Usability and comfort in Canadian offices: Interview of 170 university employees

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Usability and comfort in Canadian offices: Interview of 170 university employees

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Abstract. Increasing building automation to improve energy efficiency introduces a risk of reducing occupants' perceived control and overall comfort. To this end, this paper presents a field study that used contextual techniques to explore the relationship between occupants' perceived control and comfort, as well as their preferences for building automation. A total of 170 occupants in 23 Canadian university campus buildings were interviewed in their offices using semi-structured interviews. All interviews entailed verbally administering a survey while photographs were systematically used to identify the context of occupants' interactions with building controls. Findings revealed that occupants' perception of comfort was moderately correlated to their perception of control over their indoor environment. Occupants also showed an overwhelming preference for more control opportunities in their offices (e.g. operable windows and dimmable lighting controls). Conducting interviews in offices yielded many interesting anecdotes and enabled the researcher to identify contextual issues related to building controls' accessibility, which may have been unnoticed otherwise. The findings of this research contribute to a broader debate within the research community about the appropriate level of building automation to optimize energy efficiency and occupant comfort.

1. Introduction

Currently, there is a shift towards increasing building automation with the goal of improving energy efficiency while maintaining occupant comfort. However, there is no widespread consensus regarding the effect of increased automation (and consequently decreasing the degree of control) on occupant comfort. For example, Fanger and Toftum [1] argued that occupants with lower degree of personal control have lower thermal comfort expectations, while Nikolopoulou and Steemers [2] argued that occupants are more comfortable when they have more control over the source of their discomfort. Occupants' response to discomfort can range from personal adaptations (e.g. changing clothing levels), to manipulation of the building systems (e.g. opening windows) or to longer-term solutions such as adding personal heaters, which can have a profound impact on energy use [3]. However, the relationship between discomfort and adaptive occupant actions is not always clear [4]. Surveys are commonly used to investigate this relationship between occupant comfort and the underlying triggers for their behaviour, but many factors that influence occupant-building interaction, especially those related to the physical layout of their indoor environment and controls' accessibility, may not be captured. To this end, this study used contextual techniques that combine surveys with interviews conducted within occupants' workspaces to investigate the relationships between their perceived comfort, control, and preferences for building automation.

This paper describes an interview study of 170 university employees to better understand the relationship between adaptive opportunities, building controls, comfort, and satisfaction in private and shared offices. One of the main contributions of this research is utilizing a relatively larger sample of

interviewees from a variety of buildings, representing different vintages and levels of controls' accessibility. This was recognized as research gap in the existing literature where interviews typically focused on a smaller sample of occupants and within fewer buildings that mostly had similar features [5]–[7]. All 170 interviews were also conducted within the occupants' workspaces to ensure the contextual factors that influence occupants' daily interactions with their buildings were captured. This large set of interviews provided additional evidence to contribute to the broader debate within the research community regarding the appropriate level of building automation and the relationship between perceived comfort and control. Furthermore, administering a survey while conducting semi-structured interviews provided quantitative data in addition to qualitative data regarding occupants' interactions with their buildings, unlike other interviews where only recurring issues were identified. The findings of this research provide designers and operators with additional insight on the way occupants react to discomfort, their preferences and perspective on building automation.

2. Literature review

The relationship between occupants' perceived control and comfort was particularly investigated in more detail in previous research, but results showed mixed outcomes. Some studies found that reducing occupant control saved energy without reducing occupant comfort [8], [9], while other suggested that occupant comfort increases when they have more control [10]–[12]. Leaman and Bordass [13] argued that occupants tolerate deviations from "ideal" indoor conditions, as long as they have adequate opportunities to intervene and control their environment. Previous studies mostly relied on surveys to investigate the relationship between perceived control and comfort [14]–[16]. However, contextual factors may not be captured in these responses despite their potential effect on occupant comfort. For example, the amount of space, noise management, visual privacy and physical obstructions of controls can affect occupants' workplace satisfaction and may not be identified in survey responses [17], [18].

To examine the context of human-building interactions, interviews can provide more information about individual occupants, their attitudes, beliefs and comfort preferences. The dialogue between the researcher and each occupant facilitates sharing anecdotal information that provide further insight on their energy-related actions [19]. Furthermore, interviews allow the researcher to dwell on specific issues raised by the occupant, which may otherwise be missed. For example, Karjalainen and Koistinen [6] used semi-structured interviews with 27 occupants in 13 buildings to gain further insight on their use of building controls. This research method was adapted from "contextual inquiry" postulated by Beyer and Holtzblatt [20] as it encouraged occupants to show and tell how they use building controls. Despite its limited sample size, interview results indicated that many of the building control systems were designed with unrealistic assumptions about occupants' knowledge and ability to use them. Although some studies reported using interviews to obtain information about occupant comfort and satisfaction [5]–[7], many were not conducted within the occupants' workspaces. In these situations, occupants may be disconnected from their everyday life and interaction with their buildings, thus some of the contextual factors that influence their perceived comfort and control can be missed [18].

3. Research method

This field study took place at a Canadian university campus, where a total of 170 interviews were conducted within occupants' workspaces in 23 institutional buildings. These buildings represented different vintages with construction dates ranging from the 1960s to the late 2010s. However, all campus buildings had mechanical cooling, heating and ventilation, and were centrally controlled using a building energy management system. Interviews took approximately 20-30 minutes each, and were conducted in June and July, 2018, thus all buildings were in cooling mode. A list of 24 questions were administered as part of these interviews. Eleven of the survey questions elicited quantitative responses using a five-point Likert scale, while the remaining thirteen questions were open-ended to gather anecdotal references regarding occupants' responses. The researcher recorded occupants' responses during these interviews and finally took photographs of various office features including light switches, lights, windows, blinds, thermostats, radiators, supply air diffusers and any additional devices purchased by the occupant (e.g. space heaters, fans, air purifiers, humidifiers, lighting). To incentivize participation, $10 was provided to occupants to compensate for the time they spent while conducting these interviews.

All interviews were finally transcribed; Likert-scale questions were represented numerically and converted into quantitative survey responses. On the other hand, open-ended questions were coded and categorized using key-words. The photographs taken by the researcher were also used as part of the analysis to contextualize some of the responses received and to document examples of occupant adaptations used to improve their comfort.

Quantitative responses were not normally distributed as assessed by Shapiro-Wilk's test ($p < 0.05$), thus non-parametric statistical tests were used for the analysis. The Spearman's rank order correlation test was used to analyze the relationships between occupants' perceived comfort, control, and overall satisfaction. Spearman's rank order correlation was also used to investigate the relationship between different comfort attributes (e.g. thermal, acoustic, lighting…etc.) and occupants' perceived ability to specifically control them. Occupants' responses were also used to evaluate their preferences for additional controls in their workspaces and their perception of building automation.

4. Results and discussion

4.1. Quantitative interview findings

Results of the Spearman's rank order correlation evaluated the relationships between overall satisfaction, comfort, and perceived control, which are shown in Figure 1. The strongest correlation was found between comfort and overall satisfaction ($r_s = 0.7$, $p < 0.05$), while a moderate correlation was found between comfort and perceived control ($r_s = 0.38$, $p < 0.05$).

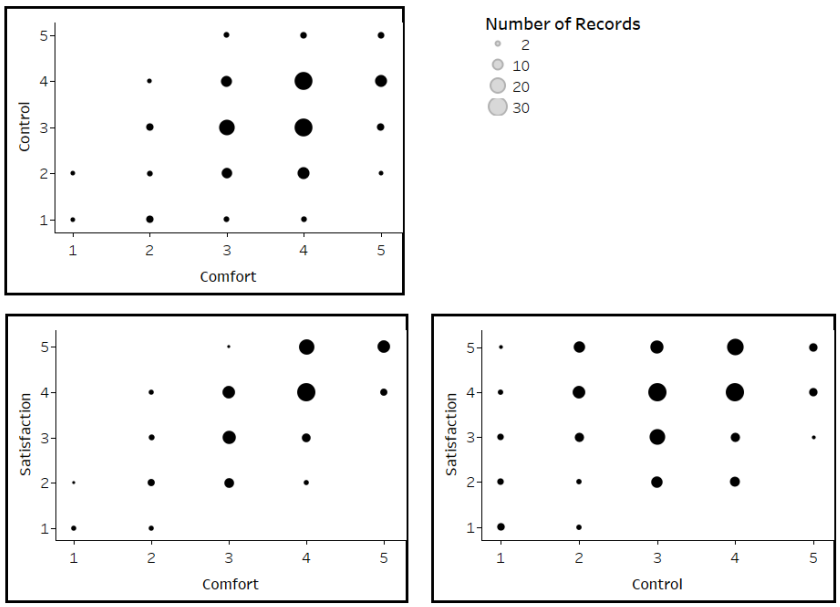

Figure 1. The relationship between self-reported comfort, control and satisfaction across all responses

The relationship between comfort and control was investigated in more detail by focusing on specific comfort attributes and their perceived level of control. Figure 2 shows the average comfort scores for the investigated attributes and the corresponding ability to improve them. Thermal comfort was the lowest-rated comfort attribute, with an average score of 2.8 across all interviewed occupants. The ability to adjust thermostats (to address thermal comfort) also received the lowest average score (1.7). Many of the interviewed occupants felt that any adjustments they made to thermostats had no impact on temperature, which may explain these findings. Based on the Spearman's correlation tests, statistically significant correlations were found between the comfort scoring of different attributes and the perceived

ability to improve it, with r_s ranging between 0.3 and 0.6 (i.e. moderate correlations). These findings suggest increasing occupants' control over their indoor environment is positively correlated to comfort.

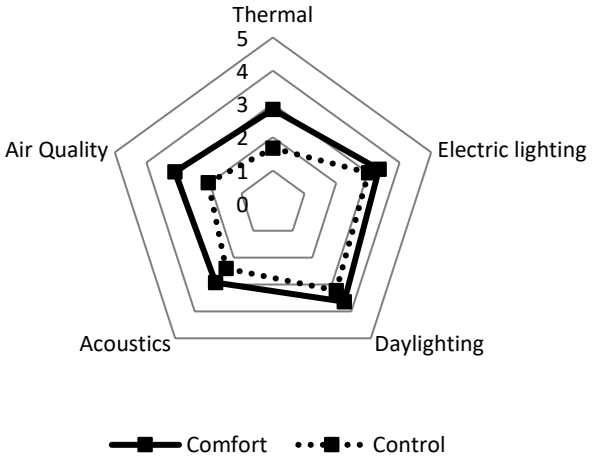

Figure 2. Average perceived comfort and control for different comfort attributes

When asked "Overall, to what extent are your lighting, heating, cooling and ventilation systems too manual vs. too automated?", 88% of respondents indicated they felt they were somewhat or too automated. The same percentage of respondents also said they prefer their office controls to be more manual compared to the current configuration. None of the respondents expressed desire for more automation. Occupants were also asked if they felt there were too many control devices on their walls, and 93% of respondents somewhat or completely disagreed.

4.2. Qualitative interview findings

Interview results indicated that many of occupant complaints (which result from discomfort) were in fact related to system functionality, rather than perceived level of control. For example, occupants in some offices suggested the supply air diffusers increased the level of contaminants and dust which led to their dissatisfaction with indoor air quality (IAQ). Two of the interviewed occupants even tried to remedy this problem by covering their diffusers with cheesecloth to filter out dust particles (Figure 3). Many of the interviewed occupants also expressed a strong desire for operable windows as they believed that would improve IAQ. Another common complaint was regarding light distribution within some offices, where occupants expressed their desire to control lighting level using dimming controls instead of only being allowed to switch it on or off. To address this issue, some occupants removed one or two light bulbs from their lighting fixtures. These examples show the extent to which occupants may adapt indoor spaces when they feel uncomfortable. These interventions are seldom accounted for during building design, yet they potentially influence energy consumption and may even introduce unanticipated safety hazards. For example, one occupant covered the florescent light in their office with paper to reduce its brightness, which introduced a fire hazard in this space (Figure 3).

Office layout and design-related issues were often raised during the conducted interviews. Occupants indicated that some of the features they liked the most about their offices were not related to controls, but rather the amount of daylight available given their office orientation, and in some cases access to outdoor views from larger windows. When asked which features they disliked the most about their offices, some of the common themes included the lack of privacy and poor acoustics, which are also related to office design rather than operations and control. One of the more critical concerns raised by occupants was the degree of obstruction of some of the available controls, which was also reported in previous research [21]. An example of this can be seen in Figure 3, where the window sill and desk provided a physical barrier between the occupant and the blind adjustment cord.

Figure 3. Examples of obstructions of building controls and occupants' adaptations to improve their comfort

5. Conclusion

One of the key findings from this study was identifying a moderate correlation between occupant perceived comfort and control, thus reinforcing previous studies' findings. Results also revealed occupants' general frustration with the way building systems are currently automated and their slow response when changes are requested (e.g. when adjusting thermostats). The overwhelming majority of occupants wanted more manual control opportunities and less automation. Conducting these interviews within occupants' workspaces revealed they often used interventions to address discomfort, which may significantly influence energy use or introduce potential hazards. These insights highlight the need for fast and reasonably effective building control strategies to improve occupant comfort.

One of the advantages of administering the survey through a face-to-face interview was providing rich qualitative context for interpreting responses. Interacting with the occupants while administering the survey also allowed the researcher to promptly identify potential misunderstandings and further clarify survey questions, which would have been challenging if the survey was administered online. Conducting these interviews within the occupants' workspace also allowed the researcher to identify contextual issues related to building controls' accessibility, which may have been unnoticed otherwise.

Although this study applied contextual research on a relatively large sample of occupants compared to previous work [5]–[7], some inherent limitations existed due to the setting in which it was conducted. For example, the buildings in which interviews were conducted represented different mechanical system types and control interfaces which were not analyzed within the scope of this study. Other limitations due to the nature of academics' work at the university, which does not require standard 9-5 occupancy, meant that some respondents spent less time in their offices than others. These absences may have influenced the occupants' perceptions of their indoor environment compared to typical office employees. Future work could involve a longitudinal element, such as periodic online surveys and concurrent sensor-based measurements (e.g., IEQ-related and occupancy) to address some of these limitations while obtaining a better sense of seasonal effects.

6. Acknowledgment

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