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Citation (APA)

Barra, P. D. L., Martinez-Alcaraz, P., Brembilla, E., & Luna-Navarro, A. (2026). Evaluating Occupant Preferences with Building Control Interfaces: Towards Personalized Interaction Strategies. In C. Zilio, F. Busato, L. Mazzarella, & M. Noro (Eds.), *Proceedings of the 15th REHVA HVAC World Congress - CLIMA 2025* (Vol. 3, pp. 1464-1473). Article 140 (Lecture Notes in Civil Engineering; Vol. 788 LNCE). Springer. https://doi.org/10.1007/978-3-032-10546-2_140

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Evaluating Occupant Preferences with Building Control Interfaces: Towards Personalized Interaction Strategies

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Abstract. The integration of smart control systems in office buildings often neglects individual expectations and preferences, especially when occupants do not have personal control over their environment. While existing research has advanced personalized comfort models, simulated energy-use behaviors, and quantitative methods for occupant-centric building design, it often overlooks the critical role of personalized control interfaces. These interfaces are essential for integrating occupants into the operable building systems. This study investigates occupant preferences for personal control after experiencing different building control interfaces for lighting and roller shades in an office environment. Using a usability testing approach, 20 participants were involved in brief interaction sessions to evaluate how interface type (digital vs. analogue), position (wall-mounted vs. desk-mounted), and level of information influence occupants' satisfaction. Additionally, we explored whether participants' preferences for indoor environmental quality conditions correspond with their reported satisfaction with building control interfaces. Results show that interface placement significantly influences user preference, beyond ease of access. While participants initially favored analogue controls and manual operation, exposure to digital and automated systems led to greater acceptance, particularly when these systems provided clear information and maintained personal control. These findings underscore the importance of actual experiences with system interfaces in understanding occupant preferences and acceptance with building technologies, which is key for occupant-centered design in building control.

Keywords: Human-Building Interaction · Preferences · Usability Test · Roller shade · Lighting

1 Introduction

Recent advancements in information technology have enabled the integration of smart systems in buildings, enhancing occupant experience and improving energy efficiency [1]. However, in office settings, automated controls often fail to accommodate individual

preferences, particularly when occupants lack direct control over their environment [2]. While Human-Building Interaction (HBI) research has progressed in analyzing occupant behavior, developing personalized comfort models, and employing data-driven occupant-centric design strategies [3], studies on control interfaces—especially those facilitating personal control—remain limited [4]. This gap is critical, as perceived control strongly influences indoor environmental satisfaction [5, 6].

Previous research provides evidence on interface design and usability in building control systems. Occupant-based testing has demonstrated that intuitive thermostats and lighting controls, particularly those with web interfaces, improve precision when interacting with building [7], while clear feedback and system transparency are essential for enhancing occupant control, particularly in office environments [8]. Despite these insights, it is unclear how the range of interaction strategies impact occupant satisfaction when controlling lighting and roller shades in an office environment. This is particularly relevant for improving occupant engagement with the building operation, acceptance of automated control and increase awareness

This study explores occupant preferences for personal control after experiencing different building control interfaces for lighting and roller shades in an office environment. Through usability testing, we examine how various interaction strategies, differentiated by interface type (digital vs. analogue), position (wall-mounted vs. desk-mounted), and information level, shape occupant preferences and influence their selection of a preferred interaction strategy.

2 Methodology

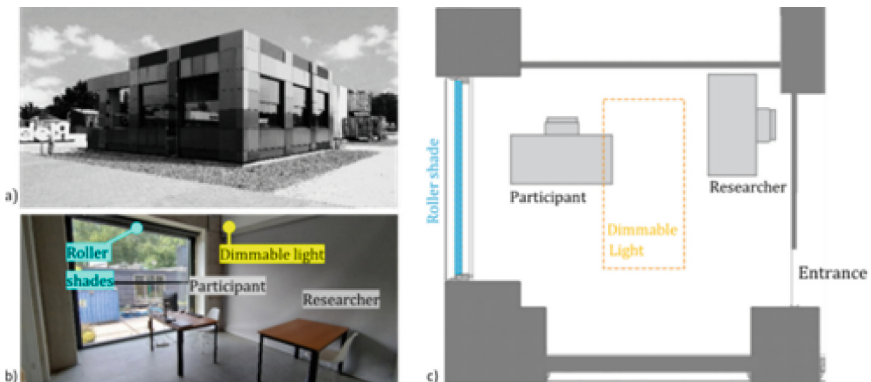


Fig. 1. The Office Lab at The Green Village, Delft University of Technology. a) Exterior view of the office lab. b) Interior view illustrating the participant's and researcher's seats, along with the position of the light fixtures and roller shades. c) Top-down schematic showing the layout of the systems, participant, researcher, and entrance.

We conducted our experiment in a controlled office lab setting, focusing on three key variables: the position of the control interface, the level of information provided, and the type of interface (analogue or digital). The office lab is located at Delft University

of Technology in the Netherlands (Fig. 1a). Measuring 2.2 x 2.45 m, the office lab was southwest-facing and equipped with dimmable LED ceiling lights and a motorized roller shade on the outer side of the window as shown in Fig. 1b. Both the lighting and roller shades were connected to a control system powered by the Home Assistant platform, enabling integration with the interfaces being tested. Inside the room, there was a desk with a computer to mimic an office environment. A separate table was positioned in the corner for the researcher, who was responsible for assisting participants as needed, and noting any important observations (Fig. 1c).

Participants were either students, lecturers or employees at Delft University of Technology. The participants were recruited via emails, word-of-mouth and social media. In total, 20 participants took part in the experiment (9 females and 11 males; age range 23–40, mean = 30, SD = 4.48). The experimental plan was reviewed and approved by the Human Research Ethics Committee of Delft University of Technology under ID 3752.

2.1 Experimental Procedure

The laboratory experiment was structured as a usability test organized around three key components: A) scenarios, B) task activity, and C) interview and questionnaires. Figure 2 shows the chronological arrangement of these components, providing an overview of the experimental procedure.

The test started with a questionnaire and an interview about their expectations for controlling lighting and roller shades in office space. Participants then completed six randomly ordered scenarios. Upon finishing all six scenarios, participants were surveyed about their experiences with the interfaces. The entire usability test lasted approximately 60 min per participant.

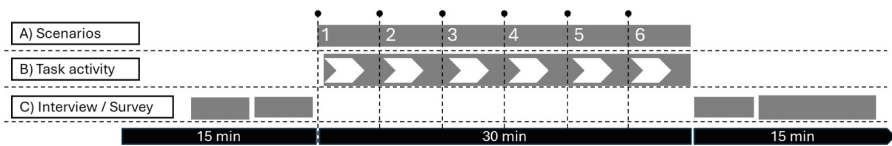


Fig. 2. Experimental procedure timeline.

A) Scenarios. Six interface scenarios were designed to explore three key factors: control type (analogue switches vs. digital touchscreens), interface position (wall-mounted, desk-mounted, or both), and information level (no information, system state, or system performance details). Control interfaces were placed in three locations: next to the entrance (switches only), near the window (switches only), and on the participant’s desk (switches or a tablet). Figure 3 provides an overview of these interface positions within the office lab.

The scenarios used two control devices: an analogue switch (Fig. 4a-b) and a tablet (Fig. 4c), both capable of controlling lighting and roller shades. The tablet featured three visual interfaces: one mimicking the switch’s basic functionality, another using

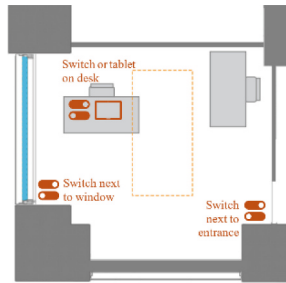


Fig. 3. Top view of the office lab indicating the positions where the interfaces were placed during the tested scenarios.



Fig. 4. Types of device interfaces used in the experiment: (a) analog light switch, (b) analogue roller shade switch, and (c) tablet interface controlling both lights and roller shades.

sliders with numerical feedback on system status, and a third providing both system-state information and detailed task completion feedback.

B) Task Activity. The task simulated realistic interactions with building control interfaces. Participants were asked to first adjusted the lighting to 50% and set the shades halfway to assess interface usability. They then engaged in a seated work simulation before an automated system action adjusted the settings, testing their reaction to automation. Finally, they restored the original settings, measuring their ability to regain control. This sequence was repeated six times to ensure participants experienced all six prepared scenarios.

C) Interview and Questionnaires. At the start of the experiment, participants completed a questionnaire assessing their familiarity with various devices, such as smart/manual roller shades, dimmable/smart lights and analogue/digital controls. Familiarity was rated on a Likert scale (1 = slightly familiar, 7 = strongly familiar), while a multiple-choice format identified devices in their typical office environment. Following the questionnaire, a short interview was conducted to understand participants' expectations regarding interface type, information level, and control position. After the experiment, a preference questionnaire evaluated interface preferences (position, information, analogue vs. digital and automation vs. manual control). Table 1 presents the questionnaire items for preferences for control position (e.g., desk, fixtures, entrance), lighting information, and interface type. Table 2 presents questionnaire items for preferences for automation versus manual control, exploring trade-offs between reliability and flexibility.

Table 1. Questionnaire items for preference for position, information and type of device for controlling lighting and shading devices. “To what extent, do you agree to the following statements regarding lighting/shading operation? Strongly disagree (1) to Strongly agree (5)”.

Item	Category
I prefer to have lighting/shading switches at my desk, even if this setup is less convenient for others.	Position
I prefer to have lighting/shading controls near the lighting/shading fixtures, even if it makes accessing other controls (heating/cooling, shading/lighting) less convenient.	Position
I prefer to have lighting/shading controls near the entrance of the room, even if I need to stand up to adjust them.	Position
I prefer to see real-time information about light levels in the room, even if I don't frequently adjust them.	Information
I prefer traditional analogue lighting/shading interfaces (e.g., switches, dimmers), even if the lighting/shading system responds more slowly.	Type of device
I prefer digital lighting/shading controls, even if they require more setup or learning.	Type of device

Table 2. Questionnaire items for preference items for automatic and manual control of lighting and shading devices. “To what extent, do you agree to the following statements regarding lighting/shading operation? Strongly disagree (1) to Strongly agree (5)”

Item	Building device	Category
I prefer automatic lighting control, even if it may fail to meet my requirements.	Lighting	Automatic
I prefer manual lighting control, even if the lighting needs vary over time.	Lighting	Manual
I prefer automatic shading control, even if it may fail operating at inconvenient times (losing view or natural daylight).	Shadings	Automatic
I prefer manual shading control, even if I have reflections or the view outside is not always the best.	Shadings	Manual

2.2 Data Analysis

The results were structured using descriptive statistics, inferential statistics (t-test), and correlation analysis to assess participants' familiarity, expectations, and preferences regarding control interfaces for lighting and shading. Familiarity levels were reported as percentages, summarizing the proportion of participants familiar with and owning specific lighting and shading systems. Subjective expectations before the experiment were analyzed using distribution of participants' agreement levels on control interface

characteristics, while statistical tests (t-test) assessed significant differences in preferences, such as interface position and automation levels for lighting and device type for shading.

Additionally, correlation analysis was conducted to examine relationships between interface attributes, with heatmaps, reporting associations between position, device type, information level, and automation. Correlation coefficients quantified these relationships, revealing trends such as the preference for digital shading controls in work environments and the link between automation acceptance and digital interfaces.

3 Results

3.1 Level of Familiarity with Lighting, Shading and Control Interfaces

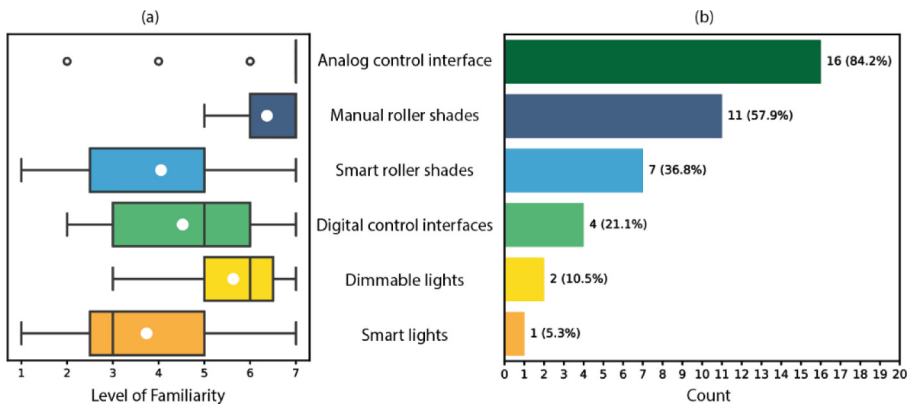


Fig. 5. Overview of participants' familiarity with and availability of different lighting, shading, and control interfaces in office spaces. (a) Participants' self-reported familiarity with manual and smart roller shades, dimmable and smart lighting, and analog or digital control interfaces. (b) Number of participants who reported having these systems in their office.

Figure 5a shows the responses of the participants in terms of the perceived familiarity with different types of lighting, shading and control interfaces in office spaces, while Fig. 5b shows the number of participants reporting the presence of one or more of these items in their office space. Most of participants reported being familiar with analog control interfaces and having them in their office spaces (84%). Second most frequently available was manual roller shades, with 58% of the participants reporting. Least frequently available, smart automated lights or manually controlled dimmable lights were present in the office spaces of only a minority of participants, 5.3% and 10.5%, respectively, even though participants reported being highly familiar with dimmable lights.

3.2 Expectations of Control Interface Before the Experiment

The interviews captured the subjective expectations of the participants before the experiment regarding (i) interface position, (ii) level of information, (iii) type of device, and

(iv) level of automation, providing the rationale behind their choices for both lighting and control.

(i) *Interface Position*: Participants expected lighting controls near the entrance and roller shade controls either by the entrance or window, valuing these placements for their intuitiveness and accessibility. (ii) *Information Level*: Minimal information was preferred on control interfaces, primarily icons and basic directional cues (e.g., up/down, brightness levels). System state feedback was expected through physical elements like dial positions, reflecting participants' familiarity with building systems that provide minimal feedback. (iii) *Device Type*: Participants favored analogue controls, such as switches and dials for lighting and cords for blinds, expecting remote controls to offer only basic up/down functionality. Their preference stemmed from distrust of complex technologies, favoring simplicity and reliability. (iv) *Automation Level*: While participants expressed concerns about automation, particularly its potential to cause frustration, they anticipated greater acceptance if they retained control and understood the system's logic.

3.3 Preferences of Control Interfaces After the Experiment

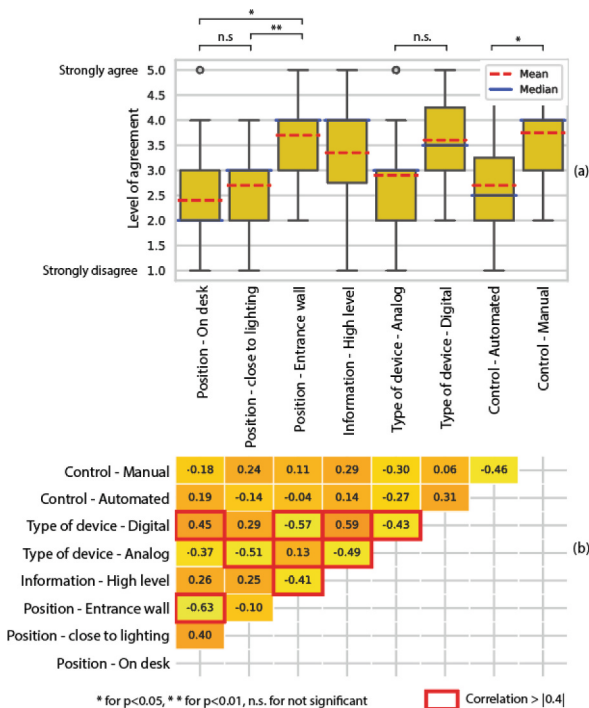


Fig. 6. Participants' perceptions of lighting control interface characteristics and their interrelationships. (a) Boxplot showing the distribution of agreement levels regarding control interface characteristics, revealing statistically significant differences based on position and automation level. (b) Correlation heatmap illustrating relationships between control interface attributes, including position, device type, information, and automation level, with stronger correlations outlined in red.

The boxplot in Fig. 6a reports statistically significant differences in participants' agreement levels regarding lighting control interfaces, particularly in position and automation level. Control interfaces on entrance walls differ significantly from those on desks ($p < 0.05$) and near light sources ($p < 0.01$), indicating position strongly influences participant preference. Automated and manual controls are perceived as fundamentally separate ($p < 0.05$), while the difference between analogue and digital devices ($p = 0.09$) is not statistically significant.

Correlation heatmap, in Fig. 6b, further clarifies these relationships. Digital devices are moderately associated with desk position (0.51), while entrance wall position correlate negatively with digital (-0.49) and positively with analogue controls. Digital devices align with higher lighting information levels (0.47), whereas analog devices rely more on habitual use (-0.49). Automation preferences reflect this pattern, with automated controls correlating positively with digital interfaces (0.31) and lighting information (0.29), while manual controls are negatively associated with automation (-0.46), emphasizing occupant-driven adjustments.

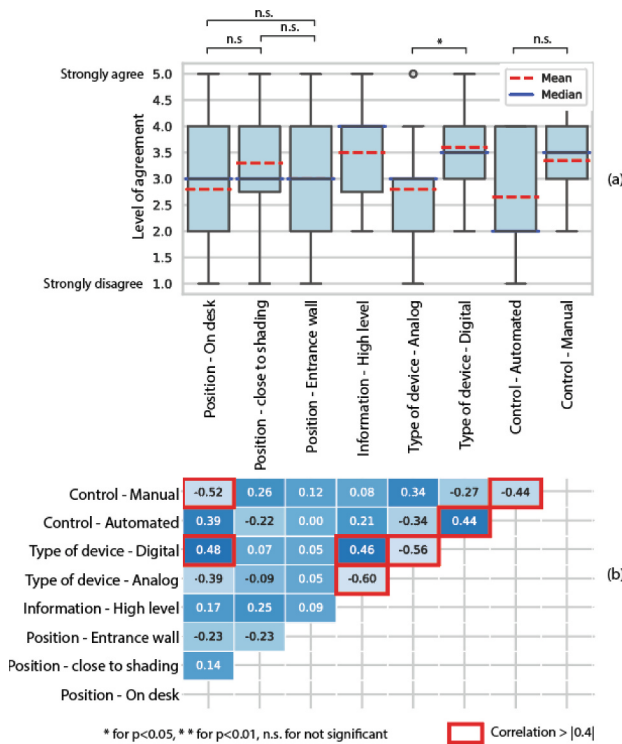


Fig. 7. Participants' perceptions of shading control interface characteristics and their interrelationships. (a) Boxplot showing the distribution of agreement levels regarding shading control interface characteristics, revealing statistically significant differences based on device type. (b) Correlation heatmap illustrating relationships between control interface attributes, including position, device type, information, and automation level, with stronger correlations outlined in red.

The boxplot in Fig. 7a illustrates statistically significant differences in participants' agreement levels regarding shading control interface characteristics, particularly device type. A paired t-test shows a significant difference ($p = 0.04$) between analogue and digital shading devices, indicating different participant preferences. However, no strong statistical differences are observed between automated and manual controls ($p = 0.07$) or among different control positions (p -values from 0.14 to 0.60). This suggests participants are differ in their preferences to interface type, but are similar regarding automation level or interface position.

Figure 7b shows a heatmap describing the correlation between interface type, information, position and automation level. Digital devices correlate moderately with desk positions (0.48), while analogue devices show a negative correlation (-0.39), suggesting participants favor digital interfaces when more personal and close control interfaces. The positive correlation between digital devices and shading information (0.46) implies participant relates digital interfaces with information accessibility. Automation preferences align with digital shading systems, as reflected in positive correlations with desk position (0.39) and digital devices (0.44), indicating participants might accept automated shading in work environments with accessible digital controls.

4 Discussion

Participants' prior familiarity with lighting, shading, and control interfaces played a significant role in shaping their initial expectations. Before the experiment, most participants were familiar with analogue control interfaces (84%) and manual roller shades (58%), while fewer had experience with smart automated lights (5.3%) or dimmable lights (10.5%). This prior exposure contributed to their initial preference for analogue controls, which were perceived as reliable and easy to use.

However, post-experiment responses shows a shift in preference. Statistical analyses reported that control position significantly influenced lighting interface preferences, contradicting the initial assumption that position would primarily affect ease of access rather than occupant preference. Automation, initially perceived negatively, demonstrated a positive correlation with digital interfaces and lighting information, suggesting that participants became more receptive when automation provided clear information and maintained a degree of occupant control.

Participant expectations were not fully aligned, as indicated by the difference in agreement levels. While many initially distrusted the automation, their preferences evolved through empirical exposure, particularly when digital and automated solutions demonstrated enhanced usability. These findings underscore the importance of actual experiences with system interfaces in shaping occupant preferences and acceptance with building technologies.

5 Conclusions

This study investigated building occupants preferences for lighting and shading control interfaces in office environments, focusing on interface type, position, and information level. The findings shows the significant role of prior familiarity in shaping initial expectations, with most participants favoring analogue controls due to their perceived reliability and ease of use. However, actual experience with different interaction strategies led to shifts in preference. Statistical analyses showed that control position influenced occupant preferences beyond accessibility, and automation was more positively received when it provided clear information and occupant personal control. These findings emphasize the importance of actual experience when developing occupant-centered design in building control interfaces.

This study is limited by its small sample size, controlled lab setting, and short-term exposure, which may not fully reflect real-world use.

Acknowledgements This study has received funding from the European Union under the Horizon Europe Research & Innovation Programme (Grant Agreement no. 101103956 SMARTeeSTORY).

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