximum, and that the flow rate to the perimeter zones never fell below 20% of maximum. These fans were switched off between 6pm – 6am each night; only the fans serving the building lobby and retail floors operated for 24 hours/day.

2.1.2 Building 2 details. Areas of three floors were visited. Office accommodation at this location was primarily open-plan, with some enclosed offices on the perimeter and at the centre of the floor plan. In the majority of cases, open-plan workstations were formed using systems furniture elements. Lighting was provided, almost universally, by recessed paracube parabolic fixtures housing a single 4' fluorescent lamp. Orange-painted hollow ceiling beam-like elements formed a 5'x5' ceiling grid, and each of these 5'x5' areas contained one (usually) fixture at the centre (usually). Sound masking was not in use at this location. The ceiling beams also contained slot air diffusers. The HVAC system comprised a ducted-air VAV cooling system, and a perimeter convection heating system. Zones served by individual VAV boxes were approximately 1500 ft^2, though some smaller perimeter zones had been created where solar gain was problematic. The building operators controlled zone thermostats. The target thermostat setting was 22^oC, though many thermostats had been adjusted to accommodate local preferences. The building had two main fresh air fans with in-line heating and cooling coils; there was also a cooling coil in the main return air duct. The VAV system utilised two compartment fans on each floor. Each fan served approximately half the floor plate, with the outside air fraction fixed at 15%. Controls ensured that the flow rate to the interior zones never fell below 10% of maximum. These fans were switched off between 6pm – 2am each night.

2.1.3 Building 3 details. Sections of four floors were visited, two in spring and two in winter. Office accommodation at this location was primarily open-plan, with some enclosed offices at the centre of the floor plan. In the majority of cases, open-plan workstations were formed using systems furniture elements. Lighting was provided, almost universally, by ceiling-recessed prismatic fixtures housing a single 4' fluorescent lamp, though there were "paracube" prismatic fixtures in a few locations. These fixtures were located in a regular grid on 5'x5' centres. Sound masking was used on all floors at this location. The HVAC system comprised a ducted-air VAV cooling system, and a perimeter hot- and chilled-water system. The perimeter system was locally controlled by occupants. The VAV system was controlled by zone thermostats in the interior; interior zones were up to 15' x 20' in size. Zones were originally aligned with office locations, but rearrangement of office furniture over the years means that this is no longer the case. The building operators controlled interior zone thermostats. Thermostats were initially set at 20-22 ^oC, though certain thermostats had been adjusted to accommodate local preferences. The VAV system utilised a total of seven fans, four dedicated to the interior and three to the perimeter. Perimeter fans served South, North-east and North-west zones. The outside air fraction varied with external climate, but never fell below 15 %. These fans were switched off between 6pm – 6am each night.

2.2 Participants

Participants were the occupants of floors scheduled to undergo renovation in the selected building within the project's time frame. All occupants present on the visit day were eligible to participate. Approximately 90% of those invited agreed to participate. Table 2 shows the descriptive statistics for the full sample and broken down by building.

Table 2. *Demographic characteristics of participants.*

Site	N	% English	% female /% male	Mean age (SD)
Full sample	419	87.3	48.7 / 50.3	38.6 (10.8)
Building 1	132	86.3	47.8 / 51.5	38.2 (12.7)

Site	**N**	**% English**	**% female /% male**	**Mean age (SD)**
Building 2	160	98.8	48.8 / 50.6	39.5 (10.2)
Building 3	127	75.6	49.6 / 48.8	37.8 (9.4)

		Job Category		
	Administration	Technical	Professional	Management
Full sample	36.0	14.8	41.3	6.7
Building 1	18.9	11.4	68.2	0
Building 2	47.5	11.3	32.5	8.1
Building 3	39.4	22.8	24.4	11.8

			Education		
	High School	Community College	University courses	Undergraduate Degree	Graduate Degree
Full sample	16.0 %	17.7	14.6	26.0	23.2
Building 1	9.1	8.3	13.6	30.3	37.1
Building 2	13.1	21.3	16.9	26.3	20.0
Building 3	26.8	22.8	12.6	21.3	12.6

Note. Percentages that do not sum to 100 are the result of rounding error and missing data.

2.3 Dependent Measures

2.3.1 Satisfaction questionnaire. Workstation occupants were asked to indicate their workplace satisfaction and demographic and other information by answering a questionnaire presented on a palmtop computer. The computer used was an NEC Mobile Pro™ 770 running Microsoft® Windows® CE. The questionnaire was developed using Microsoft® Visual Basic 6 for Windows® CE. Participants responded to information screens and questions by clicking buttons on the touch-sensitive screen using a stylus (Figure 2).

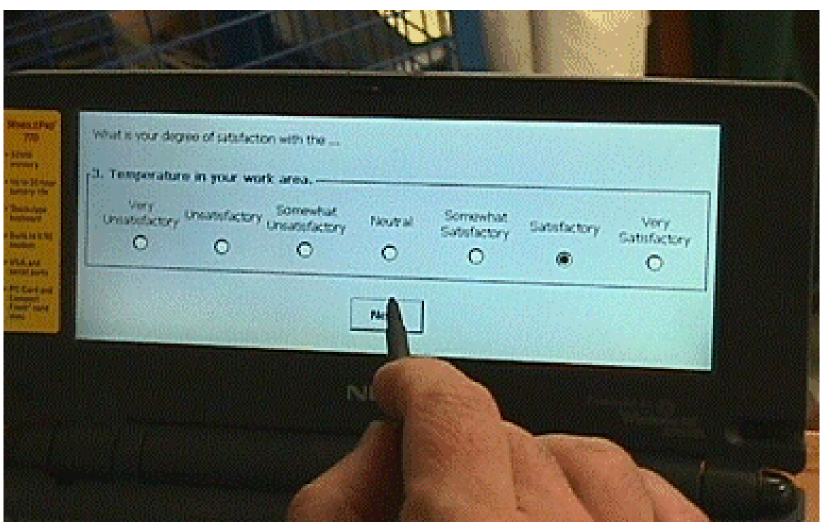


Figure 2. *The palmtop computer featuring one question from the field study questionnaire. The participant answered using a stylus on a touch-sensitive screen.*

Following a series of information screens (the first of which gave the choice of continuing in English or French), participants were presented with 27 questions. The information advised the participant to register their opinions of their workplace with reference to the conditions as they existed at the time the NRC staff arrived at their workstation seeking participation. A response with this frame of reference is more relevant with respect to the physical conditions that were measured. Each question appeared on a separate screen, and participants could proceed to the next screen (question) by completing the current question or skipping it, participants were not able to return to a screen once they had completed it. Data from each participant was stored in the palmtop's memory, one file per participant.

The questions and their response categories are shown in Table 2. Questions 1 – 18 and 27 used the same seven-point satisfaction scale. These questions were based primarily on Stokols and Scharf (1990). Question 19 asked the participant to rank order seven elements of the work environment in terms of their importance; the software prevented the participant from assigning the same importance to two or more elements. Questions 24 and 25 both used the same seven-point agree/disagree scale, and were drawn with minor modification from a recent survey of job satisfaction for the Canadian federal public service (Ross, 1999). Question 26 asked the participant to rate how the environment influenced their productivity at the time of the survey relative to general prevailing conditions (Wilson & Hedge, 1987). The French translation was produced by a professional translator from the final English version, and the adequacy of the translation was confirmed by back-translation by a second translator.

Table 3. *Satisfaction Questionnaire (English).*

Question	**Response Category**						
1. Amount of lighting on the desktop	*Very Unsatisfactory*	*Unsatisfactory*	*Somewhat Unsatisfactory*	*Neutral*	*Somewhat Satisfactory*	*Satisfactory*	*Very Satisfactory*
2. Overall air quality in your work area							
3. Temperature in your work area							
4. Aesthetic appearance of your office							
5. Level of privacy for conversations in your office							
6. Level of visual privacy within your office							
7. Amount of noise from other people's conversations while you are at your workstation							
8. Size of your personal workspace to accommodate your work, materials, and visitors							
9. Amount of background noise (i.e. not speech) you hear at your workstation							
10. Amount of light for computer work							
11. Amount of reflected light or glare in the computer screen							
12. Air movement in your work area							
13. Your ability to alter physical conditions in your work area							
14. Your access to a view of outside from where you sit							
15. Distance between you and other people you work with							
16. Quality of lighting in your work area							
17. Frequency of distractions from other people							
18. Degree of enclosure of your work area by walls, screens or furniture							
19. Rank order importance of: noise levels, temperature, privacy, air quality/ventilation, size of work space, window access, lighting	*1st*	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*
20. How old are you?	*18-29*	*30-39*	*40-49*	*50-59*	*60-69*		*70+*
21. What is your sex?		*Female*				*Male*	
22. Job category?	*Administrative*		*Technical*		*Professional*		*Managerial*
23. Highest education level?	*High school*	*Community college*		*Some university*	*Bachelor degree*		*Graduate degree*
24. My department/agency is a good place to work	*Very strongly disagree*	*Strongly disagree*	*Disagree*	*Neither agree nor disagree*	*Agree*	*Strongly agree*	*Very strongly agree*
25. I am satisfied with my job							

Table 3. *Satisfaction Questionnaire (English).*

Question	Response Category						
26. Effect of environmental conditions on personal productivity	*- 30 %*	*- 20 %*	*- 10 %*	*0 %*	*+ 10 %*	*+ 20 %*	*+ 30 %*
27. Indoor environment in your workstation, as a whole	*Very Unsatisfactory*	*Unsatisfactory*	*Somewhat Unsatisfactory*	*Neutral*	*Somewhat Satisfactory*	*Satisfactory*	*Very Satisfactory*

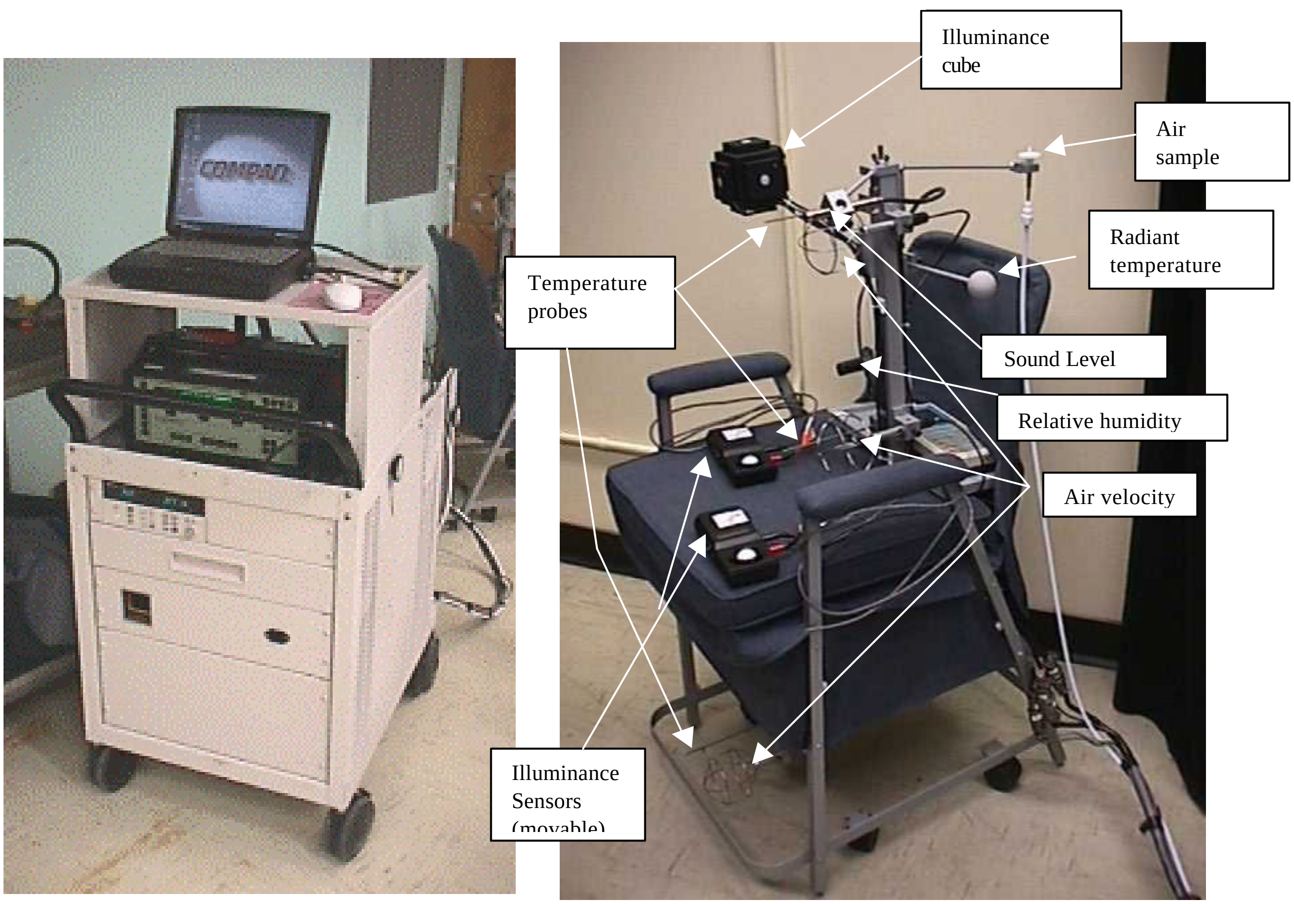
Note. French translation, showing the screen appearance, appears in Appendix A.

The employee was then thanked for his/her participation, and given a short paper questionnaire and a pre-paid envelope for return to NRC. This paper questionnaire provided a medium for any additional, open-ended comments the employee might have that they could not express in response to the electronic questionnaire. This paper questionnaire is shown in Appendix B.

2.3.2 Physical conditions. Physical measurements were made using two systems. A cart+chair system was used to make measurements of a representative set of variables at each workstation during daytime and at night. Additional equipment was used to make more detailed acoustics measurements at night. These systems are described below.

We developed a custom, mobile system to measure the microclimate at the position occupied by an employee in an open-plan office workstation. This system consists of two main components, the cart and the chair, both wheeled for mobility. The chair served as a platform for the indoor environment sensors. In taking measurements, we temporarily replaced the occupant's own chair with ours; fabricating our sensor platform in the shape of a chair meant that it had a similar effect on the

Figure 3. *The cart and chair used for physical measurements.*



microclimate as the occupant's own chair, adding to the validity of the measurements.

The various sensors mounted on the chair are described in Table 1, and the appearance of the chair is shown in Figure 3. The sensors were chosen to give as broad a characterisation of the indoor environment as possible within a reasonable time (< 15 mins.) and with reasonable mobility (cart+chair system to be moved by two staff through narrow openings typical of open-plan layouts). The selection and location of sensors related to thermal comfort (air temperature, radiant temperature, humidity, and air velocity) were designed to be as similar as possible to those followed in ASHRAE studies (Benton et al., 1990). Illuminance measurements were taken in defined locations in the workstation (Figure 4), corresponding to locations defined in lighting recommended practice documents (Human Resources Development Canada (HRDC), 1989; Illuminating Engineering Society of North America (IESNA), 1993).

The chair was connected to the cart by an "umbilical cord" of sensor lines, power cords, and communications cables. The cart (Figure 3) held a laptop computer, battery and power supply, data acquisitions equipment, and instrumentation for the air quality analysis. A custom data acquisition program on the laptop communicated with all instrumentation on the chair and cart, co-ordinated measurement cycles, and stored the resulting data. The cart also housed a camera, tape measures, open-ended questionnaire envelopes, and other miscellaneous equipment. The cart was plugged in a wall socket (building's regular 120V-AC power) overnight to charge the batteries. On a full charge it could operate independently for a full day of measurements.

Table 4. *Description of the various sensors used on the chair.*

Measures	**Sensor**	**Manufacturer**	**Location**	**Range**	**Accuracy**
Illuminance (light falling on a surface)	Silicone photocell	Minolta T1	Desktop (various)	0.01 to 99,900 lx	± 5%
Illuminance	Silicone photocell	Minolta T1	6 faces of cube at seated head height	0.01 to 99,900 lx	± 5%
Air velocity	Hot wire	TSI- 8475	0.1m, 0.7m, 1.1m	0 to 1m/s	± 3%
Octave band analyzer	Microphone	Rion NA-29	Seated head height	27 to 130 dB(a) 31.5Hz to 8kHz	± 0.1 dB
CO, CO_2, THC, CH_4	Photo-acoustic IR	B&K 1302	Seated head height		± 0.3 ppm (TVOC)
Temperature	RTD	Omega	0.1m, 0.7m, 1.1m	Room temp	< 0.1 deg C.
Relative Humidity	Resistance change of bulk polymer	General Eastern RH2	Seated torso height	20 to 95% 0 to 20%	± 2% ± 7%

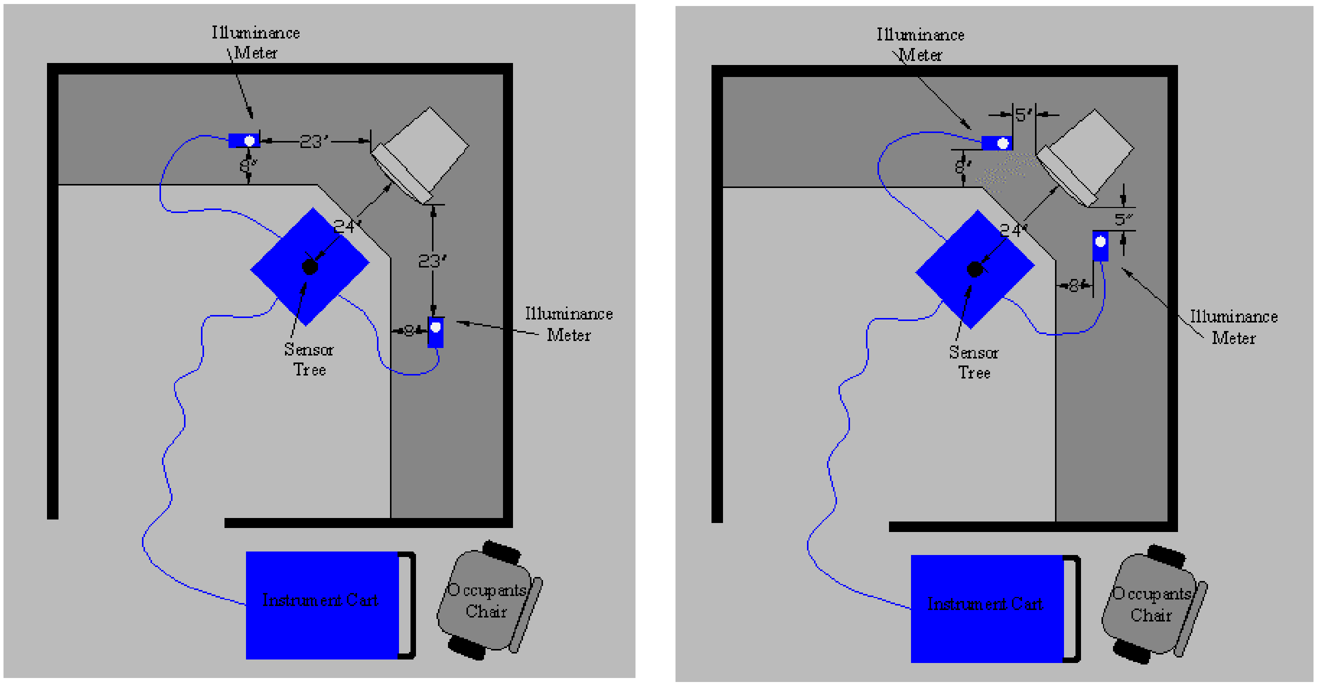


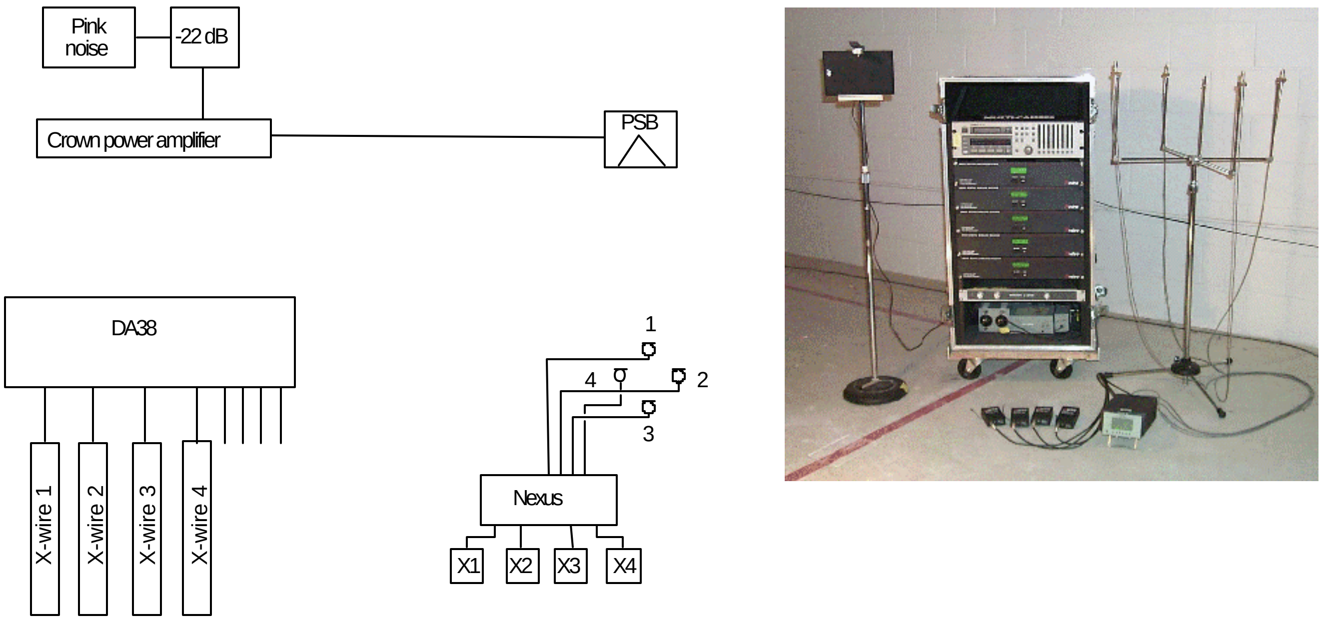
Figure 4. *Placement of sensor chair and desktop illuminance sensors for daytime measurements.*

Chair-based octave band noise level measurements were supplemented by $^{1}/_{3}$ octave band measurements at a sample of locations.

Measurements of sound propagation between adjacent workstations were performed at night. The source was a small Alpha Mite PSB loudspeaker with directionality similar to that of a human. The receivers consisted of an array of four microphones located at the corners of a square, 46cm on each side.

Measurements were made by radiating a known level of pink noise (equal sound energy in each octave) from the source and measuring the levels at the four microphones in the adjacent workstation. The sound power output of the source was separately measured in a laboratory sound power measurement. This measured sound power output was then used to calculate a reference output level of the source for a distance of 0.9m in a free field (a location with no reflected sound). The microphone signals were transmitted to receivers connected to 4 channels of an 8-channel digital tape recorder, as illustrated in the block diagram of Figure 5(a), and the photo in Figure 5(b). Calibration signals were also recorded on each channel at the beginning and end of each measurement session. The tape recordings were played back under computer control into a B&K 2144 real-time analyzer. The reduction of intruding speech sounds was estimated by subtracting these recorded levels from the known level of the source.

Figure 5. *Schematic diagram and photo of equipment for night-time acoustic measurements. (a) Block diagram of equipment used for the night-time sound propagation measurements. The upper half of the figure shows the PSB loudspeaker powered by a Crown power amplifier and the pink noise source. The lower half of the figure shows the 4-microphone array, the Nexus microphone power supply, the X-wire transmitters and receivers and the DA38 digital tape recorder. (b) Photo of equipment.*



2.4 Procedure

2.4.1 Advance communications. The NRC project manager co-ordinated all on-site activities with local staff members in each building. Local staff hosted NRC staff on building walk-throughs, provided building plans, and co-ordinated security clearance for NRC staff. For each building, following management approval for the study, NRC staff met with the local Joint Occupational Safety and Health (JOSH) committee, which included representatives from facilities management, security, unions and management. NRC explained the study in detail to the JOSH committee, and answered any questions they raised.

Prior to NRC's arrival to conduct measurements, management, after consultation with NRC, sent an e-mail to staff informing them of the study and indicating that it had management support (Appendix C). Accompanying this was our own e-mail (Appendix D), explaining the study, and emphasising NRC's independence from management. These e-mails were re-sent on the first day NRC staff made measurements.

2.4.2 Daytime measurements. A team of two NRC staff conducted daytime measurements. NRC staff introduced themselves to employees who were seated at their desks. With reference to the informational e-mails that had been circulated, NRC staff explained the study, the measurement procedure (including an estimate of the time commitment, around 15 minutes), and the employee's rights should they choose to participate. The employee was then asked if they would like to participate.

If an employee agreed to participate, he or she was asked to step outside of the workstation in the company of the one of the NRC staff. The NRC staff member took the participant to a nearby location, typically a vacant workstation similar to his or her own, and gave instructions about the questionnaire. The

NRC staff member then left the participant to answer the questionnaire in private, and returned to help the other member of the NRC team with the physical measurements in the workstation. The participant was instructed to return to his or her workstation for assistance from the NRC staff if it were needed.

The measurements in the workstation began with two photographs. The first was a close-up of the computer screen with the screen turned off, principally to identify potential sources of reflected glare. The second photograph was an overall workstation picture, taken from the entrance to the workstation. Both photographs were taken with a Kodak™ DC 260 digital camera with a wide-angle lens. A small blackboard featuring an ID code for the workstation was included in the photographs, and the same code was recorded on the building plans. In addition, the photographs were automatically time-stamped, and the time of the visit was recorded on the building plans. These measures helped ensure that all data associated with a particular workstation could be collated later.

Once the instruments were in place, software on the laptop on the cart automatically co-ordinated measurements from the various sensors. Initially, the operator entered the workstation ID code, and initials identifying him- or herself. The process began with the B&K 1302 taking an air sample for analysis; this process took about 2.5 minutes. While this was happening, NRC staff took measurements of workstation size, partition height and ceiling height, and noted them down for later data entry.

Next the noise level measurements were made; this process took about 1.5 minutes, during this time the NRC team took no actions that might disturb the measurement. The goal was to get a 20-second measurement without intelligible speech sounds (a person talking on the telephone in the next cubicle, for example). Measurements were repeated 3 times, or until a measurement without speech was captured, whichever occurred sooner. Other noises occurring during the measurement, such as ventilation noise or noise from outside the building, were noted.

Next, temperature, air speed, humidity and illuminance measurements were taken. Measurements of all these parameters were taken every 10 seconds, and six measurement cycles were completed in a one-minute period. The last of the six measurements for each variable is shown on the screen, whereas all six measurements, and the mean of all six for each variable, were written to file. On completion, the desktop illuminance sensors were moved to a second location, and the measurements for those sensors were repeated.

Finally, NRC staff entered additional information describing the workstation. These data included relative location of entrance and computer screen, workstation size, partition height and finish, ceiling height, floor finish, lighting type and location, diffuser type and location, whether the VDT had an anti-glare screen, and whether the occupant was wearing headphones when first approached. After completing this screen the operator was prompted to enter any additional comments.

At each stage in this process the operator could visually check the data and redo measurements if necessary. All data were recorded to a time-stamped text file on the laptop computer. Typically the physical measurements were completed before the questionnaire, in which case NRC staff simply waited for the participant to return to the workstation with the palmtop computer.

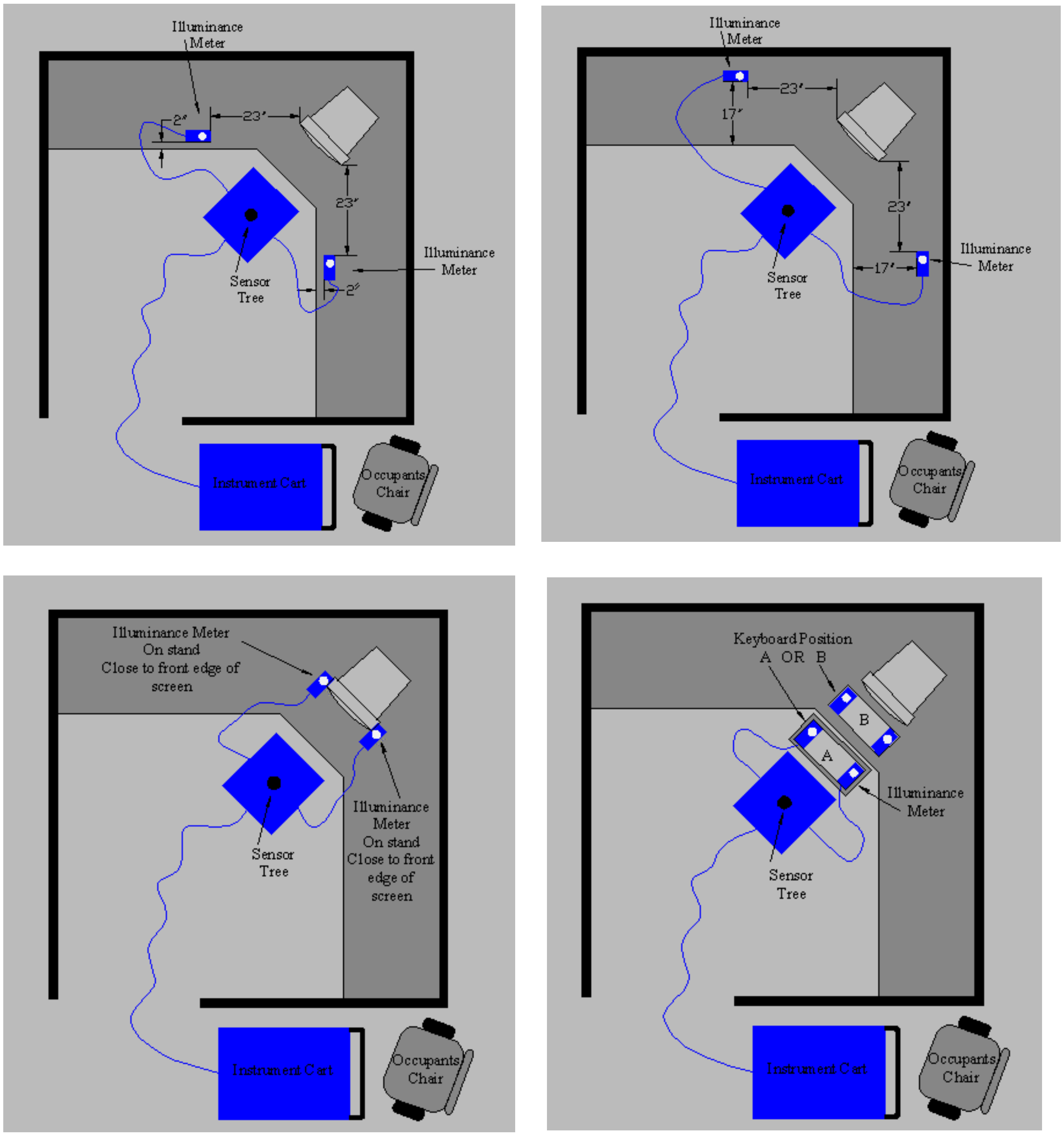


Figure 6. *Illuminance sensor locations for additional night-time measurements (electric lighting only).*

The NRC team then moved on to invite the next available person to participate. There was no set plan as to which employees were approached when, and some work areas were revisited several times to recruit employees who had been unavailable on previous visits to the work area.

2.4.3 Night-time measurements. NRC staff returned after normal working hours (typically 7 – 10 pm) to perform additional measurements with the cart+chair system. These measurements provided baseline data without occupants, and data on the light level provided by the electric lighting system independent of any daylight contribution. Measurements were made in a subset (around $^{1}/_{3}$) of the workstations that were visited during the day.

Measurements at night with the cart+chair system followed essentially the same protocol as the daytime measurements, with the following exceptions:

- Photographs were not taken, as they would have added little more information to the daytime photographs.
- Additional desktop lighting measurements were made (Figure 6).
- Workstation information on was not entered as it would have only duplicated the daytime data.

At night we also took the opportunity to take additional photographs not related to a particular workstation (e.g., overall views, light fixtures, diffuser types).

At the end of every evening of measurements all data collected with the cart+chair system that day, including questionnaire responses and photographs, were backed up to disk and CD-ROM.

2.4.4 Night-time acoustics measurements Two additional NRC staff conducted the night-time sound propagation measurements. Night-time sound propagation measurements were made in every workstation where daytime measurements had been made (although not necessarily on the same day). The participant's workstation acted as the receiver workstation, and the source workstation was selected as the adjacent workstation from which speech sounds could most readily propagate.

The sound source was located at the centre of the source workstation and was pointed towards the receiver workstation. The centre of the square receiver array was located at the centre of the receiver workstation. Locating the source and receivers at the centres of each workstation approximated the average of the many possible occupant positions.

These sound propagation measurements were combined with the daytime ambient noise levels measured using the cart+chair system to assess the expected speech privacy between adjacent workstations. A number of other acoustical measures were also derived from these two sets of measurements.

3.0 Results

This report concerns only the questionnaire data from time 1. Data concerning the physical conditions data, and analyses of other relationships between physical variables and questionnaire data, will be reported elsewhere.

3.1 Descriptive Statistics and Data Screening

The questionnaire data were transformed from their original format (Microsoft Excel) into a data file that could be read by EQS for Windows 5.7b (Bentler & Wu, 1995). A careful review of the transformed data confirmed the accuracy of data input. Data preparation and screening was conducted using the procedures recommended by Kline (1997). Univariate normality was assessed by examining the kurtosis and skewness values of the individual items. According to Kline, skewness values greater than an absolute value of 3 and kurtosis values greater than an absolute value of 8 indicate univariate normality problems. Univariate outliers were identified by examining frequency distributions of standardised scores and multivariate outliers were detected by examining the values of the Mahalanobis distance statistic. Spot checks of several scatterplots indicated the presence of bivariate normality and linearity. Multivariate normality was assessed by examining the probability plot for each variable. Correlation matrices were examined to check for multicollinearity and singularity (these terms refer to circumstances in which variables are very highly correlated, so that understanding their separate relations to other variables is impossible).

The full sample data set ($\underline{N}$=419) was screened for analyses that required the entire sample. Variable mean imputation was used for each observation of 19 cases that had missing data because the number of cases was small and the missing data were distributed across participants. A total of 12 univariate (4) and multivariate (8) outliers were identified and dropped leaving a total of 407 cases for analysis. Table 5 shows the descriptive statistics for the entire sample of 419, the basis for these decisions.

Table 5. *Descriptive Statistics: Entire Sample*

Question	Mean	Standard Deviation	Kurtosis	Skewness
EFR-1 Amount of lighting on the desktop	5.20	1.52	0.01	-0.93
EFR-2. Overall air quality in your work area	4.22	1.64	-1.19	-0.21
EFR-3. Temperature in your work area	4.22	1.64	-1.16	-0.27
EFR-4. Aesthetic appearance of your office	4.22	1.66	-0.93	-0.29
EFR-5. Level of privacy for conversations in your office	2.83	1.67	-0.68	0.68
EFR-6. Level of visual privacy within your office	4.08	1.83	-1.22	-0.21
EFR-7. Amount of noise from other people's conversations while you are at your workstation	3.02	1.60	-0.83	0.45
EFR-8. Size of your personal workspace to accommodate your work, materials, and visitors	4.60	1.78	-0.86	-0.57
EFR-9. Amount of background noise (i.e. not speech) you hear at your workstation	4.22	1.56	-0.31	-0.96
EFR-10. Amount of light for computer work	4.95	1.44	-0.81	-0.21
EFR-11. Amount of reflected light or glare in the computer screen	4.38	1.64	-0.36	-1.01
EFR-12. Air movement in your work area	3.82	1.64	-0.08	-0.16
EFR-13. Your ability to alter physical conditions in your work area	3.51	1.62	0.18	-0.93
EFR-14. Your access to a view of outside from where you sit	4.47	2.26	-0.37	-1.41
EFR-15. Distance between you and other people you work with	4.84	1.51	-0.28	-0.75
EFR-16. Quality of lighting in your work area	4.79	1.52	-0.68	-0.64
EFR-17. Frequency of distractions from other people	3.76	1.53	-0.96	0.05
EFR-18. Degree of enclosure of your work area by walls, screens or furniture	5.01	1.10	1.56	-0.90
OES-1. Effect of environmental conditions on personal productivity.	3.82	1.47	-0.62	0.22
OES-2. Indoor environment in your workstation, as a whole	4.20	1.53	-1.06	-0.10
JS-1. My department/agency is a good place to work	5.01	1.10	-0.90	1.56
JS-2. I am satisfied with my job	4.99	1.23	-0.72	0.76

Note. EFR: Environmental Features Rating. OES: Overall Environmental Satisfaction. JS: Job Satisfaction.

3.2 Independent Subsamples

To establish the latent variable structure of the 18-item Environmental Features Ratings, two independent groups were required. Using the case selection specification procedure in EQS, the data was then randomly split into two groups, one for the exploratory factor analysis (EFA, N=210) and one for the confirmatory factor analysis (CFA, N=209).

3.2.1 EFA group. The EFA group consisted of 210 subjects and represented all three sites in similar proportions to the overall group (Site 1, 32.9%; Site 2, 30.5%; and, Site 3, 39.7%), and was similar to the overall sample in terms of language of response (English, 88.10%; French, 11.90%), sex (males 51 %; females, 47.6 %), age (39.0 years), job category (professional, 41 %; administration, 36.3%; technical, 15.7%; and, managerial, 7.1%) and education level (undergraduate degree, 25.2%; graduate degree, 23.8%).

The data for the exploratory factor analysis (EFA) group was screened in accordance with the procedures outlined above. The mean, standard deviation, kurtosis and skewness for first 18 satisfaction items are presented in Table 6 (other variables are not included because they were not used in the EFA). Because the proportion of missing data was very low (5.2%) and scattered across several variables, it was decided to impute the variable mean for each missing observation (Kline, 1997). For this data, the maximum skewness value was -.895 and the maximum kurtosis value was -1.383. Therefore, these values were not considered problematic. There were three cases of univariate outliers with standardised scores greater than + or –3. Using Mahalanobis distance with $p < .001$, five cases were identified as multivariate outliers. Given that the remaining number of cases would be sufficient for the analysis (N=202) it was decided to delete the eight univariate and multivariate outliers (Kline, 1997).

Table 6. *Descriptive Statistics: EFA Group*

Question	Mean	Standard Deviation	Kurtosis	Skewness
EFR-1 Amount of lighting on the desktop	5.34	1.36	0.05	0.90
EFR-2. Overall air quality in your work area	4.23	1.68	-1.06	-0.37
EFR-3. Temperature in your work area	4.23	1.73	-1.16	-0.35
EFR-4. Aesthetic appearance of your office	4.37	1.58	-0.92	-0.31
EFR-5. Level of privacy for conversations in your office	2.86	1.74	-0.73	0.69
EFR-6. Level of visual privacy within your office	4.18	1.89	-1.25	-0.27
EFR-7. Amount of noise from other people's conversations while you are at your workstation	3.07	1.58	-0.90	0.42
EFR-8. Size of your personal workspace to accommodate your work, materials, and visitors	4.61	1.74	-0.85	-0.57
EFR-9. Amount of background noise (i.e. not speech) you hear at your workstation	4.22	1.55	-0.95	-0.25
EFR-10. Amount of light for computer work	5.02	1.39	0.04	-0.84
EFR-11. Amount of reflected light or glare in the computer screen	4.39	1.56	-0.93	-0.38
EFR-12. Air movement in your work area	3.94	1.66	-1.14	-0.17
EFR-13. Your ability to alter physical conditions in your work area	3.53	1.67	-0.95	0.20
EFR-14. Your access to a view of outside from where you sit	4.49	2.24	-1.38	-0.37
EFR-15. Distance between you and other people you work with	4.80	1.57	-0.44	-0.72
EFR-16. Quality of lighting in your work area	4.87	1.45	-0.64	-0.59
EFR-17. Frequency of distractions from other people	3.79	1.52	-1.04	0.02
EFR-18. Degree of enclosure of your work area by walls, screens or furniture	4.61	1.62	-0.76	-0.48

To test for multicollinearity and singularity, a correlation matrix for the 18 satisfaction items was constructed (Table 7). Examination of the matrix did not identify any correlations above .80 (the maximum correlation value was .76 between the items 'overall air quality in your work space' and 'air movement in your workspace'). This indicated the absence of multicollinearity. The matrix was also examined to determine the factorability of the scale. The majority of correlations were above .30 for all variables except one. The item 'your access to a view from where you sit' had only one correlation above .3 (.30; 'the aesthetic appearance of your office') indicating potential factorability problems. A review of the communality values indicated the same variable had a value of 1.0. A variable with a communality score exceeding a value of 1 may cause the covariance matrix to be singular (Kline, 1997). Given that the variable has a strong theoretical reason for being included in the questionnaire, it was decided to keep the variable in the data for the purposes of the EFA.

Table 7. *Intercorrelations between EFR questions for EFA group.*

	EFR-1	EFR-2	EFR-3	EFR-4	EFR-5	EFR-6	EFR-7	EFR-8	EFR-9	EFR-10	EFR-11	EFR-12	EFR-13	EFR-14	EFR-15	EFR-16	EFR-17	EFR-18
EFR-1	1.00																	
EFR-2	0.37	1.00																
EFR-3	0.19	0.57	1.00															
EFR-4	0.30	0.31	0.20	1.00														
EFR-5	0.25	0.39	0.25	0.45	1.00													
EFR-6	0.23	0.36	0.30	0.38	0.63	1.00												
EFR-7	0.19	0.35	0.22	0.36	0.71	0.51	1.00											
EFR-8	0.24	0.25	0.27	0.42	0.41	0.47	0.31	1.00										
EFR-9	0.25	0.31	0.30	0.32	0.37	0.48	0.49	0.24	1.00									
EFR-10	0.60	0.39	0.26	0.38	0.32	0.35	0.24	0.33	0.33	1.00								
EFR-11	0.30	0.34	0.41	0.30	0.37	0.37	0.34	0.33	0.34	0.60	1.00							
EFR-12	0.25	0.76	0.57	0.31	0.44	0.39	0.37	0.26	0.32	0.38	0.37	1.00						
EFR-13	0.26	0.38	0.38	0.48	0.51	0.40	0.44	0.42	0.30	0.33	0.37	0.42	1.00					
EFR-14	0.23	0.10	-0.14	0.30	0.06	-0.01	0.03	0.19	-0.05	0.17	-0.07	0.16	0.06	1.00				
EFR-15	0.23	0.30	0.20	0.36	0.44	0.48	0.40	0.30	0.40	0.36	0.32	0.30	0.31	0.10	1.00			
EFR-16	0.71	0.40	0.25	0.32	0.31	0.30	0.28	0.24	0.27	0.73	0.44	0.41	0.31	0.25	0.32	1.00		
EFR-17	0.23	0.36	0.28	0.25	0.55	0.43	0.71	0.24	0.50	0.32	0.33	0.39	0.36	-0.03	0.37	0.36	1.00	
EFR-18	0.23	0.28	0.22	0.42	0.44	0.57	0.42	0.49	0.33	0.35	0.24	0.32	0.36	0.11	0.42	0.26	0.43	1.00

3.2.2 CFA group. The CFA group consisted of 209 subjects and was equivalent to the overall sample and to the EFA group in terms of site, (Site 1, 30.1%; Site 2, 30.1%; and, Site 3, 39.7%) language of responding, (English, 87.6%; French, 12.4%), sex (males 49.8%; females, 50.2%), age (38.2 years), job category (professional, 41.6%; administration, 34.8%; technical, 15.7%; and, managerial, 6.2%) and education level (undergraduate degree, 26.0%; graduate degree, 23%).

The data from the CFA group was screened using the same procedures as were used for the EFA group. There were 9 cases of missing data (4.39%) scattered across several variables so variable mean imputation was used for each observation. The mean, standard deviation, kurtosis and skewness for all items in the CFA group are presented in Table 8. Similar to the EFA group, checks of univariate normality, linearity and multivariate normality revealed no problems for these data. One univariate and 3 multivariate outliers were identified in the CFA group. These cases were deleted leaving 205 cases for the analysis.

Table 8. *Descriptive Statistics: CFA Group*

Question	Mean	Standard Deviation	Kurtosis	Skewness
EFR-1 Amount of lighting on the desktop	5.11	1.60	-0.22	-0.87
EFR-2. Overall air quality in your work area	4.06	1.62	-1.29	-0.03
EFR-3. Temperature in your work area	4.22	1.55	-1.23	-0.16
EFR-4. Aesthetic appearance of your office	4.16	1.71	-0.96	-0.25
EFR-5. Level of privacy for conversations in your office	2.82	1.60	-0.62	0.65
EFR-6. Level of visual privacy within your office	4.00	1.75	-1.20	-0.14
EFR-7. Amount of noise from other people's conversations while you are at your workstation	3.04	1.63	-0.81	0.42
EFR-8. Size of your personal workspace to accommodate your work, materials, and visitors	4.58	1.82	-0.89	-0.57
EFR-9. Amount of background noise (i.e. not speech) you hear at your workstation	4.28	1.54	-0.97	-0.36
EFR-10. Amount of light for computer work	4.86	1.48	-0.40	-0.76
EFR-11. Amount of reflected light or glare in the computer screen	4.39	1.68	-1.09	-0.33
EFR-12. Air movement in your work area	3.76	1.59	-1.14	0.01
EFR-13. Your ability to alter physical conditions in your work area	3.57	1.56	-0.86	0.14
EFR-14. Your access to a view of outside from where you sit	4.43	2.25	-1.43	-0.34
EFR-15. Distance between you and other people you work with	4.90	1.40	-0.22	-0.74
EFR-16. Quality of lighting in your work area	4.77	1.54	-0.76	-0.67
EFR-17. Frequency of distractions from other people	3.79	1.54	-0.88	0.05
EFR-18. Degree of enclosure of your work area by walls, screens or furniture	4.45	1.58	-0.83	-0.43

A review of the correlation matrix (Table 9) and communality values revealed no evidence of multicollinearity (all correlations <.80) or singularity (all communality values <1.0). Similar to the EFA group, the majority of correlations were above .30 for all variables except "your access to a view from where you sit" which had only 1 correlation above .3 (.42; "the amount of lighting on the desktop"). Given these findings it was decided to proceed with the CFA.

Table 9. *Intercorrelations between EFR questions for CFA group*

	EFR-1	EFR-2	EFR-3	EFR-4	EFR-5	EFR-6	EFR-7	EFR-8	EFR-9	EFR-10	EFR-11	EFR-12	EFR-13	EFR-14	EFR-15	EFR-16	EFR-17	EFR-18
EFR-1	1.00																	
EFR-2	0.37	1.00																
EFR-3	0.22	0.50	1.00															
EFR-4	0.39	0.20	0.27	1.00														
EFR-5	0.29	0.18	0.22	0.44	1.00													
EFR-6	0.22	0.23	0.10	0.43	0.58	1.00												
EFR-7	0.28	0.18	0.11	0.41	0.61	0.53	1.00											
EFR-8	0.19	0.15	0.15	0.50	0.34	0.40	0.35	1.00										
EFR-9	0.28	0.23	0.12	0.36	0.38	0.52	0.53	0.37	1.00									
EFR-10	0.58	0.39	0.32	0.48	0.28	0.28	0.27	0.34	0.37	1.00								
EFR-11	0.26	0.26	0.31	0.23	0.16	0.20	0.21	0.20	0.28	0.46	1.00							
EFR-12	0.35	0.72	0.53	0.27	0.24	0.24	0.15	0.15	0.22	0.39	0.30	1.00						
EFR-13	0.28	0.29	0.21	0.54	0.35	0.31	0.44	0.46	0.36	0.43	0.22	0.26	1.00					
EFR-14	0.42	0.13	0.05	0.20	0.18	0.12	0.07	0.09	0.14	0.32	-0.11	0.25	0.14	1.00				
EFR-15	0.28	0.19	0.13	0.37	0.42	0.49	0.40	0.44	0.38	0.44	0.27	0.12	0.37	0.27	1.00			
EFR-16	0.71	0.35	0.25	0.49	0.32	0.26	0.25	0.32	0.33	0.70	0.39	0.44	0.38	0.40	0.39	1.00		
EFR-17	0.17	0.26	0.04	0.27	0.40	0.42	0.60	0.32	0.50	0.24	0.29	0.20	0.36	0.09	0.44	0.24	1.00	
EFR-18	0.24	0.20	0.12	0.50	0.40	0.53	0.47	0.58	0.47	0.38	0.33	0.20	0.52	0.09	0.47	0.29	0.45	1.00

3.3 Exploratory Factor Analysis

We used exploratory factor analysis to identify the existence of theoretical latent or underlying variables. This is a statistical technique that examines the intercorrelations between scores that individuals provide on individual questions, seeking a simple structure of interpretable underlying variables that might explain the intercorrelations.

Using the factor analysis procedure in EQS (maximum likelihood extraction and direct oblimin rotation) a free EFA was conducted to determine the number of factors. The cutoff for factor loadings to be included in a factor was .4. This resulted in a solution with four factors having eigenvalues greater than 1 (range = 1.038 to 7.213). Examination of the scree plot supported the four-factor solution. The four-factor solution was composed of three clear factors (labelled Satisfaction with Privacy, Satisfaction with Lighting, and Satisfaction with Ventilation) with several high value loading items on each (Table 10). A fourth factor was a stand-alone factor (View) consisting of only one variable. Although these results support a four-factor solution, the correlational problem with the "view" item identified during data screening appeared to be negatively influencing this solution. According to Tabachnick and Fidell (2001) “if only one variable loads highly on a factor, the factor is poorly defined” (p. 622). Therefore, a three-factor EFA solution was forced.

Table 10. *Factor loadings for rotated four-factor EFA solution*

Question	Sat. with Privacy	Sat. with Lighting	Sat. with Ventilation	Sat. with View
EFR-7. Amount of noise from other people’s conversations while you are at your workstation	.79			
EFR-17. Frequency of distractions from other people	.72			
EFR-18. Degree of enclosure of your work area by walls, screens or furniture	.70			
EFR-6. Level of visual privacy within your office	.69			
EFR-15. Distance between you and other people you work with	.69			
EFR-5. Level of privacy for conversations in your office	.66			
EFR-9. Amount of background noise (i.e. not speech) you hear at your workstation	.65			
EFR-8. Size of your personal workspace to accommodate your work, materials, and visitors	.56			
EFR-13. Your ability to alter physical conditions in your work area	.52			
EFR-4. Aesthetic appearance of your office	.49			
EFR-16. Quality of lighting in your work area		.78		
EFR-1 Amount of lighting on the desktop		.77		
EFR-10. Amount of light for computer work		.69		
EFR-11. Amount of reflected light or glare in the computer screen		.56		
EFR-12. Air movement in your work area			.78	
EFR-2. Overall air quality in your work area			.73	
EFR-3. Temperature in your work area			.71	
EFR-14. Your access to a view of outside from where you sit				.69
Eigenvalues	7.21	1.99	1.47	1.04

Note. Factor loading cut-off = .400

The three-factor solution (labelled Satisfaction with Privacy, Satisfaction with Lighting, and Satisfaction with Ventilation) was made up of the same items in the three-factor solution (Table 11). In this case, all items appeared in the same factor as previously with the exception of EFR-14 (access to a view of outside), which loaded moderately (.54) on the Satisfaction with Lighting factor. The three factors accounted for 57.05% of the total variance observed. There were no cross loadings and all items loaded significantly on a factor, therefore all were retained. Internal consistency values (Cronbach's alpha) were satisfactory for each factor. Correlations among factors met the criteria for oblique (direct oblimin) rotation (Table 12). According to Tabachnick and Fidell (2001), if correlations exceed .32 on average, there is enough variance overlap among factors to warrant oblique rotation.

Table 11. *Rotated three-factor EFA solution*

Question	Sat. with Privacy	Sat. with Ventilation	Sat. with Lighting
EFR-7. Amount of noise from other people's conversations while you are at your workstation	.79		
EFR-17. Frequency of distractions from other people	.71		
EFR-18. Degree of enclosure of your work area by walls, screens or furniture	.72		
EFR-6. Level of visual privacy within your office	.71		
EFR-15. Distance between you and other people you work with	.68		
EFR-5. Level of privacy for conversations in your office	.79		
EFR-9. Amount of background noise (i.e. not speech) you hear at your workstation	.64		
EFR-8. Size of your personal workspace to accommodate your work, materials, and visitors	.57		
EFR-13. Your ability to alter physical conditions in your work area	.56		
EFR-4. Aesthetic appearance of your office	.51		
EFR-12. Air movement in your work area		.71	
EFR-2. Overall air quality in your work area		.71	
EFR-3. Temperature in your work area		.70	
EFR-16. Quality of lighting in your work area			.65
EFR-1 Amount of lighting on the desktop			.65
EFR-10. Amount of light for computer work			.56
EFR-11. Amount of reflected light or glare in the computer screen			.44
EFR-14. Your access to a view of outside from where you sit			.54
% of variance explained	26.1	16.6	14.4
Cronbach's alpha	.88	.82	.76

Note. Factor loading cut-off = .400

Table 12. *Factor correlations for three-factor solution*

Factor	Sat. with Privacy	Sat. with Ventilation	Sat. with Lighting
Satisfaction with Privacy	1.00		
Satisfaction with Ventilation	.44	1.00	
Satisfaction with Lighting	.39	.25	1.00

3.4 Confirmatory Factor Analysis

Confirmatory factor analysis is a form of structural equation modelling, in which the investigator specifies a model that is expected to describe the observed data. The fit of the model to the data is evaluated against several criteria, the pattern of which leads to a judgement as to whether the fit is acceptably good or not (Kline, 1997). In this study, the initial model was the three-factor solution developed in the EFA step. It was tested against the interrelations between responses for the CFA group (recall that this group was independent of the EFA group).

The model submitted for analysis consisted of maximum likelihood estimations of the 18 target loadings, three factor variances, correlations between all factors and error variances for each of the 18 items (see Figure 7). Model fit was assessed using multiple statistical and fit indices including Chi-square, Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Bentler-Bonett Normed Fit Index (NFI), Bentler-Bonett Non-normed Fit Index (NNFI) and the Standardised Root Mean Square Residual (RMSR.) Detailed descriptions of these and other indices can be found in several sources (e.g., Byrne, 1994; Kline, 1997; Tabachnick & Fidell, 2001). Briefly, a low and non-significant value of the chi-square statistic indicates a good fit to the data. However, chi-square can not be interpreted in a standardised way (it has no theoretical upper bound) and is very sensitive to sample size. To deal with the sensitivity to sample size problem, the chi-square statistic can be divided by the degrees of freedom to get a better estimate. Kline (1997) suggested that a chi-square/df ratio of less than 3 is acceptable. Generally, statisticians recommend a multiple set of fit indices should be examined (Byrne, 1994; Kline, 1997; Tabachnick & Fidell, 2001). The GFI and AGFI values range from 0 (poor fit) to 1 (perfect fit). The GFI is analogous to a squared multiple correlation indicating the proportion of covariances explained by the model-implied covariances whereas the AGFI is like a shrinkage-corrected squared multiple correlation in that it includes an adjustment for model complexity (Kline, 1997). The NFI indicates the proportion in the improvement of the overall fit of the model to a null model (one in which the observed variables are assumed to be uncorrelated) compared to the NNFI which includes a correction for model complexity similar to the AGFI. NFI and NNFI values range from 0-1. Tabachnick and Fidell (2001) suggested that GFI, AGFI, NFI and NNFI values of .9 or greater indicate the model is a good fit to the data. In contrast, the RMSR is a standardised summary of the covariance residuals that indicates better fit with lower (closer to zero) values.

Figure 7. *Model CFA-1.*

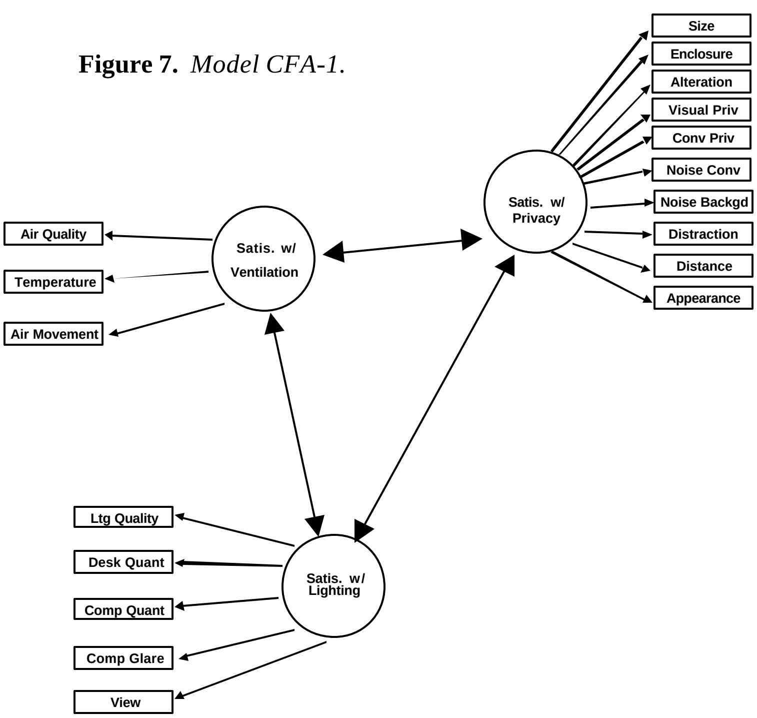


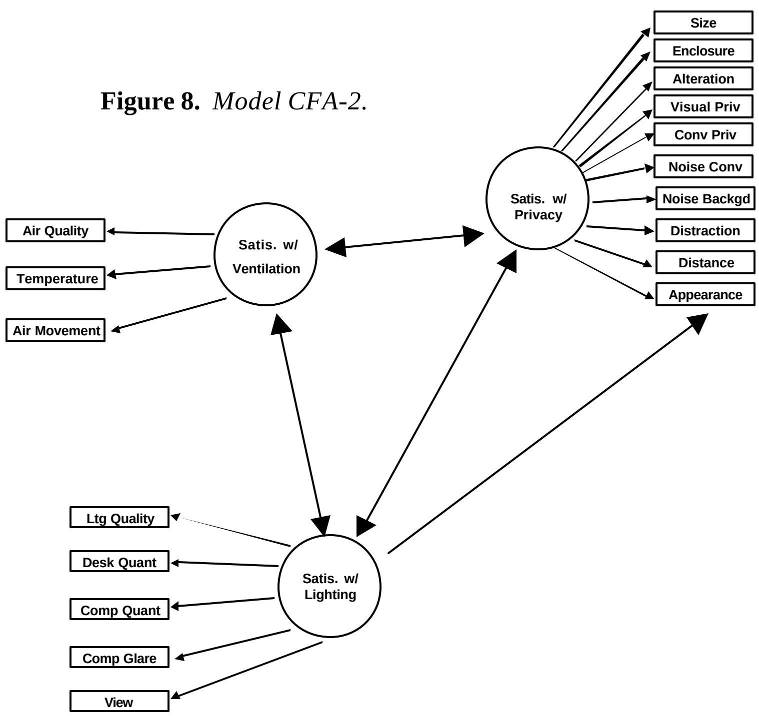
Table 13. *CFA results: Goodness of fit indices*

	?^{2}	?^{2}/*df*	GFI	AGFI	NFI	NNFI	RMSR
Optimal fit		< 3	> .90	>.90	>.90	>.90	<.10
CFA-1	363.4	2.75	.83	.77	.78	.82	.07
CFA-2	353.2	2.69	.83	.78	.79	.83	.07

Note. CFA-1, figure 7. CFA-2, figure 8. Full results with parameter estimates in Appendix E. *N*=205. Optimal values and their sources are described in the text.

Table 13 shows a summary of the results of the CFA, including optimal values for the various fit indices. The results for CFA-1 indicated a marginal fit between the model and the data. The Legrange Multiplier (LM) test and the Wald W statistic were examined to determine possible misfits. The LM test provides an estimate of how much the overall chi-square statistic would decrease if a particular parameter were added. Conversely, the Wald W test estimates the amount the overall chi-square would increase if a particular free parameter were fixed, that is, dropped from the model. In this case, the Wald W test indicated the model would not be improved by dropping any parameters. The LM test indicated the model could be improved by adding a parameter from the variable "the aesthetic appearance of your office" to Factor 3 Lighting. Satisfaction with the appearance of one’s office or workspace might reasonably be related to the quality of lighting available. Therefore, it was decided to add the parameter and run a post hoc model.

Figure 8. *Model CFA-2.*



This model, labelled CFA-2, is summarised in Table 13 and Figure 8. Additional parameters were further examined: the frequency distribution of the standardised residuals revealed that most residuals (91.81%) fell between -.10 and .10, which is desirable. All estimated factor loadings were significant and internal consistency values for each subscale were satisfactory (Privacy, alpha = .89; Lighting, alpha = .82; and, Ventilation, alpha = .82). However, this result was not judged to be enough of an improvement over CFA Model 1 to warrant the additional complexity of a cross-loading item (a variable contributing to more than one latent variable). The cross-loading item would have complicated interpretation of further analyses.

3.5 Relations to Overall Environmental Satisfaction and Job Satisfaction

Structural equation modelling (SEM) was used to examine relationships between the EFR latent variables model and the variables Overall Environmental Satisfaction and Job Satisfaction. The initial model to be tested hypothesized that all the latent variables were correlated. That is, it consisted of three factors identical to the final CFA solution and included bidirectional paths from each factor to a composite Job Satisfaction factor consisting of two items ("I am satisfied with my job" and "my department/agency is a good place to work") and another composite Environmental Satisfaction factor consisting of two items ("indoor environment in your workstation as a whole", "effect of environmental conditions on personal productivity" (Figure 9). Table 14 summarises this model.

Figure 9. *Model SEM-1.*

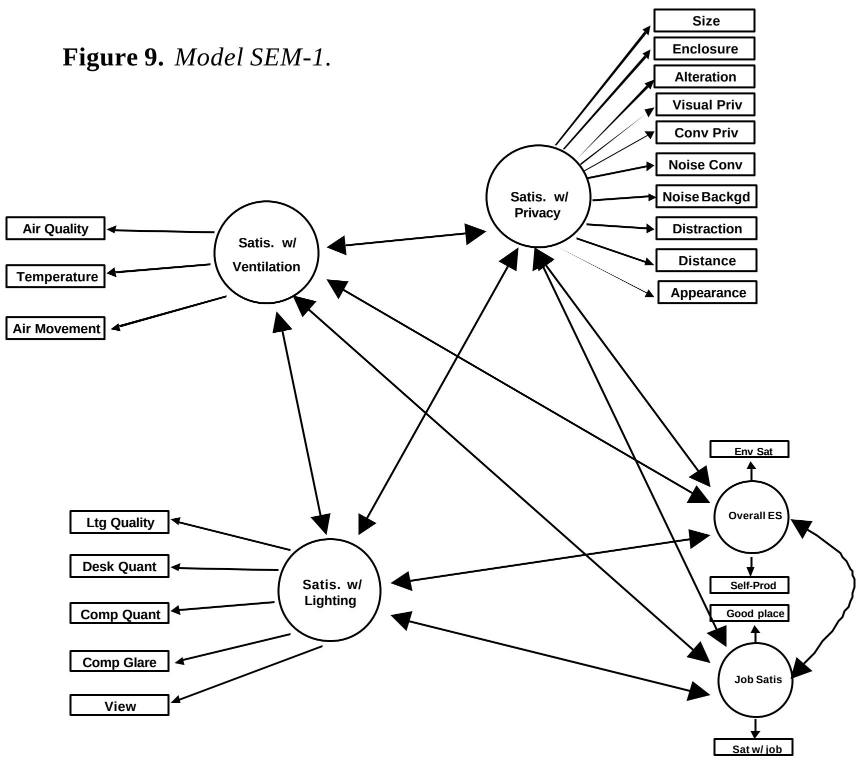


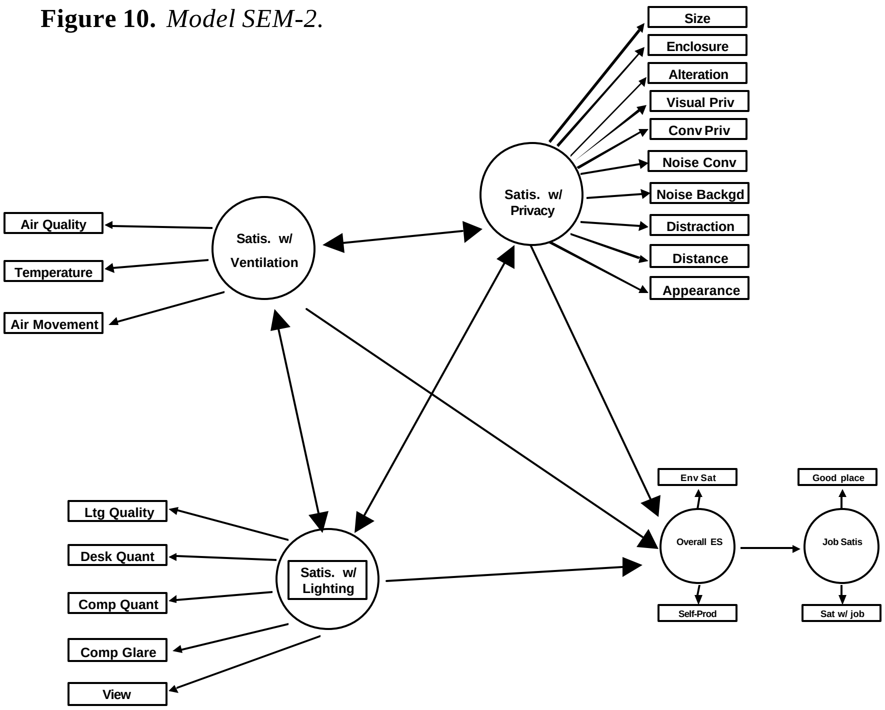
Table 14. *SEM results: Goodness of fit indices*

	$?^2$	$?^2/df$	GFI	AGFI	NFI	NNFI	RMSR
Optimal fit		< 3	> .90	>.90	>.90	>.90	<.10
SEM-1	629.3	3.16	.86	.82	.84	.87	.06
SEM-2	644.0	3.19	.86	.82	.84	.87	.06

Note. SEM-1, Figure 9. SEM-2, figure 10. Full results with parameter estimates in Appendix E. *N*=407. Optimal values and their sources are described in the text.

The results for SEM-1 indicated a moderately good fit between the model and the data. (See Appendix E for the full model with parameters.) However, the choice of bidirectional relations between the latent variables was somewhat arbitrary. We reconsidered the model, considering results such as Wells (2000), who found a direct unidirectional relationship between environmental satisfaction and job satisfaction. We tested this model, labelled SEM-2 in table 14 and shown in Figure 10. The model fit was almost identical to the first model. Model SEM-2 is more parsimonious, having fewer paths and an interpretable relationship similar to other investigations.

Figure 10. *Model SEM-2.*



4.0 Discussion

This is the first of a series of reports about the COPE project field study. The field study is a pre-post renovation study of employees in open-plan workstations, in which detailed physical measurements are taken in conjunction with a satisfaction questionnaire. The investigation will result in information concerning the relationships between these physical parameters and environmental satisfaction, both overall and specific to subscales or components of environmental satisfaction. This report describes the detailed methodology and establishes subscales of environmental satisfaction for use in future analyses of these data.

Several underlying latent variables were expected to emerge in the exploratory and confirmatory factor analyses of these time 1 data. The results were consistent with the prediction, but were most interpretable when a three-factor solution was forced in EFA The resulting components of environmental satisfaction were labelled Satisfaction with Privacy, Satisfaction with Ventilation, and Satisfaction with Lighting. Over 50% of the variance in responses to the 18 items was explained, a good result, and the internal consistency reliabilities were high. The CFA-1 model derived from the EFA result showed acceptable fit to the data. Future analyses with these components will use subscale scores that are arithmetic means of responses to the questions loading heavily on these three components (see Figure 7).

The result is broadly similar to other analyses of similar scales, although comparisons are tricky because of differing sets of items included and different analytic choices and because some investigators have used multivariate techniques despite small sample sizes. For instance, González, Fernández, & Cameselle (1997) found five latent variables underlying environmental evaluations, which they named

Evaluation (aesthetics), Temperature, Noise, Air, and Space; their analysis of a 13-item scale had only 83 participants (subjects:items = 6.4). Veitch and Newsham (1998) used a variation of the Stokols and Scharf (1990) Ratings of Environmental Features and reported a five-factor solution (Noise, Ventilation, Furniture, Washrooms, and Lighting), based on 294 participants and 23 items, a more acceptable subjects:items ratio (12.8). However, they used principal components analysis with Varimax rotation, a technique that does not permit correlations between components, as was the case here. Some authors would argue that intercorrelated components are logically expected with ratings of environments, which are experienced as an integrated whole.

The initial result for the free EFA revealed a four-factor solution (Satisfaction with Privacy, Satisfaction with Ventilation, and Satisfaction with Lighting and Satisfaction with View), in which Satisfaction with View had only one item loading on it. This indicated that the factor was poorly defined, resulting in the forced three-factor solution. The item loading on the View factor ("your access to a view from where you sit") presented some problems in data screening but was retained for theoretical reasons (e.g., Sundstrom, 1987). When a three-factor solution was forced, the item loaded on the Lighting factor. The problem with the item appears to be correlational. That is, it correlated moderately with only one other item ("the aesthetic appearance of your office"). This item proved to be somewhat problematic in the CFA analyses. Although this relation is logical (access to a view may be related to the general aesthetic appearance of one's office), the question might have been difficult to answer for those people without a window. Including these items in both the EFA and CFA might contributed to the marginal to moderate fit of the model to the data in the CFA and subsequent analyses. Future analyses will closely examine the role of having a window as a determinant of environmental satisfaction.

We tested two overall models of relations between the three components of environmental satisfaction, overall environmental satisfaction, and job satisfaction. The second (SEM-2, Figure 10) revealed good consistency with the conceptual model for the field study (Figure 1), moderately good fit, parsimony, and consistency with the literature. Wells (2000) also found that environmental satisfaction predicted job satisfaction, as did Dillon and Vischer (1987). Although the fit was not perfect, we take SEM-2 as a good representation of the data, and a guide for future research. People who are more satisfied with the work environment report higher job satisfaction.

This finding is important both as a validation of the Environmental Features Ratings, the 18-item scale developed for this field study, and because of the link it establishes between the physical work environment and the organisational psychology literature. Carlopio (1996) found that satisfaction with the physical work environment including environmental design (e.g., light quality, light direction, air quality, cleanliness) and job satisfaction together predicted organisation commitment and intent to turnover. Hellman (1997) conducted a meta-analysis of over 50 studies, confirming that the relationship between job satisfaction and intent to leave was significantly different from zero and consistently negative. The present findings suggest satisfaction with the indoor environment may play an indirect role in intent to turnover. This suggests a direction for future work, in which additional measurements of organisational outcomes such as organisational commitment, intent to turnover, or absenteeism might be added. The addition of such variables might permit tests of the hypothesis that better environmental conditions contribute to organisational productivity.

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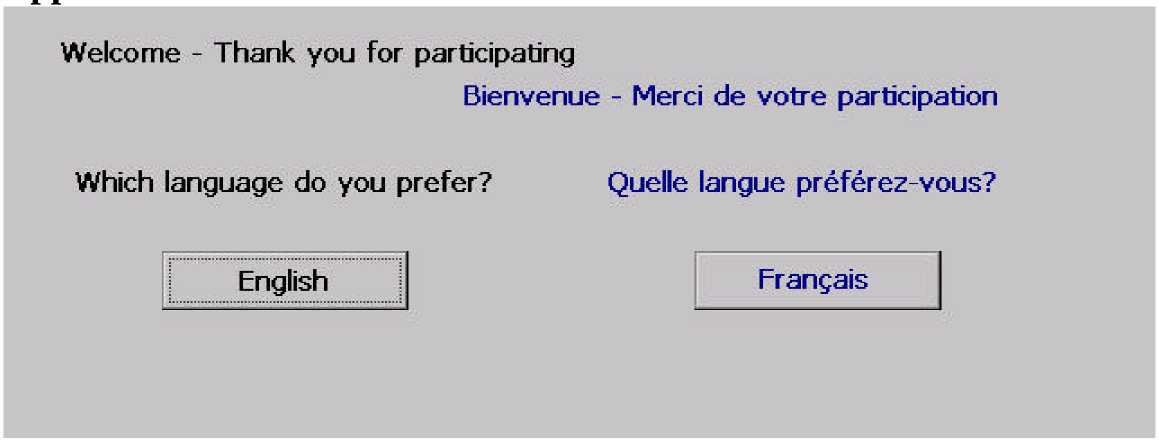
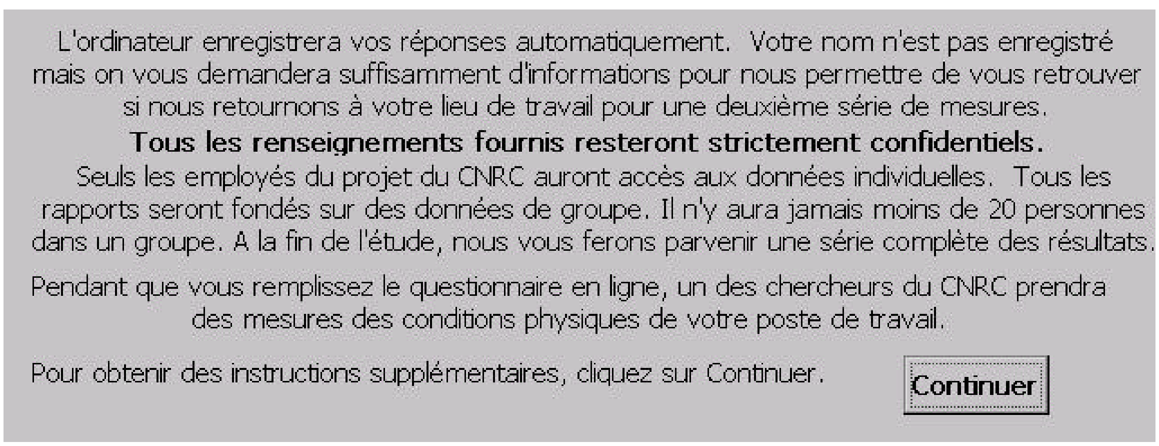
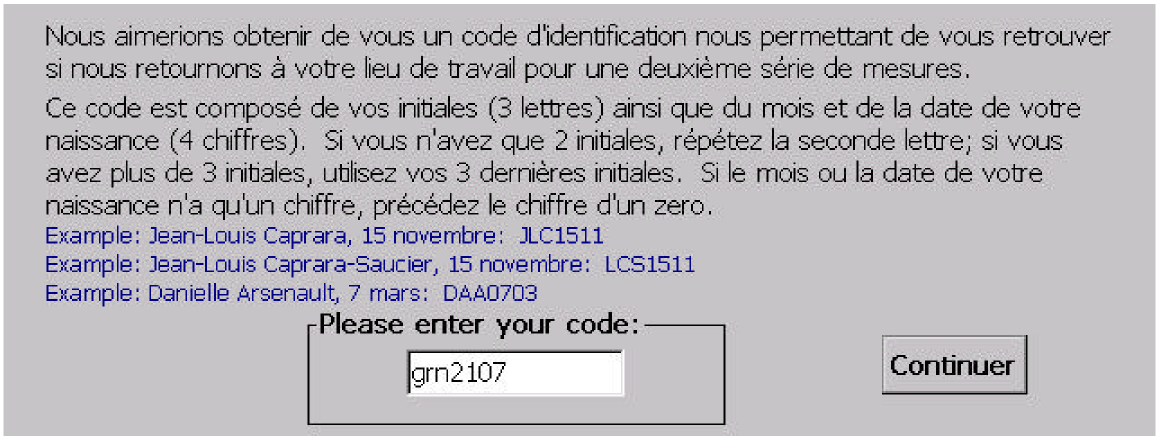
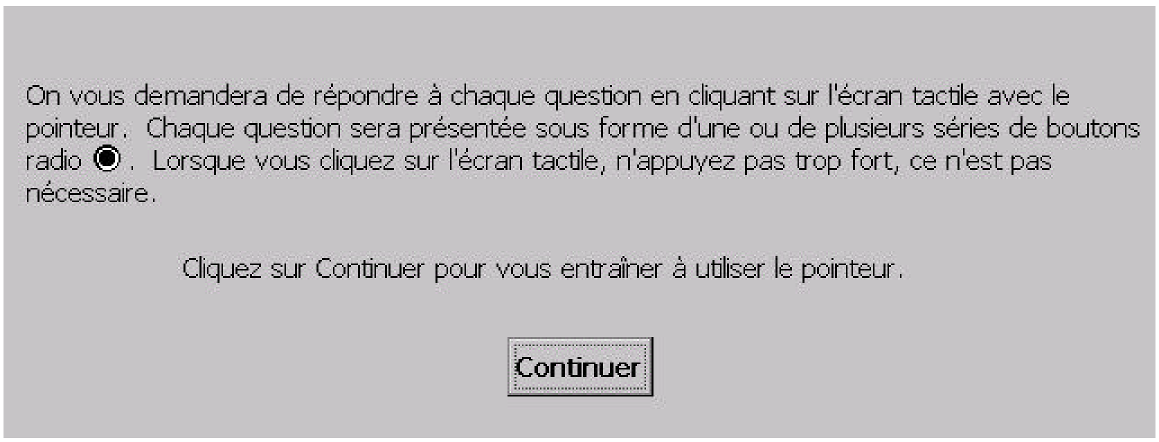
Appendix A

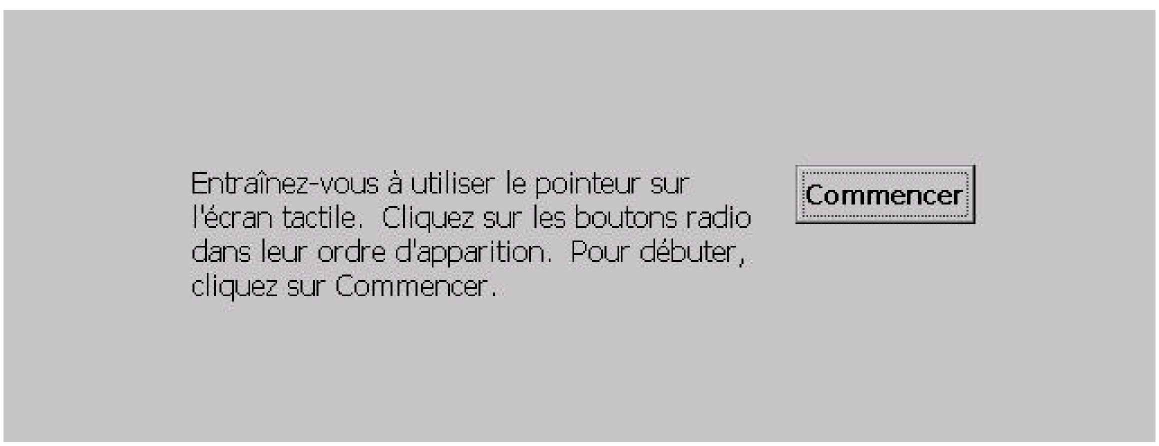

Welcome - Thank you for participating
Bienvenue - Merci de votre participation
Which language do you prefer?
Quelle langue préférez-vous?
English
Français

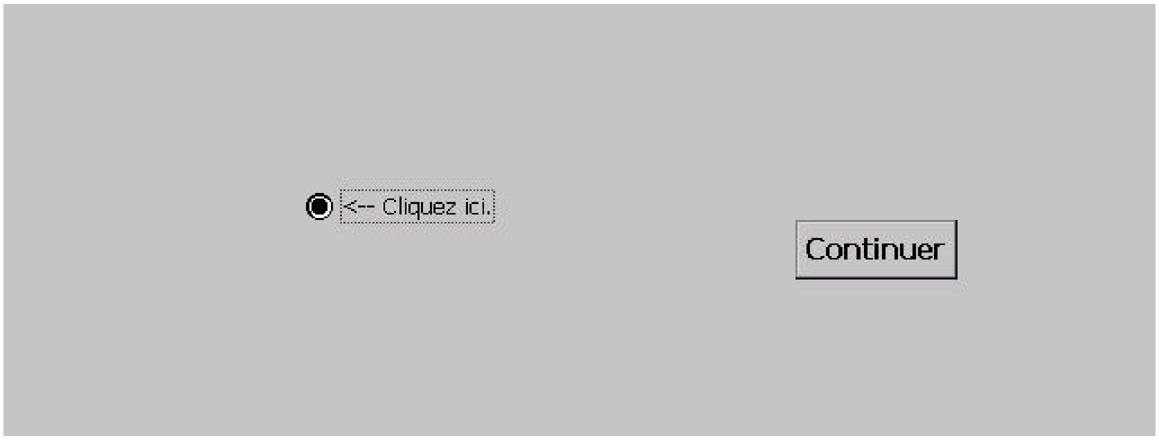

Questionnaire du CNRC sur l'environment intérieur
Nous aimerions savoir ce que vous pensez du bureau dans lequel vous travaillez. Sur les premiers écrans, vous pourrez vous familiariser avec l'écran tactile. Puis, il y aura environ 25 questions concernant différents aspects de votre milieu de travail et la façon dont vous pensez qu'ils vous influencent. Il n'y a pas de bonnes ou de mauvaises réponses. Veuillez donner votre opinion personnelle en réponse à chaque question.
Pour obtenir des instructions supplémentaires, cliquez sur Continuer.
Continuer

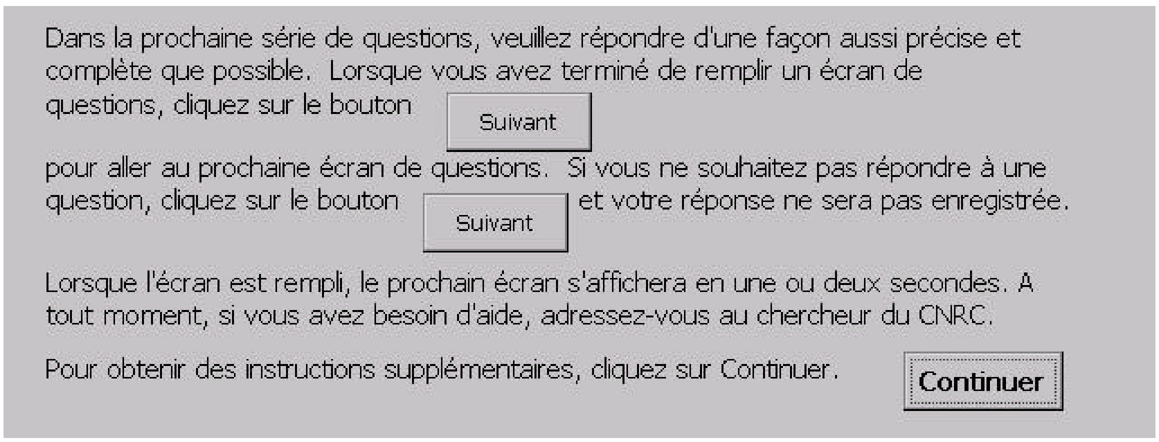

L'ordinateur enregistrera vos réponses automatiquement. Votre nom n'est pas enregistré mais on vous demandera suffisamment d'informations pour nous permettre de vous retrouver si nous retournons à votre lieu de travail pour une deuxième série de mesures.
Tous les renseignements fournis resteront strictement confidentiels.
Seuls les employés du projet du CNRC auront accès aux données individuelles. Tous les rapports seront fondés sur des données de groupe. Il n'y aura jamais moins de 20 personnes dans un groupe. A la fin de l'étude, nous vous ferons parvenir une série complète des résultats.
Pendant que vous remplissez le questionnaire en ligne, un des chercheurs du CNRC prendra des mesures des conditions physiques de votre poste de travail.
Pour obtenir des instructions supplémentaires, cliquez sur Continuer.
Continuer

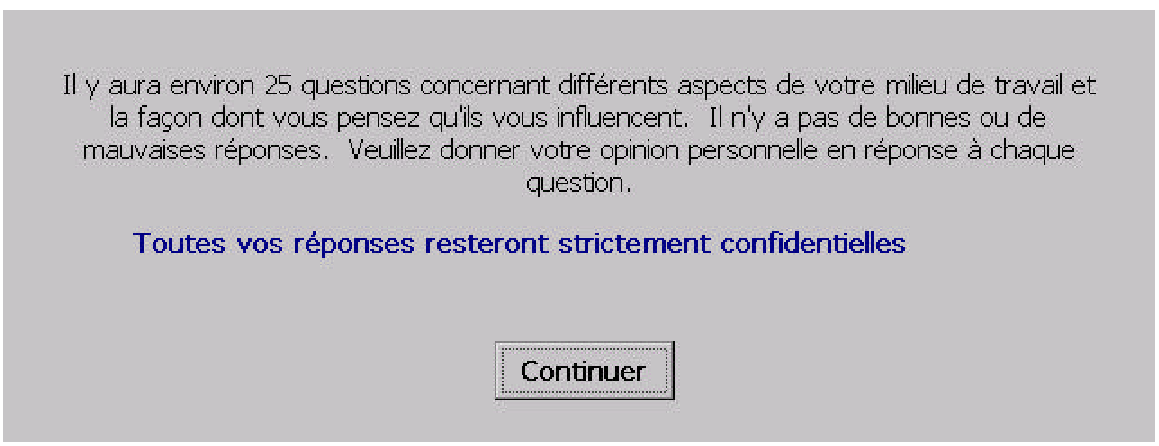

Nous aimerions obtenir de vous un code d'identification nous permettant de vous retrouver si nous retournons à votre lieu de travail pour une deuxième série de mesures.
Ce code est composé de vos initiales (3 lettres) ainsi que du mois et de la date de votre naissance (4 chiffres). Si vous n'avez que 2 initiales, répétez la seconde lettre; si vous avez plus de 3 initiales, utilisez vos 3 dernières initiales. Si le mois ou la date de votre naissance n'a qu'un chiffre, précédez le chiffre d'un zero.
Example: Jean-Louis Caprara, 15 novembre: JLC1511
Example: Jean-Louis Caprara-Saucier, 15 novembre: LCS1511
Example: Danielle Arsenault, 7 mars: DAA0703
Please enter your code:
grn2107
Continuer

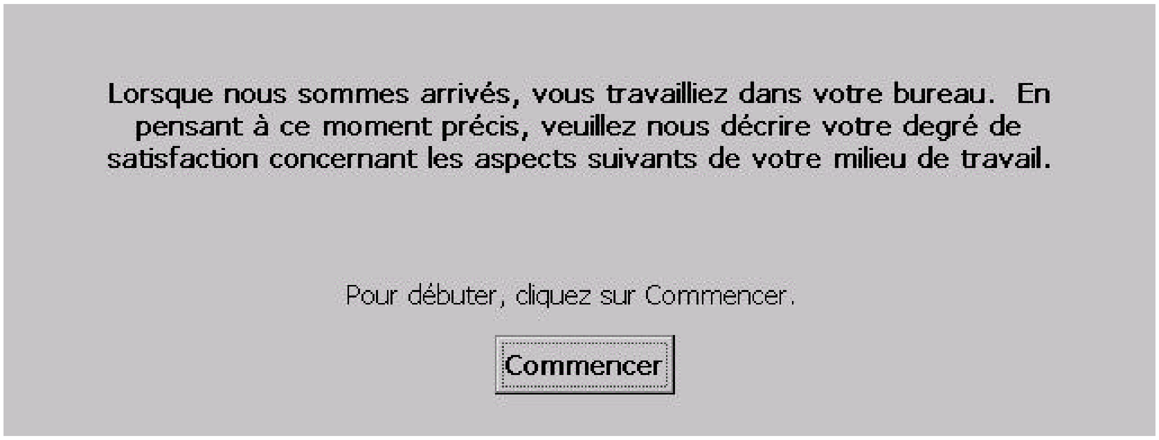

On vous demandera de répondre à chaque question en cliquant sur l'écran tactile avec le pointeur. Chaque question sera présentée sous forme d'une ou de plusieurs séries de boutons radio . Lorsque vous cliquez sur l'écran tactile, n'appuyez pas trop fort, ce n'est pas nécessaire.
Cliquez sur Continuer pour vous entraîner à utiliser le pointeur.
Continuer


Entraînez-vous à utiliser le pointeur sur l'écran tactile. Cliquez sur les boutons radio dans leur ordre d'apparition. Pour débuter, cliquez sur Commencer.
Commencer


<-- Cliquez ici.
Continuer

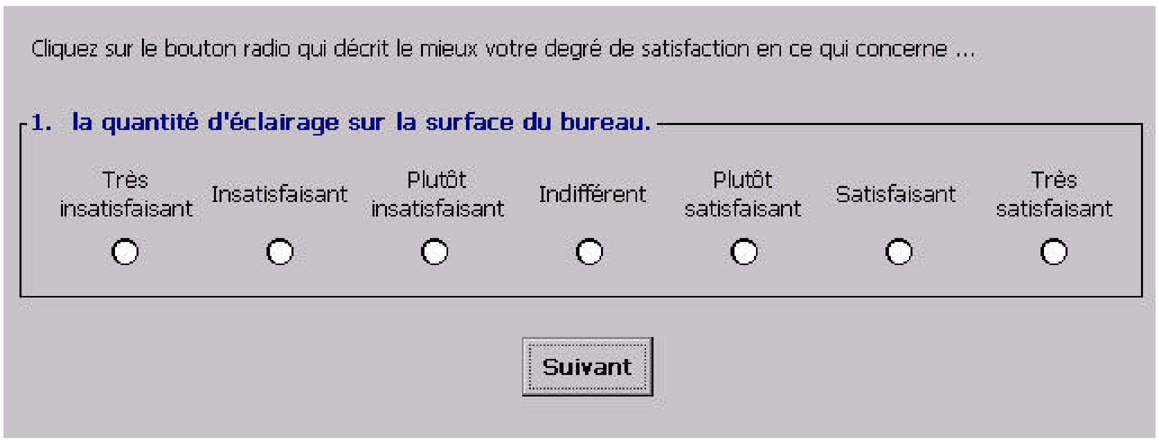

Dans la prochaine série de questions, veuillez répondre d'une façon aussi précise et complète que possible. Lorsque vous avez terminé de remplir un écran de questions, cliquez sur le bouton
Suivant
pour aller au prochaine écran de questions. Si vous ne souhaitez pas répondre à une question, cliquez sur le bouton
Suivant
et votre réponse ne sera pas enregistrée.
Lorsque l'écran est rempli, le prochain écran s'affichera en une ou deux secondes. A tout moment, si vous avez besoin d'aide, adressez-vous au chercheur du CNRC.
Pour obtenir des instructions supplémentaires, cliquez sur Continuer.
Continuer


Il y aura environ 25 questions concernant différents aspects de votre milieu de travail et la façon dont vous pensez qu'ils vous influencent. Il n'y a pas de bonnes ou de mauvaises réponses. Veuillez donner votre opinion personnelle en réponse à chaque question.
Toutes vos réponses resteront strictement confidentielles
Continuer


Lorsque nous sommes arrivés, vous travailliez dans votre bureau. En pensant à ce moment précis, veuillez nous décrire votre degré de satisfaction concernant les aspects suivants de votre milieu de travail.

Pour débuter, cliquez sur Commencer.

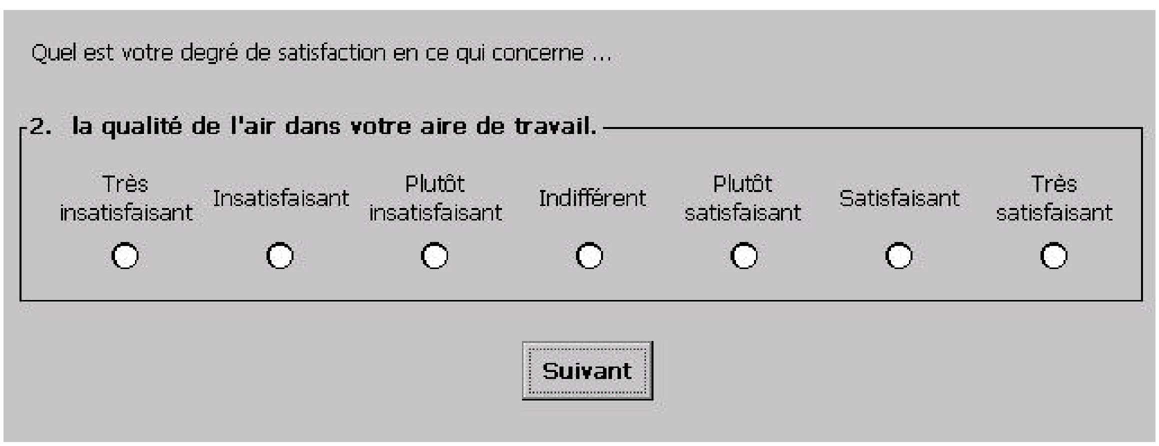
Commencer


Cliquez sur le bouton radio qui décrit le mieux votre degré de satisfaction en ce qui concerne ...

1. la quantité d'éclairage sur la surface du bureau.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant


Quel est votre degré de satisfaction en ce qui concerne ...

2. la qualité de l'air dans votre aire de travail.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

3. la température dans votre aire de travail.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

4. l'apparance esthétique de votre bureau.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

5. le niveau d'intimité pour les conversations tenues dans votre bureau.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

6. le niveau d'intimité visuelle à l'intérieur de votre bureau.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

7. le niveau de bruit créé par les conversations d'autres personnes lorsque vous travaillez à votre poste de travail.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

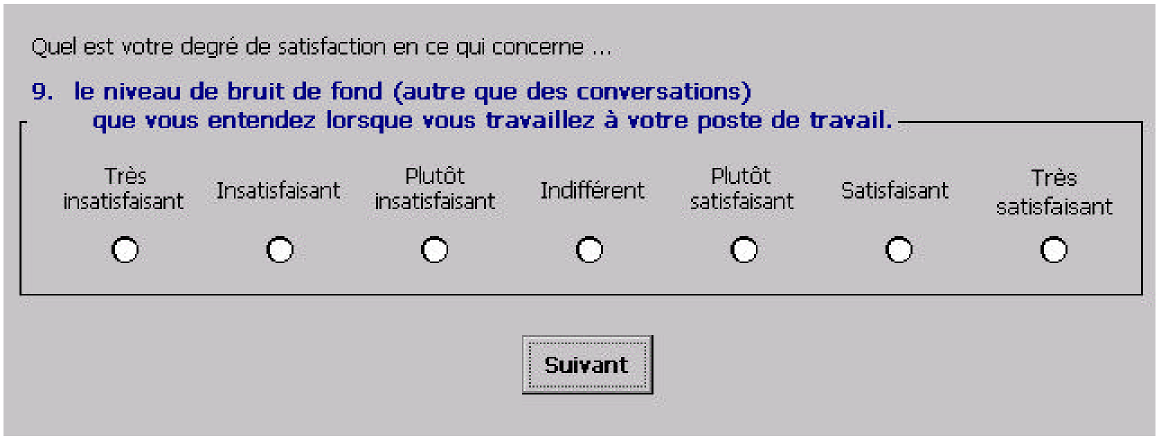
Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

8. les dimensions de votre aire de travail personnelle pour répondre à vos besoins: travail, outils de travail, et visiteurs.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

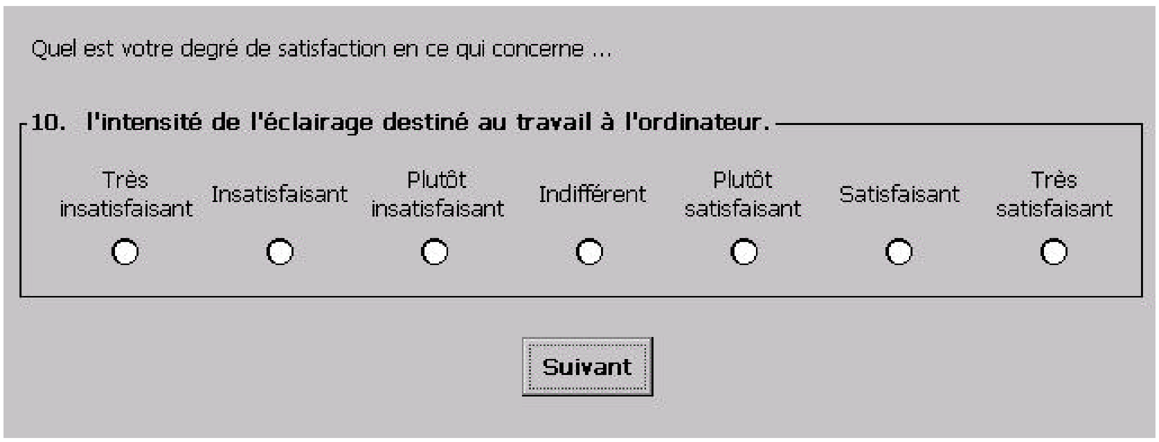


Quel est votre degré de satisfaction en ce qui concerne ...

9. le niveau de bruit de fond (autre que des conversations) que vous entendez lorsque vous travaillez à votre poste de travail.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

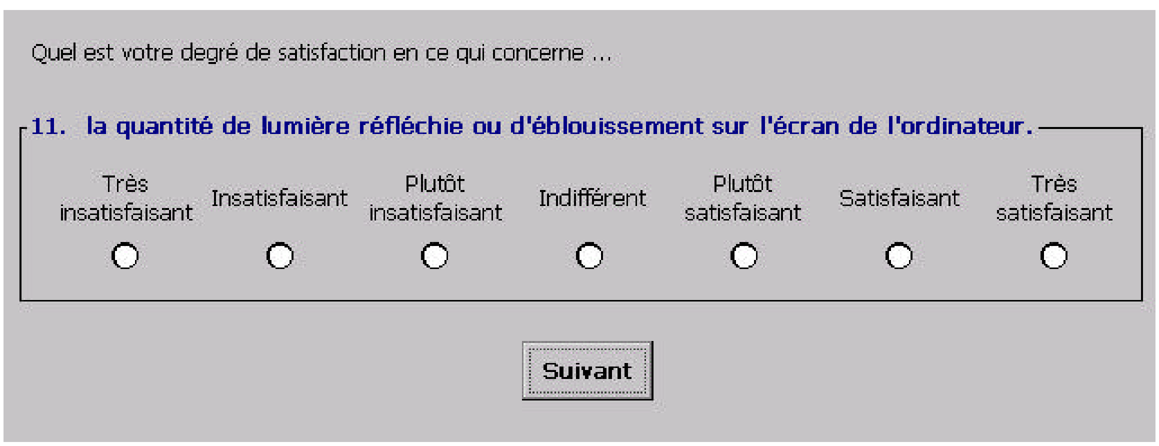


Quel est votre degré de satisfaction en ce qui concerne ...

10. l'intensité de l'éclairage destiné au travail à l'ordinateur.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant



Quel est votre degré de satisfaction en ce qui concerne ...

11. la quantité de lumière réfléchie ou d'éblouissement sur l'écran de l'ordinateur.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

12. la circulation d'air dans votre aire de travail.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

13. votre capacité de modifier les conditions physiques de votre aire de travail.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

14. la vue sur l'extérieur du point où vous êtes assis.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

15. la distance entre vous et les autres personnes avec lesquelles vous travaillez.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

16. la qualité d'éclairage dans votre aire de travail.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

17. la fréquence des distractions provenant des autres personnes.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Quel est votre degré de satisfaction en ce qui concerne ...

18. le niveau de fermeture de votre aire de travail à l'aide de murs, de cloisons ou de mobilier.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

19. Veuillez classer par ordre d'importance les éléments suivants de votre environnement de travail. Veuillez utiliser le nombre 1 pour indiquer l'élément qui est le plus important pour vous, le nombre 2 pour indiquer l'élément suivant le plus important et ainsi de suite jusqu'à ce que chaque élément soit affecté d'un ordre de grandeur unique.

	1	2	3	4	5	6	7
intimité	○	○	○	○	○	○	○
dimensions de l'aire de travail	○	○	○	○	○	○	○
accès à une fenêtre	○	○	○	○	○	○	○
température	○	○	○	○	○	○	○
éclairage	○	○	○	○	○	○	○
qualité de l'air/ventilation	○	○	○	○	○	○	○
son et bruit	○	○	○	○	○	○	○

Suivant

Veuillez cliquer sur le bouton radio qui correspond le mieux à votre situation.

20. Quel est votre âge?

○ 18-29 ○ 30-39 ○ 40-49 ○ 50-59 ○ 60-69 ○ 70 et plus

Suivant

Veuillez cliquer sur le bouton radio qui correspond le mieux à votre situation.

21. Quel est votre sexe?

- ○ Femme
- ○ Homme

Suivant

Veuillez cliquer sur le bouton radio qui décrit le mieux votre poste.

22. Quelle est la catégorie qui décrit le mieux votre emploi?

- ○ Administrative
- ○ Technique
- ○ Professionnelle
- ○ Gestionnaire

Suivant

Veuillez cliquer sur le bouton radio qui vous décrit le mieux.

23. Quel est le plus haut niveau d'instruction que vous avez terminé?

- ○ Diplôme de fin d'études secondaires ou inférieur
- ○ Diplôme d'un collège communitaire, d'un CEGEP, d'un institut de technologie, etc.
- ○ Certains cours universitaires ou un certificat universitaire inférieur à un baccalauréat
- ○ Diplôme de premier cycle (baccalauréat)
- ○ Diplôme universitaire supérieur ou diplôme de compétence professionnelle

Suivant

Lorsque vous répondrez aux prochains énoncés, veuillez considérer votre travail en général et votre expérience de travail ici.

Toutes vos réponses resteront strictement confidentielles.

Continuer

Veuillez cliquer sur le bouton radio qui indique votre degré d'accord ou de désaccord avec l'énoncé suivant.

24. Mon ministère ou mon organisme offre un bon milieu de travail.

Très fortement en désaccord	Fortement en désaccord	En désaccord	Ni l'un ni l'autre	D'accord	Fortement d'accord	Très fortement d'accord
○	○	○	○	○	○	○

Suivant

Veuillez cliquer sur le bouton radio qui indique votre degré d'accord ou de désaccord avec l'énoncé suivant.

25. Mon travail me plaît.

Très fortement en désaccord	Fortement en désaccord	En désaccord	Ni l'un ni l'autre	D'accord	Fortement d'accord	Très fortement d'accord
○	○	○	○	○	○	○

Suivant

26. Veuillez cliquer sur le bouton radio de façon à indiquer de quel pourcentage, selon vous, votre productivité personnelle au travail est augmentée ou diminuée par les présentes conditions de l'environnement, par rapport à votre productivité habituelle.

○ -30% ○ -20% ○ -10% ○ 0% ○ +10% ○ +20% ○ +30%

Suivant

Enfin, considérant toutes les conditions de l'environnement à votre poste de travail, quel est votre degré de satisfaction en ce qui concerne ...

27. l'environnement intérieur à votre poste de travail, en général.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Suivant

Nous vous remercions d'avoir rempli le questionnaire: Evaluation par le CNRC de l'environnment des bureaux en espace fonctionnel. Veuillez retourner l'ordinateur au chercheur qui vous expliquera comment communiquer avec le CNRC si vous désirez des renseignements supplémentaires au sujet du projet.

Cliquez sur le bouton radio qui décrit le mieux votre degré de satisfaction en ce qui concerne ...

1. la quantité d'éclairage sur la surface du bureau.

Très insatisfaisant	Insatisfaisant	Plutôt insatisfaisant	Indifférent	Plutôt satisfaisant	Satisfaisant	Très satisfaisant
○	○	○	○	○	○	○

Absence de réponse

Vous n'avez pas cliqué sur un bouton

Si vous souhaitez ne pas répondre à cette question, cliquez SAUTER, sinon complétez la question et cliquez SUIVANT

Sauter

Suivant

Appendix B

Open-ended Questionnaire for Additional Comments

National Research Council Canada
Conseil national de recherches Canada

Institute for Research in Construction
Institut de recherche en construction
Ottawa, ON, Canada
K1A 0R6

B3205

NRC/IRC Open-Plan Office Survey Reply Form

Thank you for participating in our survey! We hope that you will help to round out our understanding of how the physical environment at work affects people by taking a few minutes to answer the following questions.

We designed the questionnaire to be easy to complete while the NRC research team completed its measurements in your workstation. You might have found that the multiple-choice format restricted you from expressing more detailed or complex opinions. If you wish to provide us with more specific comments about your workstation and its physical conditions, please use this form. We have attached a stamped, addressed envelope that you can use to mail it directly back to the research team at NRC.

It is entirely up to you whether or not to complete this form. If you do, your responses will remain entirely confidential and anonymous. We ask that you provide us with the same identifying code on this form as you used on the computer questionnaire, so that we can match responses and the physical data about your workstation. Although we might quote from your remarks here, we will not do so in any way that would allow individuals to be identified. Management, union, and other employees will not have access to your responses here. When you mail the form back, it will be stored at NRC in a locked file cabinet accessible only to project staff.

What do like most about your office?

What do you like least about your office?

If you could change one thing about your office, what would it be and how would you do it?

National Research Council Canada / Conseil national de recherches Canada

Institute for Research in Construction / Institut de recherche en construction

Ottawa, ON, Canada
K1A 0R6

B3205

Formulaire de réponse dans le cadre de
l'Étude du CNRC/IRC sur les bureaux en espace fonctionnel

Merci d'avoir participé à notre étude! Nous espérons que vous aiderez, en prenant quelques minutes pour répondre aux questions qui se trouvent plus bas, à affiner notre compréhension de la manière dont le milieu de travail matériel influe sur les gens.

Nous avons conçu le questionnaire de façon à ce qu'il soit facile à remplir pendant que l'équipe de recherche du CNRC effectuait ses mesures à votre poste de travail. Vous avez peut-être trouvé que la formule du choix multiple vous empêchait d'exprimer des opinions plus détaillées ou complexes. Si vous désirez nous fournir d'autres précisions concernant votre poste de travail et ses conditions matérielles, veuillez utiliser ce formulaire. Vous trouverez ci-joint une enveloppe préadressée et affranchie que vous pouvez utiliser pour l'expédier directement à l'équipe de recherche du CNRC.

Vous êtes absolument libre de remplir ou non ce formulaire. Si vous décidez de le remplir, vos réponses resteront entièrement confidentielles et anonymes. Nous vous demandons d'indiquer sur ce formulaire le même code d'identification que vous avez utilisé pour le questionnaire sur ordinateur, ce qui nous permettra d'associer les réponses et les données matérielles concernant votre poste de travail. Si nous faisons état des observations que vous ferez ci-dessous, nous le ferons de manière à ce qu'elle ne permette pas de vous identifier. La direction, le syndicat et les autres employés n'auront pas accès aux réponses que vous fournirez ici. Votre formulaire sera conservé dans un classeur fermé à clef, au CNRC, et seuls les responsables du projet y auront accès.

Qu'aimez-vous le plus, dans votre bureau?

Qu'aimez-vous le moins, dans votre bureau?

Si vous pouviez changer une chose, dans votre bureau, que serait-ce et comment le feriez-vous?

Appendix C

Sample Memorandum to Employees from Management

From:
Sent: Wednesday, MMM, DD, 2000
To:

Subject: Indoor Environments: How's Ours? / Environnements intérieurs : Comment est le nôtre?

This memo is sent on behalf of XXX, Manager of XXXX

Cette note de service est envoyée au nom de XXX, Directrice de XXXX

We are pleased to welcome researchers from the National Research Council (NRC) to conduct research into indoor work environments on our premises. This will be taking place on the X floor and selected areas on the XX floor at our headquarters during the week of XXXX. Some time may also be required the following week. The work will examine the relationships between an open-plan office design such as ours, the indoor environment (sound, air quality, temperature, and lighting), and occupant satisfaction with the indoor environment. This is a long-term study that will work toward future ability to develop cost-effective office designs that are also pleasant for occupants, and new office products that enhance workplace quality.

Our offices offer an ideal setting for this research for two reasons. The NRC requires large office spaces that are primarily open-plan, which our workplace provides. And second, our planned renovations on the X floor will allow the NRC to conduct research before and after renovations, identifying any changes that occur.

Immediately prior to the research, you will find a memo on your desk from the NRC researchers, telling you about their work and what you can expect. Memos will be distributed to all workstations on the X floor, and to those affected by the research on the XX floor. Your participation will be invited, but contribution to the research is strictly voluntary. Please rest assured that all information that you provide will be held in strict confidentiality by the NRC research team. If you choose to participate, it will require no more than 15 minutes of your time.

Our department is among the sponsors of this study, so we are very supportive of the initiative and we expect that we will all benefit from it over the long term. We hope that you will be accommodating if asked to spare a few moments of your time. However we remind you that participation is on a completely voluntary basis, and if you cannot or do not wish to be involved in the research, simply respond with a polite "no thank you", and the researchers will move on.

Thank you!

Nous sommes heureux d'accueillir des chercheurs du Conseil national des recherches du Canada (CNRC) qui effectueront des travaux de recherche sur les environnements de travail intérieurs dans nos locaux. Ces travaux auront lieu au X étage et certaines sections du XX étage de l'edifice pendant la semaine du XXX et ils pourraient également se prolonger pendant la semaine suivante. Les travaux porteront sur les liens entre un bureau à aire ouverte comme le nôtre, l'environnement intérieur (son, qualité de l'air, température et éclairage) et la satisfaction que les occupants éprouvent envers cet environnement. Il s'agit d'une étude à long terme qui visera à mettre en place des capacités futures d'élaborer des plans d'aménagement rentables qui sont agréables pour les occupants, et de nouveaux produits de bureau qui rehaussent la qualité du milieu de travail.

Nos bureaux constituent un endroit idéal pour ces recherches pour deux raisons. Premièrement, le CRNC a besoin de vastes locaux à bureaux qui sont surtout à aire ouverte, et notre milieu de travail répond à ce besoin. Deuxièmement, les rénovations que nous planifions au X étage permettront au CNRC d'effectuer des recherches avant et après les rénovations, et de déterminer les changements qui se produisent.

Avant de débuter leurs travaux, les chercheurs du CNRC déposeront sur votre bureau une note de service décrivant comment ils procéderont et ce à quoi vous pouvez vous attendre. Ces notes de service seront distribuées à tous les postes de travail du X étage, et aux postes du XX étage qui feront partie de l'étude. Votre participation sera sollicitée, mais votre contribution à ces travaux est strictement volontaire. Soyez assurés que les renseignements obtenus par l'équipe de chercheurs du CNRC demeureront strictement confidentiels. Si vous décidez de participer, cela exigera au plus 15 minutes de votre temps.

Étant un des parrains de cette étude, le département appuie fortement cette initiative et s'attendent à ce qu'elle soit avantageuse pour tous à long terme. Nous espérons que vous accommoderez les chercheurs s'ils vous demandent de leur consacrer quelques minutes de votre temps. Toutefois, nous vous rappelons que votre participation est complètement volontaire. Si vous ne pouvez pas ou ne voulez pas participer aux travaux de recherche, vous n'avez qu'à répondre poliment « non merci » et les chercheurs passeront à une autre personne.

Merci!

Appendix D

Sample NRC Announcement of Field Investigation

NRC/IRC Open-Plan Office Survey

The National Research Council's Institute for Research in Construction (NRC) is working on design and operation guidelines for open-plan offices. Our goal is to develop a decision tool for interior designers and facilities managers to use when planning office renovations or new construction, and to enable predictions about the likely consequences of certain changes in terms of the physical conditions and the satisfaction those conditions will afford to occupants. This is a long-term project involving both laboratory and field investigations.

Your building has been selected as one site for our field investigations of buildings undergoing changes. We hope that you will agree to participate when the NRC team visits your area in the week of XXX, and again in the future after the changes have been completed. Participation will take only about 10-15 minutes each time. On each occasion, while you answer a short questionnaire about your opinions of the work environment, a member of the NRC research team will take measurements of the temperature, air quality, lighting, and noise where you usually sit in your workstation. In the same week as these visits take place, we will be making more detailed environmental measurements in the evenings, so as not to disturb your work.

Whether you choose to participate or not is entirely your decision. If you do decide to participate, we assure you that all questionnaire responses will be completely confidential and private. Only the NRC research team will have access to the individual data. Your name will not appear in any data file or document connected to this project. Management, unions, and individual employees will not have access to any information that you as an individual provide as part of this project. We will issue a report after the end of the data collection, based on the responses for your area [or building, as appropriate] as a whole. Everyone will receive copies of this report, and we will present it to the safety and health committee also. If you wish, we also will ensure that you receive summary information about the progress of the entire project.

All data collection, storage and reporting will be conducted in accordance with the law, including the Privacy Act.

If you have any questions about this research project, please contact Dr. Jennifer Veitch at 993-9671. She will be happy to discuss it with you.

Étude du CNRC/IRC sur les bureaux en espace fonctionnel

L'Institut de recherche en construction (IRC) du Conseil national de recherches (CNRC) a mis sur pied un projet d'élaboration de lignes directrices concernant la création et l'exploitation d'architectures intérieures pour les bureaux en espace fonctionnel. Le but visé est de mettre au point un outil de décision dont pourront se servir les architectes d'intérieur et les responsables de locaux lors de l'établissement des plans de rénovation ou de construction de bureaux, ainsi que de permettre de prévoir les conséquences probables de certains changements au niveau des conditions matérielles et de la satisfaction qu'en tireront les occupants. Il s'agit d'un projet à long terme qui nécessite des études en laboratoire et sur le terrain.

Votre immeuble a été choisi, entre autres, pour faire l'objet de notre étude sur les bâtiments faisant l'objet de changements. Nous espérons que vous accepterez d'y participer lorsque l'équipe du CNRC se rendra dans votre secteur la semaine du XXX et dans plusieurs mois une fois les changements effectués. Nous vous demanderons de nous consacrer chaque fois de 10 à 15 minutes. À chaque occasion, pendant que vous remplirez un bref questionnaire dans lequel vous direz ce que vous pensez de votre milieu de travail, un membre de l'équipe de recherche du CNRC effectuera des mesures touchant la température, la qualité de l'air, l'éclairage et le bruit à l'endroit où vous vous tenez habituellement. Au cours de ces deux semaines, nous réaliserons des mesures plus poussées concernant les conditions matérielles, le soir, de façon à ne pas perturber votre travail.

Vous êtes entièrement libre de participer à cette étude. Si vous acceptez de le faire, nous vous assurons que toutes les réponses du questionnaire resteront strictement confidentielles. Seule l'équipe de recherche du CNRC aura accès à cette information. Votre nom ne figurera dans aucun fichier de données ou autre document lié à ce projet. La direction, les syndicats et les autres employés n'auront pas accès aux informations que vous nous fournirez dans le cadre de ce projet. Une fois terminée la collecte des données, nous rédigerons un rapport basé sur l'ensemble des réponses obtenues dans votre secteur [ou immeuble, selon le cas]. Tous recevront un exemplaire de ce rapport, qui sera aussi remis au comité de santé et sécurité. Si vous le désirez, nous vous ferons aussi parvenir de l'information sommaire sur l'évolution du projet lui-même.

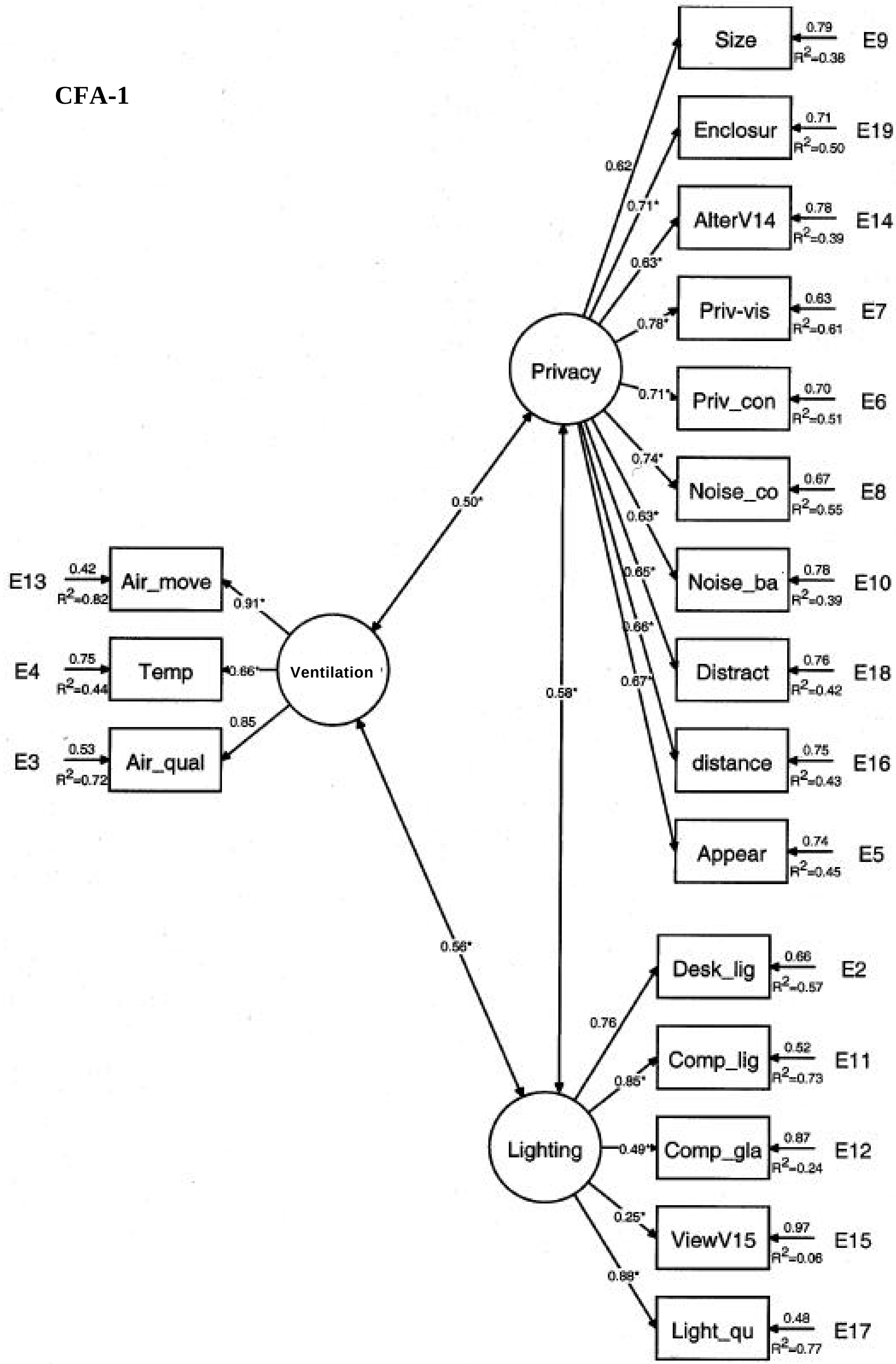
La collecte des données, l'entreposage et la présentation des rapports seront effectués en toute légalité, notamment selon la *Loi sur la protection des renseignements personnels*.

Si vous avez des questions à poser au sujet de ce projet de recherche, veuillez communiquer avec Jennifer Veitch, Ph.D., au 993-9671. Elle sera heureuse d'y répondre.

Appendix E

Complete CFA and SEM Models

CFA-1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E9
Enclosur
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R2=0.50
E19
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E14
Priv-vis
0.63
R2=0.61
E7
Priv_con
0.70
R2=0.51
E6
Noise_co
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R2=0.55
E8
Noise_ba
0.78
R2=0.39
E10
Distract
0.76
R2=0.42
E18
distance
0.75
R2=0.43
E16
Appear
0.74
R2=0.45
E5
Privacy
0.62
0.71*
0.63*
0.78*
0.71*
0.74*
0.63*
0.65*
0.66*
0.67*
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0.58*
0.56*
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Air_move
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E4
0.75
R2=0.44
Temp
0.66*
Ventilation
E3
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R2=0.72
Air_qual
0.85
Desk_lig
0.66
R2=0.57
E2
Comp_lig
0.52
R2=0.73
E11
Comp_gla
0.87
R2=0.24
E12
ViewV15
0.97
R2=0.06
E15
Light_qu
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E17
Lighting
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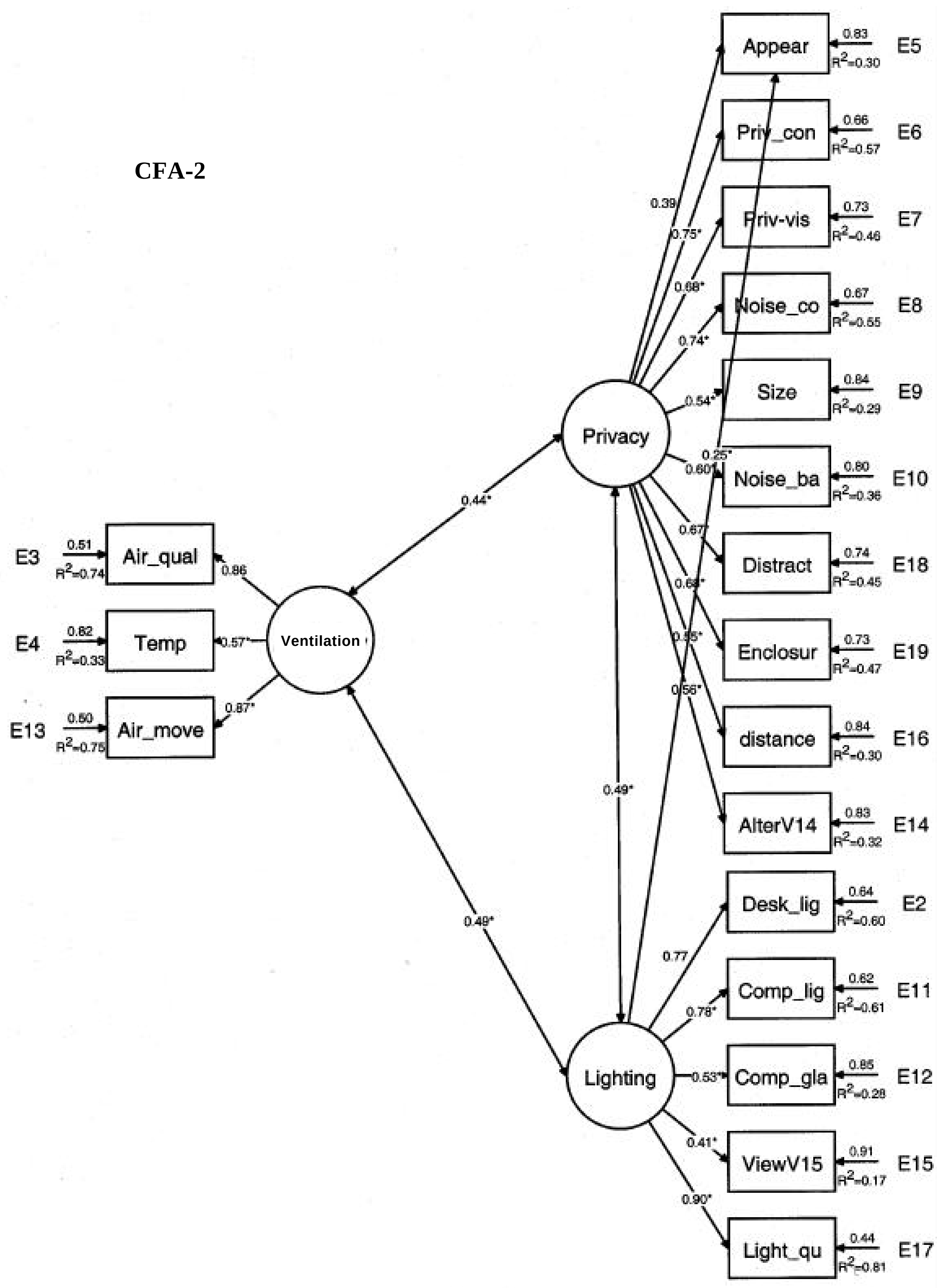
0.49*
0.25*
0.88*

CFA-2



Appear
Priv_con
Priv-vis
Noise_co
Size
Noise_ba
Distract
Enclosur
distance
AlterV14
Desk_lig
Comp_lig
Comp_gla
ViewV15
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Privacy
Lighting
Ventilation
Air_qual
Temp
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E3
E4
E13
E5
E6
E7
E8
E9
E10
E18
E19
E16
E14
E2
E11
E12
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E17
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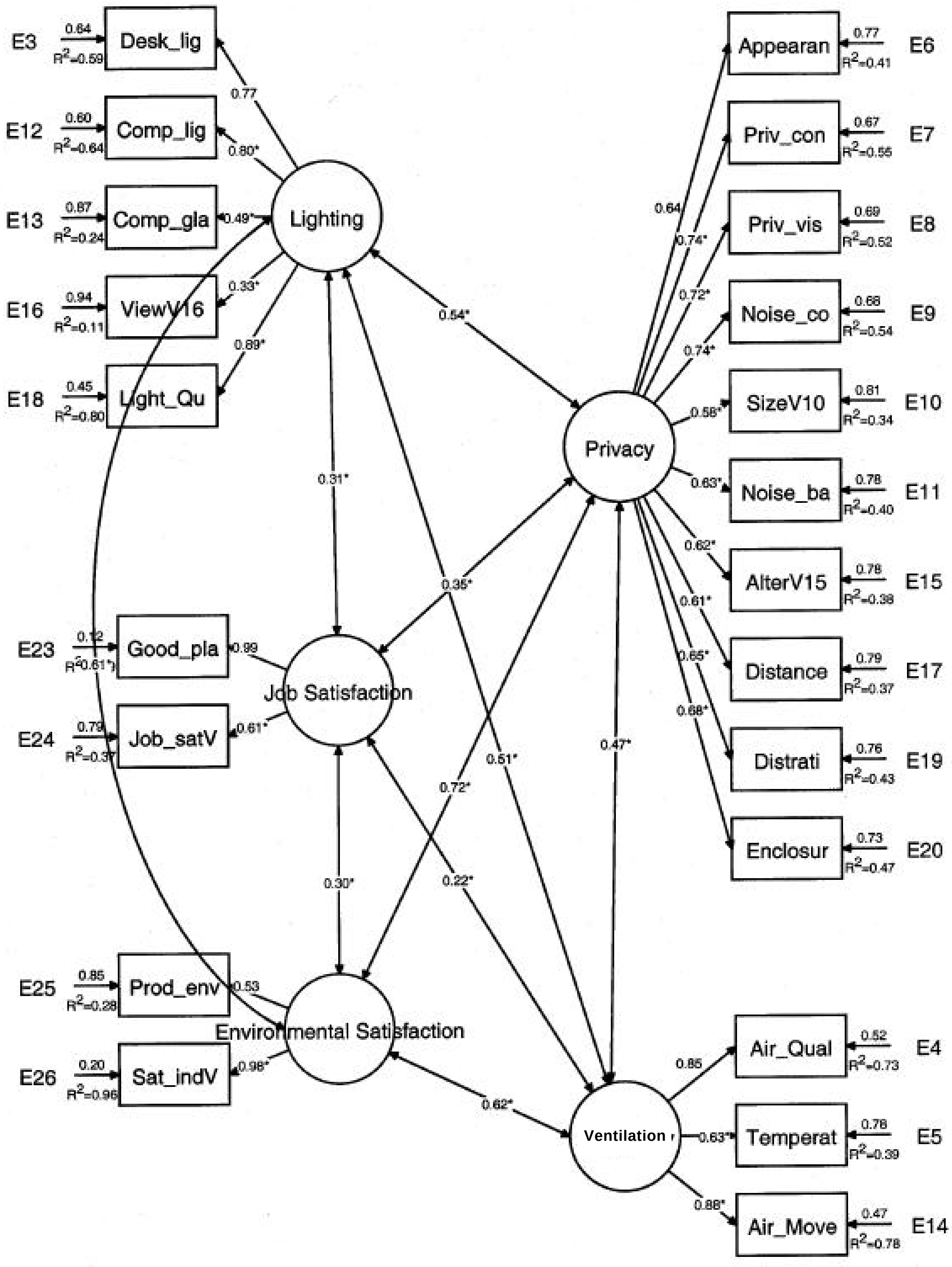
0.49*
0.49*
0.86
0.57*
0.87*
0.39
0.75*
0.68*
0.74*
0.54*
0.25*
0.60*
0.67*
0.77
0.78*
0.53*
0.41*
0.90*

SEM-1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Job Satisfaction
Environmental Satisfaction
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Ventilation
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Comp_lig
Comp_gla
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Light_Qu
Good_pla
Job_satV
Prod_env
Sat_indV
Appearan
Priv_con
Priv_vis
Noise_co
SizeV10
Noise_ba
AlterV15
Distance
Distrati
Enclosur
Air_Qual
Temperat
Air_Move
E3
E12
E13
E16
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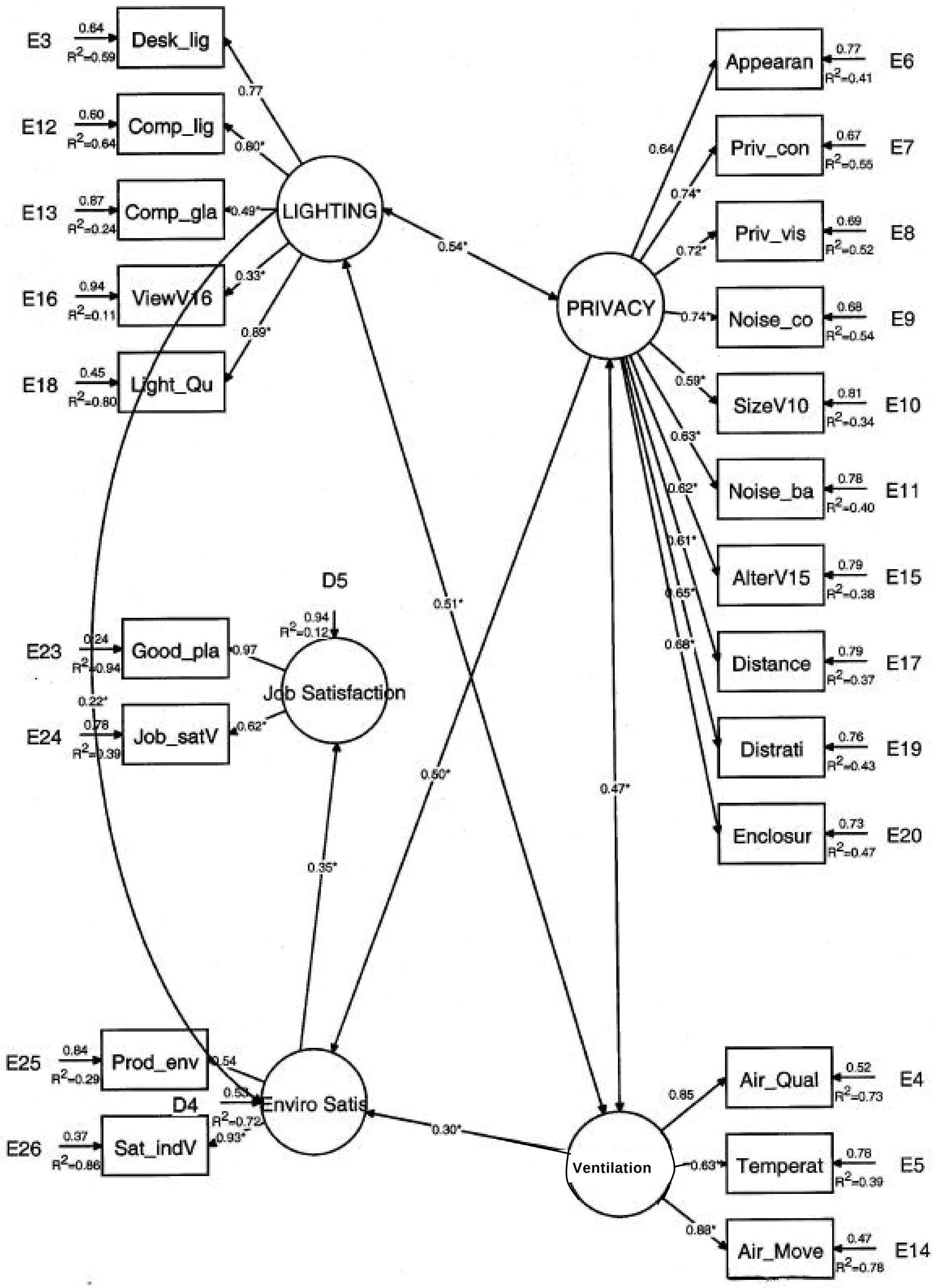
E17
E19
E20
E4
E5
E14

SEM-2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Comp_lig
Comp_gla
ViewV16
Light_Qu
Appearan
Priv_con
Priv_vis
Noise_co
SizeV10
Noise_ba
AlterV15
Distance
Distrati
Enclosur
Good_pla
Job_satV
Prod_env
Sat_indV
Air_Qual
Temperat
Air_Move
E3
E12
E13
E16
E18
E6
E7
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E19
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E23
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E25
E26
E4
E5
E14