The Persuasive Potential of Lighting: Exploring User Lighting Setting Preferences for a Warm Room Atmosphere and Energy Consumption Feedback

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***Abstract*—Ambient lighting can be used for influencing users' experience of the environment and their subsequent (energy consumption) behavior. Our research explored which lighting settings users prefer for lighting that is designed to give a room a 'warm' atmosphere and for lighting that is used as energy consumption feedback. In the experiment, three lighting characteristics (brightness, color temperature, and color hue and saturation) could be adjusted through an interactive interface according to participants' preferences. Results showed that for creating a 'warm' atmosphere, lighting with a low luminance, a low color temperature, and a highly saturated, warm color (i.e., orange/red) was preferred. For providing negative feedback about energy consumption, lighting with a high luminance, and a highly saturated, red color was preferred. Thereby, current results suggested that ambient lighting's persuasive potential might be most optimal when lighting settings are used that are appropriate to a situation.**

Keywords-Ambient Lighting, Persuasive Technology, Energy Conservation, Lighting Characteristics.

I. INTRODUCTION

Earlier research showed that ambient lighting can be used for influencing (energy conservation) behavior [1]. Thereby, lighting is used as ambient persuasive technology (e.g., [2] - [6]). More specifically, earlier research effectively used colors of ambient lighting as feedback to indicate a user's energy consumption level, e.g., more red for higher energy consumption and more green for lower energy consumption [7] - [9]. Research [8] showed that colors of ambient lighting feedback can carry meaning that has pre-existing associations with energy consumption and these associations help users to easily process the feedback messages, and thereby enhance the effectiveness of ambient persuasive technology.

In addition to using colors of ambient lighting to communicate feedback, other characteristics of lighting (e.g., brightness level, color temperature etc.) can also influence users' experience of the ambient lighting, their environment, and importantly, their subsequent behavior [6]. For instance, people prefer 'warm' lighting (i.e., lighting with a low color temperature) in winter [10], and household energy consumption for heating systems could be reduced by 5% to 8% by using this 'warm' light in winter while maintain the same thermal comfort level [11].

To expand our knowledge on how lighting settings are able to influence energy consumption behavior, the current research investigated which lighting settings users prefer for lighting designed to give a room a 'warm' atmosphere and for lighting that is used as energy consumption feedback. That is, participants were seated in a room of which they could set the lighting characteristics (brightness, color temperature, and color), and participants were asked to set lighting characteristics to their preferences for two types of scenarios. In the first series of scenarios, participants were to set the room lighting characteristics such that room lighting gave the room a warm (or fresh) atmosphere. In the second series of scenarios, participants were asked to indicate which room lighting characteristics they would prefer the room lighting to have when that lighting was to be used to give them (positive or negative) feedback about their energy consumption (e.g., caused by heating the room).

II. METHOD

Fifteen participants (11 males and 4 females) aged between 17 and 35 participated in the experiment, all without a known visual handicap (e.g., color-blindness). Participants received 5 Euros for their participation in the experiment that lasted approximately 30 minutes. The experiment was computer-based and conducted in the Lighting Lab in the IPO building at the Eindhoven University of Technology campus.

Participants were welcomed and seated in a room in which they could set the lighting characteristics. The settings interface allowed them to change three characteristics of the room lighting: Brightness, Color temperature, and Color (both hue and saturation). Participants could select one of these characteristics at a time, and change its settings using the 'right' and 'left' arrows on a computer keyboard.

After participants had gotten familiar with the interactive lighting system, they were asked to set the room lighting to their preferences for a series of room atmosphere scenarios. That is, participants were presented with a scenario (e.g., "you are feeling a bit chilly and you want to create a warm atmosphere with the light"), and then could set the lighting characteristics to their preferences for that scenario. In half of the scenarios, participants were asked to create a 'warm'

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atmosphere, and in the other half of the scenarios, participants were asked to create a 'fresh' atmosphere.

In the next task, participants were presented with a different series of scenarios, and asked to indicate which lighting settings they would prefer for receiving energy consumption feedback through changes in room lighting. For this, participants were first given a short introduction: "We are currently performing research on how lighting can be used as feedback to stimulate energy different behavior in home environments. For example, lighting can provide the feedback to inform you to turn down the temperature, use less water, shut down devices that are not in use, etc." Next, participants were asked to set the lighting characteristics for a series of scenarios related to saving energy and resources (e.g., "You've set the bathroom temperature to 28 Celsius degrees, although it will not be used until tomorrow morning. How can lighting inform you that the temperature is set too high?" as an example of negative lighting feedback). For one scenario at a time, participants were asked to set lighting characteristics to their preferences, using the room lighting interface. In half of the scenarios, participants were asked to set the lighting such that it indicated negative feedback, and in the other half of the scenarios, participants were asked to set the lighting such that it indicated positive feedback. Finally, participants were thanked for participation, paid and debriefed.

III. RESULTS

Results showed that for giving a room a 'warm' atmosphere, participants preferred lighting with 1) a lower luminance, 2) a lower color temperature, 3) higher saturated, and 4) warmer colors (i.e., orange/red), compared to the lighting settings participants preferred for giving a room a 'fresh' atmosphere (all p's< .05).

Furthermore, results showed that for receiving negative energy consumption feedback, participants preferred lighting with 1) a higher luminance, and 2) a higher saturated 3) color with a lower hue (i.e., red light), compared to lighting settings participants preferred for receiving positive energy consumption feedback (all p's< .05).

IV. DISCUSSION

The current research explored which lighting settings users prefer for lighting designed to give a room a 'warm' atmosphere and for lighting that is used as energy consumption feedback. The results of this study describe the lighting settings users prefer for these two purposes, and thereby add to our knowledge of people's associations of lighting characteristics with room atmosphere and heating (energy consumption) feedback, and thereby of the persuasive potential of lighting. The current results suggest that this persuasive potential might be most optimal when lighting settings are used that are appropriate to a situation. This research studied basic lighting characteristics (brightness; color temperature; and color, both hue and saturation), and future research might assess other characteristics of room lighting (e.g., patterns, movement, etc.). Based on the current results, future research can investigate the effectiveness of changing these characteristics of lighting for actually changing people's perception of ('warm') room atmosphere, temperature perception, effectiveness of energy consumption feedback, and ultimately, the effectiveness of ambient lighting changes for influencing energy consumption behaviors.

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