Influence of the indoor climate on the use of blinds in offices

M. Te Kulve (Univ. Eindhoven); M. P. J. Aarts (Univ. Eindhoven); B. W. Meerbeek
Philips Research Europe

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Authors’ address

M. Te Kulve
(Univ. Eindhoven)
m.t.kulve@student.tue.nl

M.P.J. Aarts
(Univ. Eindhoven)
M.P.J.Aarts@tue.nl

B.W. Meerbeek
HTC34-51
bernt.meerbeek@philips.com
Title: Influence of the indoor climate on the use of blinds in offices

Author(s): M. Te Kulve (Univ.Eindhoven); M.P.J. Aarts (Univ.Eindhoven); B.W. Meerbeek

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Abstract: In the contextual study, we examined the satisfaction of two types of users of the blinds system: users who use the automatic control and users who use the manual control. During ten working days, seventeen office workers completed a diary about blind usage and comfort with the indoor climate. Furthermore, physical measurements of the indoor climate were made during this period. Main research questions were:

1. How does the indoor climate influence the use of the blinds?
2. What is the difference in satisfaction with the indoor climate between the two types of users: manual and automatic users?

The study was conducted in Eindhoven between 23rd of November and 6th of December 2011.

A summary of the main findings:
- Most important reasons for adjusting blinds are related to glare and outside view.
- There is not one particular indoor parameter that is normative to changing the positions of the blinds.
- Participants do not consider potential energy saving by changing the blinds.
- Automatic blind system does not work well according to most participants.
- Some users leave blinds system on automatic mode and accept some discomfort as manual adjustments take too much effort.
- The availability of only one control per room, the difficulty of the
- Interface, and the presence of a colleague are aspects that limit the frequency of blinds usage.
- No major differences found in the users’ satisfaction with the indoor climate between automatic users and manual users.
- Manual users seem to be more conscious and critical about the indoor climate than automatic users.
- 86% of the female participants are manual users, compared to 30% of their male colleagues.
- All participants have the feeling of being in control of the blinds system because they can overrule the system.

Note: This TN contains the main report. Appendices are available on request (bernt.meerbeek@philips.com)
Management Summary

A comfortable indoor working environment is important for the health and wellbeing as well as the productivity of office workers. Sunlight can be a source of discomfort in office buildings. Blinds can prevent sunlight from penetrating the room and prevent glare. However, blinds can also take away highly appreciated elements in a working environment, namely an outside view and daylight. Besides the effect on user comfort, the usage of blinds influences the energy usage of a building both for lighting and HVAC.

Automatic systems can assist to use sun- and daylight in an energy efficient way. However, automatic systems might decrease the users’ feeling of control or comfort which can cause low acceptance and even rejection or sabotaging of the system.

This study examined the satisfaction of two types of users of blinds systems: those who use the automatic control and those who use the manual control. During ten working days, seventeen office workers completed a diary about blind usage and comfort with the indoor climate and were interviewed afterwards. Furthermore, physical measurements of the indoor climate were made during this period, including air temperature, relative humidity, illuminance and luminance at various locations in the office. The main research questions are: 1) How does the indoor climate influence the use of the blinds? and 2) What is the difference in satisfaction with the indoor climate between the two types of users? The study was conducted in Eindhoven between 23rd of November and 6th of December 2011.

The study resulted in a large amount of data about the usage of an automated blind system in a real office environment. The most important conclusions are listed here:

- Most important reasons for adjusting blinds are related to glare and outside view.
- There is not one particular indoor parameter that is normative to changing the positions of the blinds.
- Participants do not consider potential energy saving by changing the blinds.
- Automatic blind system does not work well according to most participants.
- Some users leave blinds system on automatic mode and accept some discomfort as manual adjustments take too much effort.
- The availability of only one controller per room, the difficulty of the interface, and the presence of a colleague are aspects that limit the frequency of blinds usage.
- No major differences found in the users' satisfaction with the indoor climate between automatic users and manual users.
- Manual users seem to be more conscious and critical about the indoor climate than automatic users.
- 86% of the female participants are manual users, compared to 30% of their male colleagues.
- All participants have the feeling of being in control of the blinds system because they can overrule the system.

The results of this study contribute to a better understanding of user behaviour in smart office environments. Combined with the findings of other contextual user studies in the office domain, it will inspire the research and development of new solutions for future office environments that will primarily focus on optimizing the comfort levels of office workers in an energy efficient way.
Influence of the indoor climate on the use of blinds in offices

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| Student:      | M. te Kulve                   |
| Supervisors:  | ir. M.P.J. Aarts              |
|               | B.W. Meerbeek MSc. PDEng.     |
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// Abstract

Visual discomfort in office buildings is often caused by sunlight. Blinds can prevent sunlight from penetrating the room and can prevent glare. However, it also takes away a view and daylight.

The energy use of a building depends on the use of blinds because of their ability to contribute to the regulation of a comfortable indoor climate.

Automatic systems can assist to use sun- and daylight in an efficient way. However, automatic systems decrease the users’ feeling of control which can cause low acceptance.

This research will examine the satisfaction of two types of users of the blinds system: users who use the automatic control and users who use the manual control.

How does the indoor climate influence the use of the blinds?
- Which parameters, of the indoor climate, are normative for users to adjust the position of the blinds?

What is the difference in satisfaction with the indoor climate between the two types of users: manual and automatic users?
- Does the range of values in which people experience a comfortable indoor climate differ between manual and automatic users?
- What are the differences between the measured and perceived values of the indoor climate for manual and automatic users?

The study was conducted in an office building in Eindhoven between 23rd of November and 6th of December 2011. Seventeen employees participated in this research by keeping a diary for ten working days. They judged the indoor climate and logged their blind adjustments. Nine participants used the manual control of the outside blinds and the other participants used the automatic control.

After the user diary, all participants were interviewed.

Physical measurements have been performed in one automatically controlled room and one manually controlled room. Air temperature, relative humidity, illuminance and luminance have been measured at different spots in the room.

The main reasons for adjusting the blinds are perception of glare and creating a view to outside. There does not seem to be a particular value which is normative to change the positions of the blinds. People do not think about energy saving by changing the position of the blinds.

Although automatic users prefer a different position of the blinds, they do not want to spend time on adjusting the blinds and rather accept more discomfort. Having only one control unit in each room, the difficulty of the interface and the presence of a colleague are aspects which, to some extent, limit the use of blinds.

Not much difference has been found between the users’ satisfaction with the indoor climate of automatic users and manual users. Manual users however seem to be more conscious and critical about the indoor climate. In this case, 86 % of the participating women are manual users, compared to 30 % of their male colleagues. All participants have the feeling of being in control of the blinds system because they are always able to overrule the system.
Table of contents

Abstract

Table of contents

1 Introduction
   1.1 Problem definition
   1.2 Research context
   1.3 Purpose and research question
   1.4 Structure of the report

2 Method
   2.1 Participants
   2.2 Diaries
   2.3 Physical measurements
   2.4 Interviews
   2.5 Planning

3 Blinds and indoor climate
   3.1 Working principle of the blind system
   3.2 Artificial lighting
   3.3 Indoor climate

4 Results
   4.1 Diaries and physical measurements
   4.2 Blinds use
   4.3 Satisfaction
   4.4 Interviews

5. Conclusion
   5.1 Conclusion
   5.2 Discussion
   5.3 Recommendations

Acknowledgement

References

Appendices
Influence of the indoor climate on the use of blinds in offices
1 Introduction

1.1 Problem definition

Sunlight is an important and well-known cause of visual discomfort in offices. Blinds can help to prevent sunlight from penetrating the building, but also take away daylight and a view outside which are both important to satisfy the occupants with the indoor climate.

Next to that, blinds influence energy use of the building. By keeping sunlight from penetrating the building, blinds prevent the building from overheating during summertime. This results in less energy demand for cooling. The opposite is true during wintertime; sunlight penetrating the building contributes to a decrease in heating demand. When blinds are open, daylight can contribute to a comfortable lighting intensity which reduces the demand of artificial light. Given these opportunities, optimal use of blinds can result in a considerable reduction of energy use.

Automatic systems can assist to use sun- and daylight in an efficient way. However, automatically controlled systems decrease the users’ feeling of control which can cause low acceptance.

This exploring research is part of the office behavior study (Meerbeek et al., 2011) and investigates automatic and manual blind use in an office setting and users’ comfort.

1.2 Research context

A study on the behavior of lighting controls showed that most users prefer a system which they can control (Escuyer and Fontoynont, 2001). Those systems tend to be evaluated more positive than automatic systems even though the luminance in those rooms is not always better. This suggests people prefer the ability to adjust the luminance over automatic settings of the luminance. (Moore et al., 2001; Moore et al., 2002a; Moore et al., 2002b). The blind system, which has been investigated in this study, contains outside blinds which can be controlled automatically. Yet, people always have the possibility to overrule the system. Thereby people can experience the feeling of having control while using the automatic function.

When the manual function is activated, users have to open or close the blinds themselves. A study by Galasius and Veitch (2006) reports that people only adjust the blinds when they arrive and do not, or rarely, change the position of the blinds during the day. For that reason, daylight will not be used as efficient as possible.

Day- and sunlight have the potential to reduce the energy consumption of buildings. To what extend that happens, depends on the use of daylight and artificial light due to the behavior of occupants. The users’ attitude is the main explanatory parameter for daylight utilization. (Ham van den and Haartsen, 2006). People usually pertain to one of the following user profiles regarding manual control of electric lighting (Love, 1998):

- The ideal daylight user:
  - Only switches the artificial lighting on when daylight is insufficient for performing his/her tasks.
  - Reduces artificial lighting as much as possible and constantly checks if the conditions have changed. For this profile improvement of daylighting conditions is effective.

- The permanent artificial light user:
  - Turns on the light disregarding actual circumstances and keeps it on even after he leaves the room. Maximum saving is possible with automatic lighting control.

1.3 Purpose and research question
This research, part of a larger “office behavior study”, will examine the satisfaction of two types of users with the blinds: users who use the automatic control and users who use the manual control. The focus will be on the satisfaction with the indoor climate and the influence of the indoor climate on the use of the blinds.

How does the indoor climate influence the use of the blinds?
- Which parameters, of the indoor climate, are normative for users to adjust the position of the blinds?

What is the difference in satisfaction with the indoor climate between the two types of users: manual and automatic users?
- Does the range of values in which people experience a comfortable indoor climate differ between manual and automatic users?
- What are the differences between the measured and perceived values of the indoor climate for manual and automatic users?

For the ‘Office Behavior Study’ study, a trial has started in an office building, High Tech Campus 34 in Eindhoven. On the outside and inside of the façade, windows are provided with blinds. The inside blinds can be controlled manually in all offices. The external blinds can be switched to automatic or manual control.

1.4 Structure of the report
After this introduction, the research method will be discussed in chapter two. Chapter three elaborates on the blind system and the aspects that determine indoor comfort. The results of the research will be presented in chapter four. The final chapter contains conclusions and recommendations for future research.
2 Method

To examine the influence of the indoor climate on the use of the blinds and the differences in satisfaction between the two types of users, seventeen office workers participated in this research. These participants kept a diary during 10 working days and were interviewed afterwards. Next to that, indoor climate measurements have been done in two office rooms and the adjustments of the blinds were continuously monitored by a camera facing the façade.

2.1 Participants

The number of automatic and manual users who participated in this research are approximately equal, to be able to compare the results of the two types of users. A list of requirements for the participants has been made:

- Office room with two employees, all with the same layout
- Window at the south façade
- People are present at least 4 days a week

Eight out of seventeen recruited participants use the automatic control of the outside blinds; nine participants use the manual control. Both ‘types’ of users are spread over five different offices. Appendix I gives an overview of the profiles of the seventeen participants who completed the study. In spite of the requirements, some varying parameters remain:

- Time spend in their office room
- The activities people perform
- Workplace facing east or west
- Sitting next to the control or not (only one controller situated in each room)

The setting of an office room can be seen in figure 2.1.1

![Figure 2.1.1 Picture of a typical office room](image)

![Figure 2.1.2 Floor plan office room](image)
2.2 Diaries
The occupants in the selected offices were asked to fill in a diary during ten working days, from the 23rd of November till the 6th of December 2011. The diary started with an introduction and explanation, followed by a questionnaire about general personal information. Each day the participants had to judge the indoor climate and report their blind adjustments. The diary can be found in appendix II; each day the questions were the same, so only one day has been attached. The diaries should give information on the number of, and reasons for adjusting the blinds, and the users’ satisfaction with the indoor climate. The participants judged the indoor climate if they were present that day, so the number of responses differs per day as indicated in figure 2.2.1. At the end of the day, the participants answered the questions regarding the satisfaction with the indoor climate and made a schedule of the activities on that day. Each day the participant had to fill in the same questionnaire about their perception of the indoor climate on the following aspects:
- Daylight
- Artificial light
- Temperature
- Air quality
- Room acoustics

2.3 Physical measurements
Measurements are taken to compare objective physical values with the perception of people. Indoor temperature, relative humidity, light illumination and luminance were measured. Values of the outdoor conditions are available at KNMI.

The indoor measurements were done in two office rooms during the same period the seventeen participants kept their dairies. Both rooms belong to two persons who are also part of the diary study. The two users in the first room use the automatic function and the two users in the second room use the manual function. The occupants of these rooms were instructed not to switch from automatic to manual control or vice versa. In each room, 4 sensors were placed. Each sensor measures the air temperature, relative humidity, and the light intensity every 60 seconds. The setup for the measurement is illustrated in figure 2.4.1.

Air temperature has been measured at both sides of the room, person 1 (P1) and person 2 (P2) and at the back of the room. If the sun shines directly on the sensors, the temperature will increase. When the sunlight disappears, the temperature values of the sensors will not drop immediately, because there is a delay in sensors. Therefore, a sensor is placed at the backside of the office, so this can be used as a reference temperature for the air temperature in the room.

Illuminance has been measured horizontally at the back and the front of the offices, as well as vertically just behind the occupants, P1 and P2, to measure the illuminance at eye level. This height has been
determined after several experiments, by placing the sensor at different positions and comparing the measured Illuminance with the real Illuminance on spot of the eyes. A specification of the sensors can be found in appendix IV.

Next to that a calibrated luminance camera (Canon EOS with a fish-eye lens) has been placed at the back of the office to measure the luminance. The view of the camera is shown in figure 2.4.1. A set of seven pictures at different exposure levels was taken each 60 minutes. With these seven pictures the DGP, Daylight Glare Probability (Wienold 2010), can be calculated. In this case, the DGP of the window and the surface of the desks could be calculated. Due to the availability of only one camera and some technical problems, the luminance measurements have only been performed on three days in each office room. Specification of this camera can be found in Appendix IV as well.

2.4 Interview
After the diaries were completed, the seventeen participants had a short interview about the diary and their experiences during the ten working days. Appendix III gives an overview of those questions. The purpose of the interview was to get additional information about how people perceive the indoor climate and why they made blind adjustments or not. Furthermore, answers in the diary could be clarified.

2.5 Planning
This research started in October 2011 and will be finished in February 2012. The measurements have been performed from 23rd of November till the 6th of December. A detailed planning of this research has been attached in appendix V.
3 Blinds and indoor climate

3.1 Working principle of the system
The ‘Mastercontrol II’ (Somfy, 2007), is a sun and wind controlled microprocessor which can operate on the blinds at the outside of the façade. The position of the outside blinds depends on:
- Sun-intensity
- Wind speed
- Time
- Manual control

Table 3.1.1 gives an overview of the up and down movements of the blinds when the automatic control is activated and when the manual control is activated. Below the table, a more detailed description about the working principle has been added.

<table>
<thead>
<tr>
<th></th>
<th>Automatic</th>
<th>Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down</td>
<td>Light intensity is high ( &gt; 16kLux) within the activation period (6.00 A.M. 9.00 P.M.)</td>
<td>Manual within the activation period (6.00 A.M. 9.00 P.M.)</td>
</tr>
<tr>
<td>Up</td>
<td>The activation period has been passed (at 9:00 P.M.)</td>
<td>The activation period has been passed (at 9:00 P.M.).</td>
</tr>
<tr>
<td></td>
<td>The wind speed is too high (&gt; 30 km/h)</td>
<td>The wind speed is too high (&gt; 30 km/h)</td>
</tr>
</tbody>
</table>

Table 3.1.1 Working principle of the system

Solar-intensity
Two solar panels are connected with one façade. The blinds which are controlled by the automatic function will be lowered when the light intensity exceeds the established 16 klux measured on the roof top of the building. The delay time of this operation is 3 minutes, so the light intensity has to be larger than 16 klux for at least 3 minutes before the blinds will go down. The blinds will not go up as a result of reduction of the light intensity, but will be raised because of the clock function or the wind security setting.

Wind security
When the wind speed exceeds the limit of 30 km/h, all blinds, automatically and manually controlled blinds, will be raised after 11 seconds. The manual control cannot overrule this. When the wind speed is below the limit for at least 12 minutes, the blinds can go down again using the manual control or when the light intensity exceeds 16 kLux.

Clock function
The activation period is set from 6.00 A.M. till 9.00 P.M. During this time period the blinds will go up and down as mentioned or can be controlled manually. At 9.00 P.M. all blinds will go up automatically and cannot be adjusted until 6.00 A.M.

Tilting of the blinds
After given an automatic or manual command to adjust the positions of the blinds, the Mastercontrol automatically gives a turning pulse.

Manual control
When the switch is set at manual control, the user is able to raise and lower the blinds and adjust the angle of the outside blinds, provided the action takes place within the activation period and the system is not blocked because of wind security.

Automatic control
When the switch is set to automatic control, the users are able to adjust the outside blinds in the same way as the manual control. The difference is the blinds go down automatically as mentioned above. During an automatic up or down going movement of the blinds, it is not possible to overrule the system locally. When the blinds are lowered, the user is able to adjust the angle of the blinds or raise the blinds without changing the switch from automatic to manual.

3.2 Artificial lighting
The artificial lighting in the room is controlled by a presence based electric lighting system with daylight linked dimming. Occupants are not able to adjust the artificial light. The daylight linked lighting provides a constant illuminance and the presence detection puts the lights out when there is no movement in the room for a certain time interval.

3.3 Indoor climate
Satisfaction with the indoor climate depends on several physical aspects. The following aspects of indoor comfort are taken into account in the diary:

- Lighting (daylight and artificial light)
- Thermal comfort
- Indoor air quality (humidity, air velocity and ventilation rates)
- Noise

Because the use of blinds primarily influences visual and thermal comfort, those aspects are discussed more detailed in the next two paragraphs.

### 3.3.1 Visual comfort

Visual comfort is inter alia affected by light illuminance levels and perception of glare. Glare is a significant issue related to visual comfort, but is very difficult to measure. *(Kolokotsa et al., 2002)* The illumination levels, required to ensure comfortable conditions, are determined in international investigations, and are published in guidelines, standards and regulations. In order to achieve visual comfort, it is necessary to control the influence of luminance, and to adjust the glare index values determined for rooms with different functions. *(Koçlar Oral et al., 2002)*

Glare is the perceived brightness within the field of vision. Any strong light source may cause glare. The Daylight Glare Probability is the probability that a person is disturbed by daylight glare. This index is based on human reactions to daylight-based glare *(Wienold 2010)*.

Glare can also be quantified by a glare index. The glare index depends mainly on the window luminance and the reflections within the room. Glare is considered acceptable if the glare index (DGI) does not exceed the recommended level for the particular operation. Table 3.3.1 shows visual comfort at different glare indexes.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Region</th>
<th>DGI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discomfort zone</td>
<td>Intolerable</td>
<td>&gt; 28</td>
</tr>
<tr>
<td></td>
<td>Just intolerable</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Uncomfortable</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Just uncomfortable</td>
<td>24</td>
</tr>
<tr>
<td>Comfort zone</td>
<td>Acceptable</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Just acceptable</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Noticeable</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Just perceptible</td>
<td>16</td>
</tr>
</tbody>
</table>

*Fig. 3.3.1 Glare regions and their related glare index [Clear, Comfortable Low Energy Architecture]*

### 3.3.2 Thermal comfort

Thermal comfort can be defined as “that condition of mind which expresses satisfaction with the thermal environment” and is influenced by six parameters:

- Air temperature
- Mean radiant temperature
- Relative humidity
- Relative air velocity
- Thermal insulation clothing
- Activity level

*(Andersen et al, 2010)*
4 Results

The research should result in an overview of the influence of different aspects of the indoor climate on the use of the blinds in office rooms and satisfaction with the indoor climate of the automatic and manual users.

4.1 Diaries and physical measurements

The results from the physical measurements and the diaries can be found in the appendix VI. The results are given for each day separately. The first page gives an overview of the weather conditions for that day and the presence of the participants. The adjustments which have been performed are indicated in the graph together with the presence of the participants and the outside sun radiation. The next two pages give the results from the diaries of all participants. The adjustments, reasons for adjustments, and the perceived indoor climate are presented at those pages. The fourth and fifth page, give the results of the indoor physical measurements done in two office rooms. The adjustments which are performed in those rooms are integrated in the graphs. Judgments of the indoor climate of the two people in each room are given as well.

Monday the 28th of November has been provided below as an example and the results of that day are explained. This Monday was a sunny day with a low cloud cover. Between 9:00–9:30 A.M., five manual adjustments have been performed. About an hour after that the blinds went down automatically.

**Weather data**

(source: Koninklijk Nederlands Meteorologisch Instituut)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Temperature</td>
<td>4.2 °C</td>
</tr>
<tr>
<td>Max Temperature</td>
<td>9.7 °C</td>
</tr>
<tr>
<td>Min Temperature</td>
<td>4.1 °C</td>
</tr>
<tr>
<td>Duration of sunshine</td>
<td>7.3 hours</td>
</tr>
<tr>
<td>Relative sunshine</td>
<td>88 %</td>
</tr>
<tr>
<td>duration</td>
<td>1 octas</td>
</tr>
<tr>
<td>Cloudcover</td>
<td>Blue sky</td>
</tr>
<tr>
<td>Minimum visibility</td>
<td>300 - 400 m</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>89 %</td>
</tr>
</tbody>
</table>

**Presence**

*Automatic users (4/8)*

*Manual users (9/9)*

**Global sun radiation and presence**

(source: Koninklijk Nederlands Meteorologisch Instituut)

*Figure 4.1.1 Weather data and presence (28-11-2012)*
The people in the automatically controlled room did not perform any manual adjustments. The persons in the manually controlled room performed 12 adjustments to the blinds. From figure 4.1.2 it can be seen that only in 2 of 12 adjustments the blinds went up. Too much light has been mentioned as a reason to lower the outside blinds in 50% of the adjustments, figure 4.1.3.

The questionnaire consisted of separate questions about 5 aspects of the indoor environment (daylight, artificial light, room temperature, room acoustics, and air quality) and their judgment of the overall indoor climate. People could judge each aspect at a five point scale: 1 being uncomfortable and 5 being comfortable. The overall indoor climate could be ranked from 1 to 10: 10 being the most comfortable.

Automatic users give a better judgment for all separate aspects of the indoor climate. Judgment of the automatic users is more monotonous than the judgment of manual users. The average judgment of the overall indoor climate is a bit higher for manual users, 7.8 compared to 7.5. Perception of glare is about the same for manual and automatic users. These results can be found in figure 4.1.4 and 4.1.5.
Automatic users

Judgement indoor climate

![Graph showing satisfaction of automatic users](image)

*Figure 4.1.4 Satisfaction automatic users (28-11-2012)*

Manual users

Judgement indoor climate

![Graph showing satisfaction of manual users](image)

*Figure 4.1.5 Satisfaction manual users (28-11-2012)*

The results of the indoor climate measurements can be seen in figure 4.1.6 and 4.1.7. Both in the automatic and the manual room the blinds went down in the morning. However, the users in the manual room adjusted the blinds afterwards to decrease the amount of sunlight in the room and around 12:00 the blinds are rotated again to create a view. The users in the automatic room did not do any adjustment anymore.

The judgment shown in the tables is slightly more positive for the automatic user, 7.0 and 9.0 compared to manual users 7.0 and 8.0. These however, are personal judgments of the four people in the rooms where the measurements have been performed.
Influence of the indoor climate on the use of blinds in offices

Figure 4.1. Indoor climate measurements automatic room (28-11-2012)
Figure 4.1.7 Indoor climate measurements manual room (28-11-2012)
4.2 Blinds use

4.2.1 Differences in presence in office manual and automatic users
The presence of the participants in their office room has been analyzed. People who use the automatic control spend a bit more time in their office room than the ones who use the manual function. On average manual users are 6.6 days out of 10 present compared to 5.7 days for automatic users. Manual users spend on average 5.7 hours in their office room compared to 6.4 hours for automatic users. The graphs of these results are provided in appendix VII.

4.2.2 Number of adjustments per type of user (Lower, raise and rotate separately)
The number of adjustment of the inside and outside blinds during the ten day people kept a diary, are taken together. In the graphs of figure 4.2.1., a distinction has been made between the type of users, people who use the automatic control and people who use the manual control, and between the type of adjustments, lowering, raising and rotating blinds. The automatic adjustments are only counted for the rooms which were occupied that day. The black bars represent the automatic adjustments. Automatic users are also able to overrule the system, but they do not use that function that often.

From the graph it can be seen that the number of adjustments per type of user differs. Manual users make lot more adjustments than automatic users, 10 adjustments performed by automatic users and 62 adjustments performed by manual users. During those 10 days, the automatic users overruled the system 10 times and those adjustments have been performed by 2 persons. The other 6 persons did not do a manual adjustment at all.

The blinds were raised automatically 7 times, but this is because of the wind (not because of light intensity).

<table>
<thead>
<tr>
<th></th>
<th>Automatic users</th>
<th>Manual users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustments</td>
<td>Automatic</td>
<td>Manual</td>
</tr>
<tr>
<td>Lower blinds</td>
<td>37</td>
<td>29</td>
</tr>
<tr>
<td>Raise the blinds</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>Rotate the blinds</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

Fig. 4.2.1 Number of adjustments outside blinds

4.3.2 Reasons for adjusting the blinds
The adjustments of the inside and outside blinds are taken together and a distinction has been made between the different kinds of adjustment: lower the blinds, raise the blinds and rotate the blinds. However, no distinction has been made between manual and automatic users due to the small number of adjustments for the automatic users. The percentages represent for which part of the adjustments that aspect was given as a reason.
For lowering and rotating the blinds, glare is the most important reason respectively 70% and 55%.
For raising the blinds the most important reason, 52%, is to create a view. In 28% people mentioned other reasons which are:
- Like to have sunlight
- Very windy
- It is too dark
- More daylight
- I want more light even if it is not necessary to perform my tasks.

4.2.3 Perceived glare
As seen above, glare has been mentioned most often as a reason to lower the blinds. Therefore, the correlation between the weather data and the amount of perceived glare was analyzed. The weather aspect consisted of the cloud cover, the relative sunshine duration and the relative humidity.

In graph 4.2.3, the relative sunshine duration and the level of perceived glare are combined. The days, represented on the x-axes are ordered from the day with shortest to the day with the longest sunshine duration. The white bars represent the relative sunshine duration. The colors at the background represent the amount of perceived glare, from grey ‘no perception of glare’ to red ‘Intolerable perception of glare’. The number of people who gave a judgment about their glare perception differs per day.

When sun appears during a day, perception of glare occurs. The amount of relative sunshine duration does not really influence the level of perceived glare. The two other aspects, cloud cover and relative humidity did not seem to have a direct correlation with the level of perceived glare. Graphs with the combined results of glare and cloud cover and relative humidity are attached in appendix VIII.
4.2.4 Measured indoor climate at time of adjustment

Appendix IX shows the measured lighting intensity and air temperature at the moment of an adjustment. To compare the values during an adjustment, the same adjustments are combined in one graph. At t=1:00 hour, the adjustment took place. In the legend the absolute time of the adjustment can be found.

Per type of adjustment (raise blind manually, lower blinds manually and lower blinds automatically), the light intensity and temperature at each spot are given in different graphs. Figure 4.2.4 shows the example of the lighting intensity at the screen one hour before till one hour after manually lowering of the outside blinds. The lighting intensity during the adjustments which took place at ±9:30 A.M. are higher, around 6000 and 8000 lux, compared to the adjustment which took place between 10:26 and 11:14 A.M., around 4000 lux. This could be explained by a different position of the sun, so the occupant of the room perceives discomfort at a lower lighting intensity level at the screen.

Although the blinds go down automatically at a certain outside lighting intensity (16kLux), this does not result in constant indoor conditions during automatic lowering of the blinds. The lighting intensity at the back of the office is the most constant during an adjustment, between 700 and 1500 lux. The lighting intensity at the screen varies a lot but that mostly depends on the time of the adjustment. When the blinds were lowered automatically during the morning the lighting intensity at the spot of the screen is much lower than during lunchtime. The lighting conditions for both occupants are quite the same.
The lighting intensity at the back of the room in the manually controlled room reaches much higher values whereas, at the display the values are lower compared to the automatically controlled room. All lowerings of the blinds were performed by person 1. The graph shows a more constant and lower lighting intensity at person 1 at the moment of the adjustment compared to person 2. It could be because this person was not present in the room or accepts higher lighting intensities. Raising the blinds is only performed by person 2. The lighting intensity at that time is below 500 lux. Lighting intensity at person 1 was slightly higher.

During wintertime temperature is not a reason to change the position of the blinds, but from the graphs it is clear that it has a clear effect on the room temperature.

4.2.5 Activities and adjustments

Graph 4.2.5a shows when a colleague was present in the room at the time of a manual adjustment (32%). This could be because people do feel limited to adjust the blinds when their colleague is present in the same room which is different from outcomes of the interviews. Or it could be because people are not often together in the same room. Graph 4.2.5b represents the percentages in which someone adjusted the blinds when he or she changed his/her activity. Change of activity does not seem to be a direct reason to adjust the blinds.

4.3 Satisfaction

4.3.1 Satisfaction different types of users

In this paragraph satisfaction of different types of users will be compared to find out whether there is a difference between people who use the automatic control and people who use the manual control. This research focuses on daylight, so satisfaction of this aspect has been compared.

Graph 4.3.1.1 shows judgment over 10 days, during the whole experiment. The left graph shows satisfaction with the overall indoor climate. Rating between 1-10: 10 being the best, 1 the worst. The average of automatic users is 7.8 and of manual users 7.7. Manual users give a bit more diversified marks.

The right graph shows satisfaction with daylight. Rating between 1-5: 1 being comfortable, 5 being uncomfortable. The manual users are on average a bit more uncomfortable, difference of 0.4.
In appendix X, judgments of all the aspects of the indoor environment from automatic and manual users are compared. The differences between the average judgments are very small but the distribution is larger for manual users. They tend to be a bit more conscious about the indoor environment.

![Overall indoor climate and Daylight satisfaction for automatic and manual users](image1)

**Fig 4.3.1.1 Satisfaction indoor climate automatic and manual users**

Because there is only one controller in each room, only one occupant sits next to the controller of the outside blinds. The controller has been placed behind the desk of one of the two users. To verify whether this influences the satisfaction with the indoor climate, these two types of users are compared in the same way as has been done with people who use the manual or automatic control (fig 4.4.1.2). However, there is another aspect which could influence judgment of the indoor climate. All offices are situated at the south façade but because people sit opposite each other, some people face the east direction and some face the west direction (fig. 4.4.1.3).

People who sit at the control often face the east direction; seven out of nine. The results do not suggest there is a difference in satisfaction between people who sit or do not sit next to the controller of the outside blinds nor between people who face the east or west direction.

![Overall indoor climate and Daylight satisfaction for users at and not at the controller](image2)

**Fig 4.3.1.2 Satisfaction indoor climate people who sit (not) at the controller**
Other aspects of the indoor climate can influence satisfaction of daylight when they are very disturbing. Comfort levels of artificial light, room temperature, room acoustics and air quality are attached in appendix X.

From all aspects of the indoor climate, daylight has been given the worst judgment, see table 4.3.1.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Daylight</th>
<th>Artificial light</th>
<th>Room temperature</th>
<th>Room acoustics</th>
<th>Air quality</th>
</tr>
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<tbody>
<tr>
<td>Average</td>
<td>2.23</td>
<td>1.72</td>
<td>1.86</td>
<td>1.63</td>
<td>1.69</td>
</tr>
</tbody>
</table>

Table 4.3.1 Satisfaction indoor climate all aspects separately (1=comfortable -> 5 = uncomfortable)

Finally there are some personal factors which could affect the results. These are gender, age, visual aids and eye color. Comparison has been made and has been attached in appendix X as well. Comparing female and male, female seem to be more critical. This is in line with the comparison between automatic and manual users because in 4 of the 5 rooms which are controlled manually there is at least one woman present, compared to only one woman in five automatic rooms.

4.3.2 Influences blinds on the indoor climate

As seen in previous results, the blinds movements in automatically rooms have different frequencies as manually controlled rooms. The influence of those differences on the indoor climate can be seen in table 4.3.2 and graph 4.3.2. It is expected the values of the lighting intensity and the temperature are higher in rooms which are controlled manually because in these rooms the blinds are open more often.

The values in the table and graph are from measurements in only two rooms. The result at the spot of the occupants can also be seen in appendix X where, inter alia, the automatic and manual rooms have been compared.

Temperature in the manually controlled room is indeed higher but the average lighting intensity is not necessarily higher. This could be because the intensity of the artificial light adjusts automatically depending on the light intensity in the room. Energy use of lighting is necessary to determine the contribution of daylight to the total lighting intensity.
Influence of the indoor climate on the use of blinds in offices

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Light at screen</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto</td>
<td>664</td>
<td></td>
<td>10509</td>
<td>1123</td>
<td>4264</td>
</tr>
<tr>
<td>Manual</td>
<td>505</td>
<td>0</td>
<td>8854</td>
<td>672</td>
<td>4302</td>
</tr>
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<td><strong>Light back of office</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Auto</td>
<td>374</td>
<td>0</td>
<td>908</td>
<td>229</td>
<td>4190</td>
</tr>
<tr>
<td>Manual</td>
<td>432</td>
<td>0</td>
<td>5039</td>
<td>324</td>
<td>4278</td>
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<td><strong>Light P1</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto</td>
<td>290</td>
<td>0</td>
<td>1720</td>
<td>298</td>
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<tr>
<td>Manual</td>
<td>291</td>
<td>0</td>
<td>3578</td>
<td>349</td>
<td>4330</td>
</tr>
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<td><strong>Light P2</strong></td>
<td></td>
<td></td>
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<tr>
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<td>0</td>
<td>1778</td>
<td>220</td>
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<tr>
<td>Manual</td>
<td>369</td>
<td>0</td>
<td>11230</td>
<td>777</td>
<td>4305</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature back office</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto</td>
<td>22,11</td>
<td>20,63</td>
<td>23,31</td>
<td>0,49</td>
<td>4412</td>
</tr>
<tr>
<td>Manual</td>
<td>22,89</td>
<td>21,35</td>
<td>24,24</td>
<td>0,48</td>
<td>4412</td>
</tr>
<tr>
<td><strong>Temperature P1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto</td>
<td>21,73</td>
<td>20,02</td>
<td>23,77</td>
<td>0,68</td>
<td>4014</td>
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<tr>
<td>Manual</td>
<td>22,43</td>
<td>20,35</td>
<td>24,41</td>
<td>0,71</td>
<td>4412</td>
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<tr>
<td><strong>Temperature P2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto</td>
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<td>20,01</td>
<td>23,47</td>
<td>0,64</td>
<td>3365</td>
</tr>
<tr>
<td>Manual</td>
<td>22,73</td>
<td>20,74</td>
<td>27,80</td>
<td>0,74</td>
<td>4412</td>
</tr>
</tbody>
</table>

Table 4.3.2 Values indoor climate automatic and manual room

### Fig 4.3.2 Average values indoor climate automatic and manual room

#### 4.3.3 Different conditions indoor climate

In appendix XI an overview is given of the differences between the temperature and lighting intensity at the spot of person 1 and person 2 for the manually controlled room and the automatically controlled room. For each day the progress of these values has been given. The average temperature differences can be found in the previous paragraph in table 4.3.2.

During the morning the light intensity at P2 is higher than at P1. Depending on the position of the blinds, the opposite is true during the afternoon. This effect is most visible on days with a lot of sunshine.

The difference between P2-P1 is larger in the manual room. Likely because the blinds are more often (partly) open in manual rooms and therefore more influenced by outdoor conditions. The differences between P2 and P1 are more visible in the temperatures than in the light intensity measurements.
4.3.4 Luminance

The Daylight Glare Probability (DGP) and the Daylight Glare Index (DGI) have been explained shortly in chapter 3.2. Table 4.4.4 shows the visual comfort at different glare indexes.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Region</th>
<th>DGI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discomfort zone</td>
<td>Intolerable</td>
<td>&gt; 28</td>
</tr>
<tr>
<td></td>
<td>Just intolerable</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Uncomfortable</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Just uncomfortable</td>
<td>24</td>
</tr>
<tr>
<td>Comfort zone</td>
<td>Acceptable</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Just acceptable</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Noticeable</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Just perceptible</td>
<td>16</td>
</tr>
</tbody>
</table>

*Table 4.4.4. Comfort levels DGI*

As explained, the DGP has been calculated from 7 pictures with different shutter speed. In appendix XII, each image shows the relative luminance, because the camera has not been calibrated it is not possible to calculate the absolute values. The colored surfaces at the image below indicate the luminance sources.

Because there was only one camera with a fisheye lens available, it was not possible to measure in both rooms at the same time. Due to some problems with the lifespan of the battery, not as many pictures have been made as planned. For some moments the outside illuminance is known and added, at the other moments the sensor at the roof did not register the illuminance. From the pictures which have been made, the following can be derived:

- Glare indexes are higher during the morning compared to the afternoon,
- Because of the position of the sun, luminance at the spot of P2 is higher in the morning and lower in the afternoon than P1.
- The white wall at the right is an important glare source.
- Only when there is very much sunlight, glare can occur while the outside blinds are fully closed.
- From these 32 measurements it seems that a DGP around 0.26 and a DGI around 20.0 is normative to close the blinds in the manual room. The moment before the automatic adjustments the DGP and DGI were a bit smaller, respectively 0.22 and 18.0.

4.4 Interviews

After keeping a diary, all participants were interviewed afterwards about their experience during the ten working days, (see questions in appendix III). Below a summary of the interview results.

Overall, all participants are positive about the indoor climate. However, people mention aspects they do not find comfortable. Two people mentioned dry air and five people temperature as somewhat uncomfortable. Opinions about the temperature vary. Three people say it really depends on the weather: when the sun shines it is warm, when the sun is gone it is cold. Another participant mentioned: “Positive and constant.”(R8)

Interaction with the outside is important, people mention daylight, sunlight and a view. They accept glare to get daylight. The amount of glare people accept depends on the activity people perform. When
Influence of the indoor climate on the use of blinds in offices

Glare is too much to perform tasks, people regulate “daylight. “Why I find artificial light uncomfortable? Just because it is not daylight. I noticed that I accept glare just to get daylight. And I did not raise the blinds because I want to create a view or more light, but to receive daylight.” (R4)

Nobody answered that the automatic function works properly. Blinds go down when you do not want them to and vice versa. Automatic users mentioned that as well but they do not want to spend time on adjusting the blinds. They change the position of their screen or chair to prevent glare. “The switch is on automatic, it does not work well, but it is difficult to improve it so it is okay” (R15)

“I do not like the really heavy blinds, which really darken the room.” (R11)

Most people do not think their behavior was influenced by the research and believed they acted as they normally do. Five respondents said it is possible their behavior was slightly influenced because they were more conscious of their behavior. Besides that about half of the participants mentioned they were more aware of the conditions of the indoor climate. “If you ask me at a specific moment, I probably find something uncomfortable but normally I am not aware of that. It made me more conscious of my opinion of the indoor climate” (R2). This however did not influence their behavior.

During the measurement period the participants experienced there was a lot of sun compared to the weeks before. According to four participants this resulted in more blind adjustments than usual to prevent glare. “The low position of the sun causes more discomfort because the system does not seem to react on this position.” (R1)

All participants feel in control of regulating the amount of daylight and sunlight in their office room. Automatic users say they feel in control as well, because they are still able to overrule the system if they want to. However, a few people mentioned the system does not always function. Because of that they have to use the inside blinds which do not prevent glare as good as the outside system, since light penetrates between the blind and the window frame.

There is one controller for the outside blinds in a room and it is positioned next to the desk of one of the participants. People who do not sit at the control say it is a barrier for them to adjust the outside blinds. They rather use the inside blinds. From the people who do sit at the controller, nobody mentioned they find it disturbing that there is only one control or that they experience nuisance from their colleague.

Another barrier mentioned by three respondents is the difficult interface. They say the system does not do what you expect it to do after a specific action. “I would prefer an easier control. The amount of control is enough.” (R16) “Last time I wanted to use it, I looked for the button to put it down and then for the button to stop and rotate, but I do not know how to do it” (R12)

One participant mentioned it is unnecessary to have both inside and outside blinds. “Strange that there are two blind systems, you can sell one of them.” (R3)

The feeling of control over artificial light is however not sufficient. This is regulated by a sensor but people are not able to overrule that. “I cannot control the artificial light system and that is a problem sometimes” (R12) “Especially in a research building you would expect more stimulating lighting” (R13)

Most people think the blind system reacts on the amount of light or sun radiation which is measured at the outside of the building, for example on the roof. Two people say it will depend on the angle of the sun, others do not mention the position of the sun. However, most of the participants did not think about the working mechanism behind the automated blinds before the start of the study. “I have no idea when, I assume it will react on sunlight.” (R2) “I think there is a sensor which tries to think whether there is much annoying light, if so all blinds will go down simultaneously unless you use the manual
function.” (R4) Temperature has been mentioned only once as an aspect which is normative to automatically adjust the blinds. One person did not even know the automatic control exists, another thought the blinds go down depending on what most manual users do and another person said the blinds go up and down at random.

People have different opinions about the reactivity of the system. “The automatic blind system is not very reactive. It often takes too long before the blinds go down.” (R7) “The blinds go down quite quickly and go down fully, that is a shame.” (R10)

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. “I like to have light in my face, even though it causes glare. That is different during summertime because then temperature rises too much.” (R5) Glare has been mentioned most often (50 %) as a reason to lower the blinds. Computer screens become unreadable because of glare. Glasses increase that effect.

Most manual users say they raise the blinds when glare has disappeared. Automatic users say they like daylight but just do not think of raising the blinds again.

Most of the automatic users just do not make any adjustments. “I do not want to spend time on adjusting the blinds, I avoid glare by sitting differently.” (R1)

Almost everyone mentioned daylight as very important. “I prefer daylight; I rather have daylight with a lower lighting intensity than using artificial light.” (R13) “View is important, so I do not feel enclosed that much.” (R12)

Nobody mentioned that energy usage influences their use of the blinds systems. Most people did not even think about it, or knew it was possible. Only four people explicitly say that they do know it is possible, but they do not do it. They prefer to create a visual comfortable workplace. Others say they cannot influence it. “I do not control the artificial light so I cannot influence the energy use of that. And I can imagine that it contributes to the heating of the room, but I do not turn off the heating when I leave the room.”

Most people do not feel limited by their colleague to adjust the blinds. However, their behavior would be slightly different if they had a room of their own. However, they do not mind adjusting to the preferences of their colleague. The fact that the control is situated behind the desk of their colleague does limit the use. “The controller is hidden behind the desk of my colleague, if I could use it more easily, for example at my computer, I probably would use it more often.” (R1) “We agree about the position of the blinds. If my colleague experiences glare, I agree with his adjustment, although I would prefer daylight.” (R4) “It makes sense; the sun at my side is stronger because it is in the morning” (R12)
5 Conclusion

The aim of this research has been to investigate the influence of the indoor climate on the use of blinds in offices and the satisfaction of users with the indoor climate. A distinction has been made between persons who use the automatic function and persons who use the manual function.

5.1 Conclusion

How does the indoor climate influence the use of the blinds?

The aspect of the indoor climate which has been mentioned in 70% of the cases as a reason to lower the blinds is glare. People perceive glare during days when sun radiation occurs. The amount of sun radiation does not seem to influence the level of perceived glare.

Creating a view has been mentioned the most often, 52%, as a reason to raise the blinds. The interviews with the participants confirm that a connection with the outdoor environment is an important aspect in satisfaction with the indoor climate. People accept more discomfort when they have interaction with the outdoor environment.

Energy has not been taken into consideration using the blinds. People do not think about it or even do not know sunlight and daylight influence energy usage. Reasons to adjust the blinds all deal with the amount of light and connection with the outdoor environment. Temperature has been mentioned only three times.

Manual users do use the blinds more often: 62 adjustments performed by 9 manual users spread over 5 offices compared to 10 manual performed adjustments by 8 automatic users spread over 5 offices. The blinds do not go up automatically (only time based or due to wind security) manual users however, do put them up. Because of that, the temperature in the manually controlled room is higher and it is expected that in those rooms less artificial light is necessary to reach a certain lighting intensity.

The position of the blinds influences the indoor illuminance and the air temperature. For both the automatically as well as the manually controlled room, there does not seem to be one particular value which is normative to changing the positions of the blinds. In the manually controlled room the lighting intensity at the spot of the person who performed the lowering of the blinds is within smaller limits. For raising the blinds the lighting intensity is below 500 lux at the spot of the person who changed the position of the blinds.

Having only a control behind the desk of a colleague has been mentioned several times as a barrier to adjust the blinds. Except that, two other things prevent from doing adjustments. Three people indicated the interface to control the outside blinds is unclear for them. Outcomes of the diaries suggest that people do more adjustments when their colleague is not in the room, during 68% of the adjustment there is no colleague in the room.
What is the difference in satisfaction with the indoor climate between the two types of users: manual and automatic users?

Comparing the comfort level of people who use the automatic function and people who use the manual function, the average satisfaction seems to be the same: an average of 7.8 for automatic users and 7.7 for manual users. However, manual users give more diversified marks. They tend to be more aware of or critical about the indoor climate. This is confirmed during the interviews. 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.

From the interviews the following can be stated

- Nobody says the automatic function works properly. Automatic users confirm that as well, but they do not want to spend time on adjusting the blinds. They prefer to accept some discomfort.
- There is only one control at each room which is placed behind the desk of one of the two users. For the other person it is a barrier to adjust the outside blinds with this control. Those users say it is more easy for them to use the inside blinds.
- Almost all participants say they usually agree with the adjustment performed by their colleague and that it only would not differ when they would have room for their own.

Both types of users have a feeling of control to regulate daylight and sunlight intensity. The type of control people use does not influence the feeling of control, because they are always able to overrule the system if they want to. The fact there is only one controller in each room is a barrier, but does not limit the feeling of being in control; during the interviews all participants mentioned they feel in control of the blind system.

Results from the measurements show different indoor conditions for person who face the east and persons who face the west direction. This does not translate into differences in satisfaction. There does not seem to be a relation between presence in office room and the choice between the manual or the automatic function. However, female are more likely to choose the manual function.

Daylight and interaction with the outdoor environment are important; therefore people are very critical about it. It changes during the day and season and because of that it is hard to control.

Automatic and manual users seem to have a different approach dealing with discomfort. Manual users change the position of the blinds, while automatic users change position or accept discomfort. There are different indoor conditions at different spots of the room, within acceptable limits, but this does not influence judgments that much. Assuming that their judgment is influenced by the indoor climate and the feeling of having control, the latter aspect seems to be more important because all participants have the feeling of being in control but are exposed to different indoor climate conditions. In the measured rooms, daylight and sunlight is used more efficiently in the manually controlled room.
5.2 Discussion
There are several aspects which are important to take into account interpreting the results of this survey:

- The number of participants was small and many varying parameters. The same conditions never occurred by different persons so situations and judgment are hard to compare.
- The adjustments done by the automatic users only included 2 persons. The other 6 people did not do any adjustments at all.
- Judgment of the indoor climate took place only at the end of the day, and therefore could be influenced by conditions at that time.
- Some people have difficulties with the interface and do not know how it functions, so this could have influenced their behavior.
- There might be different interpretations by the participants of the term comfortable.

5.3 Recommendations
This research provides starting points for further research:

- This study is done during winter. The same study during summer will give different results due to the position of the sun and different indoor conditions. An investigation could be done to indicate the importance of a different (use of the) system during the different seasons.
- A study could be done to investigate the activities in relation with the use of blinds. How do activities influence the use of blinds and the need for different ways to control the system?
- Investigate the influence of different interaction solutions to control the blinds.
- Investigate differences in acceptance of automatic systems with different functioning principles: react on position of sun, indoor or outdoor conditions, light intensity or behavior of other users.
- Investigate the influence of the amount of control. Although there were two different systems in this survey, everyone felt in control because they were able to choose the manual or automatic function and were able to overrule the system.

Recommendation for making a questionnaire:

- Define the term ‘comfort’ as clear as possible so no misinterpretation can occur. People find it hard to give a level of (dis)comfort.
- Keep a clear format so people can easily see where they have to fill in their answers and do not miss anything when they fill in the questionnaire quickly.
- Be aware of the fact that people are influenced by how they feel when they fill in the questionnaire.
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Marije te Kulve
Student Building Physics and Systems

Eindhoven University of Technology
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// Appendices

I  Profile participants
II  Diary and bind adjustments
III  Questions interview
IV  Specification sensors
V  Planning
VI  Results per day
VII  Presence office room automatic and manual users
VIII  Glare
IX  Values indoor climate at moment of adjustment
X  Satisfaction indoor climate
XI  Differences measurements automatic versus manual and P1 versus P2
XII  Luminance
XIII Philips Demo Quick Guide