



## Discussion

## Considerations about the impact of public lighting on pedestrians' perception of safety and well-being



A. Peña-García<sup>a,b,\*</sup>, A. Hurtado<sup>b,c</sup>, M.C. Aguilar-Luzón<sup>d</sup>

<sup>a</sup> Department of Civil Engineering, University of Granada, Granada 18071, Spain

<sup>b</sup> Research Group "Lighting Technology for Safety and Sustainability", University of Granada, Spain

<sup>c</sup> Granada City Hall, P. del Carmen, Granada 18071, Spain

<sup>d</sup> Department of Social Psychology, University of Granada, Granada 18071, Spain

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### ABSTRACT

One recent Comment proposed some remarks concerning the study entitled "Impact of public lighting on pedestrians' perception of safety and well-being". This study presents some considerations about the Comment and clarifies some points of our previous study that might have not been well understood.

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### 1. Introduction

Fotios (2016) recently published a Comment with several considerations about an article (Peña-García et al., 2015) which conducted a survey of 275 pedestrians in a nocturnal urban environment in the city of Granada (Spain). The objective was to evaluate user perceptions of the impact of different kinds of public lighting on general well-being (avoidance of stress, glare, headaches, etc.), perceived safety from criminal actions and other important factors. Besides the scores of the survey, average illuminance was also measured in each street to detect potential correlations between survey data, illumination levels, and color of light.

For the sake of a structured and more comprehensive reading of the complete sequence "original work-Comments of Prof. Fotios-analysis and considerations on Fotios Comment", the main conclusions of Peña-García et al. (2015) are summarized here:

- (1) For a given color of public lighting (white or yellow-sodium), the average scores for every question were found to increase with the average illuminance.
- (2) The scores for almost every question were higher when the light was yellow-sodium.

- (3) The scores for white light were higher on average only in Question 6 (see Annex), which dealt with safety perception.
- (4) With regard to stress, the relative difference between the scores for white and yellow-sodium light was lower than in the remaining questions (except for Question 6).

A careful read of Fotios remarks to the study of Peña-García et al. is really interesting because some of the main problems and difficulties of research in lighting are highlighted.

In this work, the arguments of Fotios (2016) are analyzed from a scientific and constructive perspective, remarking some important lacks and errors, but also pointing out some features that make research on illumination a complex matter due to the variability among users of lighting installations and other singular factors.

It will be demonstrated that any attempt to compare different studies carried out under just slightly different situations, can lead to wrong conclusions. It will be also shown that some of these mistakes are sometimes the consequence of weak basis on the fundamentals of lighting and vision.

In summary, the diversity among the users of urban lighting installations and the high amount of circumstances around them in each situation, make illumination and its impact on people a non-exact matter where some results that might seem trivial, are really complex at all. Thus, categorical affirmations, may lead sometimes to paradoxical conclusions.

\* Corresponding author at: ETSI Caminos, Canales y Puertos, Universidad de Granada, Campus Fuentenueva s.n., 18071 Granada, Spain.

E-mail address: [pgarcia@ugr.es](mailto:pgarcia@ugr.es) (A. Peña-García).

## 2. Discussion

The most relevant arguments in Fotios (2016) will be sequentially presented and discussed in this section.

According to Fotios (2016), one of the conclusions of Peña-García et al. (2015) is "... the average scores for every question were found to increase with average illuminance...". The argument of Fotios concerning this conclusion is the following: "The first statement is suggested here to be trivial: all such studies show that higher illuminances lead to higher ratings of perceived safety, but that makes no contribution to finding desirable conditions for pedestrians". This conclusion is rather surprising because the survey of Peña-García et al. (2015) had 11 items, and only two of them were focused on perceived safety. The remaining ones dealt with other concepts related with preferences or well-being (environmental perception, glare, stress and well-being, aesthetical preferences...). Hence, the perceived safety was not the only target of Peña-García et al. (2015) as claimed by Fotios. The original survey is included as Annex in this study.

The contribution of Peña-García et al. (2015) meant that almost all the scores in all the questions, including those focused on parameters different from perceived safety, increased with the illumination levels. Since literature up to date does not cover all the items in this survey, the global perspective in this study is different and far away (not better nor worse) from other interesting studies exclusively focused on perceived safety or other aspects.

Thus, a first conclusion of this study is that the reading of Fotios (2016) of the questioned article (Peña-García et al., 2015) was not global, maybe too quick and hence, the comprehension of the content was incomplete. Perhaps, a calmer and deeper reading would have lead to more constructive remarks really useful for everyone.

In section "Measuring perceived safety", another interesting remark of Fotios (2016) concerns the clarity of the questions in the survey. For example, it is said that "Peña-García et al. do not describe any attempt to anchor the response range to a stimulus. Consider for example Q3, "How intense do you find the lighting on this street?": what is not known are the light intensities a respondent would have attributed to the response scale, such as whether the maximum level (5) represented their expectation of good street lighting, their expectation of office lighting, or their expectation of daylight".

With regard to this remark, the first paragraph of section "Materials and method" in Peña-García et al. reads: "An in situ five-point scaled survey with 11 questions was administered to 275 randomly chosen pedestrians who were approached as they were walking along five streets...". It is clear that the interest of this research were the spontaneous feelings of people and, to our understanding, additional information or instructions on specific issues in lighting could have impaired the spontaneity of the answers, which was the target. If participants are orientated to imagine office lighting or daylight, their answers would have biased towards these patterns, with the subsequent loose of information about their personal and non-elaborated feelings. Of course, other researchers can be interested in answers more specifically orientated to comparison with patterns of illumination, but that was not our intention.

To our understanding, a calmer reading and maybe a private question to the authors about their real intentions, would have clarified the doubts of Prof. Fotios and maybe, avoided unnecessary polemics.

Besides the methodology of the survey, Fotios (2016) makes the following remark: "In this study the light levels were clustered into three groups, with average illuminances of approximately 15 lux, 25 lux and 50 lux". This sentence is false. Peña-García et al. chose five streets with similar characteristics with no particular prefer-

ence and the following constrains that could not bias the study: "All the streets under consideration were similar in terms of pedestrians and cars flow, especially during the hours when the surveys were carried out. In addition, the selected streets belonged to residential areas in the center of the city with no specially intense commercial activity due to the potential influence of the lighting from shop windows etc." (Peña-García et al., 2015. Section "Materials and Methods"). Hence, there was no clustering: the illuminance values were just a real picture of the situation. Once more, we conclude that the reading of Prof. Fotios was quick and superficial.

Furthermore, several additional remarks in this section are based on the wrong affirmation that the investigation Peña-García et al. is exclusively orientated to perceived safety. Fotios (2016) does not mention anything about items concerning stress, headache, aesthetical preferences etc. (see Annex), which shows again a quick and incomplete reading.

The last proposal in section "Measuring perceived safety" (Fotios, 2016) deserves a detailed analysis. According to this article, the comparison of the different illumination conditions would have been better if daylight conditions were used as control: "There is an alternative approach to investigating light levels and perceived safety. That is to record evaluations both in daytime and after dark and use the day-minus-dark difference...". We feel that this proposal is rather questionable due to remarkable social factors that are not considered and, mainly, to extremely important basic concepts in human vision.

The choice of accurate baselines or control conditions is a non-trivial problem, and wrong choices have led researchers in many areas, including lighting and human vision, to major mistakes. In fact, different studies with different objectives may need different control measures if any.

When dealing with vision, and the presence of non-visual effects of light is suspected, the choice of one control situation in which strong effects appear, can be fatal, especially when these effects appear together, are mixed and/or partially involve the effects we wish to study. Daylight conditions as control situation are proposed in Fotios (2016) but we consider that the application of this choice to the study of Peña-García et al. (2015) would have been incorrect due to the following reasons:

- (i) Vision under high luminance levels like daytime conditions (photopic vision) and vision under the typical levels of public lighting (mainly mesopic conditions (CIE, 2010; Kostic and Djokic, 2012)) are radically different. Photopic vision is mediated almost exclusively by the retinal cells called cones, whereas other retinal cells, the rods, play an important (but not exclusive) role in mesopic vision, where cones also participate.

Although there are many differences between photopic and mesopic vision, just a few of them are summarized here:

- Cones are sensible to the color, whereas rods are not (Foley and Matlin, 2009).
- Each cone converges to one single neuron, whereas many rods converge to one neuron (Purves et al., 2001). The consequences of this difference in convergence would be extremely important if daylight conditions were used as control situation to compare two kinds of public lighting as proposed in Fotios (2016): a maximal visual acuity arises in photopic conditions (better recognition of facial expressions or details in incoming pedestrians) due to the one-to-one convergence but, on the other hand, faint objects are easier to detect in mesopic and scotopic vision.
- Rods and cones are also distributed in the retina in different ways. Cones are mainly concentrated in the fovea, where there are no rods. On the other hand, the density of cones decreases

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