THE ROLE OF DAYLIGHT ON USERS' SEAT PREFERENCES

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Abstract

Seating that meets the needs and preferences of students can promote a longer stay in libraries and keep students motivated, which in turn influences their emotions and learning abilities. However, existing knowledge on the interaction between daylighting and seating preferences is limited. This study aims to understand what type of spaces are in more demand and the relationship between seat occupancy and daylight availability. Occupancy data of the UCL Bartlett library acquired from motion sensors located underneath each desk was used to assess occupancy, which was then compared to characteristics of space, including daylight availability. The study revealed that although daylight has a considerable impact on students' seat selection, the seating preference of the students cannot be explained by daylight alone. The seats with a good combination of daylight, outdoor view and privacy are in more demand compared to seats that provide only a high level of daylight. Future research should involve individual perception in addition to occupancy monitoring data, considering daylight conditions together with other components such as privacy, outdoor views, and quietness.

***Keywords*:** Daylight, Seat preference, Occupancy monitoring, Sensors

1 Introduction

The expectation of occupants and their behaviour in the built environment could vary depending on the building type, building design features, climatic conditions, type of activity (Delzendeh et al., 2017), and people's personalities (Nel and Fourie, 2016). Understanding occupants behaviour and their interactions with the indoor environment could provide insights into how to improve occupants' satisfaction (Paone and Bacher, 2018) and the energy efficiency of a building (Andersen, 2009) (Fabi *et al.*, 2012). For instance, understanding the reasons behind selecting a particular seat in an environment could help inform the strategies to improve occupants' satisfaction and maximise the benefit of an environment such as a library that has an essential role in enhancing students' achievements.

The seat selection process results from the individuals' prior experiences in a space or a deliberate choice among alternatives while entering the space (Stone, 2002), regardless of whether deciding consciously or unconsciously (Kahneman, 2011). Seating selection is different for individuals familiar or unfamiliar with a space's physical settings (Keskin, 2019). The human response to the physical environment is strongly subject to prior experiences (Boyce, 2014). For example, library users could repeatedly choose the same seat depending on prior experiences, whereas first-comers need to rely on external sources such as existing lighting conditions, noise level, etc. The availability of seats at a particular time could also influence seat selection; individuals who arrive earlier at the library have more chances to select a seat than those arriving later. Individual differences, namely arousal, motivation, and expectation, also matter in human behaviour (Boyce, 2014), influencing the decision-making process. All these factors considered together could make a difference in individuals' seat preference behaviour.

Linking the seating behaviour of individuals with a particular stimulus in the physical environment is quite difficult because individuals are exposed to multiple sources of information during the seat selection process. The behavioural response to a physical stimulus in an environment is not directly associated with its magnitude, but with the interaction of the people and the environment, they are exposed to (Boyce, 2014). According to Barker et al.(1978), human behaviour in a space could be explained by the physical environment conditions they are exposed to rather than individual characteristics. Barker et al.(1978) proved that human behaviour shows similarity against a set of physical object arrangements (i.e. chairs and desks) regardless of the individual differences.

The factors influencing seating behaviour in the learning environment have been defined in various studies as ambient temperature, type of furniture, proximity to other occupants (Dubois, Demers and Potvin, 2009), quietness, outdoor view, privacy, social interactions such as close to friends, entrance or circulation (Gou, Khoshbakht and Mahdoudi, 2018), daylight (Keskin, Chen and Fotios, 2017) (Othman and Mazli, 2012), students' degree of territoriality and seat arrangements (Kaya and Burgess, 2007). It is also known that when choosing a space, individuals tend to value a few specific variables rather than evaluate each environmental variable equally (Keskin, 2019). For example, the impact of daylight on seating behaviour is also affected by the variations in other factors that influence the decision-making process, and the role of daylight in seat selection remains hidden behind them (Boyce, Hunter and Howlett, 2003). The underlying processes of seating behaviour within a specific physical environment have not been completely understood yet.

The spatial orientation of an individual relies on the interpretation of changing retinal images and the updating of this information whilst walking through a space (Cuttle, 2008). The received visual information with auditory and tactile senses is used to decide on location, position and movement (Keskin, 2019). Therefore, as a part of the dominant source of sensory information (vision), daylight is regarded as an essential component for the spatial orientation of an individual. It gives individuals a sense of place with the changing intensity and direction of illumination over time (Keskin, 2019) and potentially influences their spatial orientation within an environment (Boyce, 2014) (Dubois, Demers and Potvin, 2009).
The luminous environment could impact individuals' decision-making process in remaining at the same location or moving somewhere else. In the case of changing the location and ultimately luminous environment, individuals may develop a sense of awareness of the luminous similarity or contrast (higher or lower amount of illumination) with other spaces. In other words, they put the spaces in luminous order during their seat selection (Flynn, J E; Segil, A W; Steffy, 1988).

The type of task to be also performed matters for the importance of daylight on seat selection. For example, visual tasks that require greater attention, such as reading, may influence individuals to choose particular locations with mostly higher daylight levels (Flynn, J E; Segil, A W; Steffy, 1988) (Steane, 2011). However, in some situations, people may need a place to focus with less awareness of sensory information arising from their external environment (Steane, 2011). For instance, during exam periods, privacy and quietness are more critical aspects for students (Cox, 2018) (Walton, 2006) than daylight levels.

This study aims to investigate the impact of daylight availability on the students' seating selection in order to understand how to improve the students' satisfaction with a space and reduce energy consumption.

2 Methodology

2.1 Field site

The study was carried out in the UCL Bartlett library located on the ground floor of a six-storey building. The library comprises three main study areas (Figure 1) with different layouts and lighting designs. Room 1 has eight shared desks and four individual cubicles, Room 2 has twelve shared desks and eleven individual desks, and Room 3 has thirty-two shared desks. In terms of daylight, Room 1 has two north-facing side windows, and Room 2 has several side windows facing north and east orientations. Room 3 is an open plan space with two skylights.

Figure 1 – Plan of the Bartlett Library

2.2 Occupancy monitoring

The utilization of seats in each UCL library has been monitored and recorded on a 10-minute basis since 2017 (UCL, 2017). The purpose of monitoring the occupancy of 4,000 seats is to provide students with real-time availability of the study space via an app called UCL Go!. The app aims to help students save time, enabling them to choose an adequate study space according to their needs and expectations, which in turn will have a considerable impact on students' academic performance (Will, Bischof and Kingstone, 2020).

Occupancy data was obtained from PIR sensor boxes (infra-red technology) attached to the base of each desk that detect if the desk is available. The information regarding whether the particular desk is occupied at a specific time is sent to OccupEye Cloud and is plotted using a range of red and green colours that indicate for what percentage (%) the desks have been occupied (Figure 2). This study has analysed data recorded from the Bartlett Library between 2018 and 2019.

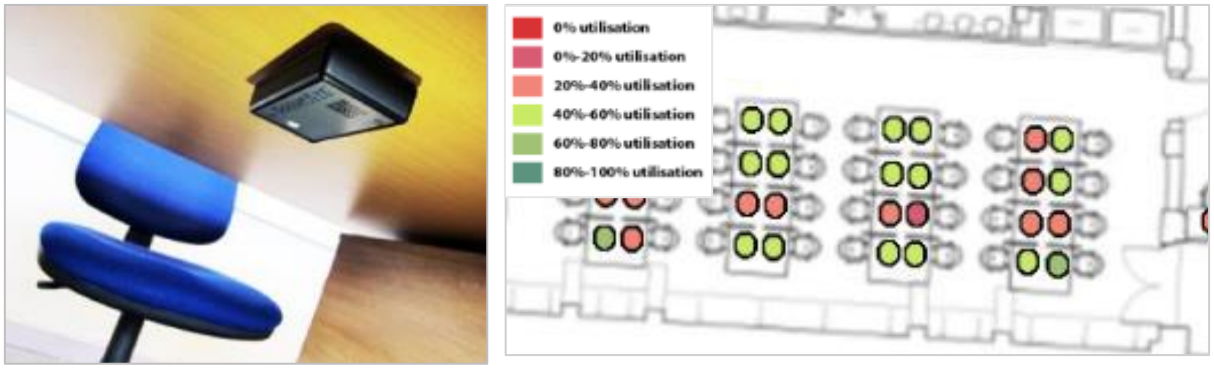

Figure 2 – PIR sensor boxes (left)
Representation of occupancy at each seat in Occupeye Cloud (right)

2.3 Quantification of daylight availability

In order to analyse the role of daylight availability on seating selection, AutoCAD and Rhino were used to produce 2D and 3D drawings of the library. Then, Grasshopper was used to create lighting performance analysis for the parametric modelling with Ladybug and Honeybee plugins.

Spot illuminance measurements were taken using a KONICA MINOLTA illuminance meter and luminance gun meter. The measurements were used to calibrate the developed model.

2.4 Procedure and methods of analysis

The data obtained from the UCL library occupancy monitoring system was analysed to understand what type of spaces were most in demand in the library and the role of daylight on seating selection. The data used in the analysis considered the utilisation of desks between 9:00 and 20:00 on weekdays and between 11:00 and 18:00 on Saturdays, between the 1st of January 2018 and 1st of January 2019. The data were analysed in the following ways:

- ***The desks/ rooms in most and least demand:*** The annual occupancy of each desk was analysed to investigate the desks and rooms with the most and least demand, hence, the popularity of the desk and its relationship with daylight availability.

- ***Order of preference of desks:*** The degree of freedom of choice could influence the seating decision because individuals can choose only available seats. For instance, they could have more chances to select desks early in the morning than those who arrive in the afternoon. Thus, the selection of desks in the morning hours was analysed.

  The analysis was conducted for weekdays from 9:00 to 12:00 at 30 min intervals. The seating pattern on a typical day was defined considering the percentage of the time a desk was occupied between 9:00 and 12:00 for an entire year (Table 1). If a desk was occupied at equal or more than 90% of the time, then that desk was regarded as occupied (Figure 7).

DESK 1	9:00-9:30	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00
01.01.2018	1	1	1	1	0	1
02.01.2018	1	0	1	0	1	0
03.01.2018	0	0	0	1	0	1
04.01.2018	1	1	1	1	0	1
⋮	⋮	⋮	⋮	⋮	⋮	⋮
31.12.2018	1	0	1	1	0	0
The utilization of Desk 1 on a typical day	The percentage of occupied cases/ Total cases	The percentage of occupied cases/ Total cases	The percentage of occupied cases/ Total cases	The percentage of occupied cases/ Total cases	The percentage of occupied cases/ Total cases	The percentage of occupied cases/ Total cases

Table 1 – Method of analysis for the occupancy of each desk at a specific time interval
(1: occupied, 0: unoccupied)

- ***Length of stay at the same desk:*** This method aims to understand how long a desk was utilised without interruption or becoming vacant on a typical day. The analysis was conducted for weekdays from 12:00 to 20:00 with an hour interval. The seating pattern on a typical day was defined considering the percentage of the time a desk was occupied between 12:00 and 20:00 for an entire year. If a desk was occupied at equal or more than 90% of the time, then that desk was regarded as occupied.

3 Results and Discussion

As seen in Figure 4, the library reaches maximum occupancy in Springtime (March, April, May), whereas there is not much demand in Summer. April and September are the most and least busy times of the library, respectively. Mondays seem to be the busiest days, while Saturdays are the quietest. On a weekday, the library reaches the first peak occupied time at around midday and then the second one at around 15:50. In contrast, the busiest time in a day is around 15:30 at the weekend (Figure 4)

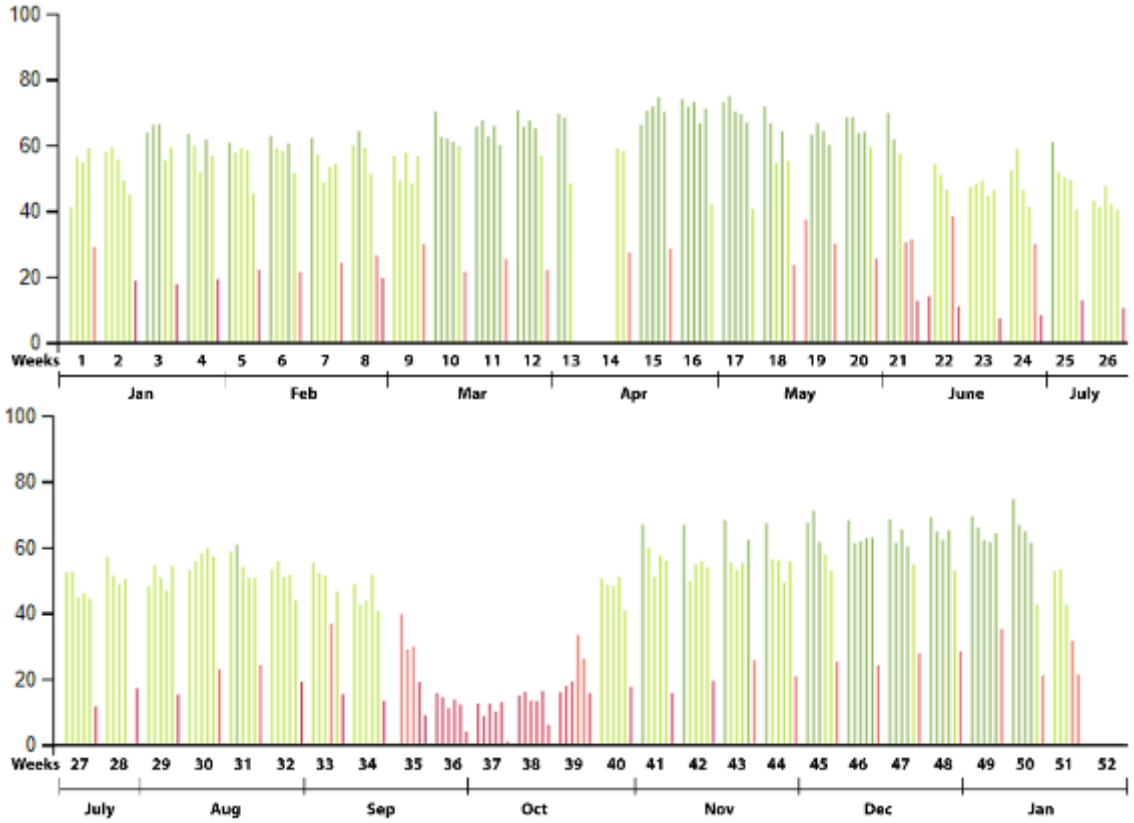

Figure 3 – Occupancy of the Bartlett Library (Jan 2018 to Jan 2019)

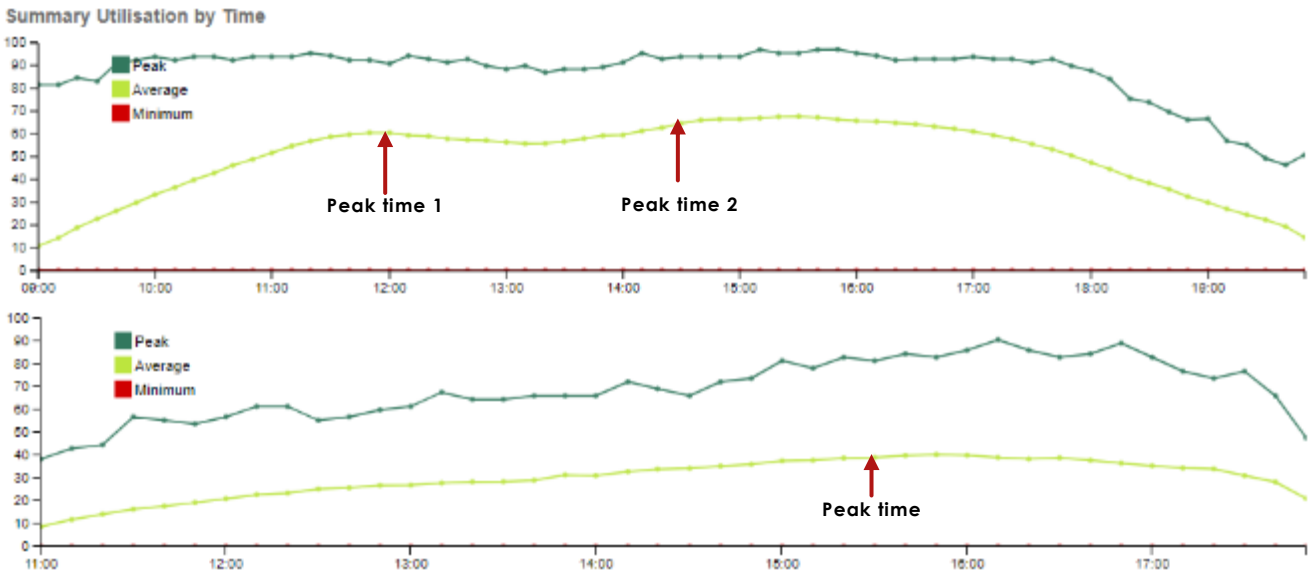

Figure 4 – Daytime occupancy during weekdays (top) and weekend (bottom)

3.1 The desks in most and least demand

Figure 5 shows that the most preferred desks are located in Room 2, which has access to daylight and an outdoor view. In this room, the individual desks were in higher demand than shared desks. Desk 32, an individual desk with both daylight and outdoor views, is the desk with the highest demand. The least utilised desk is Desk 35; it lacks access to daylight and outdoor view and privacy as it is located close to the circulation between Room 2 and 3.
The desks in Room 2 were positively appraised by most participants even though they have lower daylight levels than the desks under the skylights in Room 3. This preference could be explained due to the absence of an outdoor view of Room 3 and its open-plan layout, hence the lack of privacy.

Figure 5 – Utilisation level of each desk and daylight availability

3.2 The rooms in most and least demand

As previously stated, Room 1 and Room 2 have several side windows allowing the students to have desks with access to daylight and outdoor views in contrast to Room 3, illuminated by skylights without access to outdoor views but with high daylight levels, especially at some desks. As seen in Figure 6a, desks with higher daylight on the horizontal plane and illuminated by side windows are those with higher utilisation. The highest utilization belongs to desks near a window followed by desks with access to outdoor view and less daylight. The least utilized desks are desks with no outdoor view and the least daylight. Although daylight does not seem to affect the utilization of desks lit by the skylights in Room 3 (Figure 6b), desks under the skylight still show the highest utilisation. It can be concluded that daylight promotes seat selection in places daylit by the side windows; however, the importance of daylight on seat selection under the skylight is minimal.

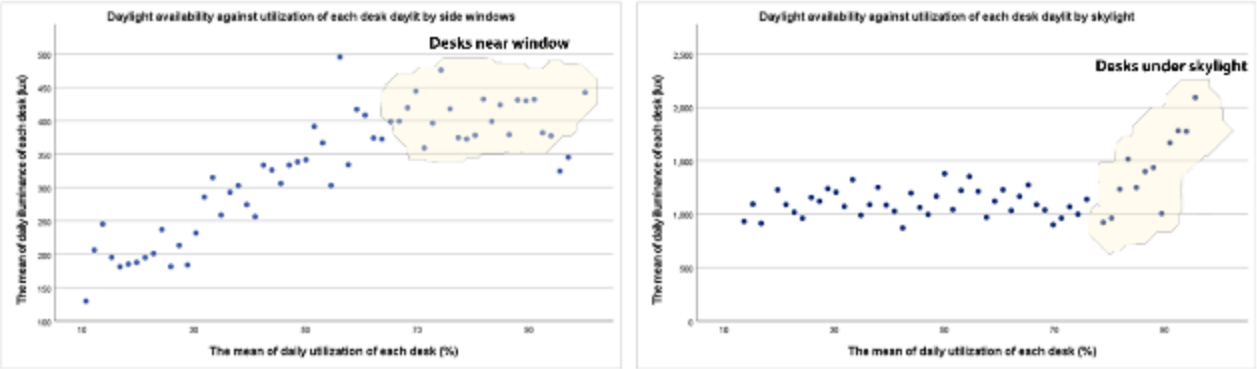

Figure 6 – Daily illuminance against daily utilization of each desk lit by side windows (a) and skylights (b)

Access to outdoor views and acceptable daylight levels make certain seats more preferable than seats with only adequate daylight levels, such as those in Room 3. Privacy could also be affecting the selection of seats in Room 3 (open plan). These findings emphasise that although daylight is one of the most important factors for seat selection, seat preference cannot be explained by daylight alone. It should be investigated together with other components such as privacy, outdoor views, and quietness.

3.3 Order of preference of the desks on a typical day

Figure 7 presents the association between the order of preference for the desks between 9:00 and 12:00. As seen, first comers to the library mostly prefer the individual desks in Room 2. These desks mostly have a good combination of daylight, outdoor view and privacy, but they are not necessarily the ones with the highest daylight availability. Following, students seem to prefer the shared desks in Room 2 with an outdoor view and comparatively less daylight availability and less privacy. After the desks in Room 2 are fully occupied (between 10:00-10:30), students select desks in other rooms, mostly with the highest daylight levels initially. After all, desks getting a high amount of daylight in Room 3 are fully occupied, students begin to select the other desks in the same room with the lack or insufficient daylight levels. These desks are mostly with the least daylight availability with no privacy and no outdoor view. Corner desks were more preferable in this period because they are comparatively more private. Although some desks in Room 1 have access to daylight and outdoor view like Room 2, some of them are not preferred by students. It could be explained that Room 1 has a North orientation and is comparatively darker than Room 1, especially in the early morning hours. These findings show that a high amount of daylight promotes people to select particular places; however, the role of daylight should be considered with the combination of other factors.

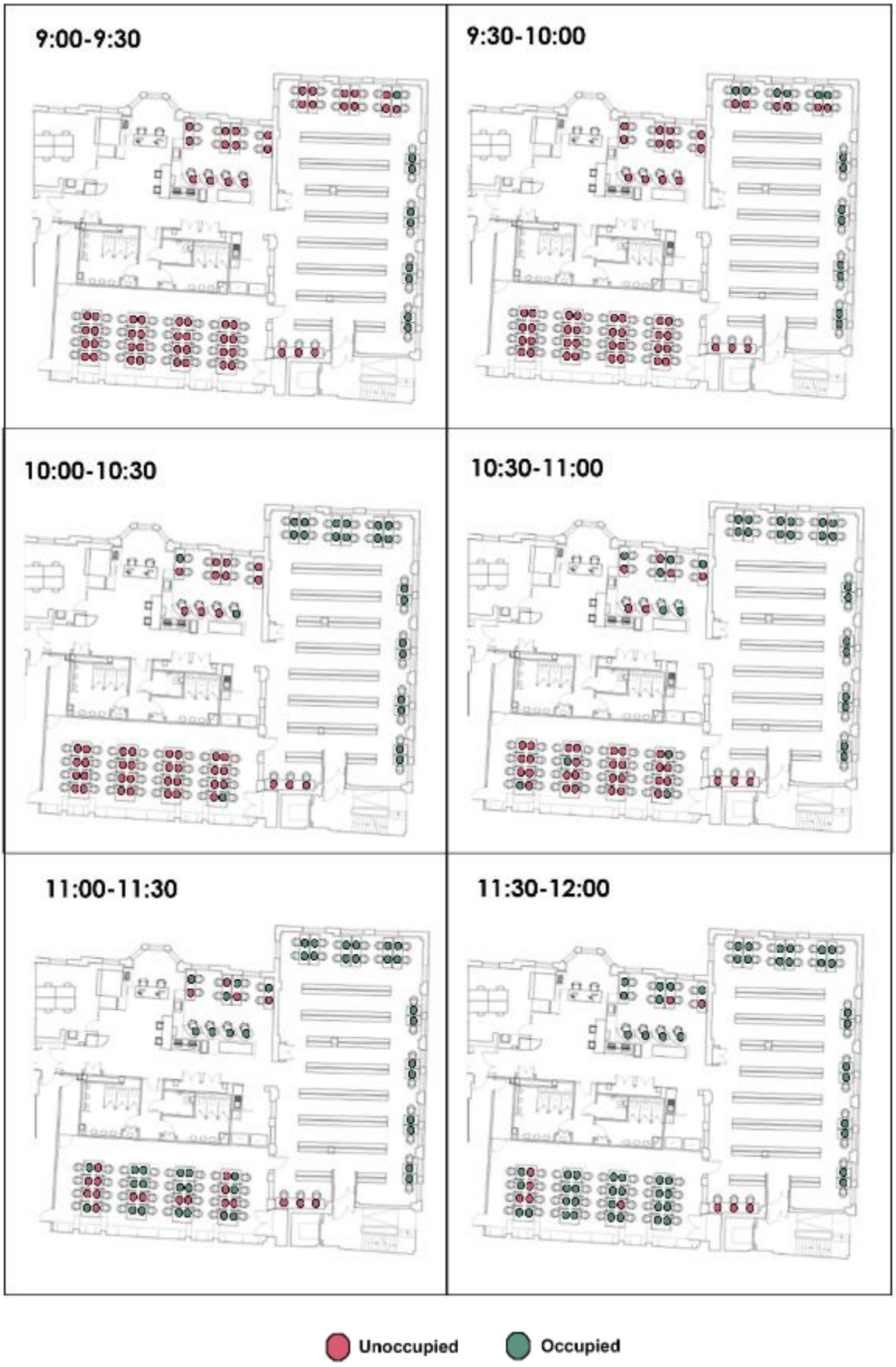

Figure 7 – Seating preference of the students in the early hours on a typical day

3.4 Length of stay at a desk

In terms of length of stay at the same desk, as seen in Figure 9, the desks in Room 2 are utilised most of the day without interruption or becoming vacant. However, desks in Room 1 and 3 seem to be used for shorter periods, especially after 17:00. As supported by previous findings, individual desks in Room 2 were continuously used, followed by shared desks in the same room. The desks in Room 3 used for longer periods were mainly those located under the skylights and those located in the corners despite the lack or insufficient daylight levels. Interestingly, individual cubicles in Room 1 showed a continuous utilization against shared desks in the same room despite the access to outdoor view and daylight availability.

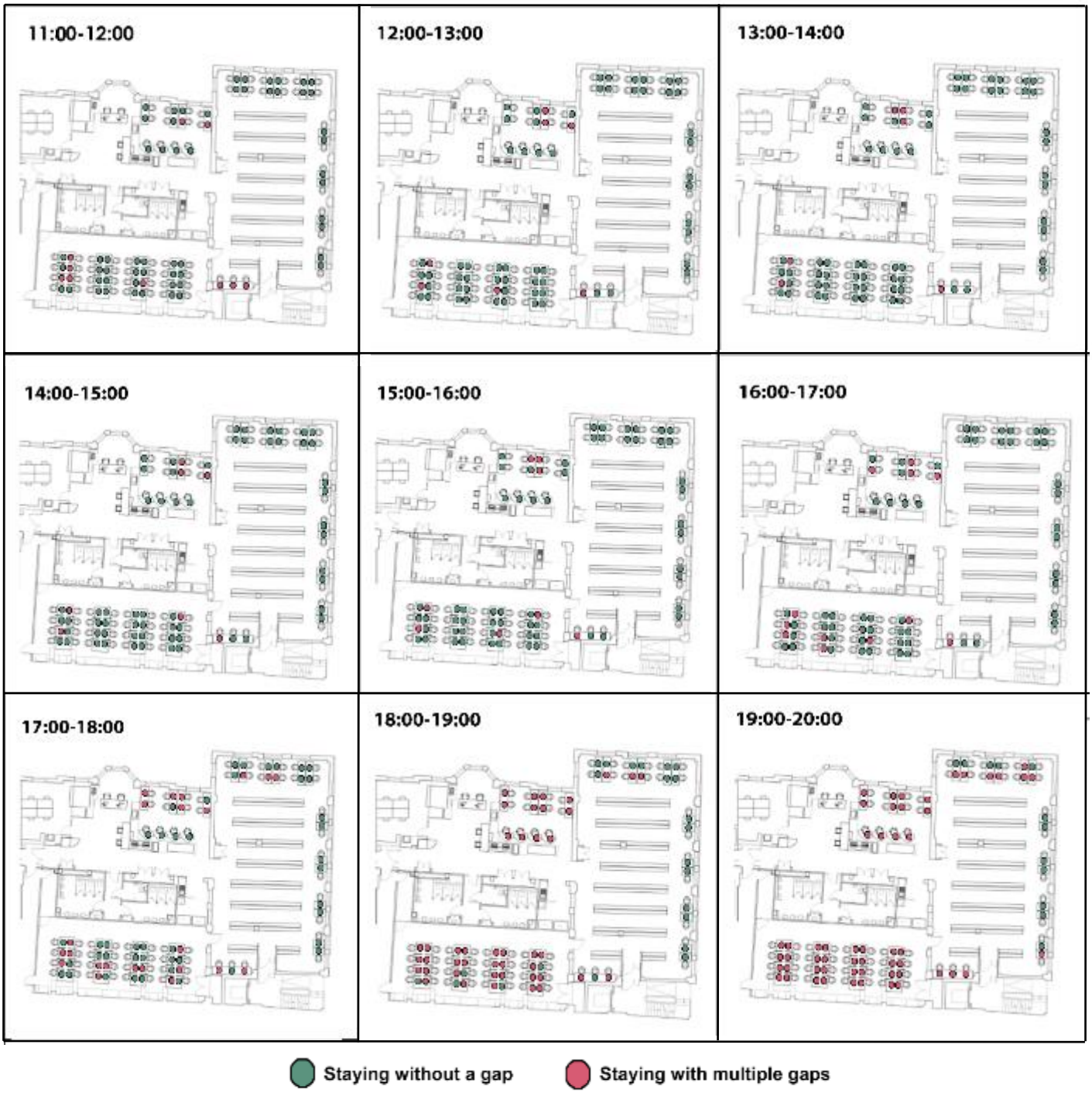

Figure 9 – Length of stay at a desk on a typical day

3.5 Limitations

Although the data collected through the sensors indicate whether the space is in use or available, demonstrating which desks are most preferred, these devices do not collect any personal data and cannot identify an individual. Therefore, study results do not represent students' personalities, individual perceptions and expectations. Another limitation is that students occasionally leave their laptops, water bottles, and backpacks to claim a seat while they go outside. PIR sensors can not detect a claimed seat due to no large heat signatures or movement. This situation could affect the students' freedom of choice and ultimately study findings because it assumes that it is available for selection if a desk seems unoccupied.

4 Conclusion

This paper describes a method that uses seat preference to understand what people choose to do in a space. Data obtained from the UCL library occupancy monitoring system was analysed to understand what type of desks were more in demand during 2018 and 2019. Then, the utilisation of the desks was evaluated specifically using daylight availability to explore the role of daylight on human seating behaviour. This study considered the seating preference of the students in terms of the frequency of selecting a specific desk, its order of preference and length of stay at the same desk.

Most of the seats selected as the best were located in areas with high illumination. However, the seats with a good combination of daylight, outdoor view, and privacy were more demanded than the seats providing only a high level of daylight. The study findings also demonstrated that the increase in the illumination of the desks is generally followed by higher utilisation in places daylit by the side windows rather than skylights. It could be argued that access to outdoor views and acceptable daylight levels makes the seating places more preferable than only daylight. Privacy seems to be another critical component because the area lit by skylight is an open plan space and comparatively less private than other rooms.

These findings emphasised that although daylight has a considerable impact on students' seat selection, the seating preference of the students cannot be explained by daylight alone. Future research should consider daylight factor together with other components such as privacy, outdoor views, and quietness, and it should also involve exploration of how people perceive space.

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