

Studying the Effect of Expressive Light Animation on Human Perception and Behavior of Human-Machine Interaction

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I. MOTIVATION

As robots begin entering human society and interacting with people, it is important for them to be able to express affect. Although many studies have investigated human-like interaction methods involving facial expressions and gestures, there has been little focus on appearance-constrained robots due to their restrictions in interaction modalities. Existing approaches for promoting affective interaction for such robots mainly focused on motion cues or body postures. However, such approaches lack expressibility and are hard, if not impossible, to be applied in many application scenarios.

To address this issue, we investigate an alternative modality, expressive light, as an affective interaction modality. Compared to other modalities such as motion cue, body posture, and acoustic cue, expressive light offers a much broader design space, is less intrusive, and less restricted to spatiotemporal limitations. However until now, it has been unclear how robots can take advantage of expressive light as a primary modality to express affect, and furthermore, how expressive light can affect people's perceptions towards and behaviors toward the robot.

II. COLOR PSYCHOLOGY AND EXPRESSIVE LIGHT ANIMATION DESIGN

Color psychologists have intensively investigated on various aspects of color, including color effects on psychological and biological functioning in particular. Their work primarily focuses on red, blue, and green, since such colors (especially red) have been considered as special and have positive links in the natural realm. According to the Color-in-Context (CIC) theory, each color activates associations that contain psychologically-relevant messages. Therefore, viewing a color can influence psychological functioning and foster motivational and behavioral processes, such as **approach** or **avoidance** tendencies. In general, color stimuli that carry a positive meaning produce approach responses, whereas those that carry a negative meaning produce avoidance responses.

Accordingly, we designed two kinds of (LED) light animations, low intensive triangle waveform in green color and high intensive square waveform in red color. The intension (frequency) and waveform are introduced to amplify the color effects and manipulate the perception of light animation in the arousal level. We assume that the *green and low*

intensive (GL) light animation will be perceived as positive and lowly arousing (pleasing) while the *red and high intensive (RH)* light animation be perceived as negative and highly arousing (unpleasing). Further, the GL light animation may induce people's approach-like behaviors while RH light animation may induce avoidance-like behaviors.

III. EXPERIMENTS AND RESULTS

To investigate the effect of expressive light animation on both people's perception and behavior, we performed a series of two experiments using an Ultimatum game and a Give-Some game in which we attached an LED strip to the front-bottom of a computer monitor and had it display the two light animations, GL and RH. Specifically, we applied the Ultimatum game to study how people's tolerance regarding unfair offers changed when the computer showed the two light animations, and we applied the Give-Some game to see whether people will behave more cooperative/selfish with respect to each light animation.

The results are in line with color psychology theories. The participants perceived the GL light animation positively and further acted approach-like behaviors by showing higher tolerance regarding unfair offers and behaving more cooperatively. Similarly, they perceived the RH light animation negatively and further acted avoidance-like behaviors by showing lower tolerance regarding unfair offers and behaving less cooperatively (selfishly). In addition, analysis of the post-experiment questionnaire showed that the participants used contrasting descriptions for the two light animations, as listed in Table I. Therefore, the results reveal evidence of the effect of expressive light animation on both people's perception and behavior.

The current results are based on studies taken between people and a computer. We are now working on installing an LED lighting system to an iRobot Create 2 robot and going to use it as a robotic platform to translate this study to human-robot interaction scenarios.

TABLE I
LIST OF ADJECTIVES USED BY PARTICIPANTS TO DESCRIBE THE LIGHT ANIMATIONS.

| | Green & low intensive | Red & high intensive | No light animation |
|-------------|---|--|--------------------|
| Description | friendly, calm, gentle, smiling, beautiful, kind, alive | angry, oppressive, feeling of tension, warning, challenging, dangerous | normal |

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