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OFFICE WORKER'S SATISFACTION WITH THE LIT ENVIRONMENT

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Abstract

Lighting has been proven to influence human directly and indirectly. In addition to office worker's needs of lighting conditions, it is essential to investigate office worker's preferences regarding the lit environment. The objective of this paper was to identify lighting parameters which relate to overall satisfaction with lighting in a cross-country field study, based on subjective data. Two field studies were performed (the Netherlands: spring 2016 and Italy: spring 2018). The Office Lighting Survey (OLS) was distributed to gather data on office worker's satisfaction with lighting. In both field studies, the significant correlation between overall satisfaction with lighting and the evaluations of the lighting conditions for all work tasks highlights that lighting conditions need to be examined for every work task. In addition, the OLS results demonstrated that the light aspects 'illuminance', 'uniformity', and 'luminance' are highly important. This is in accordance to what the CIE proposed: describing the total lit environment and not individual elements within it.

Keywords: Photometric quantities, office occupants, cross-country comparison, and preferences.

1 Introduction

The fact that most office workers approximately spend one-third of their daily time at their workspaces illustrates the need to identify and optimize interior lighting conditions (Borisuit *et al.*, 2014). Over the years, office lighting has been a large area of focus from a variety of perspectives including psychology and health (Veitch *et al.*, 2013)(van Duijnhoven *et al.*, 2019)(Gou *et al.*, 2015). Office lighting influences the human performance of an office worker via three pathways (Boyce, 2014). Firstly, the amount and type of light directly influences visual performance and through task performance indirectly human performance. Secondly, lighting conditions, over time, influence human performance via the circadian timing system. And lastly, lighting indirectly impacts human performance through mood and motivation. It is not only essential to know which aspects of office lighting influence the office workers' needs but also which aspects influence their satisfaction with office lighting (Galasiu and Veitch, 2006).

The current paper focuses on overall satisfaction with lighting. The objective was to identify lighting parameters which relate to the overall satisfaction with lighting in a cross-country field study, based on subjective data. A second objective was to discuss whether these identifiers for overall satisfaction with lighting differ between the two countries.

2 Method

2.1 Office environments

Two field studies were performed, one in the Netherlands in May 2016 (van Duijnhoven *et al.*, 2017) and one in Central-Italy in June 2018. The Dutch office workers were working in office landscapes (Figure 1) and the Italian office workers worked in private offices (3-5 persons) (Figure 2). The window-to-wall ratios (WWR) in the Dutch office environment were higher compared to the offices of the Italian field study. All offices included in the field studies contained daylight openings. Most of these daylight openings consisted of sun shading devices.



Figure 1 – The office environment of the Dutch field study



Figure 2 – An office environment of the Italian field study

2.2 Participants

In the Dutch field study 46 (22 male and 24 female) office workers participated. In the Italian field study 32 (14 male and 18 female) office workers participated. Both participant samples were mostly aged within the range 25-34 years and worked on average 5 days a week.

2.3 Procedures

Office Lighting Surveys (OLS, developed by Eklund and Boyce (Eklund and Boyce, 1996)) were distributed amongst the office workers via work email addresses. The OLS was separated into five categories: (1) general statements, questions regarding (2) attributes, (3) tasks, (4) glare, and other questions (5). In the Dutch field study, the participants were asked to complete the OLS at the end of their workday for 5 consecutive days (resulting in 113 completed questionnaires) whereas the Italian office workers were only asked once (resulting in 32 completed questionnaires).

2.4 Data analysis

First, the data was analysed per field study and later comparisons were made between the results of both field studies.

2.4.1 Data analysis per field study

The data of the Dutch field study was already analysed and published (van Duijnhoven *et al.*, 2017). The dataset of the Italian field study was analysed similarly to the Dutch study. The office worker's overall satisfaction with lighting was the main outcome variable. Overall satisfaction with lighting was rated on a 5-point scale from (1) 'Very satisfied' to (5) 'Not at all satisfied'. Correlation coefficients were calculated between the lighting descriptors (subjective measures within the OLS) and the overall satisfaction with lighting using IBM SPSS Statistics 23. Since the data was not normally distributed, the non-parametric Kendall's correlation coefficients τ were calculated. The significance level of 0.05 was used to identify statistical significance.

2.4.2 Comparison of the two field studies

The calculated Kendall's correlation coefficient between all lighting descriptors and overall satisfaction with lighting of the Dutch study were compared to the correlation coefficients of the Italian study.

3 Results

The results from the OLS were analysed per subcategory (as mentioned in section 2.3). The results of both studies are provided in Table 1.

Firstly, in both studies, a significant correlation was found between the overall satisfaction with lighting and the statements 1, 3, and 4 (S1: Overall the lighting is comfortable ($\tau_{NL}=0.740$, $\tau_{IT}=0.465$), S3: The lighting is uncomfortably dim for the tasks that I perform ($\tau_{NL}=-0.250$, $\tau_{IT}=-$

0.597), S4: The lighting is poorly distributed here ($T_{NL}=-0.481$, $T_{IT}=-0.520$). In addition, in the Dutch study, statements 2, 6 and 7 (S2: The lighting is uncomfortably bright for the tasks that I perform ($T_{NL}=-0.672$), S6: Reflections from the light fixtures hinder my work ($T_{NL}=-0.394$), and S7: The light fixtures are too bright ($T_{NL}=-0.515$)) also significantly correlated with the overall satisfaction with lighting whereas in the Italian study only statement 5 did (S5: The lighting causes deep shadow ($T_{IT}=-0.562$)).

Secondly, all three attributes (electrical lighting, brightness of the lights, and glare from the lights) significantly correlated with overall satisfaction with lighting according to the Dutch dataset (respectively $T_{NL}=-0.557$, $T_{NL}=-0.356$, and $T_{NL}=-0.367$). According to the Italian office workers only the attribute electrical lighting significantly correlated with overall satisfaction with lighting ($T_{IT}=-0.369$).

Thirdly, in both countries, the evaluations of the office lighting conditions regarding all work tasks (e.g., writing on paper or using the computer) significantly correlated with the overall satisfaction with lighting (all τ values between 0.181 and 0.684).

Fourthly, all glare cases were found to significantly correlate with overall satisfaction with lighting according to the Dutch office workers (all τ values between 0.290 and 0.454). In contrast, none of the glare cases were found to significantly correlate with the satisfaction with lighting of the Italian office workers.

And lastly, the amount of light and the comparison of the lighting conditions to other buildings significantly correlated to the overall satisfaction with lighting in the Dutch study. These correlations were not significant (both $p>.07$) in the Italian study.

Table 1 – Correlation coefficients between lighting descriptors and overall satisfaction with lighting for both field studies. The significance level of 0.05 was used to identify statistical significance (* and marked green).

Subjective OLS Items		Netherlands	Italy
		Overall satisfaction with lighting	Overall satisfaction with lighting
Statements	S1: Overall the lighting is comfortable (agree – disagree)	$\tau = 0.740$, $p=.000^*$	$\tau = 0.465$, $p= .007^*$
	S2: The lighting is uncomfortably bright for the tasks that I perform (agree – disagree)	$\tau = -0.672$, $p=.000^*$	$\tau = 0.021$, $p= .902$
	S3: The lighting is uncomfortably dim for the tasks that I perform (agree – disagree)	$\tau = -0.250$, $p=.005^*$	$\tau = -0.597$, $p= .001^*$
	S4: The lighting is poorly distributed here (agree – disagree)	$\tau = -0.481$, $p=.000^*$	$\tau = -0.520$, $p= .002^*$
	S5: The lighting causes deep shadow (agree – disagree)	$\tau = -0.094$, $p=.287$	$\tau = -0.562$, $p= .001^*$
	S6: Reflections from the light fixtures hinder my work (agree – disagree)	$\tau = -0.394$, $p=.000^*$	$\tau = -0.268$, $p= .120$
	S7: The light fixtures are too bright (agree – disagree)	$\tau = -0.515$, $p=.000^*$	$\tau = 0.021$, $p= .902$
	S8: My skin is an unnatural tone under the lighting (agree – disagree)	$\tau = -0.061$, $p=.488$	$\tau = -0.328$, $p= .056$
	S9: The lights flicker throughout the day (agree – disagree)	$\tau = -0.164$, $p=.062$	$\tau = 0.017$, $p= .922$
Attribute	Attribute 1: Electrical lighting (Bad 1 2 3 4 5 Good)	$\tau = -0.557$, $p=.000^*$	$\tau = -0.369$, $p= .024^*$
	Attribute 2: How bright are the lights? (Too much light 1 2 3 4 5 Does not get too bright)	$\tau = -0.356$, $p=.000^*$	$\tau = -0.298$, $p= .066$

	Attribute 3: Glare from lights (High glare 1 2 3 4 5 No glare)	$\tau = -.367$, $p=.000^*$	$\tau = -0.289$, $p= .066$
Tasks	Task: Reading from paper (Excellent - Pretty good – Neutral – Not very good – Poor – Not applicable)	$\tau = 0.324$, $p=.000^*$	$\tau = 0.498$, $p= .002^*$
	Task: Writing on paper (Excellent - Pretty good – Neutral – Not very good – Poor – Not applicable)	$\tau = 0.347$, $p=.000^*$	$\tau = 0.498$, $p= .002^*$
	Task: Using the computer (Excellent - Pretty good – Neutral – Not very good – Poor – Not applicable)	$\tau = 0.578$, $p=.000^*$	$\tau = 0.488$, $p= .003^*$
	Task: Drawing on paper (Excellent - Pretty good – Neutral – Not very good – Poor – Not applicable)	$\tau = 0.181$, $p=.026^*$	$\tau = 0.521$, $p= .001^*$
	Would you say that the amount of light for the work you do is (excellent – good – fair – poor)	$\tau = 0.554$, $p=.000^*$	$\tau = 0.684$, $p= .000^*$
Glare	Glare case 1: Reflected glare from work surface (Not at all bothersome – Not very bothersome – Fairly bothersome – Bothersome – Not applicable)	$\tau = 0.290$, $p=.000^*$	$\tau = 0.216$, $p= .177$
	Glare case 2: Glare from ceiling lights (Not at all bothersome – Not very bothersome – Fairly bothersome – Bothersome – Not applicable)	$\tau = 0.378$, $p=.000^*$	$\tau = 0.228$, $p= .153$
	Glare case 3: Glare from task lights/desk lamps (Not at all bothersome – Not very bothersome – Fairly bothersome – Bothersome – Not applicable)	$\tau = 0.361$, $p=.000^*$	$\tau = -0.043$, $p= .782$
	Glare case 4: Bright lights in workspace (Not at all bothersome – Not very bothersome – Fairly bothersome – Bothersome – Not applicable)	$\tau = 0.454$, $p=.000^*$	$\tau = 0.280$, $p= .080$
	Glare case 5: Glare reflected in computer screen (Not at all bothersome – Not very bothersome – Fairly bothersome – Bothersome – Not applicable)	$\tau = 0.308$, $p=.000^*$	$\tau = 0.261$, $p= .099$
Other	How would you describe the amount of light (Much too bright – A bit too bright – Just about right – A bit too dim – Much too dim)	$\tau = -0.467$, $p=.000^*$	$\tau = 0.215$, $p= .197$
	How does light appear compared to other buildings (Worse – about the same – better – I don't know)	$\tau = -0.255$, $p=.002^*$	$\tau = -0.297$, $p= .070$

4 Discussion and conclusion

In both field studies, the OLS results demonstrated that the light aspects 'illuminance', 'uniformity', and 'luminance' are of high importance (e.g., statements 2-5 and glare aspects). In addition, the significant correlation between overall satisfaction with lighting and the evaluations of the lighting conditions for all work tasks highlights that lighting conditions need to be checked for every work task.

In the Dutch field study, glare cases were found to influence the overall satisfaction of office workers whereas in the Italian study this link was not found. This discrepancy between the two studies may be explained by the fact that 90% of the Italian office workers filled in that they experienced glare as 'not at all bothersome', 'not very bothersome', or 'fairly bothersome'. Glare experience may be influenced by the office configurations. In office landscapes, it is less easy to adjust the position and orientation of the desk or the sun shading devices according to individual preferences. In private offices this is easier and this may explain lower glare experiences in the Italian offices. A limitation for the comparison of overall satisfaction with lighting between both field studies is the absence of objective light measurements. On one hand, it may be that the office lighting conditions in the Dutch study were more in accordance to the recommendations (e.g., EN-12464 (CIE, 2011)). On the other hand, it may be that the Italian office workers were less bothered by high luminances (or luminance differences)

because they were more used to it. Field studies including both subjective and objective measurements related to satisfaction with lighting are topic for further research.

Nevertheless, the large number of correlations between lighting parameters and overall satisfaction with lighting demonstrated that satisfaction with lighting includes multiple light aspects (e.g., illuminance or uniformity). This is in accordance to what the CIE proposed in their research roadmap for healthful interior lighting applications: describing the total lit environment and not individual elements within it (CIE, 2016). In addition, the identifiers for overall satisfaction with lighting suggest to not only look at individual's needs but also to take into account individual's preferences.

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