Lighting survey of Carrel 1.06

Introduction

A complaint was received regarding the lighting in the Carrel 1.06 room of the library. As an independent study room, the lighting should be appropriate for reading and writing in particular, and comfortable to be used for extended periods of time. Upon looking inside the room, the room seemed too dark to work in comfortably and the partly occluded, bare fluorescent tube provided a stark contrast between the lit desk and the surrounding area.

Method

Apparatus

Minolta illuminance meter TL-1;
Hagner Universal photometer model S8 (for luminance);
tape measure for finding measurement locations and making a straight line in the air;
electrical tape for temporary location markers.

Procedure

Both objective and subjective data was collected. The objective measurements comprised illuminance ratings of the desk, drop-off beyond the edge of the desk and for determining the directionality of light, as well as luminance ratings for the light itself, the desk and the walls. The subjective data came from a questionnaire, given to users of the room, that included both quantitative and qualitative aspects.

Illuminance was taken by positioning the illuminance meter facing along the normal of the plane of measurement (e.g. directly upwards on the desk) and for the desk a 5x2 matrix was taken to find a representative average as well as an indication of the variance. One of the points (G in *Figure 1*) was located where paper would be if a student was writing at the desk; the directionality of light was measured 30cm above this point, directing the illuminance meter in the six directions of a cube (facing horizontally

from the chair to the desk as a student would) for later calculation. The light drop-off started at the point above G (B), and went through G, taking measurements at regular intervals of 20cm. The measurements beyond the edge of the desk were kept on the plane by using a tape measure to form a straight line from the edge of the desk to the same height on the back wall.

Wall and desk luminance were both measured with the photometer from a sitting position on the chair. The desk luminance was taken at the brightest point, and the wall luminance was taken at the brightest point at eyeline. Luminance of the fluorescent tube was measured from directly beneath it at 3 points: the centre, and the two quarter lines. All measurements were taken 3 times and the median recorded, to minimise the effect of outliers.

The questionnaire (see Appendix A) was given to undergraduate ergonomics students who had just used the room. All were male and within the age range 18-21. The questions were created based on BS EN ISO 28802:2012.

Results

Table 1: summary of main findings

Measurement	Value
Mean desk illuminance (lux)	273.8 (σ = 13.23)
Mean light source luminance (cd/m^2)	9230
Vector/scalar ratio	2.22
Illuminance reduction over 1m (lux)	192.3

The mean illuminance on the desk (values shown in *Figure 1*) was 273.8 lux with a standard deviation of 13.23. The drop-off of illuminance was pronounced, with a 192.3 lux reduction from the peak value to 1m away (for more details, see *Appendix B*). The most pertinent points raised in answers to the questionnaire were that the lighting was “too hard” and “too orangey”, and that the ends of the light source were not shielded by the shade, resulting in points of distractingly high luminance visible, which caused discomfort glare.

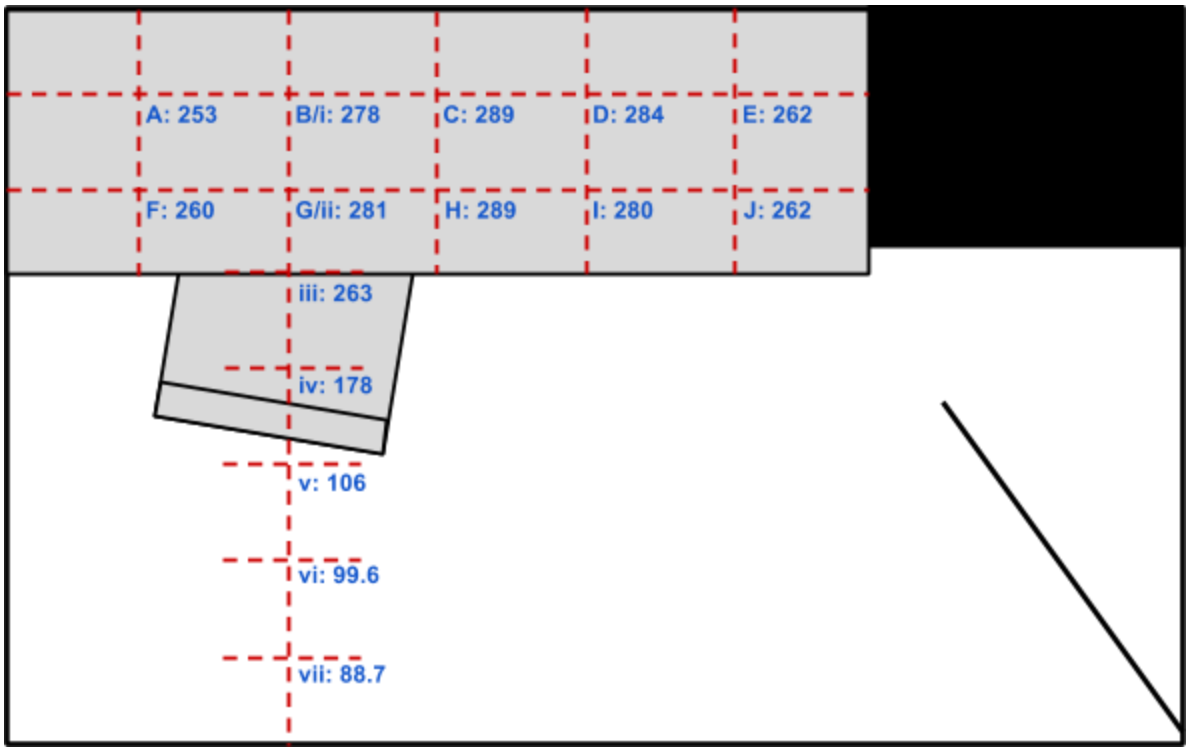


Figure 1: room plan showing illuminance values (in lux) of desk and drop-off; measurements at dashed line intersections

Discussion

For comparison to the standard (BS EN 12464-1:2011), the room was considered most like an office area for “Writing, typing, reading, data processing” (Ref. no. 5.26.2), as these are the activity types performed in it. The recommended illuminance value for this room type was 500 lux, from which the measured mean value of 273.8 lux and even the highest value of 289 lux fall short.

The vector/scalar ratio of 2.22 was considered by Boyce (2003) to be moderately strong to strong in terms of strength of flow, which may render detail that is in shadow difficult to perceive. As the direction of the light is 25° away from the vertical, toward the person sitting at the desk, this may cause an issue. Page lines on the body side of a writing arm may be obscured, making the student strain more to see their work. The reason for the high directionality of light is the single light source that is largely blocked

by its shade (visible in *Appendix C*), which means that very little light is reflected from the ceiling or from high on the walls except at the front of the room.

Many students use the room to work late at night, particularly during the exam period. Wright and Lack (2001) found that a warmer light would not keep people as alert at night as a cool light, because cool light suppresses melatonin production. This is consistent with one of the questionnaire responses, in which the participant said that the warm light made him want to sleep. This may be a good or bad thing for students, depending on which they value higher: immediate work at night or better sleep once they are done.

The warm light may also have a detrimental effect on the long term memory of some female students, as Knez (2001) found. Care should be taken not to overcorrect this, as the same study found male students were more greatly negatively impacted when light was too cool. Knez (2001) found that lighting at 4000K had the least detrimental impact across both genders.

Factors other than lighting that very quickly became obvious were that the enclosed space led to thermal discomfort and poor air quality. A simple natural ventilation system would likely mitigate these issues, but if not, a powered system could be considered. The author recommends that the air to ventilate the room comes from outdoors, as Wargocki (2000) found that increased outdoor air flow improved perceived air quality, increased comfort levels and improved performance both subjectively (clear thinking) and objectively (text typing rate).

A solution to all these problems would be to have more spread out, more diffused, and more, lights with a lower luminance each, but that would increase the illuminance on the desk to the recommended level of the standard. More lights would reduce the vector/scalar ratio to a more preferable value, but could be have their position or angle decided such that the workspace is still highlighted. These could be LED-based, which would also provide the opportunity to have light at 4000K. As there would be more, diffuse light sources, the complaints on the questionnaire of glare and hard light should also be resolved.

References

Boyce, P. 2003. Human factors in lighting. London: Taylor & Francis.

BSI. 2012. BS EN ISO 28802:2012: *Ergonomics of the physical environment — Assessment of environments by means of an environmental survey involving physical measurements of the environment and subjective responses of people*. London, BSI.

BSI. 2011. BS EN 12464-1:2011: *Light and lighting — Lighting of work places. Part 1: Indoor work places*. London, BSI.

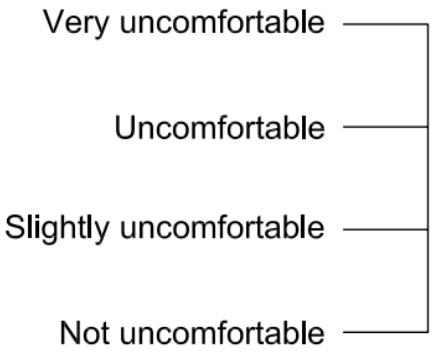
Knez, I. 2001. Effects of colour of light on nonvisual psychological processes. Jo*urnal of Environmental Psychology*, 21(2), (201-208).

Wargocki, P., Wyon, D. P., Sundell, J., Clausen, G., & Fanger, P. 2000. The effects of outdoor air supply rate in an office on perceived air quality, sick building syndrome (SBS) symptoms and productivity. *Indoor air*, 10(4), (222-236).

Wright, H. R., & Lack, L. C. 2001. Effect of light wavelength on suppression and phase delay of the melatonin rhythm. *Chronobiology international*, 18(5), (801-808).

Appendix A: Questionnaire questions

1) Please indicate on the following scale how YOU find your VISUAL environment NOW

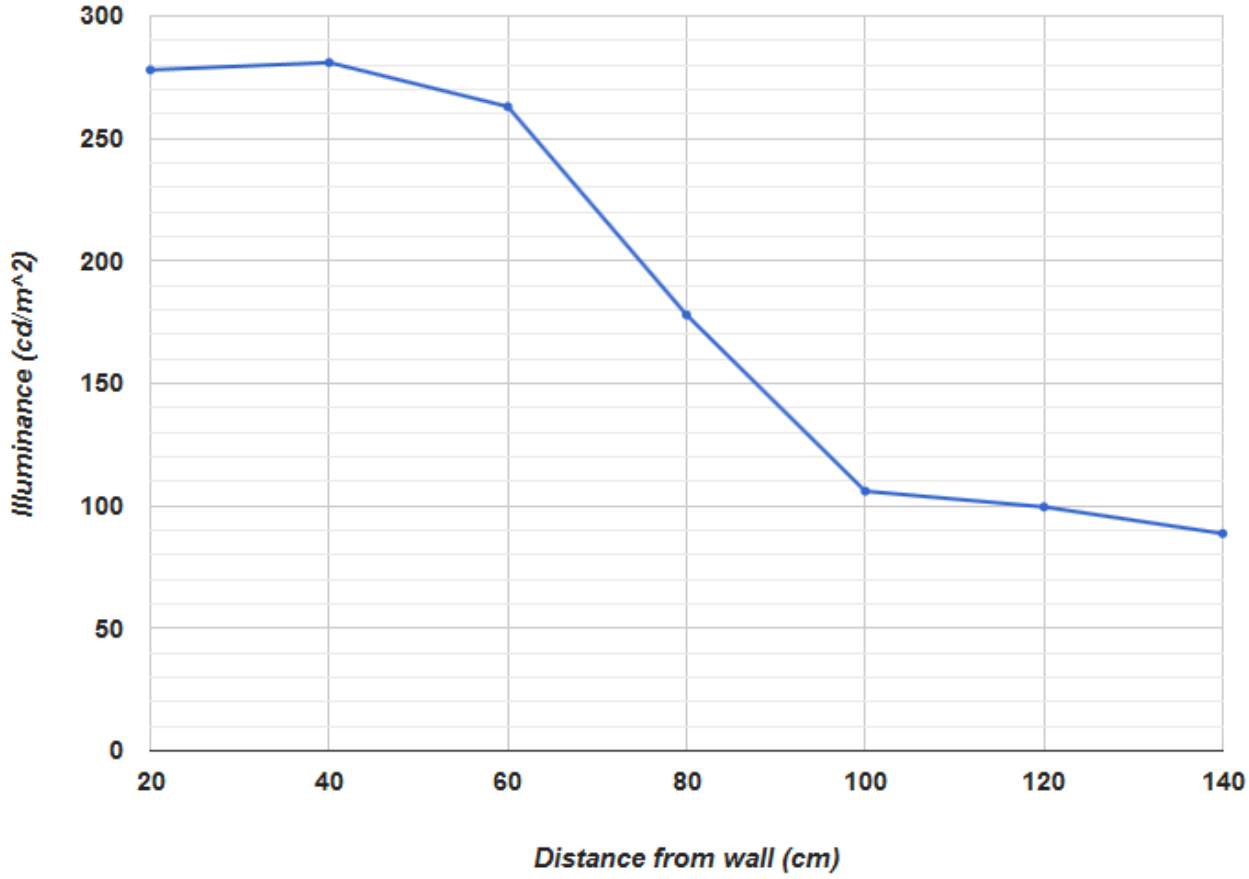


[Measured as 0-3, where 0 was not uncomfortable]

2) Please indicate any sources of glare YOU can see in your VISUAL environment NOW.
3) Please give any additional information or comments which you think are relevant to the assessment of your VISUAL environment at work (e.g. glare, visual scene and view, general visual impression, flicker, colour).
4) Please rate on the following scale how YOU would like your visual environment to be NOW:

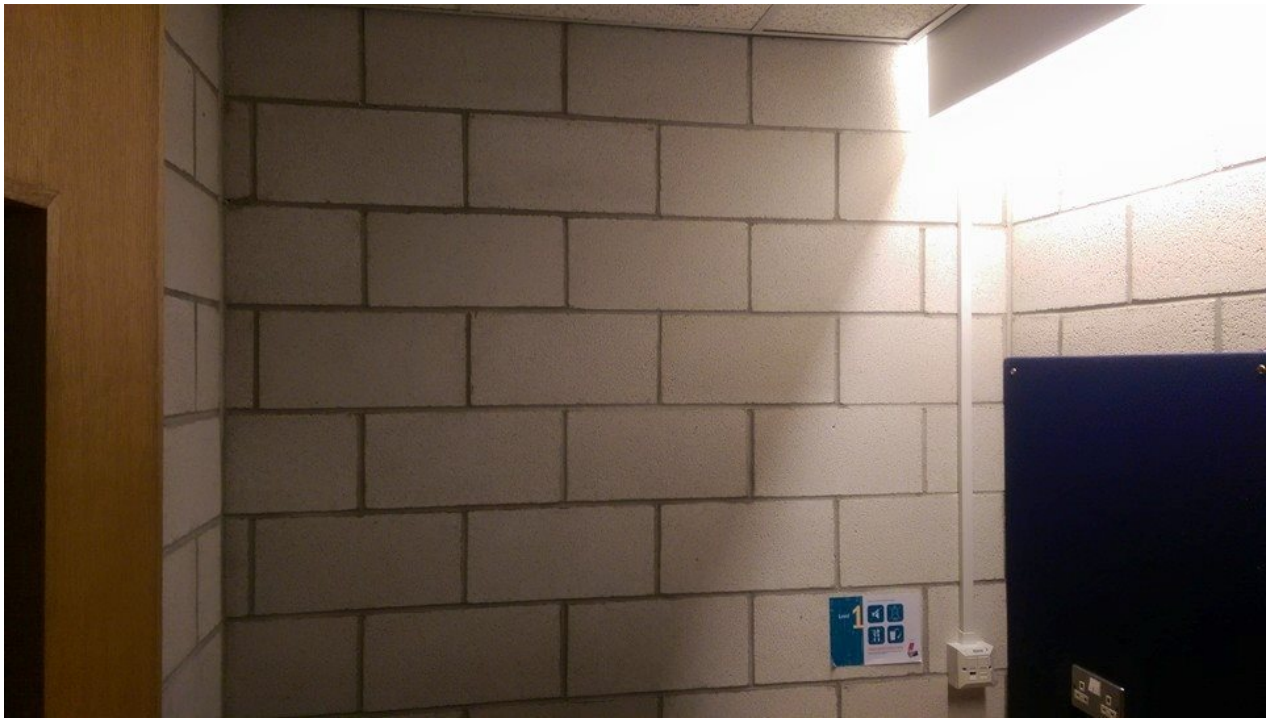
7. Much lighter
6. Lighter
5. Slightly lighter
4. No change
3. Slightly darker
2. Darker
1. Much darker

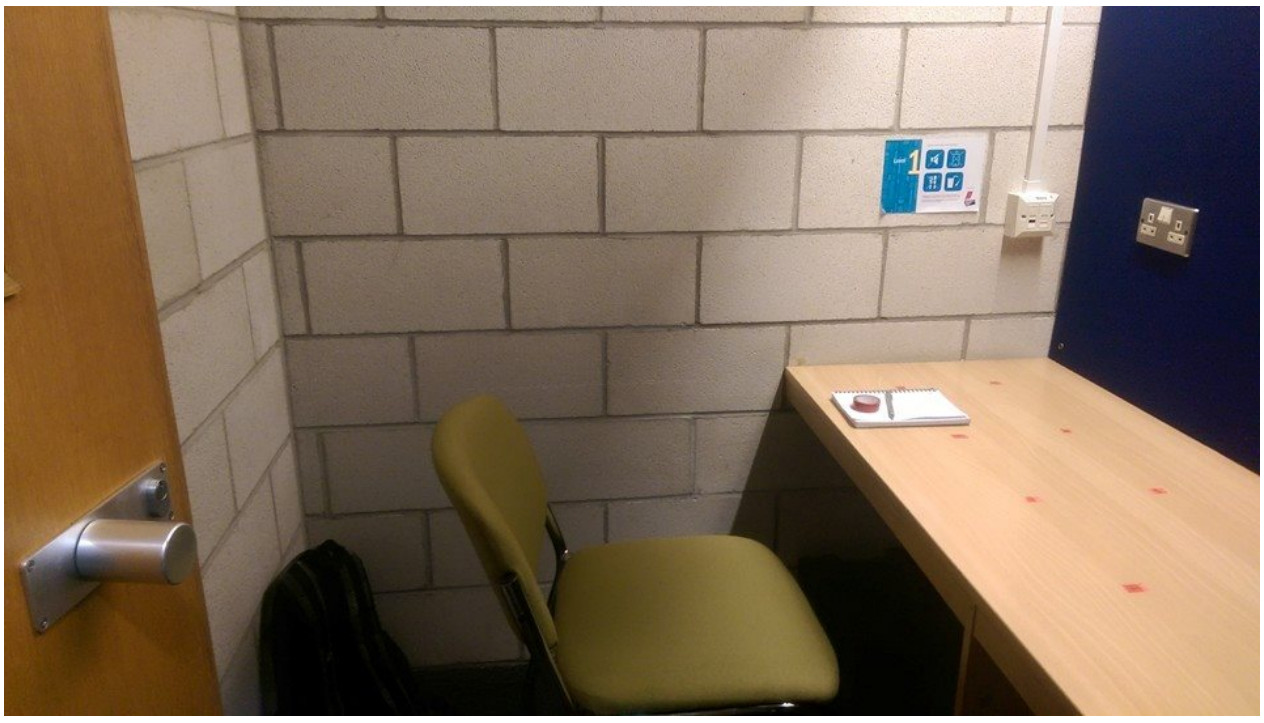
Appendix B: Graph showing drop-off in illuminance along the plane of the table



The sudden drop beyond 60cm (the edge of the table) appeared to be a result of the light shade occluding the light beyond that angle.

Appendix C: Photos of Carrel 1.06





Appendix D: Raw data

Measurement	Value
Light source #1 (cd/m^2)	9680
Light source #2	9240
Light source #3	8770
Immediate wall #1 (cd/m^2)	845
Immediate wall #2	755
Immediate wall #3	712
Desk illuminance A (lux)	253
Desk illuminance B	278
Desk illuminance C	289
Desk illuminance D	284
Desk illuminance E	262
Desk illuminance F	260
Desk illuminance G	281
Desk illuminance H	289
Desk illuminance I	280
Desk illuminance J	262
Desk luminance (bare) (cd/m^2)	70.2
Desk luminance (with paper)	58.5
Upper (top) face (lux)	373
Lower (bottom) face	82.9
Left face	90.3
Right face	120.4
Front face	101
Back (towards you) face	38.5
Scalar illuminance	134.35
Vector illuminance	298.28
Vector/scalar ratio	2.22
Wall luminance A (front facing) (cd/m^2)	2.53
Wall luminance B (right)	4.92
Wall luminance C (back facing)	17.2
Wall luminance D (left)	14.6
Drop off #1 (lux)	278
Drop off #2	281
Drop off #3	263
Drop off #4	178
Drop off #5	106
Drop off #6	99.6
Drop off #7	88.7

Appendix E: Questionnaire results

Participant	Answer
Question 1	
P1	1.2
P2	0.8
P3	1.7
Question 2	
P1	top of the wall (immediate wall)
P2	first few centimetres of the desk
P3	immediate wall & unshielded light source
Question 3	
P1	Area surrounding desk is really dark, there it's a distracting level of contrast & I don't like florescent lighting & it's too hard a lighting, as opposed to soft lighting
P2	The blind doesn't come right to the end, so each end is uncomfortable & too orangey, I want to sleep.
P3	It's too dark, the contrast is too great between the desk and the rest of the environment & doesn't feel sterile enough, it's too orangey to work.
Question 4	
P1	Lighter
P2	Lighter
P3	Much Lighter