User Experience of Automated Blinds in Offices

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Introduction

The increasing attention for energy efficient buildings combined with technological advances in sensors, processing power, lighting, and networks drive the development of so called 'Smart Buildings'. In line with the Ambient Intelligence vision, it is expected that buildings will evolve into 'ambient intelligent office environments' (Aarts & Marzano, 2003). Technology will be embedded into the office environment, aware of our context, personalized to individuals, and adaptive and anticipatory to our needs. This vision is starting to become a reality in today's office buildings. Simple forms of building intelligence such as occupancy sensing or daylight-based dimming are already common practice.

There are clear economical drivers for ambient intelligent office environments. For example, the energy and cost savings that can be made by automatically switching off the light when people are not in a room or by dimming the electric light if sufficient daylight is available. The intelligent behavior should not only result in energy and cost savings, but also make sure that occupants are satisfied with and feel in control of their working environment. However, automation might reduce this feeling of control. If decisions are based solely on economic criteria such as energy saving, the resulting conditions might not be beneficial for the comfort of occupants. A balance between energy efficiency and comfort needs to be found.

As a large part of the population spends a significant part of the day in an office environment, it is not surprising to see an increasing awareness of user comfort in office buildings. Besides the positive effects of a comfortable work environment on the health and wellbeing of office workers, studies have shown correlations between the level of comfort and job satisfaction, and even productivity (Boyce, 2003). Hence, there are also economic reasons for employers and building owners to focus on comfortable work environments.

Although comfort is a subjective concept, much research has been done on objective determinants and measures of comfort. Many aspects have been identified that influence the perception of comfort in offices, including environmental aspects (e.g. building characteristics, climate), social aspects (e.g. relationships with colleagues), and personal aspects (e.g. gender, age) (Bluyssen et al., 2011). It is unclear how all of these different aspects relate to each other and contribute to an overall perception of comfort, but studies have shown the importance of individual aspects such as daylight and electric lighting on perception of comfort. The perception of control is an important psychological process that influences perceived lighting quality and satisfaction with the working environment (Veitch, 2001).

In this paper, we report our work on the user experience of automated daylight control systems in relation to occupants' perceived comfort with the indoor climate. But first, we discuss related work.

Daylight, Blinds, and Control

People generally have a clear preference for daylight over artificial lighting as a source of illumination (Boyce et al., 2003; Cuttle, 1983). Studies have shown this preference for daylight also in offices for various reasons, including enhanced psychological comfort, increased productivity, more pleasant office appearance, and assumed health benefits (Heerwagen & Heerwagen, 1986; Veitch & Gifford, 1996). Hence, it is not surprising

Fig. 1:Office building at the High Tech Campus (left), 2-person office with internal shades and external blinds (center), blinds controller in the office (right)

that Christoffersen (2000) and others found that people prefer to sit near windows. The most positive aspects of a window according to this study in twenty Danish buildings are to have a view out, to be able to check the weather outside, and to have the ability to open the window. But windows can also be a source of visual and thermal discomfort and therefore they mostly come with blinds.

Previous studies show that people do not regularly change the blinds positions manually: they lower them to block direct sunlight, but seldom raise them again for daylight entrance, energy saving or view (Galasiu & Veitch, 2006). Interestingly however, Reinhart and Voss (2003) found that in 88% of the cases when the blinds lowered automatically, people manually raised them within 15 minutes. They also found that people are more likely to accept automatic raising than automatic lowering of blinds. A study by Lindsay and Littlefair (in Galasiu & Veitch, 2006) showed that some blinds were hardly ever used while other blinds were used > 70% of the days studied.

As a result of the technological advances and increasing focus on energy efficient buildings as mentioned before, automatic daylight management systems are being developed. The algorithms for the blinds behavior are often optimized to achieve maximum energy saving in simulations. But what about user comfort? How do occupants experience and use these systems in a real office setting? In the remainder of this paper, we report our field study to investigate how office workers experience a current implementation of an automated daylight control system.

Research method

We conducted contextual research using a diary study and semi-structured interviews with building occupants on satisfaction with the indoor climate, focusing on the blinds usage. The study was setup in two-person offices at the south façade of a building on the High Tech Campus in Eindhoven (see Figure 1). The selected offices were located at the 3rd, 4th, and 5th floor with an unobstructed view on natural scenery including several buildings. The façade is equipped with motorized blinds that can be controlled automatically per segment of the building and/or manually per room. These blinds are lowered automatically if the roof-top light sensors detect intensities exceeding a threshold value (16kLux) and raised at fixed times (21:00) or with high wind speeds. Furthermore, each room is equipped with three manually operable indoor shades and one controller for the exterior blinds. With this controller, occupants can choose to set the blinds in automatic or manual mode and use up and down keys to manually control the blinds. Each room is equipped with fluorescent lighting automatically controlled based on occupant presence (on/off) and daylight linked dimming. Occupants are not able to manually adjust the artificial light. The daylight linked lighting is setup to provide a constant 500 lux on the desk.

Given our interest in the experiences of building occupants with the automated blind system, we selected two groups of blinds users for our study: 9 ‘automatics’ (in 5 offices) and 8 ‘manuals’ (in 5 offices). These groups were formed based on their current setting (on automatic or manual) of the switch as shown in Figure 1 on the right. By having both groups in our study, we expected to get a rich picture of the user experience of automated blinds for various user types.

The 17 occupants in the 10 selected offices were asked to fill in a diary during 10 working days, from the 23rd of November till the 6th of December 2011. The diary started with an introduction and explanation of the study, followed by a questionnaire about general personal information. Each day, the participants judged the indoor climate on the following aspects: daylight, artificial light, temperature, air quality, and room acoustics. Furthermore, they listed all their blind adjustments, including the reasons for making the adjustments. The participants judged the indoor climate only if they were present that day, so the number of responses differs per day. At the end of the day, the participants made an overview of their activities in the office. After ten working days, the researchers interviewed the participants to discuss their answers in the diary and ask additional questions on comfort of the working environment and the automated blind system.

Results

The study was held on 10 working days from 23rd of November until 6th of December (excluding the weekend) in the Netherlands and included 3 days without sunshine, 5 days with less than 30% sunshine duration, and 2 days with around 60% of sunshine. Global radiation and sunshine duration data is presented in Table 1.

Table 1 Weather data

	10-day average	minimum	maximum
Global radiation (J/cm2). Daily average	22	8	36
Global radiation (J/cm2). Daily maximum	61	17	92
Sunshine duration	22%	0%	66%

In total, 112 blind adjustments were recorded in the 10 selected offices during the ten working days of the study. Table 2 shows the distribution between automatics and manuals and the type of blind adjustments. For example, the number in the row 'Down user' and column 'Auto' shows that four times an automatic user manually lowered the blinds. The table shows that manuals have more adjustments in total than automatics (62 vs 50) and, as expected, more manual adjustments (62 vs. 10)

Prevention of discomfort glare was the most frequently mentioned reason for lowering (70% of all manual lowering events) or rotating the blinds (55% of all rotating events). Thermal comfort was only mentioned in 5% of the manual lowering events. For raising the blinds, the most frequently mentioned reason is to create a view outside (52% of all manual raising events). In 35% of the manual raising events, a lack of light in the room was mentioned. Some less frequently mentioned reasons for raising the blinds are appreciation of direct sunlight or too strong wind. In 68% of the manual adjustments, participants were alone in the office, and in 32% of the cases their roommate was present.

There was no significant difference in the overall satisfaction with the indoor environment between automatics and manuals (7.8 and 7.7 on a 10-point scale). Zooming in on specific elements of the indoor environments, the participants were least satisfied with (1) daylight, followed by the (2) room temperature, (3) artificial lighting, (4) air quality, and (5) room acoustics. 27% of the participants judged the daylight as uncomfortable. For artificial lighting, this percentage is much lower (4%).

Table 2 Number of blind adjustments

	Auto	Manual	Sum
Up system	7	-	7
Up user	4	21	25
Down system	33	-	33
Down user	4	29	33
Rotate	2	12	14
Total	50	62	112

During the interviews, participants mentioned the importance of interaction with the outside: daylight, sunlight and a view. People accept some glare to get daylight in their room. Nobody answered that the automatic function works properly. Blinds go down when people do not want them to and vice versa. Automatic users mentioned that as well, but they still put the blinds system on automatic. They do not want to spend time on adjusting the blinds and rather change the position of their screen or chair to prevent discomfort glare. Daylight entrance is a very important reason to open the blinds. It is also a reason to postpone lowering the blinds and accept more glare. Most manuals say they raise the blinds when glare has disappeared. Automatics say they like daylight but just do not think of raising the blinds again. Nobody mentioned that concerns about energy usage influence their usage of the blinds system. They mainly adjust blinds to create a visually comfortable workplace.

Conclusion and discussion

People in working environments lower blinds mainly to prevent discomfort glare and raise blinds to create a view outside or increase daylight entrance. This is in line with earlier findings reported in other studies (Galasiu & Veitch, 2006). The average amount of blind adjustments during our study is 1.12 per office per day.

The overall comfort level between automatics and manuals in our study did not differ. All occupants expressed to feel in control of the blinds system. Even the automatics, since they could still manually override the system if they wanted to. This suggests that it is rather the *perception of control* rather than the objective amount of control that affects user comfort.

We did see a bit more spread in the comfort ratings of manuals. They tend to be more aware of or concerned with the indoor climate than automatics. This was confirmed during the interviews and also for example by the number of blind rotations. Most automatic users say the automatic function does not work properly, but they do not want to spend time on adjusting the blinds and rather accept some discomfort. Manual users decide to switch off the automatic mode and take manual control over the blinds.

Daylight, sunlight, view and the perception of control are important elements that affect comfort levels in working environments. This should be considered when designing the algorithms of intelligent blinds, while maintaining energy requirements as boundary conditions for the blinds behavior. If not, people will switch automatic blind systems off which leads to suboptimal indoor climates, user comfort and energy usage in office buildings. Furthermore, one should acknowledge the different type of blind users and tailor the solutions towards these different usage patterns.

This diary study and interviews provided useful initial insights on how occupants experience and use automatic blind systems. As a next step, we want to combine the current findings with the blind usage data of 45 offices in the same building that we collected over a longer period (from July to December 2011) to provide more detailed blind usage data for various weather conditions.

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