## Defining light atmospheres physically (DeLAP)

**Proposal for 2 PhD students**

**Supervising team: Ingrid Vogels and Ingrid Heynderickx (TU/e)**

## Objectives of the project

## The aim of the project is to define atmospheres created with light in a room in terms of relevant physical characteristics of the light distribution in that room, such that the same atmosphere can be created in multiple rooms, independent of the dimensions of the room and the lighting infrastructure in it.

## Motivation

The huge flexibility in the chromaticity, intensity, beam shape and spatial and temporal patterns of LED-based lighting systems enable the creation of almost any atmosphere that suits the end user’s needs. Because of this enormous range of freedom in the lighting design, however, it is far from trivial to know how to support users in creating the desired atmosphere. This problem becomes even more challenging when taking into account local variations in room dimensions and/or lighting infrastructure.

Defining a desired light atmosphere is relevant to many application domains. In homes people may want to create various atmospheres depending on their activity by using the presets of an intelligent lighting system; the main challenge here is how to define these presets, such that they approach the desired atmosphere as closely as possible with the number and positions of the light sources available in the specific room. In chains (of shops, restaurants, hotels, etc.) the lighting design should contribute to brand recognition, and thus this lighting design needs to be copied over various affiliations of the chain, taking into account variations in the characteristics of the space and the lighting infrastructure.

## Background

Being able to define a specific atmosphere independent of characteristics of the space and lighting infrastructure basically entails two research topics: (1) modelling atmosphere in terms of underlying perceptual attributes (such as brightness, contrast, color and uniformity), and (2) knowing how to express these perceptual attributes in terms of physical characteristics of the light distribution in the space.

Earlier research (a.o., by Vogels and Stokkermans) has shown that perceived atmosphere can be modelled in terms of brightness and perceived uniformity, at least for lighting distributions that vary in terms of intensity, number of light sources and beam shape. Additional studies (by MSc-students of TU/e and TU Twente at Philips) have shown that colored (accent) lighting strongly influences the perceived atmosphere, with the specific changes in atmosphere depending on the color(s) and the spatial uniformity of the colored light. From a different perspective, Choy (MSc TU Delft) has measured to what extent intensity and color of the light may change before these changes affect the perceived atmosphere. The resulting degrees of freedom may be used to create the same atmosphere in a different space with a different lighting infrastructure, but one should note that the level of uniformity in the light distribution wasn’t included in this study.

With respect to the second research topic, there is existing literature attempting to express perceptual attributes in terms of physical descriptors of the light distribution in the room, but all these measures have their shortcomings. Room brightness has been extensively studied, and has been expressed in terms of light intensity, luminance or illuminance, averaged over a certain area of the room. In practice, though, these measures are insufficiently accurate, in part because they do not take into account local or global light adaptation. There is also proof that these measures become even more unreliable when the light intensity is not uniformly distributed over the space.

## Description of the research

In this project we will focus on the impact of the spatial uniformity of the light on atmosphere. There are several reasons why this is the logical next step in atmosphere research:

* the uniformity of the light distribution (in intensity and color) has a strong impact on the perceived atmosphere
* differences in lighting infrastructure between rooms will have a stronger impact on uniformity than on brightness and color (since, in practice, the latter two may be more easily tuned)
* the degrees of freedom in uniformity that still yield the same atmosphere are not known yet
* how to characterize the perceived uniformity of light that is a mixture of directional and diffuse white and colored light is unknown
* understanding perceived uniformity may help on the longer term to better be able to describe brightness in terms of physical characteristics of the light distribution

Hence, the resulting research questions become:

1. how can we model the impact of perceived uniformity on perceived atmosphere, and what are the degrees of freedom in perceived uniformity that still enable the same atmosphere
2. how do we express perceived uniformity in terms of physical characteristics of the light distribution in a room for mixtures of directional and diffuse white and colored light

Since both research questions need – to some extent – a different disciplinary background, we propose to divide the research over two work packages, each addressed by a different PhD. The various tasks and experiments that we envision in both work packages are detailed below. For both work packages, we are convinced that most (if not all) research can be done using visualizations of real rooms on a computer display.

*WP1: impact of perceived uniformity on atmosphere* with the following possible tasks:

1. Experiment in which we vary the beam size, beam shape, number and position of light sources emitting white light, and in which we measure their impact on (a) atmosphere and (b) perceptual light attributes, such as uniformity, brightness and contrast
2. Similar experiment as in (1), but now also including colored light, and extending the measurement of the perceptual light attributes accordingly
3. Experiment in which we change the beam size, beam shape and/or the distance between light sources to see when a given atmosphere changes (in other words, to measure the range of freedom around a given atmosphere)
4. Validation experiment: using a model based on the above results, we should be able to create light settings that yield the same atmosphere in different rooms.

So, for this work package we need a student that is strong in user testing and has affinity with modeling.

*WP2: definition of perceived uniformity*

1. Use already available data from earlier studies on perceived uniformity to develop and fit an objective measure for perceived uniformity in terms of physical characteristics of the light distribution
2. Perform additional experiments with different levels of physical uniformity created by changing the beam shape, beam size and position of the white and/or colored light sources, and measure perceived uniformity
3. Perform experiments with more complex light distributions in the room, such that the effect of (il)luminance of walls, floor and ceiling on perceived uniformity can be disentangled.
4. Use these additional experimental data to refine the objective measure for perceived uniformity, also including colored light
5. Validate the objective measure by creating the same value of the objective measure in different ways (i.e., with different combinations of beam shape and lamp position) and measure perceived uniformity

So, for this work package we need a student that is strong in modelling and has affinity with user testing.