

# **Daylight and Behaviour**

## Daylight and Seating Preference in Open-Plan Spaces

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Lighting Research Group

School of Architecture

University of Sheffield

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# BACKGROUND

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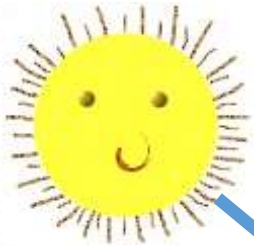
Past research suggests that daylight affects seating location.

STUDY	METHOD	OUTCOME: DID DAYLIGHT AFFECT OCCUPANT BEHAVIOUR?
Wang & Boubekri (2009)	<ul style="list-style-type: none"><li>• Occupants' seat choice in a south-facing student union lounge</li><li>• Observation period: 1pm-4pm on three consecutive afternoons during mid-April</li></ul>	<ul style="list-style-type: none"><li>• <b>YES:</b> Participants preferred seats in sunlight</li><li>• Away from sunny area, they preferred seats in more open spaces</li></ul>
Christoffersen et al. (2000)	<ul style="list-style-type: none"><li>• A survey was carried out in 20 Danish office buildings during the spring and autumn of 1997</li></ul>	<ul style="list-style-type: none"><li>• <b>YES:</b> Participants preferred seats in the window zone</li><li>• The degree of satisfaction increased with increasing daylight factor</li></ul>
Organ & Jantti (1997)	<ul style="list-style-type: none"><li>• Occupants' seat choice in a daylit library building</li><li>• Observation period: 10am,1pm,3.30pm from 20 June to 30 October 1996</li></ul>	<ul style="list-style-type: none"><li>• <b>YES:</b> It was observed that the most popular areas were quiet, well lit and adjacent to windows.</li></ul>

- However, whilst they have reported a tendency to sit near windows, they did not provide a quantified measure of seat use and daylight.
- This project is investigating a link between daylight quantity and seating preference.

# MEASURES OF DAYLIGHT

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We can measure the illuminance ( $E_h$ ) from daylight at a point.



Daylight illuminance ( $E_h$ ) varies as outside illuminance ( $E_{out}$ ) varies with time of day, year and cloud cover.

Therefore, illuminance is not a suitable measure.

## Daylight Factor (DF)

A measure of internal daylight versus external daylight.

$$DF = E_h / E_{out} (\%)$$

## Daylight Autonomy (DA)

The percentage of working year when  $E_h$  is above a minimum threshold (typically 300 lux), and thus provides sufficient light for working.

## Useful Daylight Illuminance (UDI)

The percentage of working year when  $E_h$  is above a minimum threshold (typically 100 lux) but below an upper limit of 3000 lux – the risk of glare when blinds may be closed.

# RESEARCH PROJECT

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## Research question:

- Does a significant relationship exist between occupant's seating preference and daylight availability?
- Can this be predicted with current daylight performance metrics such as daylight factor, useful daylight illuminance or daylight autonomy?



**Observations were recorded in the  
reading room of the Western Bank  
Library at Sheffield University**

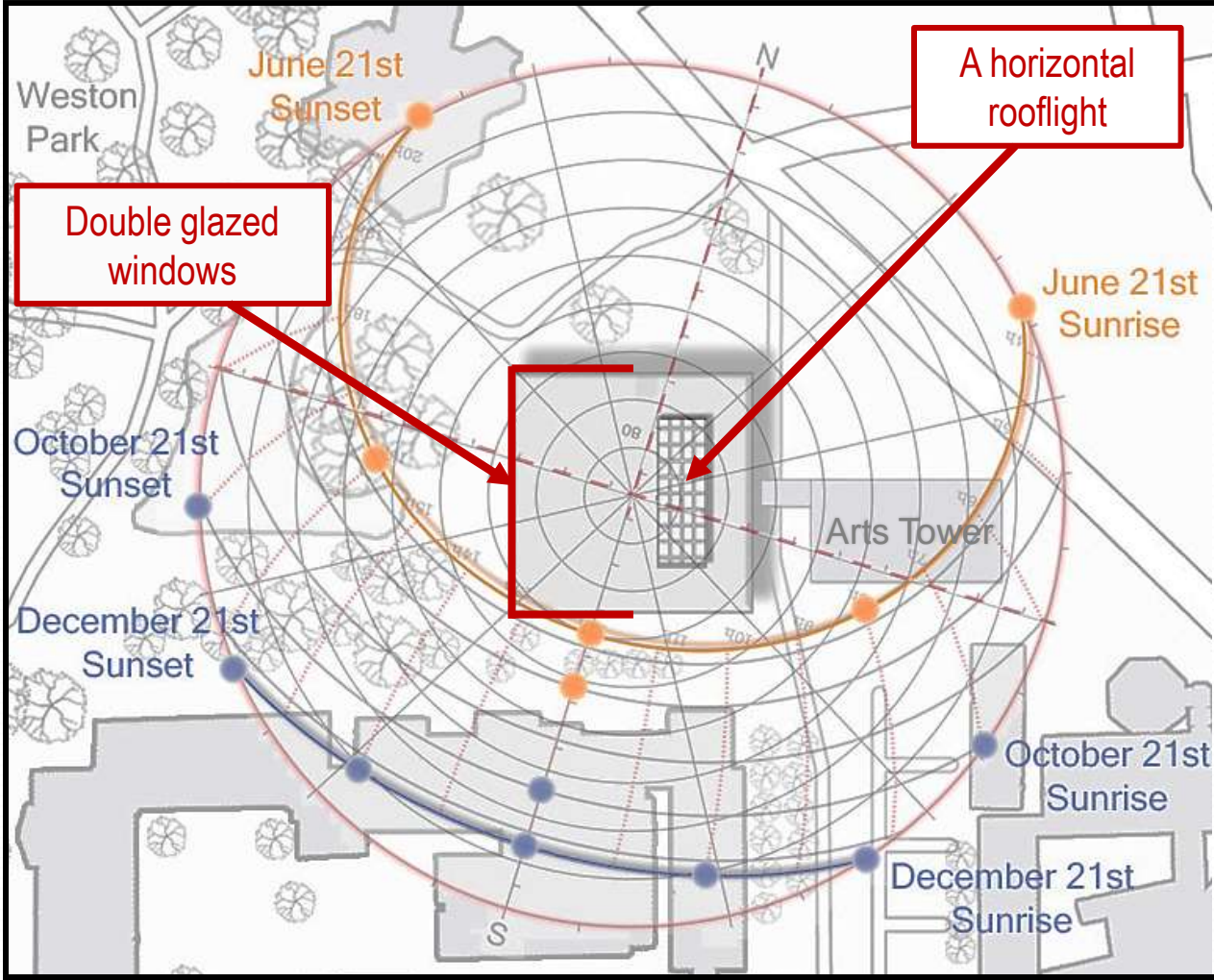
**Observations were recorded from a mezzanine above the reading room**



**Observations were recorded;**

- **At hourly intervals (10:00 to 18:00)**
- **Over a two-week period**
- **Summer and Autumn**

# Daylight enters the reading room through:



(a)



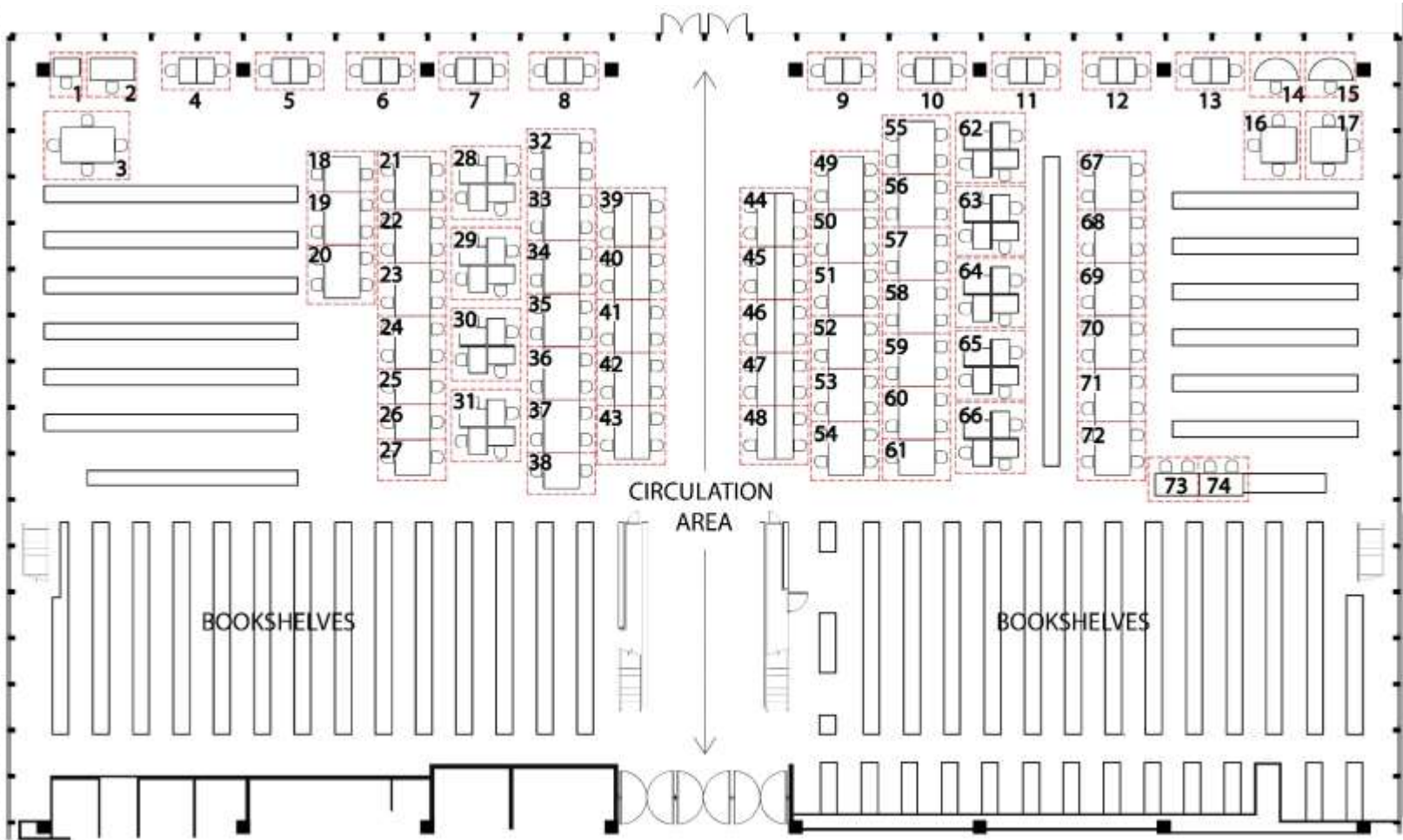
(b)

model for western bank library  
sheffield university / pre- arts tower  
(a) General view; (b) North-west view

Glazed south-west facade

Glazed south-east facade

Glazed north-west facade



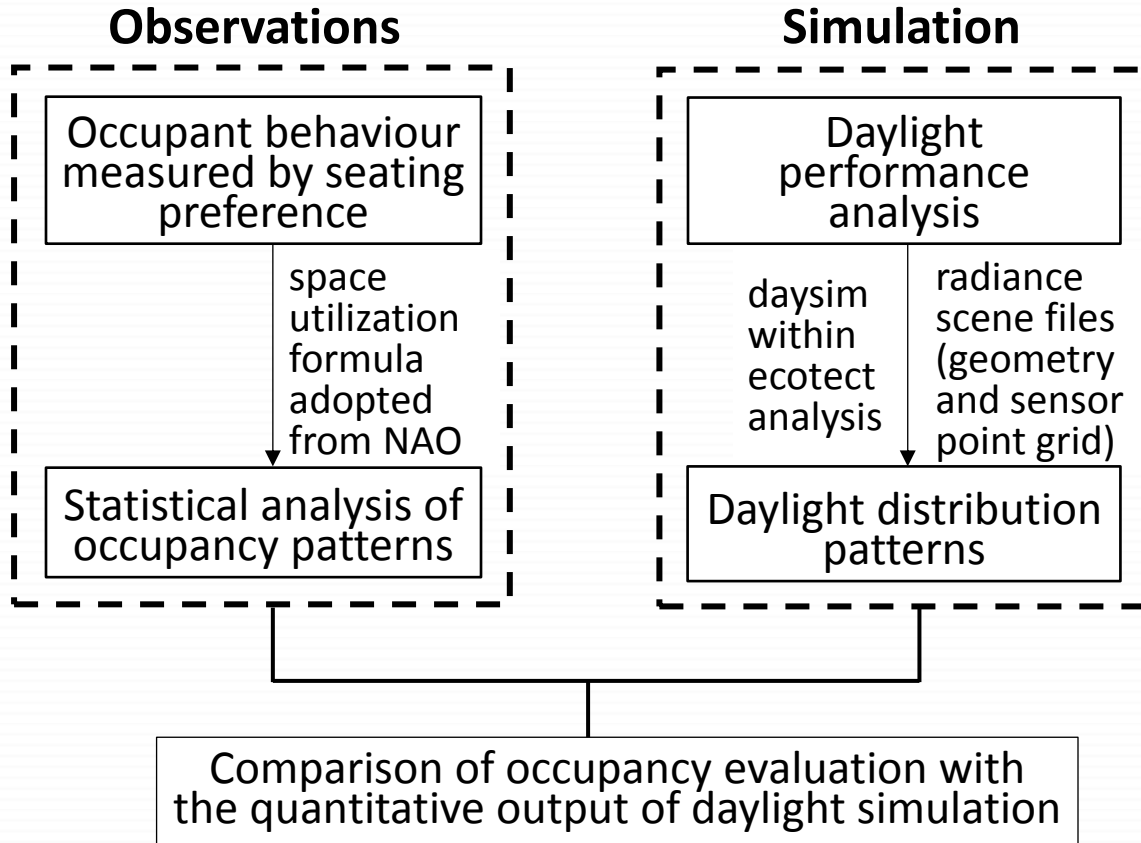
### Seat Map and Observation Zones

(The space was divided into 74 zones based on seating configuration)



# METHOD

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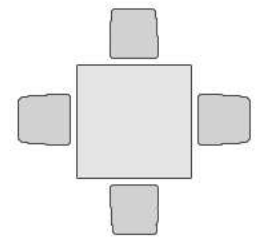


# MEASURES OF SEAT USAGE

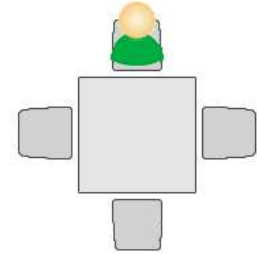
- The room was divided into observation zones.
- Methods for measuring seat usage in a zone were explored using guidance from the National Audit Office [NAO, 1996].

MEASURE	DESCRIPTION	ZONE VALUE
Frequency Rate (%)	The proportion of observation points at which an observation zone is occupied by at least one person	
Occupancy Rate (%)	The proportion of total capacity that is occupied, where total capacity is number of seats in an observation zone multiplied by the number of observation points	
Space Utilization (%)	The product of Frequency Rate (%) and Occupancy Rate (%)	

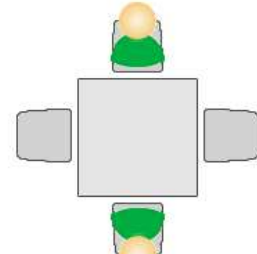
**An example of a zone plan, showing a table with four chairs (Observation period: 10:00 - 14:00)**



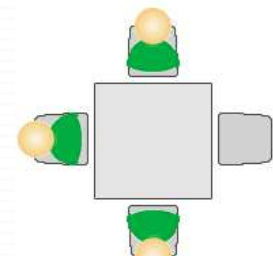
10:00



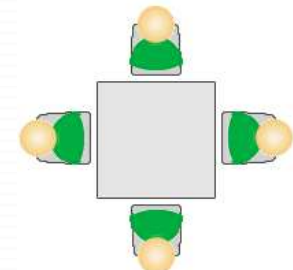
11:00



12:00




13:00



14:00

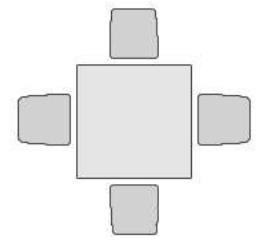
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MEASURE	DESCRIPTION	ZONE VALUE
Frequency Rate (%) 	The proportion of observation points at which an observation zone is occupied by at least one person	4/5
Occupancy Rate (%)	The proportion of total capacity that is occupied, where total capacity is number of seats in an observation zone multiplied by the number of observation points	
Space Utilization (%)	The product of Frequency Rate (%) and Occupancy Rate (%)	

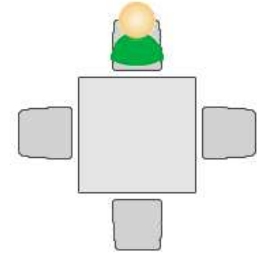
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0



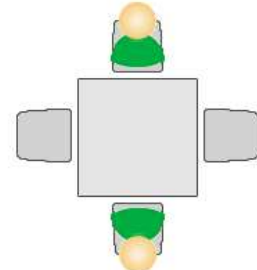
10:00

1



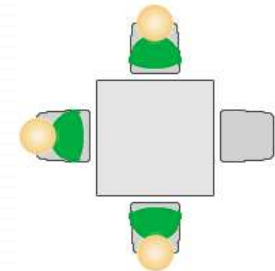
11:00

1



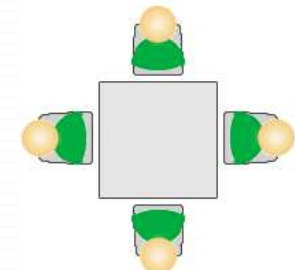
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1



13:00

1



14:00

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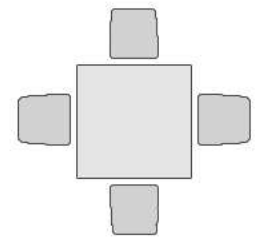
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Frequency Rate (%)	The proportion of observation points in a zone is occupied by at least one person	4/5
Occupancy Rate (%)	The proportion of total capacity that is occupied, where total capacity is number of seats in an observation zone multiplied by the number of observation points	10/20
Space Utilization (%)		

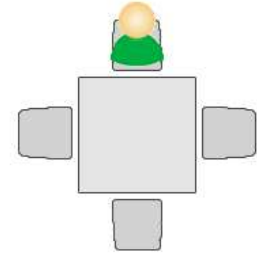
Occupancy  
= 0+1+2+3+4  
= 10

Total capacity  
= 4 seats x 5 observations  
= 20

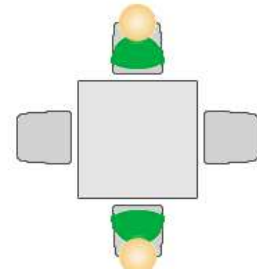
Following a table with four chairs (Observation period: 10:00 - 14:00)



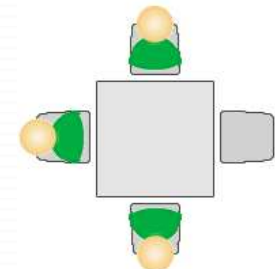
10:00



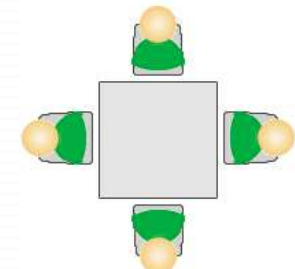
11:00



12:00



13:00

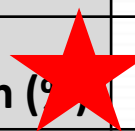


14:00

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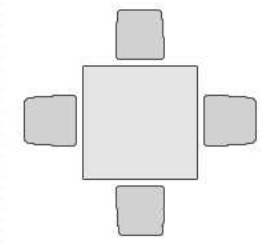
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Space Utilization (%)	The product of Frequency Rate (%) and Occupancy Rate (%)	4/10

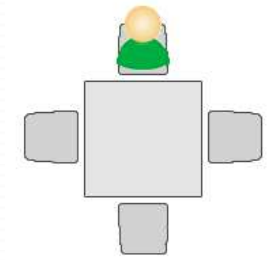


$$4/5 \times 10/20$$

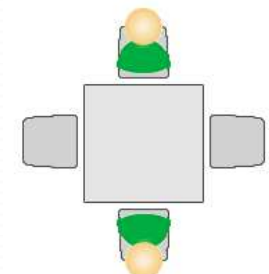
An example calculation, showing a table with four chairs (Observation period: 10:00 - 14:00)



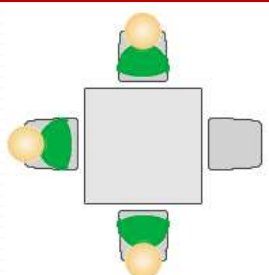
10:00



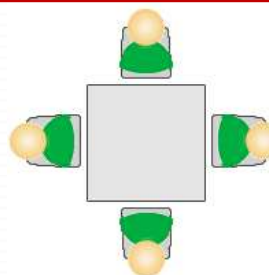
11:00



12:00



13:00



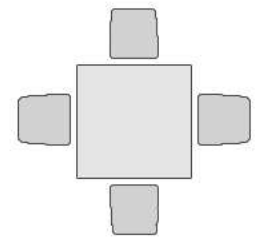
14:00

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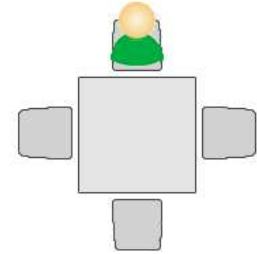
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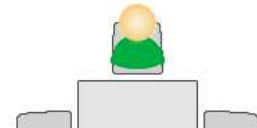
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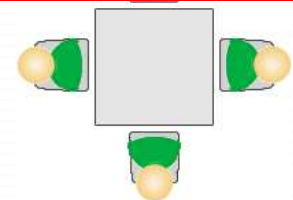
10:00



11:00



Each measure gives a different value as to seat usage



14:00

# RESULTS: SPACE USE VERSUS DAYLIGHT

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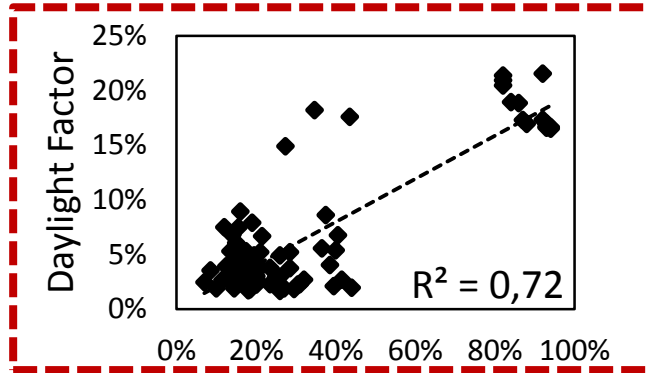
Coefficient of linear determination ( $R^2$ ) between daylight performance measures and space usage

Measures of space usage	Daylight Performance Measures					
	Daylight Factor		Useful Daylight Illuminance (100-3000 lux)		Daylight Autonomy (300 lux)	
	Summer	Autumn	Summer	Autumn	Summer	Autumn
Occupancy rate	0.68	0.72	0.63	0.33	0.44	0.30
Frequency rate	0.60	0.44	0.56	0.12	0.43	0.27
Space utilization	0.54	0.71	0.54	0.30	0.37	0.31

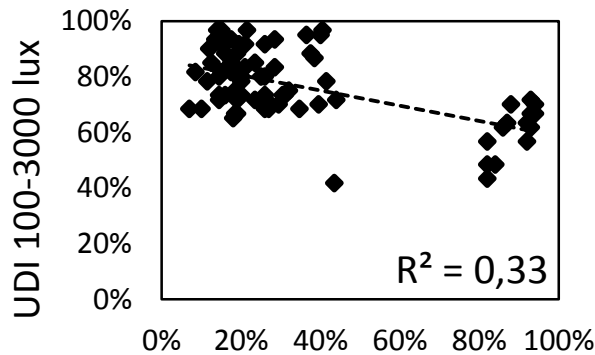
Occupancy rate gives a slightly higher correlation with daylight metrics than does frequency rate or space utilization.

# RESULTS: SPACE USE VERSUS DAYLIGHT

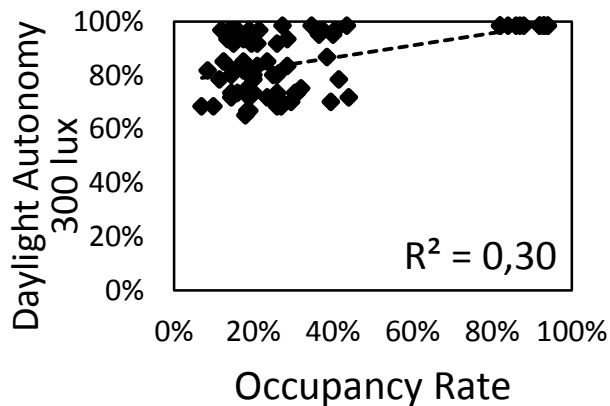
AUTUMN



DF gives a higher degree of correlation with space use than does UDI or DA.



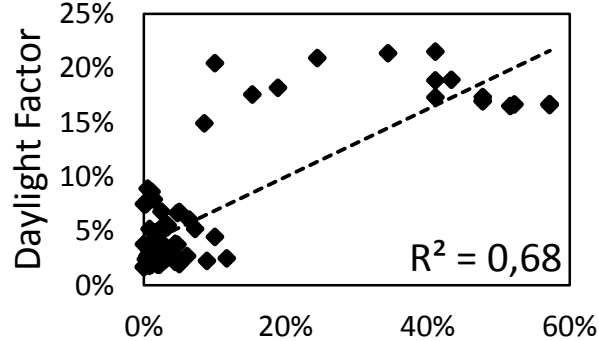
$R^2 = 0.72$  (higher than UDI and DA)



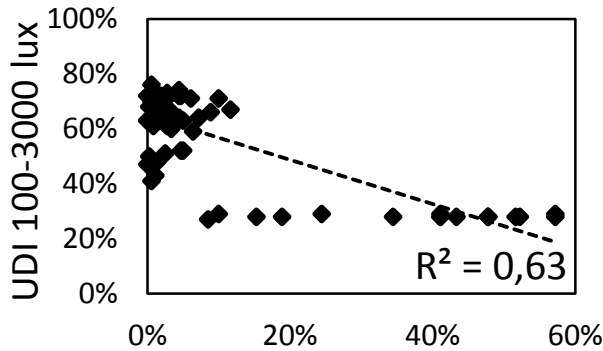


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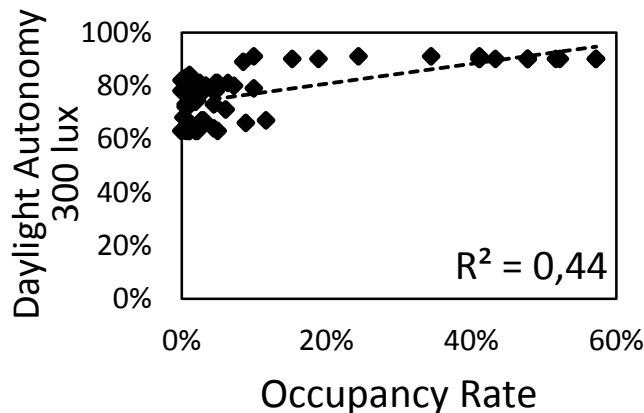
SUMMER



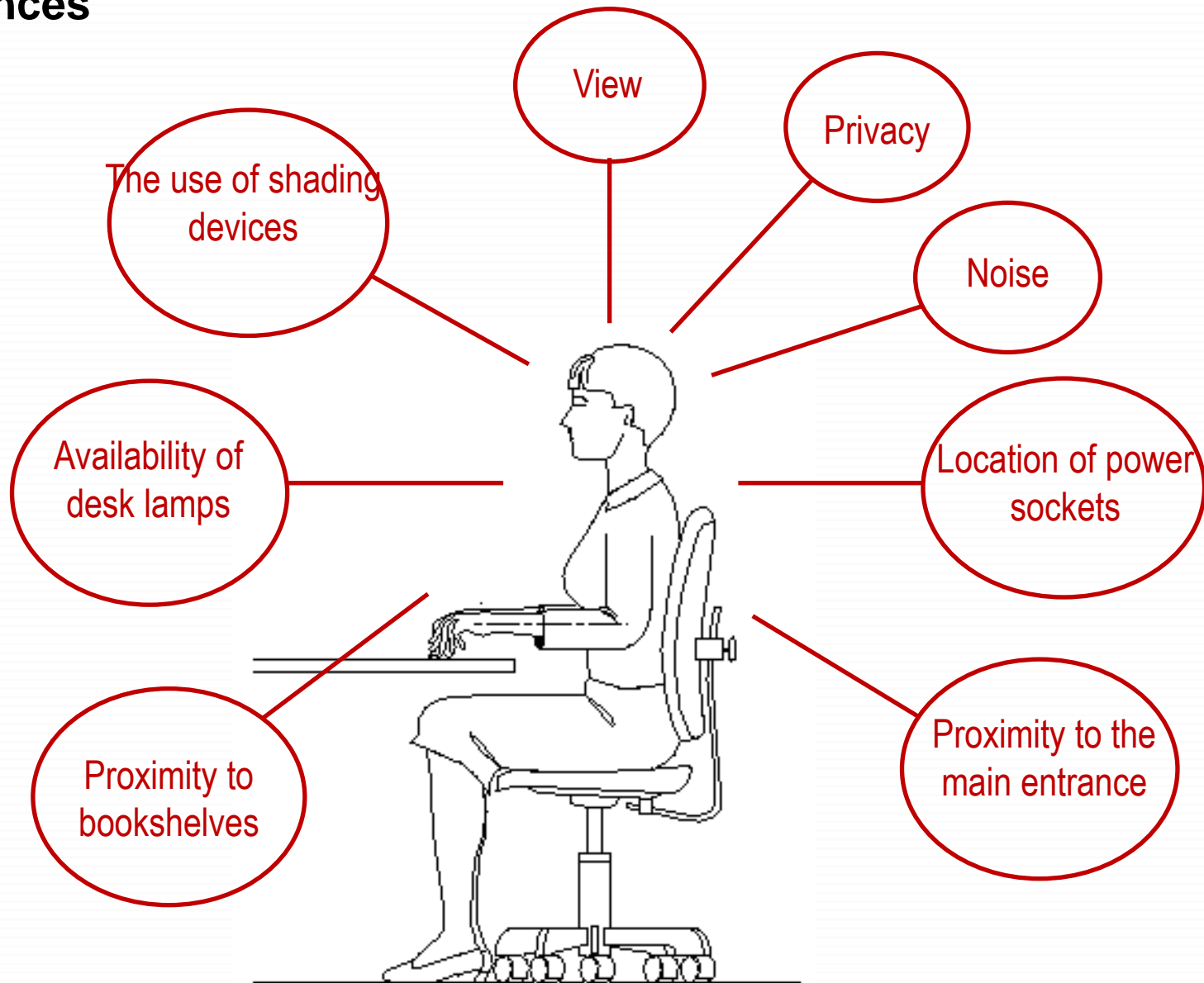
DF gives the better correlation with seat use ( $R^2 = 0.68$ )



There is a significant negative correlation between UDI and seat use ( $R^2 = 0.63$ )



**Initial results support the hypothesis that daylight affects behaviour, however, other factors could play a role in influencing seating preferences**



# CONCLUSION

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Daylight affects seating preference: there is an association between DF and occupancy rate.

- ***Space Usage:*** Occupancy rate gives a slightly higher correlation with daylight metrics than does frequency rate or space utilization.
- ***Daylight Metrics:*** DF gives better correlation than UDI or DA.

## Further work

1. Examine whether the observation interval matters
2. Follow individual occupants as they choose a seat rather than the snapshot approach.
3. Use a questionnaire to investigate perceived behaviour in addition to actual behaviour.