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The Role of Personal Control in Alleviating Negative Perceptions in the Open-Plan Workplace

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Abstract: Today's office buildings adopt open-plan settings for collaboration and space efficiency. However, the open plan setting has been intensively criticized for its adverse user experiences, such as noise, privacy loss, and over cooling. The provision of personal control in open-plan work environments is an important means to alleviating the adverse perceptions. This research is to investigate the relationship between the availability of personal controls and the degree of control over the physical environment, as well as their effectiveness in alleviating adverse perceptions in open-plan workplaces. The study combined three systematic occupant survey tools and collected responses from open-plan offices in Shenzhen, China. Specifically, this survey covered 12 personal controls in open-plan workplaces; respondents were asked to report their degree of control over the physical environment and also were required to report if they had adverse perceptions such as sick building syndrome in their offices. The results showed that most of the 12 personal controls supported perceived degree of control over the physical environment but only half of them were negatively associated with adverse perceptions. Non-mechanical controls, such as windows and blinds, were found to be more effective than mechanical controls such as fans and air-conditioning in alleviating adverse perceptions. Conflicts were found between task/desk lights and other personal controls. The research generates important evidence for the interior design of open-plan offices.

Keywords: open-plan workplace; environmental control; productivity; satisfaction

1. Introduction

Open plan has become the most popular workplace setting for contemporary office buildings. It has many advantages in terms of flexibility, space efficiency, interaction, and collaboration. On the other side, it has been intensively criticized for a multitude of adverse perceptions being experienced by its occupants, such as loss of privacy, loss of identity, low work productivity, various health issues, overstimulation, and low job satisfaction [1]. Human oriented design should be addressed in the design of open-plan workplaces, as employees' health and productivity are associated with a significant portion of business costs. How to alleviate adverse perceptions and promote a positive user experience in open plan offices has become the key issue for workplace design [2].

Previous research on open-plan offices highlighted the role of individual control in alleviating the negative perceptions and promoting human-oriented workplace design [3,4]. The research found that one of key problems of open plan settings is that the freedom of choices is lacking and, therefore, building occupants feel powerlessness and unhappiness, which would consequently decrease task performance [5–10]. Occupants who perceived their control opportunities as being insufficient were less tolerant of their thermal conditions [11] and less stimulated [12]. The provision of personal control in open-plan work environments is one means of preventing the detrimental effects and leading to desirable outcomes [13,14]. A positive association was found between high work control and job satisfaction, work performance and psychological well-being [15,16].

In addition to comfort and satisfaction, energy saving reasons also supported the provision of individual control in office environments. Research demonstrated great energy saving potential due to lighting and ventilation controls [17]. Both laboratory and field experiments suggested that occupants' behaviors, especially how they interacted with personal control, should be included in the loop of control strategies for office buildings [18,19].

Meanwhile, the precedent research also raised some unsolved questions about personal controls in workplaces. For example, how occupants perceive different controls (on lighting, ventilation, noise, etc.)? Whether occupants really use these controls? How these controls work synergistically in workplace environments? How to design these controls to optimize their benefits? This article continues the dialogue on personal controls in open plan office environments to explore the role of different personal controls in open plan settings, aiming to provide evidence and guidelines for human-oriented workplace design.

2. Brief Literature Review

The personal control at workplaces is usually investigated differently in the relevant literature. In some studies [15,20], personal control refers to the degree to which employees perceive they can change their physical work environment, especially by determining, altering, or modifying work areas as necessary to support or to allow their work behaviors. Therefore, the questions were asked in the following ways: "What is your ability to alter physical conditions in your work area?"; "To what degree you feel control over the thermal environment in your workspace?" and the like. On the other hand, in some studies [21,22], personal control is defined in terms of specific environmental adjustment referring to modifying the surroundings themselves, such as opening/closing windows or shades, turning on fans or heating, air diffusers, light switches, and so on. Based on a database accumulated from several recent surveys of office buildings located in a temperate climate, Andersen [23] found that degree of control satisfaction with the perceived control was more likely to affect the prevalence of adverse perceptions and symptoms than the actual control; the most important control actions were access to a thermostat or an operable window. To study personal control, Paciuk [24] identified three dimensions: available control, exercised control, and perceived control and found that perceived degree of control was one of the strongest predictors of thermal comfort and had a significant impact on both comfort and satisfaction.

Noticeably, there is a research gap between actual control opportunities and perceived degree of control over the physical environment. This research is to investigate the availability of control opportunities (windows, blinds, switches, and so on) and the degree of control effectiveness over the physical environment (thermal, lighting, and noise). The research is also to find their relations to the adverse environmental perceptions. Therefore, there are two key research questions: (1) what is the relationship between the actual control opportunities and the degree of control over the physical environment? Which individual controls are most effective in reducing occupants' adverse perceptions in open-plan office environments?

3. Method

Personal control opportunities in workplaces are dependent on a variety of building features, including the windows, blinds, task lights, electrical fans, and the like. In the European Union-funded project Smart Controls and Thermal Comfort (SCATs), McCartney and Nicol identified possible control opportunities [25]: "Open or close a window", "Adjust curtains or a blind", "Open or close an internal door", "Open or close an external door", "Adjust a thermostat", "Adjust a local heater/radiator", "Turn lighting on or off (your desk only), "Turn office lighting on or off", "Adjust the office lighting level (dimmer switch)", "Adjust office air-conditioning", and "Adjust a local fan/air outlet". In the study of Occupant Indoor Environmental Quality (IEQ) Survey by the Center for the Built Environment of UC Berkeley, individual control opportunities in modern office environments, especially on thermal and lighting environments, were identified as follows [26]: "Window blinds or shades", "Operable window", "Thermostat", "Portable heater", "Permanent heater", "Room air-conditioning unit", "Portable fan", "Ceiling fan", "Adjustable air vent in wall or ceiling", "Adjustable floor air vent (diffuser)", "Door to interior space", "Door to exterior space", "Light switch", "Light dimmer", "Window blinds or shades", "Desk (task) light". Combining these two studies, this research listed 12 possible control opportunities in the survey: (1) "Window blinds or shades", (2) "Operable window", (3) "Thermostat", (4) "Room air-conditioning unit", (5) "Ceiling fan", (6) "Portable fan", (7) "Adjustable air vent", (8) "Heater", (9) "Door to interior or exterior space", (10) "Light switch", (11) "Light dimmer", and (12) "Desk (task) light".

For the degree of control over the physical environment and adverse perceptions, the survey used the BUS (Building Use Studies) questionnaire. Respondents were asked to answer the question: "How much control do you personally have over the following aspects of your indoor working environment?" The aspects covered heating, cooling, ventilation, lighting, and noise. The answer ranged from 1 "Little Control" to 7 "Full Control" on each aspect. Respondents were also asked to report their adverse perceptions experience on five aspects representing sick building syndrome: "Do you have any symptoms (see below) which you feel may be associated with being in the building? (We are thinking of any of the following which may appear when you come into the building and disappear when you leave.)" The five aspects covered eyes (irritated, itching, dry, watering), nose (irritated, itching, runny, dry, blocked), throat (sore, constricted, dry mouth), head (headache, lethargy, irritability, difficulty in concentrating), and skin (dryness, itching, irritation, rashes).

To answer the research questions and find out effective personal control resolutions for designing building and interior elements, the research surveyed 411 occupants working in open-plan office settings in six office buildings in Shenzhen (Table 1). To conduct the statistical analyses, a certain ratio of questions to responses (1:10) are needed. In this case, 24 questions (14 on available control opportunities, five on perceived degree of control, and five on sick building syndrome) were asked and the analysis needs at least 240 responses. Therefore, the 411 responses are sufficient for the data analysis. Among the surveyed six office buildings, two buildings use split air-conditioning or room air-conditioning systems which are usually accompanied with ceiling fans and operable windows for alternative ventilation; three use central air-conditioning systems without operable windows; one uses mixed-mode ventilation with both central air-conditioning as well as operable windows. Some of workstations in these buildings also have other control opportunities such as desk lights and portable fans for individual uses. Most of respondents had worked in these building for more than one year. They worked 5.1 days per week on average and 8.3 h per day in their offices. Forty-one percentage respondents perceived that they were seated next to windows while 59% were sitting far from windows.

Table 1. Surveyed office buildings and occupants.

No.	Building's Basic Features	Samples	Demographics
1	4 storeys; split air-conditioning; fans	55	60% male & 40% female; 58% under 30 years old & 42% 30 and above year old
2	5 storeys; split air-conditioning; fans	33	
3	5 storeys; central air-conditioning	46	
4	10 storeys; central air-conditioning	160	
5	4 storeys; central air-conditioning	61	
6	3 storeys; mixed-mode ventilation	56	

4. Results

Frequencies of personal controls available are shown in Table 2. The most frequently reported control opportunity was light switches, and the second was operable windows and window blinds or shades; the least frequently reported was ceiling fans. Numbers of control opportunities available to the respondents are shown in Table 3. The numbers of respondents decreased stably as the numbers of control opportunities increased. Less than half of the respondents had three or more control opportunities available in their workspaces. Table 4 shows the differences in total numbers on each control opportunity. For example, respondents who had window blinds or shades had, on average, a greater number of control opportunities. The most significant difference was found on light dimmers while the least was found on desk/task lights. In other words, light dimmers were more likely to appear with other control opportunities while desk/task lights were less likely to do so. Table 5 shows responses on the degree of control over heating, cooling, ventilation, lighting, and noise. On average, respondents had the highest degree of control over lighting, and then cooling; they had the least degree of control over noise and heating.

Table 2. Frequencies of control opportunities.

C1	Window shades	234
C2	Operable window	241
C3	Thermostat	102
C4	Room air-conditioning unit	119
C5	Ceiling fan	21
C6	Portable fan	75
C7	Adjustable air vent	109
C8	Heater	25
C9	Door to interior or exterior space	137
C10	Light switch	324
C11	Light dimmer	76
C12	Desk (task) light	147
C13	None of the above	98
C14	Others	18

Table 3. Numbers of control opportunities.

Number	Percent	Cumulative Percent
0	21.5	21.5
1	18.6	40.0
2	18.1	58.1
3	17.9	76.1
4	11.7	87.7
5	5.7	93.4
6	3.8	97.2
7	0.6	97.9
8	0.2	98.0
9	0.6	98.6
10	0.6	99.2
11	0.5	99.7
12	0.3	100.0

Table 4. Cross-table of different control opportunities and total numbers of controls.

Control Opportunities (0 = No; 1 = Yes)			Numbers of Controls (0–12)		
			Mean	**Std. Deviation**	**Mean Difference**
C1	Window shades	0	1.42	1.36	−2.51
		1	3.94	2.15	
C2	Operable window	0	1.42	1.31	−2.51
		1	3.94	2.10	
C3	Thermostat	0	2.00	1.68	−2.08
		1	4.08	2.94	
C4	Room air-conditioning unit	0	1.89	1.59	−2.38
		1	4.27	2.78	
C5	Ceiling fan	0	2.23	1.86	−2.86
		1	5.10	4.73	
C6	Portable fan	0	2.06	1.76	−2.31
		1	4.37	2.98	
C7	Adjustable air vent	0	1.96	1.64	−2.19
		1	4.15	2.89	
C8	Heater	0	2.27	1.96	−1.49
		1	3.76	3.79	
C9	Door to interior or exterior space	0	1.75	1.48	−2.74
		1	4.49	2.52	
C10	Light switch	0	1.24	1.37	−2.18
		1	3.42	2.08	
C11	Light dimmer	0	2.03	1.67	−2.57
		1	4.59	3.15	
C12	Desk (task) light	0	2.08	1.85	−1.10

Table 5. Degree of control (1 = Little control; 7 = Full control).

Personal Control	Minimum	Maximum	Mean	Median	Std. Deviation
Control Over Heating	1	7	3.86	4	1.85
Control Over Cooling	1	7	4.67	5	1.81
Control Over Ventilation	1	7	4.25	4	1.963
Control Over Lighting	1	7	5.02	5	1.662
Control Over Noise	1	7	3.77	4	1.953

t-test was conducted to see whether perceived degree of control was significantly different between those who had more opportunities and who had fewer opportunities. Table 6 is the *t*-test table for control opportunities and the degree of control. Most of the control opportunities contributed to significant differences on control degree perceptions. However, respondents who had desk or task lights available did not perceive that they had significantly more control over the physical environment including heating, cooling, ventilation, and lighting. Table 7 is the *t*-test table for control opportunities and adverse perceptions. Respondents who had window blinds or shades, operable windows, thermostats, a light switch, a light dimmer or desk (task) lights reported significantly fewer adverse perceptions than those who did not have them. On the other side, room air-conditioning units, ceiling fans, portable fans, adjustable air vents, heater, and doors to interior or exterior space might not significantly contribute to the alleviation of adverse perceptions.

Table 6. Control opportunities and degree of control.

Control Opportunities (0 = No; 1 = Yes)		Control Over Heating (1–7)		Control Over Cooling (1–7)		Control Over Ventilation (1–7)		Control Over Lighting (1–7)		Control Over Noise (1–7)	
		Mean	Diff. (Sig.)	Mean	Diff. (Sig.)	Mean	Diff. (Sig.)	Mean	Diff. (Sig.)	Mean	Diff. (Sig.)
Window shades	0	3.8	−0.4	4.3	−1.0	3.7	−1.4	4.7	−0.9	3.9	0.5
	1	4.1	(0.045)	5.3	0.000	5.2	0.000	5.6	0.000	3.5	0.004
Operable window	0	3.8	−0.3	4.3	−0.9	3.8	−1.3	4.7	−0.9	3.9	0.5
	1	4.1	0.085	5.2	0.000	5.1	0.000	5.6	0.000	3.5	0.004
Thermostat	0	3.7	−1.3	4.5	−1.1	4.0	−1.3	4.9	−0.9	3.7	−0.7
	1	5.0	0.000	5.6	0.000	5.3	0.000	5.7	0.000	4.3	0.002
Room air-conditioning unit	0	3.7	−0.8	4.5	−0.8	4.2	−0.5	4.9	−0.6	3.6	−1.0
	1	4.5	0.001	5.3	0.000	4.7	0.013	5.5	0.000	4.6	0.000
Ceiling fan	0	3.8	−2.3	4.6	−1.4	4.2	−2.2	5.0	−1.3	3.7	−2.2
	1	6.0	0.000	6.0	0.001	6.3	0.000	6.3	0.000	5.9	0.000
Portable fan	0	3.7	−1.0	4.6	−0.6	4.2	−0.3	5.0	−0.5	3.6	−1.3
	1	4.7	0.001	5.2	0.014	4.5	0.228	5.5	0.013	5.0	0.000
Adjustable air vent	0	3.7	−1.1	4.5	−0.9	4.1	−1.0	4.9	−0.7	3.6	−1.0
	1	4.8	0.000	5.5	0.000	5.1	0.000	5.6	0.000	4.6	0.000
Heater	0	3.8	−2.3	4.6	−1.7	4.2	−1.9	5.0	−1.4	3.7	−2.2
	1	6.0	0.000	6.3	0.000	6.0	0.000	6.3	0.000	5.9	0.000
Door to interior or exterior space	0	3.7	−0.8	4.5	−0.7	4.1	−0.7	4.8	−0.9	3.6	−0.9
	1	4.5	0.000	5.2	0.000	4.8	0.000	5.7	0.000	4.4	0.000
Light switch	0	3.7	−0.3	4.3	−0.7	3.8	−0.8	4.5	−1.0	3.9	0.2
	1	4.0	0.042	5.0	0.000	4.7	0.000	5.5	0.000	3.7	0.139
Light dimmer	0	3.7	−1.2	4.5	−1.0	4.1	−1.2	4.9	−0.7	3.6	−1.3
	1	4.9	0.000	5.6	0.000	5.3	0.000	5.7	0.000	4.9	0.000
Desk (task) light	0	3.9	0.1 0.675	4.6	−0.2 0.279	4.2	−0.3 0.170	5.0	−0.3 0.096	3.6	−0.5 0.003

Table 8 shows relationships between the total number of control opportunities, degree of control over the physical environment, and adverse perceptions. The perceived degree of control over each indoor physical environment aspect such as heating, cooling, ventilation, lighting, and noise were closely related to each other. The most significant relationship exists between the control over cooling and ventilation (Pearson Coefficient = 0.686; Sig. = 0.000); the least significant relationship exists between the control over lighting and noise (Pearson Coefficient = 0.196; Sig. = 0.000). The number of control opportunities was also significantly related to the degree of control over heating, cooling, ventilation, and lighting, especially to the control over ventilation (Pearson Coefficient = 0.315, Sig. = 0.000) and lighting (Pearson Coefficient = 0.315, Sig. = 0.000). The number of control opportunities was not significantly related to the degree of control over noise. This is because most of the control opportunities listed in this study were about heating, cooling, ventilation, and lighting, while no noise control opportunities were included in this study nor in other studies. Noise control opportunities were not so tangible as an environmental system or interior elements to occupants. Both the number of control opportunities and the degree of control over each aspect except noise were significantly negatively related to adverse perceptions. The most influential aspect is the degree of control over ventilation (Pearson Coefficient = −0.370, Sig. = 0.000).

Table 7. Control opportunities and adverse perceptions.

Control Opportunities (0 = No; 1 = Yes)		Number of Adverse Perceptions		
		Mean	**Difference**	**Significance**
Window shades	0 1	1.4 0.9	0.5	0.000
Operable window	0 1	1.4 1.0	0.4	0.000
Thermostat	0 1	1.3 1.0	0.3	0.012
Room air-conditioning unit	0 1	1.2 1.2	0.0	0.969
Ceiling fan	0 1	1.2 0.7	0.5	0.087
Portable fan	0 1	1.2 1.2	0.0	0.953
Adjustable air vent	0 1	1.2 1.0	0.2	0.140
Heater	0 1	1.2 0.7	0.5	0.051
Door to interior or exterior space	0 1	1.2 1.1	0.1	0.216
Light switch	0 1	1.5 1.0	0.5	0.000
Light dimmer	0 1	1.3 0.9	0.4	0.017
Desk (task) light	0	1.3	0.3	0.013

Table 8. Correlation table.

		Control over Heating	Control over Cooling	Control over Ventilation	Control over Lighting	Control over Noise	Number of Controls	Number of Adverse Perceptions
Control Over Heating	Pearson Correlation Sig. (2-tailed)	1	0.606 ** 0.000	0.544 ** 0.000	0.342 ** 0.000	0.561 ** 0.000	0.178 ** 0.000	−0.111 ** 0.010
Control Over Cooling	Pearson Correlation Sig. (2-tailed)	0.606 ** 0.000	1	0.686 ** 0.000	0.628 ** 0.000	0.270 ** 0.000	0.290 ** 0.000	−0.270 ** 0.000
Control Over Ventilation	Pearson Correlation Sig. (2-tailed)	0.544 ** 0.000	0.686 ** 0.000	1	0.554 ** 0.000	0.271 ** 0.000	0.315 ** 0.000	−0.370 ** 0.000
Control Over Lighting	Pearson Correlation Sig. (2-tailed)	0.342 ** 0.000	0.628 ** 0.000	0.554 ** 0.000	1	0.196 ** 0.000	0.315 ** 0.000	−0.277 ** 0.000
Control Over Noise	Pearson Correlation Sig. (2-tailed)	0.561 ** 0.000	0.270 ** 0.000	0.271 ** 0.000	0.196 ** 0.000	1	0.070 0.086	−0.002 0.965
Number of Controls	Pearson Correlation Sig. (2-tailed)	0.178 ** 0.000	0.290 ** 0.000	0.315 ** 0.000	0.315 ** 0.000	0.070 0.086	1	−0.142 ** 0.000
Number of Adverse Perceptions	Pearson Correlation Sig. (2-tailed)	−0.111 ** 0.010	−0.270 ** 0.000	−0.370 ** 0.000	−0.277 ** 0.000	−0.002 0.965	−0.142 ** 0.000	1

** Correlation is significant at the 0.01 level (2-tailed).

5. Findings

The study presents a personal control survey in open-plan workplaces. The most common control opportunities available in open-plan offices were light switches, operable windows, and window shades. Respondents had higher degree of control over lighting, cooling, and ventilation than noise and heating. This is because heating is seldom used in Shenzhen which is located in a subtropical climate, and noise control is always a problem in open-plan offices. Figure 1 illustrates the relationships which are statistically significant in this study. Most of control opportunities except desk or task lights were closely associated with the degree of control. Among the 12 control opportunities, only six of them were negatively related to the adverse perceptions. They were window shades, operable windows, thermostat, light switch, light dimmer, and desk (task) light. The degree of control over heating, cooling, ventilation, and lighting were negatively related to the number of adverse perceptions. In sum, some control opportunities supporting the degree of control did not necessarily play a role in alleviating adverse perceptions.

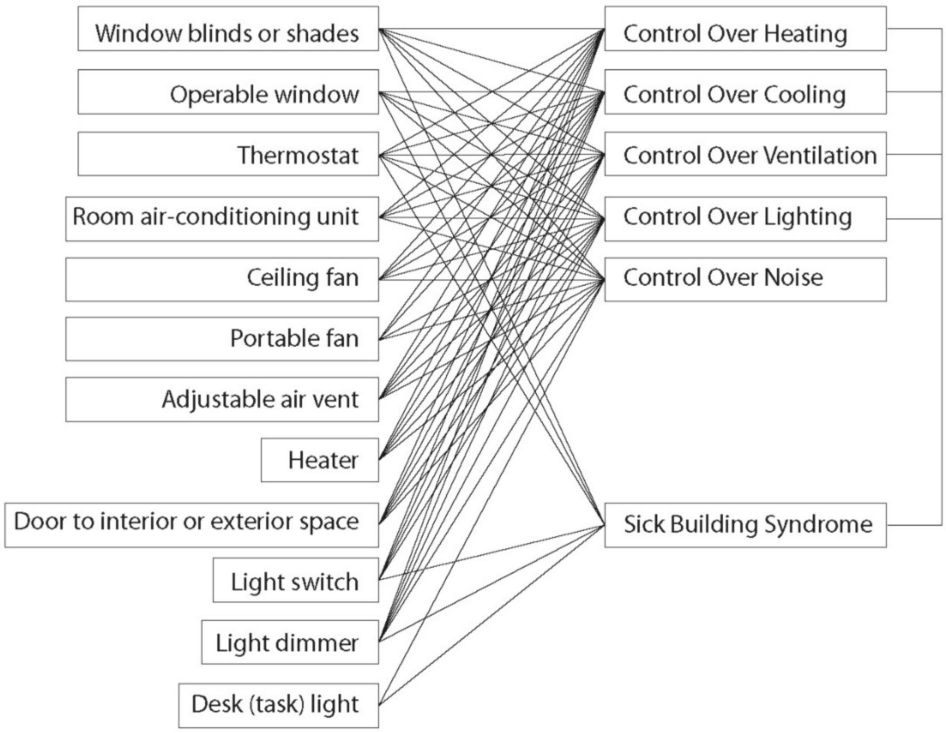

Figure 1. Relationship and effectiveness.

The two research questions raised in the beginning of this study could be responded as follows:

Are the controls (such as operable windows, electric fans, task lights, blinds, and the like.) associated with a high degree of perceived individual control over the physical environment? Most of the control opportunities contributed to significant differences on the control degree perceptions. However, respondents who had desk or task lights available did not perceive that they had significantly more control over heating, cooling, ventilation, and lighting. Among all control opportunities, light dimmers were more likely to appear with other control opportunities while desk/task lights were not likely to do so. The two findings disclosed the conflict between desk or task lights with other control opportunities. In this study, most of workstations with desk or task lights were cubicles with high partitions, where respondents had high privacy but less access to other opportunities. The numbers of control opportunities significantly related to degree of control over heating, cooling, ventilation, and lighting, especially control over ventilation and lighting. The number of control opportunities was not significantly associated with the degree of control over noise.

Are the perceived controls and degree of control over the physical environment negatively associated with adverse perceptions? Respondents who had window blinds or shades, operable windows, thermostats, a light switch, a light dimmer, or desk (task) lights reported significantly fewer adverse perceptions than those who did not have them. On the other side, room air-conditioning units, ceiling fans, portable fans, adjustable air vents, heater, and doors to interior or exterior space did not contribute to a significant difference, which indicates that although these opportunities were important to increasing users' degree of control over the physical environment, they did not play a role in alleviating adverse perceptions. Both the number of control opportunities and the degree of control over the physical environment (except the noise environment) were negatively associated with the number of adverse perceptions. The most influential one was the degree of control over ventilation.

6. Conclusions

Comfort and satisfaction studies address that it is important for occupants to have adaptive opportunities that can help them to alter and control their indoor environmental conditions. This study points out that the mere sum of control opportunities is not a good measure of adaptive opportunities. To assess the usefulness of the personal control in workplaces, the study combined control questions from three systematic occupant survey tools: the U.K. BUS questionnaire, the U.S. IEQ occupant survey, as well as SCATs project in Europe. The results address the following three issues in interior design and the research for effective individual control.

Avoid control opportunities conflicting. Control opportunities should be available for controlling different indoor environments, including heating, cooling, ventilation, lighting, and noise. Some of them are closely related to each other. For example, operable windows and blinds can provide controls over heating, cooling, and lighting. However, some of them may probably conflict with others. For example, private workstations can improve noise environments in open-plan offices while it may reduce accessibility to some controls such as switches or windows which are located outside of the workstation.

Differentiate effective and ineffective control strategies. This study reviewed literature on individual control over the office physical environment, and identified 12 possible control opportunities for occupants working in open-plan workplaces. However, not all of these opportunities are negatively associated with occupants' adverse perceptions. The most effective ones were found out to be operable windows and blinds; while the most ineffective ones were some mechanical solutions (heaters, fans and air-conditioning units), and doors to interior or exterior space. Interior design or environmental control system should consider prioritize non-mechanical personal controls. In office environments, doors should be cautiously used as a control strategy.

Design noise control strategies and interfaces. In this study, the perceived degree of control over noise did not increase as the total number of individual control opportunities increased; meanwhile, the perceived degree of control over noise was not negatively related to adverse perceptions. Most of control opportunities were about heating, cooling, ventilation and lighting. Few studies mentioned noise control, and occupants could hardly think of tangible noise control opportunities. Although previous studies proposed acoustic solutions such as noise mask, how occupants have tangible individual control over noise is still an unanswered question.

Due to the limitations of sampling, the findings and implications could not be generalized to all work environments. There are many factors influencing positive or negative environmental perceptions in workplaces, including demographic, social, and economic ones. Therefore, the association of personal controls with environmental perceptions found in this study should be cautiously interpreted. This study mainly investigated the perception of existence the personal control opportunities and the related effects; while it did not collect the data about how these controls were used, in other words, actual use behaviors of occupants. The future studies should observe the actual use behaviors of occupants on these personal controls to validate this study. How to design effective control opportunities remains an active contentious topic that will need further investigation.

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