Stakeholder perception of the intangible value of a public lighting solution in an ecological zone

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Introduction

New lighting technologies are going to create a revolution in the lighting industry. According to Aarts (2011), the lighting industry will go through an evolution similar to the developments in computing since the invention of the first transistor. In the next 12 years, 80 billion light bulbs will be replaced by leds. Led technology offers many advantages, such as chromaticity control, better light quality and higher efficiency (Shur & Zukauskas, 2005).

One of the application areas for new lighting solutions is public lighting. With the extended possibilities that led offers, and integration with smart sensor networks, new opportunities arise to further reduce energy use and light pollution, and, at the same time, increase people's sense of perceived personal safety and comfort. Municipalities aim to implement such solutions, but little is known yet about their acceptance by the general public, nor the effects on the perceived safety and comfort.

The municipality of Veldhoven, The Netherlands asked THE LUX LAB to design a smart lighting solution for a bicycle path that runs through an ecological zone. The proposed solution aimed to use different lighting settings (varying in color and intensity) at different times to accommodate different stakeholders (see: Figure 1) The proposed solution offers the following settings:

In the early evening the path is intensely used by commuters, particularly children heading home. This is why lighting was placed in that zone in the first place. Cyclists' feelings of comfort and safety are increased with more light, as people need more light when dusk is setting. Thus white, 5 lux light is proposed for this time of day (setting A).

Later in the evening as traffic ceases the light dims to a light that is less disturbing for animals and plants but still provides good visibility for cyclists (setting B: yellow-greenish, 3,5 lux). The yellow-greenish light offers good visibility at significant lower energy use caused by led efficiency in such color range combined with high sensitivity of people's eyes to these wavelengths.

During the night as there is hardly any traffic the wild life becomes the most important stakeholder. Therefore, the light is

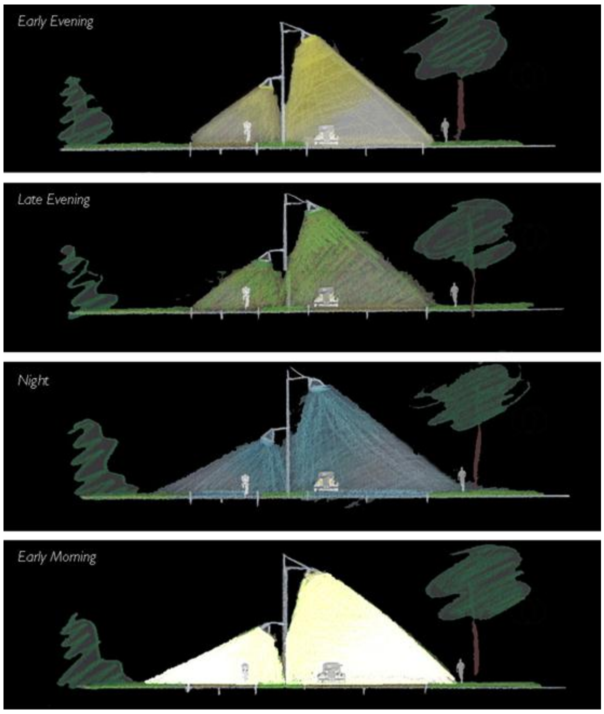

Fig. 1: Design sketches for the lighting scenarios (THE LUX LAB, 2010)

dimmed to the equivalent of 'full moonlight' (setting C: cool white, less than 1 lux), which does not disturb animals and at the same time requires significantly less energy while stays aesthetically pleasing. In the case of an emergency the system automatically gears up to increased lighting levels to ensure maximum safety for the incidental cyclists.

In the morning bright cool white lighting setting (setting D: cool white, 7 lux) is used to increase alertness of the cyclists.

The proposed solution differs from traditional lighting installations as it aims not just to reduce the energy use but at the same time to increase life quality in the ecological zone while not sacrificing safety of the road users. The role of the designer is to understand the needs and requirements from the various stakeholders, and to integrate seemingly opposing needs into a solution that is attractive, or at least acceptable, to them. The difficulty in these kinds of projects is that the solution is very different from what is currently available, so for the stakeholders to be able to judge the concept they will have to be able to imagine it. Moreover, to address issues like perceived safety and comfort means that potential users should be able to assess the intangible values of the concept.

Testing traditional lighting for public spaces involves comparison of different lamp types or lighting settings for a similar purpose (Boyce & Bruno, 1999). In this case, as the different light settings were part of the same concept we knew that some conditions, like night setting, would be perceived as less safe due to its low luminance (Boyce et al, 2000). So, the question was not which of these settings would be preferred but whether using different settings over the course of the night is acceptable for different stakeholders. Furthermore, we wanted to know if such people knowing that such lighting aims to accommodate flora and fauna in the ecological zone would influence their acceptance. The research program 'Brilliant Streets' of the Intelligent Lighting Institute at TU/e was invited to support the concept evaluation in line with the reflective transformative design process (Hummels & Frens, 2008).

Study design

For the first iteration in the reflective transformative design process, a demonstrator was created which was then shown during the 'Liberation of Light' exhibition. For setting A a less bright setting with a high color rendering was chosen, to avoid a longer accommodation times to the less bright settings in B and C. In the demonstrator the settings A (1,32 lx Ra 90.2 K 2507), B (3.44 lx Ra 61.8 K 4283), and C (0,21 lx Ra 81,9 K 3966) were presented in darkened corridors. This allowed people to experience the lighting levels and assess the concept. Due to restrictions in available space setting D was left out..

The demonstrator was used to collect feedback from relevant stakeholders using two methods. First, an interactive questionnaire was used to measure light setting preference and perceived level of safety for the general public. Visitors of the exhibition were asked to complete a short questionnaire after exiting the experiment area. After answering a set of questions regarding the preference for each separate light setting, participants were asked to rate the light settings with relation to their feelings of safety by using VERO tool (Szostek & Karapanos, 2011). In short, participants were asked to drag each light setting onto a circle. The closer a given lighting design was placed to the center of the circle the higher was the level of perceived safety. Additional measurements for age, gender and frequency of bicycle usage were used.

Secondly, workshops with different stakeholders were conducted. The goal of these workshops was to collect feedback from multiple points of view and to facilitate an elaborate discussion on the validity of the lighting solutions in the surroundings of an ecological zone. These stakeholders included the municipality, people living in the neighborhood, local police, an environmental organization and also other users: school children, athletes who use the path for their weekly running exercise and elderly. A workshop consisted of the following steps:

4. Visit to the demonstrator
5. Reflection on the concept
6. Concept presentation using video material
7. Reflection on the concept
8. Evaluation of the importance of the key parameters of the concept for further development

'Stakeholder types' were not mixed in the workshops and at least two individuals participated representing each 'stakeholder type'. An independent facilitator was invited to facilitate the discussion on the value of the concept.

Results

Firstly, the results of the questionnaire are discussed and then the qualitative insights regarding most important outcomes from the workshops are presented.

A total of 966 persons volunteered to fill in the questionnaire. However, due to incompleteness of records, 602 answers were used for the analysis. Among the participants 283 were male (47%) and 391 female (53%). The majority (60%) rode a bicycle daily. Among those, 13.5% of people rode a bicycle daily after dark.

The majority of participants either preferred setting A (46.3%) or had no preference regarding the light for bicycle paths (36.3%). Setting B has been chosen as the preferred one by 14% and setting C by 3.3% of people. There was no difference with respect to the light preferences by people of different age (X2=.062, d.f.=21), gender (X2=.101, d.f.=3) and frequency of riding a bike after dark (X2=.735, d.f.=12). Significant difference was detected that depended on the overall frequency of riding a bike (X2=.044, $p<0.05$, d.f.=12). The study showed that participants who either never or about once a year rode a bicycle had no preference for one of the light settings. If they showed preference they would most often select B and then A as preferred settings. Participants riding bicycles more frequently (once a month, once a week and daily) showed strong preference for A, then none and then B.

Similarly, the results of the repertory grid technique showed that setting A was perceived as the safest (mean distance from the center = 85.41, median = 71.72, dominant = 50), then B (mean = 95.25, median = 94.59, dominant = 50) and finally C (mean = 141.51, median = 141.51, dominant = 150).

Furthermore, the analysis showed that gender, the overall frequency of cycling or frequency of cycling after dark) did not differentiate the perception of the tested light conditions as more or less safe. With respect to age, significant correlation (.002, $P < .001$) was detected in the case of setting B, which was perceived as the least safe among the youngest and the oldest participants. The group who considered setting B as relatively safe was between 41 and 70 years old.

A and B settings were considered as the most similar in terms of safety (mean = 62.96; median = 61.2), while B and C were seen as the least similar (mean = 105.68, median = 108.94). Based on the t-test for two dependent samples with normal distributions can be concluded that the perceived similarity between A and B is significantly different from the perception of similarity between B and C ($t = 19.96$, $p < .000$).

The results gathered during the 7 workshop sessions are summarized in Table 1. The first important observation is that although all stakeholders were at least fairly positive towards the concept as a whole, the ranking of key parameters for its further development differed significantly. Interestingly, the road users indicated energy efficiency to be the most important parameter, whereas municipality marked it as the least important one. This seems to indicate that citizens expect from municipalities to find a balance between energy efficiency on the one hand and social safety and ecology on the other. Furthermore, during the workshops multiple questions arose that mostly related to the perception of safety. Example are: can we control light intensity in the case of emergencies; would green and yellow lighting result in unwanted changes in color perception; does car and urban lighting in the surroundings change the atmosphere?

	Police	Supplier	Environmental organisation	Users	Municipality
Ecology	4	3	1	3	2
Social safety	1	2	2	2	1
Energy efficiency	6	4	3	1	6
Atmosphere	2	1	4	4	3
Promotional value	5	6	5	5	5
Purchase and maintenance costs	3	5	6	6	4

Table 1: Overview of the ranking of key parameters

Conclusions and discussion

This research aimed to generate insights regarding the perception of intangible value of light settings as experienced by different stakeholders. One of the most prominent difficulties in testing such radical innovations is to ensure that the participants understand the concept properly. For the concept presented in this article, two problems arose during concept evaluation: 1) despite using a demonstrator the lighting concept and its associated values were still intangible; 2) the concept itself is dynamic for which people have no previous reference.

In line with the previous research, the quantitative results confirmed that settings with higher light levels were preferred. But the results also suggest that a lower light level with a high color rendering is perceived as similar to a higher level with lower color rendering. This is an aspect for further study.

Although the experimental set-up was not similar to a realistic outdoor situation, the fact that people could experience the light settings give rise to interesting discussions on the different stakeholder perspectives. This confirmed the usefulness of this co-reflection session in an early phase of the project to elicit stakeholders' needs. Moreover, the results of the co-reflection proved to be a strong element in building commitment from a supplier to invest in the production of specific prototypes for a next iteration.

This study had some limitations. For people participating in the survey it may not have been clear enough that the three settings were to be used over the course of the night, so they might not be triggered to reflect on the settings in relation to the probability of them using the path at the respective time blocks.

Further research aims to address these limitations and will include new moments of reflection when a limited set of prototypes is placed on the real-life situations (2012) and longitudinal studies when the complete installation is placed (2013). It will also further study the perception of different combinations of light and color rendering levels.

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