SmartHeliosity: Emotional Ergonomics through Coloured Light

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Abstract. In this paper we present research activities on the interaction between light and human emotion. We describe the SmartHeliosity prototype which evaluates human emotions to provide appropriate coloured light in order to enhance emotional wellbeing within the working environment. We present technical specifications, colour concepts to provoke certain emotions and user feedback to the prototype system.

Keywords: Adaptive light, coloured light, emotion, face detection.

1 Introduction

Colour and light are an integral part of human life. Colour is a very important factor for human emotional development and growth. Light is important for the sleep-wake cycle, health and well-being [1], [2], [3], [4]. Dynamic light can be activating [5] and give a sense of nature, progression and growth. SmartHeliosity aims at inducing positive emotions by providing an adaptive mood light. Our system evaluates human emotions and controls a colour changing light based on this information, with the aim to enhance the emotional well-being within the working environment (figure 1).

Designing ergonomic workplaces involves elements of working systems and environmental factors. An often neglected but important factor is human emotion. Psychological balance is an important factor, well-known for its influence on physical health. Colour therapy or sometimes called chromotherapy is an established alternative medicine method. Even our choice of decoration and clothing is strongly influenced by colour. Some physiological and psychological effects of colours on humans are described in chapter 1.1. [6].

1.1 Colour and Emotion

Red, being a long wavelength, is a powerful colour. Even though the highest sensitivity of the human eye is in the green region, red-colored objects have the property of appearing to be closer than they really are, and therefore red grabs our

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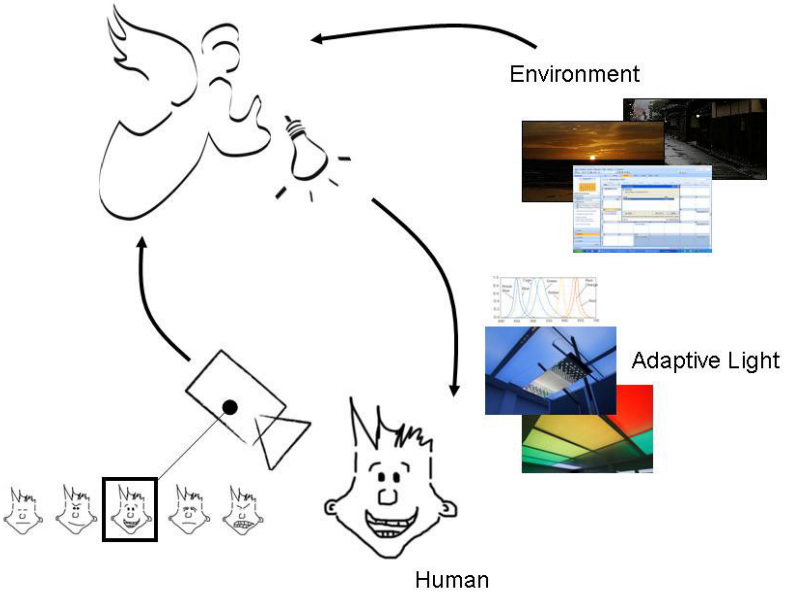

Fig. 1. SmartHeliosity closed loop: A lighting system that adapts to the user and its environment

attention first (hence it is used in traffic lights the world all over). Red can raise the pulse rate, giving the impression that time is passing faster. Red is stimulating, lively and friendly but at the same time, it can be perceived as demanding and aggressive.

Blue, being a short wavelength, is the colour of the mind and is essentially soothing. It affects us mentally rather than physically. Strong blue will stimulate clear thoughts and soft blue will calm the mind and aid concentration. Consequently it is serene and mentally calming. It is the colour of clear communication. Blue objects do not appear to be as close to us as red ones. However, blue can be perceived as cold, unemotional and unfriendly.

Yellow is an emotional colour and has a strong psychological effect. Yellow can lift our spirits and our self-esteem and it is the colour of confidence and optimism. Too much of it or the wrong tone in relation to the other tones in a colour scheme can rise fear and anxiety.

Green is restful for the eye. Being in the centre of the spectrum, it is the colour of balance. When the world around us contains plenty of green, it indicates the presence of water, so we are reassured by green on a primitive level. Negatively, it can indicate stagnation and, incorrectly used it can be perceived as being too bland.

Violet is very introversive and encourages meditation. It has associations with royalty and usually communicates the finest possible quality. Excessive use of violet can cause too much introspection and the wrong tone of it communicates something cheap and nasty.

Orange is stimulating and very warm. It is also a 'fun' colour. Too much orange suggests frivolity and a lack of serious intellectual values.

Pink also affects us physically and soothes. "Baker Miller Pink" in prison cells is used to calm prisoners. Pink represents feminism. Too much pink is physically draining.

Light and colour can be used for creating or inducing certain emotions or moods for specific situations. Axel Venn [7] shows that certain colour combinations imply certain feelings. In a survey with more than 60 participants, 1625 colours of the RAL design system have been connected to more than 360 feelings and adjectives. Some examples are

- Cosy: Warm red-orange-yellow shades with light toned beige-brown
- Spring: More than eighty percent of the colour range is yellow-green
- Tasteful: About 50 percent of the colours contain blue and black
- Painful: Reddish-black, turquoise, rose and lemon-yellow

1.2 Measurement of Emotion

Measurement of emotions is possible with multi-sensory systems using physiological parameters (heart frequency, skin resistance, etc.) as well as patterns of behaviour and facial expressions. SmartHeliosity connects dynamic light with multi-sensory systems with the goal to ensure emotional ergonomics of the user. With our prototype, emotions are detected through facial expression via a web cam and the software SHORE™ from Fraunhofer IIS. Using the SDK we modified the software to give us an emotional value of the user on a predefined scale. SHORE™ is a highly optimized software library for face and object detection and fine analysis (figure 2). SHORE stands for Sophisticated Highspeed Object Recognition Engine. The software recognises the emotional value of the user like happy, sad, excited, etc. [8]

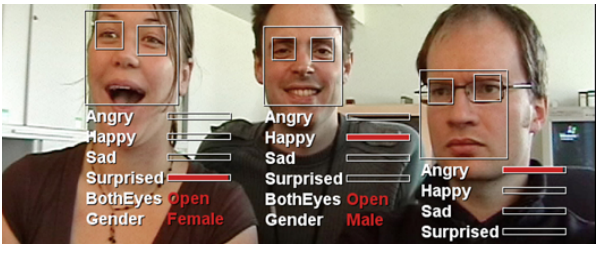

Fig. 2. Fraunhofer IIS face detection software SHORE™

The information about the emotion is passed to the colour database which provides light algorithms to tune to the emotions of the user. Eventually this will create an ambient light in an emotionally ergonomic work environment. So far no physical interface is involved as we trigger the light by the facial expression only. We believe it

is important that there are no additional interfaces as this may have effects on the user's emotional state. Facial features are interpreted by the following characteristics [9]:

- Anger: Lowered, inward slanting eyebrows squeezed together in a wrinkle. Eyelids are tight and straight as a result of the lowered brow. Mouth is either closed as tight straight lips, or the lips are puckered. Forward thrust of the jaw or lift of the chin.
- Annoyance: Inward slanting eyebrows squeezed together in a wrinkle or crease. Mouth twisted into a side placement creating a crease in the cheek. Puckered lips are optional.
- Depression: The upward slanted eyebrows; there is no prominent frown involved. Also, the lowering of the eyes looking downward give the helpless, dejected mood that is associated with depression.
- Excitement: The excited facial expression is a positive face expression that is often characterized through an open mouthed smile. The eyes are usually open to their fullest and the eye brows are up high to show an active energy level.
- Fear: The fear facial expression is characterized by upward slanted eyebrows with wide open eyes. The mouth is typically open as a wide gape
- Happiness: The happy facial expression is characterized through the use of a smile. The facial characteristics are different from that of a grin, because typically just the upper teeth are exposed. The lower lids of the eyes are raised to form crescent shapes.

1.3 SmartHeliosity Scenario

As SmartHeliosity is intended to be used in offices we would like to describe a typical scenario, how the luminaire system could support a worker at his office workplace: Mr. John Doe enters his office in early morning and is still a little sleepy. SmartHeliosity detects the tiredness in his eye movements and reacts with a blue-enriched spectrum, in order to suppress melatonin. As Mr. John Doe is annoyed because of an email, SmartHeliosity detects its annoyance by face recognition and reacts with a relaxing light program. An activating lighting program helps him during the preparation for his meeting at 10:30 and brings him into the right form for discussion.

1.4 Related Projects

The "ALADIN" project (Ambient lighting assistance for an ageing population) received funding from the ICT strand of the European Union's Sixth Framework Programme. It addressed the impact of lighting on the wellbeing and health of older people. The system used information from biosensors to determine what users are doing and then changed the lighting accordingly. The researchers' goal was to improve the wellbeing of elderly people suffering from age-related illnesses and people with reduced mobility. [10]

2 SmartHeliosity Specifications

2.1 SmartHeliosity Concept

The technical realization of the SmartHeliosity concept is based on the integration of various already available sources of information about the working environment and the user as well as an adaptive LED-luminaire. The luminaire is flexible and can be adapted to the environment and to the preferences of the user in size and form like a modular sculpture. It is made of LEDs embedded in silicone. Each module is like a "Lego" which can be joined together in any numbers to create different patterns in three dimensions. This gives flexibility to the user to have its own light sculpture.

As already mentioned, the detected emotions are linked to a colour database. Our software provides light algorithms to tune to the emotions of the user. These algorithms continuously calculate appropriate colour combinations to suite emotion of the user. Basically we try to provide a light condition to bring the user's emotional level to the desired and appropriate condition. Whenever some negative emotions are induced, such as angriness, annoyance or sadness, it tries to normalize it to well being conditions like relaxed and calm conditions. Whenever positive emotions are detected it tries to maintain them at a certain level and not to go into hyper emotional conditions. Figure 4 shows some emotions and the corresponding colour combinations [6].

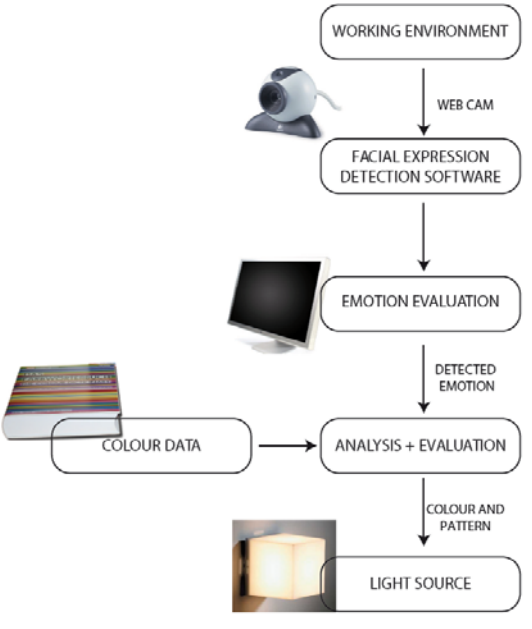

Fig. 3. SmartHeliosity technical concept

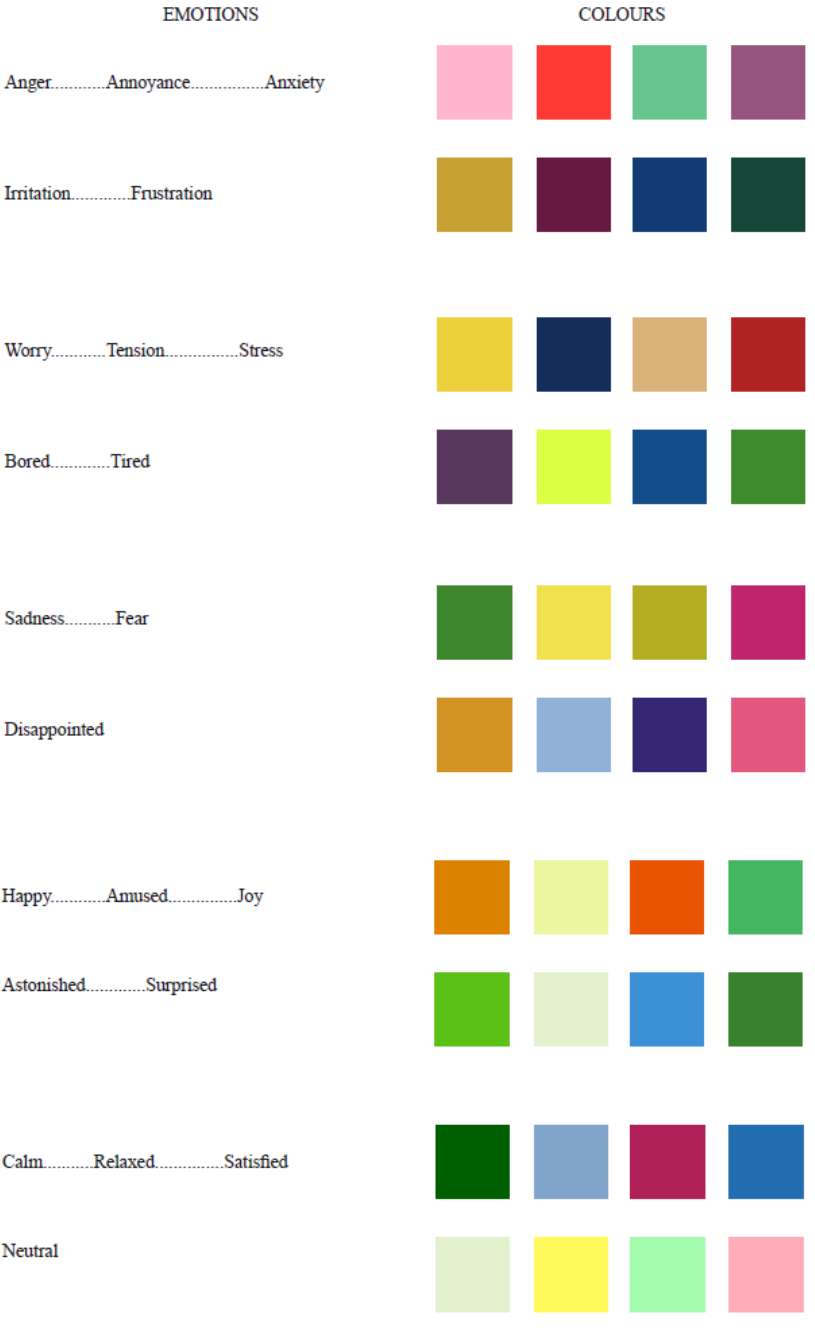

Fig. 4. Mood and corresponding colour combinations

2.2 Heliosity Light Fixture Design

SmartHeliosity is flexible in two respects: the material itself is flexible and can be bent in various shapes, and several single tiles can be connected to each other to build a modular light sculpture in various forms and sizes. It can be adapted to the environment and to the preferences of the user. One module is shown in figure 5. Figure 7 shows four separate modules that can be connected to each other. Several modules can be joined together in any numbers to create different patterns in 3 dimensional spaces.

LED stripes are embedded in silicone. The aluminium wire mesh allows for bending and forming the structure to the desired shape. The silicone protects the LEDs and holds the structure together. The flexible LED stripes are endowed with RGB 120° viewing angle PLCC2 SMD LEDs. They are driven with 12V and have a luminous flux of 800 lm. The LEDs are controlled by a 12 channel 16 bit DMX dimmer [11]. The transformation from the computer signal to the DMX values is realized by an Ethernet / DMX512 Control Box [12].

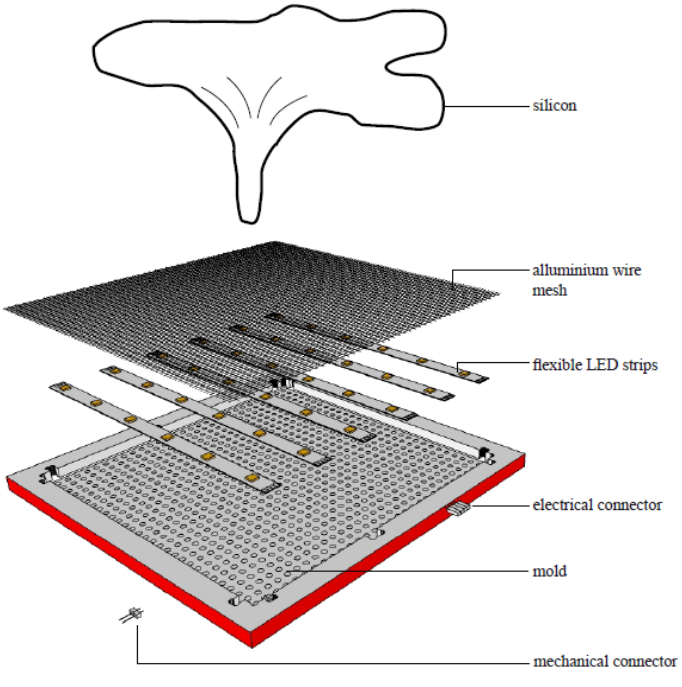

Fig. 5. SmartHeliosity mechanical design

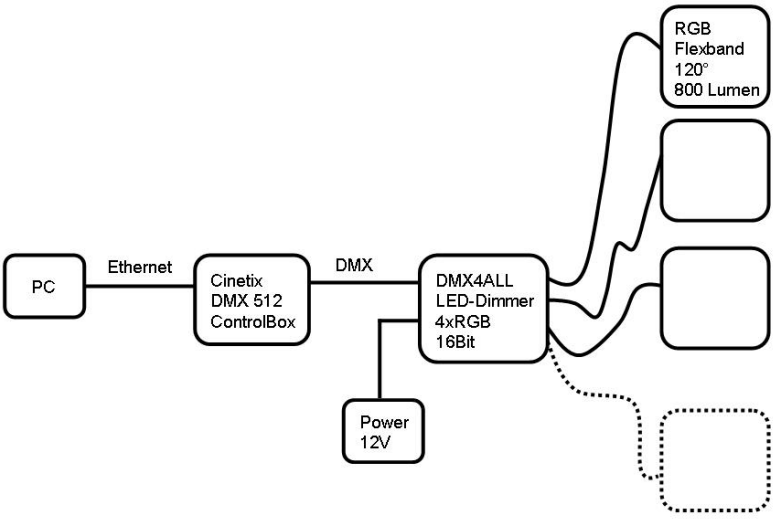

Fig. 6. SmartHeliosity electronic design

Fig. 7. SmartHeliosity final prototype of the light modules

3 User Feedback

Our user test was conducted with seven male and two female participants. Their age was between 25 and 44 years. The test was divided into two parts, where in first part users were asked to play a game (four in a row) against the computer for 15 minutes. While playing the game, users were not informed about the SmartHeliosity concept and that their emotion was evaluated. After the game, users were asked about the influence of the ambient lighting and the change of the colours during the game. In the second part of the test, users were informed about the SmartHeliosity concept and how everything works. Users were then allowed to use the system for a few minutes and subsequently asked to rate different aspects of the concept, such as response to emotions, detection of emotions, appropriateness of colours, etc.

In general, seven participants would like to use the system at their workplace while two participants denied to use it at their workplace.

Five participants answered with "yes", to the question "do you like the changing of ambient light?". Two participants found the change of light distracting while two other participants did not recognize any change of light at all. After the test, four participants reported to be relaxed, and two to be excited. Only one participant was bored at the end, while two other participants were happy and more awake. To the question "How well did the light respond to your emotions?", seven participants said "good" and two said "ok". Possible answers were "very bad", "bad", "ok", "good" and "very good". The answers to the question "How well did the system recognize your emotion "happy", "angry", and "surprised?" are presented in the following figures.

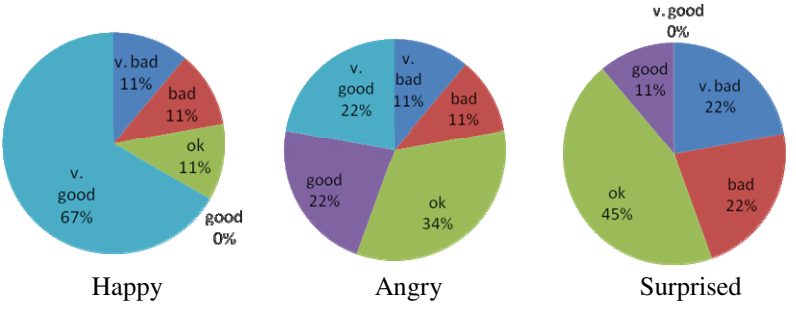

Fig. 8. User responses to the question "How well did the system recognize your emotion "happy", "angry", and "surprised?"

4 Future Work

Based on the user feedback we will improve the adaptive lighting design. In particular we have to improve the recognisability of the emotion "angry" and "surprised". We also discovered, that the system can not differentiate between an angry and concentrated face, so we will work on this issue. Furthermore we will integrate more input parameters such as body temperature, perspiration, and pulse rate. We will also consider voice modulation and gestures. Together with environmental parameters

such as the outlook calendar, emails, weather and natural light conditions we will refine the adaptive lighting system to respond to the user's emotion with more appropriate coloured light.

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