# Lumicons: Mapping Light Patterns to Information Classes

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**Abstract**

The current development of ambient light systems lacks an evaluation and guidelines in the design process. We present a study design with two complementary parts, which aims to fill the gaps in the understanding of information encoding via light. In the first part of our study we want to find out light patterns that represent different types of everyday information, and in the second part we want to verify the appropriate mappings of these light patterns suggested by participants. An appropriate mapping of the light pattern should be perceptible and distinct with a degree of attention arousal and aesthetic appearance. The goal of the study is to derive light patterns and guidelines for building new light systems and applications.

## 1 Introduction

Light as a medium is often used in ambient systems to gain user's attention unobtrusively and convey different types of information. For example, Mankoff et al. suggested heuristics for ambient displays in general. However, ambient displays using light still lack guidelines on how to design these types of systems and what light patterns are more suitable for an encoding of some piece of information. Recent research about improving the monitoring performance of commanders in highly automated unmanned aerial vehicles with support of ambient light displays (Fortmann et al.) underlines the importance of having such guidelines and light patterns.

We conducted a thorough literature search and found many similar properties among 33 light prototypes and their information encodings. We defined the information classes that collect these similarities: Progress, Status, Spatial, and Notification. Their definitions are the following:

> *Progress* shows a relative indication of goal achievement by monotonously increasing or decreasing values.
>
> *Status* shows the absolute current value with possible change of tendency with no indication of goal reachability.
>
> *Spatial* shows a direction to a point-of-interest.
>
> *Notification* shows information that grabs the user's attention.

In the first part of the study we aim to determine light patterns for different scenarios that belong to the four information classes, and in the second part to verify the designed light patterns.

# 2 Study Design

We got the inspiration for the design and methodology of our study from the studies of Harrison et al. and Laugwitz et al.. Harrison et al. defined information categories, showed participants different light behaviors and asked to classify these light patterns. Laugwitz et al. verified their brainstorming items for a questionnaire with a validation study. Therefore, we suggest a study with two parts as described in the next section.

## 2.1 Procedure

For the first part of the study we decided to create scenarios, which describe existing use cases of all four information classes. For this we first abstracted ten use cases from the prototypes found in the literature search for which we created one scenario per use case. The scenarios are about everyday life situations and examples from each class are listed below:

> Scenario Progress: *Imagine there is an event in two hours: how could light inform you about the time left before this events starts? (elapsing time)*
>
> Scenario Status: *Imagine you are going for a walk. How could light inform you about the current distance to your home? (closer − further)*
>
> Scenario Spatial: *Imagine you have to display the concrete way to a POI with light - how would the following directions look like: forward, backward, right, and left?*
>
> Scenario Notification: *Imagine there are unread messages. How could a light notify you?*

In the first part of the study we present ten scenarios for different kinds of everyday activities. All participants receive the same set of scenarios. The order of the scenarios is counterbalanced.

The participants receive the Android application *Creating Light Patterns* (Figure 1) and two Arduino prototypes (Figure 2). We intend on asking participants to design a light pattern for each scenario by manipulating light parameters such as color and brightness. Therefore, the participant will select the parameters from the Android application for each scenario they think it fits best. After selecting the preferred light parameters from the app and sending the data to the according prototype, LEDs start glowing in the suggested way. After each of the scenarios, we interview participants about the selected parameters (e.g. Why did you choose this color?).

If possible we derive one light pattern for each scenario for study part two from study part one. This time the participants try to map a light pattern to suitable information. The participant selects a light pattern from the list of ten light patterns from the Android application *List of Light Patterns* (Figure 3). We pursue the principles of Latin square to sort the range of light patterns and we present the same ten scenarios for different kinds of everyday activities to all participants. A participant uses a 5-point Likert scale to indicate how well a light pattern suits to specific information. If participants face mapping problems they can skip a light pattern or leave out a scenario.

## 2.2 Participants

We plan to recruit 50 participants (20 for the first and 30 for the second part of the study) aged between 18 and 80. None of them should have vision problems, color blindness, or any other color recognition limitations.

## 2.3 Apparatus

For the first part of the study we programmed the Android application *Creating Light Patterns* (Figure 1) for a tablet that communicates via Bluetooth with the *single-light display* (Figure 2, left). Both of the prototypes are enclosed in wooden boxes in form of parallelepiped. The *single-light display* (Figure 2, left) shows a light in different colors and brightness levels through the diffuse acrylic glass side of the box, and the *spatial data display* (Figure 2, right) uses only one color and different positions of LEDs to convey spatial information. With the *spatial data display* we want to give users an opportunity to suggest spatial information encoding not only with color and brightness, but also with LED position.

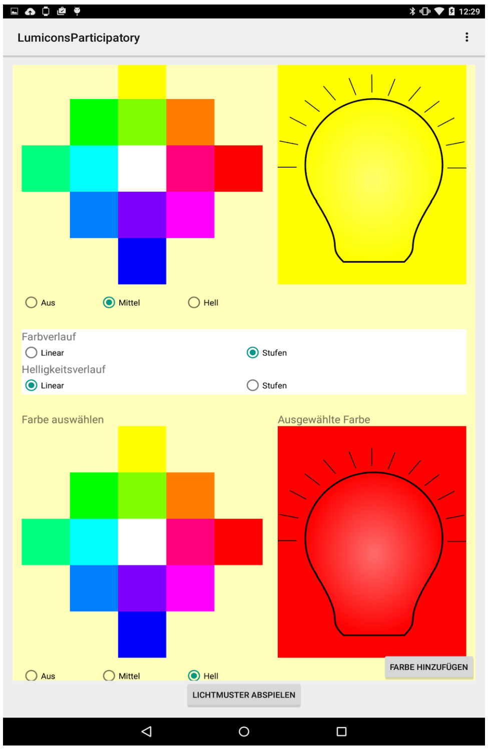


*Figure 1: Android application: Creating Light Patterns*

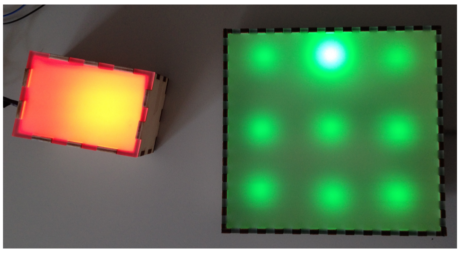

*Figure 2: Arduino prototypes: single-light display (left), spatial data display (right)*

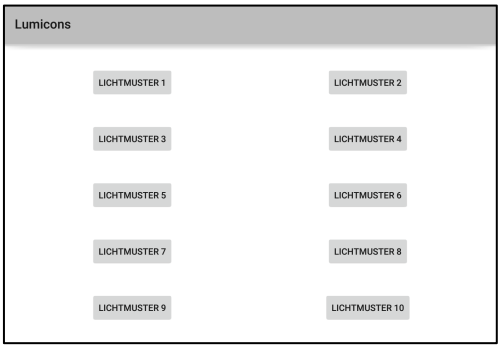


*Figure 3: Android application: List of Light Patterns*

During the first part of the study the user specifies the light parameters and sets the changes of color, brightness or fading for initial and end state in the Android application. In the upper part of the screen the user selects a color from the color cross by tapping on it, and brightness using radio buttons (Figure 1, upper part). We change the color representation from the common color circle (Hammer 2008) to cross to make the size of white color equal to the rest without shifting the arrangement of complementary colors. The result of the chosen parameters is directly displayed on the picture on the right side (bulb) and on the *single-light display*. Then the user selects the gradient for color and brightness - linear or stepwise

(Figure 1, middle part). Afterwards a participant selects the color and brightness for the end and middle states of an LED in the same way as for the initial one. Finally, the user presses a button (Figure 1, lower part) and the light pattern is displayed on the *single-light display*.

For the second part of the study we use the same two light prototypes with Bluetooth connection. The technical difference lays only in the Android application *List of Light Patterns* (Figure 3). The participant selects one pre-programmed light pattern from a randomized list of patterns and sends it to the according prototype. The selected button for the current light pattern stays highlighted in the application till the moment the light pattern ends. The participants can send the same light pattern to a prototype as many times as they want by repeatedly tapping on the light pattern button. The application sends a light pattern automatically to the appropriate prototype, i.e. the participant does not have to choose a prototype manually.

# 3 Expected Results and Future Work

In this paper, we present a reasonable categorization derived from existing ambient light systems called information classes such as Progress, Status, Spatial, and Notification. Besides we describe a study design to explore light patterns for different scenarios. We expect to derive suitable light patterns and guidelines for the development of future ambient light displays and systems, and to draw generalized conclusions for the design of light patterns for generic information classes. In future work we aim to conduct the designed study and evaluate the derived patterns in the application domain.

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