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An Investigation on Occupant Preferences with Automated Façades

Pedro de la Barra Luegmayer [a], *Alessandra* Luna-Navarro [a], *Ulrich* Knaack [a], *Alejandro* Prieto Hoces [b], *Claudio* Vásquez [c].

[a] Delft University of Technology, Netherlands, The

[b] Universidad Diego Portales

[c] Pontificia Universidad Católica de Chile

Abstract

Background. The automated operation of facades in buildings can positively impact indoor environmental quality (i.e. thermal regulation, acoustic control, air quality, and access to daylight and outside view) whilst reducing cooling, heating, and lighting energy demand. Conversely, several studies have also pointed out that the automated operation of dynamic façades can be disruptive to occupants and a source of discomfort when it does not meet occupant requirements. A number of factors affect occupant requirements regarding façade operation. However, the preference with which individual occupants perceive these requirements, in particular window visual effects, is yet to be understood, and it could inform better user-centred controls of automated facades.

Aims. This study aims at capturing individual occupant preferences on window visual effects (daylight, glare, outside view, and privacy) concerning façade configuration and operation in a laboratory facility.

Methods. Experiments were conducted in a laboratory (1.7x2.2x1.9 m), which had a switchable glazing able to get dark or transparent, controlled by an automated system with override options. The override control was through a switch placed on the desk, which activated the manual control, and a dimmer which allowed the subject to fine-tune the switchable glazing. Every subject was sitting behind a desk next to the switchable glazing. The direction of the table and the chair relative to the façade was fixed. The subjects had an unobstructed view of the outside, consisting of a natural setting. All experiments were carried out in the month of December. Sensors were installed to monitor illuminance on the window, illuminance on the work plane, and temperature on the work plane. Additionally, the state of the switchable glazing was recorded over time.

In total, 14 test subjects participated in the experiments (8 males and 6 females between 20 to 40 years old). All the subjects were used to reading on a computer. The weather conditions were mostly cloudy, with no direct sunlight. Four scenarios were tested on each subject: (i) glazing change from fully transparent to fully dark with a slow transition (30 sec), (ii) from fully transparent to fully dark with a fast transition (2 sec), (iii) from fully dark to fully transparent with a slow transition (30 sec), and (iv) from fully dark to fully transparent with a fast transition (2 sec). Each scenario lasted 10 minutes. In the fifth minute, the automated system triggered the transition to the next state and subjects was allowed to override the system if they disagreed. After every scenario tested, the subjects completed a survey to gather their satisfaction with the automated system, the override option, distractions on performing the task activity and their comfort with the visual environment.

Results. The subjects overrode the system mainly to regulate daylight incoming throughout the window. This is supported by the correlation between window illuminance and satisfaction with the visual environment declared by subjects (R^2=0.91). Thus, the closer window's vertical

illuminance to 2300lx was, the higher the satisfaction with the visual environment reported by subjects.

Concerning subjects' agreement with the automated control of the window, 9 out of 14 subjects did not override the system when the window was slowly opened. Additionally, 6 out of 14 did not override when the window was opened fast. In contrast, 3 and 1 out of 14 subjects agreed with the automated slow close and fast close of the window, respectively.

Even though subjects reported that they did not experience annoyance with the window control on average, the data showed a wider range of answers among the participants when the system automatically reacted fast (from 2 to 5 (on a scale of 1 to 5)) compared to a slow reaction (from 3 to 4).

10 out of 14 subjects reported that when the façade closed slowly, they did not feel distracted from the reading task. Fast opening and slowly closing the façade are also reported as not distractors from the reading task activity.

Regarding the subject interaction with the system, the data gathered shows that participants interacted more when the window closed automatically rather than opened (Figure 1). The main difference between the speeds of the automated mode is the subjects' reaction time. When the window changed its state slowly, the subjects overrode the automated control later, compared to the fast mode, in which subjects tended to react quicker.

Conclusions. The experiment showed that subjects preferred interacting with the automated facade to fine-tune the daylight conditions when the system did not provide satisfactory visual conditions instead of adjusting outside view or privacy. Additionally, subjects preferred to maximise incoming daylight instead of dim it.

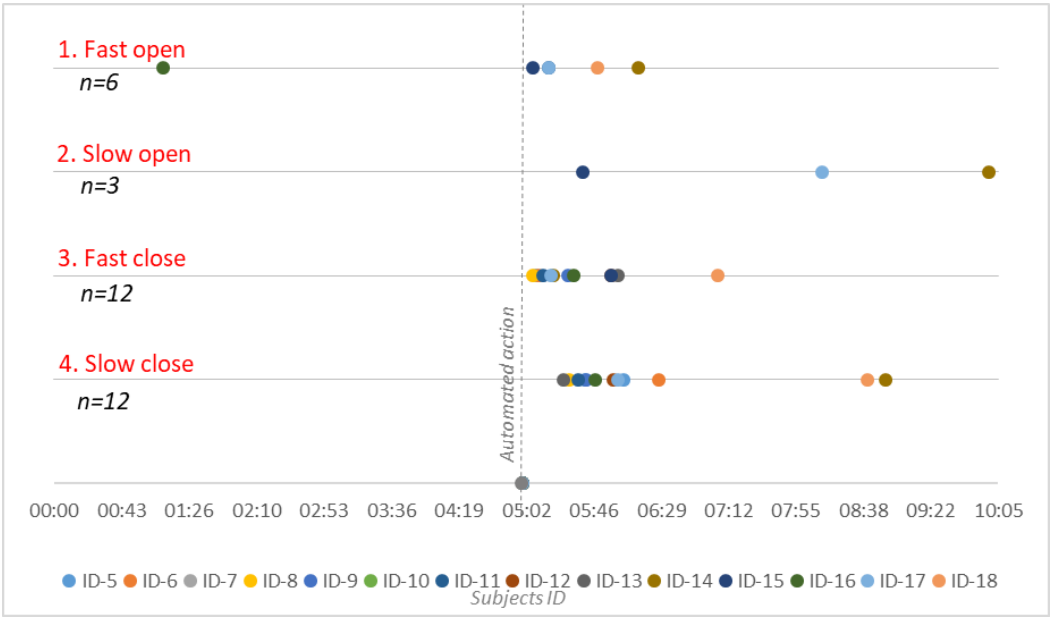
Override actions have the potential to describe the level of occupant agreement with the automated system. Regarding satisfaction levels and degree of agreement with the automated system, the subjects were not unsatisfied despite the automated system behaving randomly. It could be explained because the subjects were always allowed to override the system.

Among the subjects, their preferences were similar. Nonetheless, further research is needed to explore how weather conditions, exposure time to the automated system, type of interface, indoor environmental conditions, habituation and personal significance of controlling indoor quality affect occupant interaction with the automated façade.

Keywords. Automated façade, switchable glazing, laboratory experiment, occupant preference.

Figure 1

Override actions performed per scenario within the 10-minute test. The plot shows the frequency and time of the override for each participant.


1. Fast open
n=6
2. Slow open
n=3
3. Fast close
n=12
4. Slow close
n=12
Automated action
00:00 00:43 01:26 02:10 02:53 03:36 04:19 05:02 05:46 06:29 07:12 07:55 08:38 09:22 10:05
ID-5 ID-6 ID-7 ID-8 ID-9 ID-10 ID-11 ID-12 ID-13 ID-14 ID-15 ID-16 ID-17 ID-18
Subjects ID