

# Designing a Smart Scarf to Influence Group Members' Emotions in Ambience: Design Process and User Experience

Chen Guo<sup>(✉)</sup>, Yingjie Victor Chen, Zhenyu Cheryl Qian, Yue Ma, Hanhdung Dinh, and Saikiran Anasingaraju

Purdue University, West Lafayette, IN, USA  
{guo171, victorchen, qianz, mal73, hdinh, sanasing}@purdue.edu

**Abstract.** This paper presents the design rationale of a color-changing and olfactory scarf to affect people's emotional states in a group environment. The goal of the design is to cheer up depressed individuals or calm down those who are overexcited. Our design uses a heart rate sensor and a skin conductance sensor to detect and recognize emotional information. The scarf will change its color and emit an odor to enhance positive emotions or reduce negative ones. We went through a user-centered design process and discussed different forms of design. Given the wearability and comfort characteristics of scarves, we decided to choose scarves as the solution to regulate emotions.

**Keywords:** Design process · Wearable technology · Emotion regulation

## 1 Introduction

With the development of wearable sensors and textile technologies, wearable devices have been incorporated into our everyday life. Using unobtrusive and wearable technology as emotional assistance for wearers has been considered as an important research question in the field of Human-computer interaction (HCI). Not only is it essential to boost one's own emotional health, it also crucial to influence others' emotional states through interactions in a group environment. People are easily affected by the emotions and feelings among group members. For example, surrounded by people complaining about their situations, most likely you will feel depressed and sad. If your spouse comes home wearing a big smiling face, your mood can be dramatically affected and you will soon become happier. Researchers call this phenomenon "group emotional contagion" [1]. Affective devices should take into account the shared emotions occurring in groups and help their wearers to be aware of their bodily experience in depression or overexcitement and consequently help modify or pacify their emotions.

Designing for group emotional health with wearable technologies presents a new challenge to interaction designers. Wearable tech design should also be put in a group's context. It raises different issues and principles in addition to those of self-emotional awareness and regulation. Designers need to find the important touchpoints with users during the design process. This paper focuses only on people's bodily experiences in

two extreme emotions: depression and overexcitement. After discussing existing design process and concepts within the wearable computing field, we conducted a phenomenological research to understand the aesthetic and technical needs of users for group emotional comfort. By comparing design alternatives and gathering feedbacks from users, our work extends current smart textile artifacts by proposing a scarf design concept aiming to assist in group emotional interactions.

## 2 Related Work

### 2.1 Quantified Self in Emotions

Quantified self is defined as the individual activities to track and monitor biological, physical, behavioral, or environmental information [2]. One recent trend in quantified self is that wearable technology is becoming more and more popular [3]. Humans are able to fabricate biosensors to detect physiological and mental changes. Many studies focus on how to monitor emotions and moods. Instead of using self-reports to measure moods, physiological signals, including heart rate, skin conductance, electrocardiogram, blood volume, and temperature, are broadly used to recognize them [4]. With an extensive survey of the work in emotion elicitation and recognition, researchers developed a multimodal affective user interface to monitor emotions via wearable computers and physiological signals [4]. To measure automobile drivers' stress, we used electrocardiogram, electromyogram, skin conductance, and respiration as metrics to classify their varied states [5]. Some researchers reported that five physiological signals, including blood volume pulse, electromyography, skin conductance, skin temperature, and respiration successfully extracted 30 features to recognize and classify emotional states [6]. Researches proposed that heart rate variability and skin conductance response were the dominant physiological signals to differentiate basic emotions such as happiness, sadness, indifference, anger, and stress [5, 7].

### 2.2 Affective Computing in Emotion Contagion

As an active research topic, affective computing aims to provide promising applications with computational technology to elicit and affect users' emotional experiences [8]. A few affective wearable products have been designed and created not only to modify emotional states of wearers, but also to transfer emotional states to others. SWARM is a wearable scarf to regulate wearer's emotions and to alert others' emotions through actuations [9]. The paper clearly presented the iterative, user-centered approach to address affective computing. The laughing dress supports social trust and enhances positive feelings among strangers by relating laughter to visual patterns of LED lights [10]. In the design concept, laughter is used as an emotional contagion to explore psychophysiological mirroring in HCI. Sensory Fiction is a wearable reading system to induce and evoke emotions of a person reading a book [11]. The paper reported that a social network was very powerful in altering people's moods through emotion con-

tagion. It also proposed that affective computing and emotion monitoring should be regulated in the private sphere instead of face-to-face interactions and habitual emotional suppression [11].

### 2.3 Design Process in Wearable Computing

Wearable computing addresses product design problems from an interdisciplinary perspective that requires the close collaboration between textile designers and electronics engineers. Some researchers stated that design for wearables is not simply combining electronic components with fashionable clothing; it should include physical form, electronic components, GUI (graphical user interface), physical interface, and embodied product value [12]. The design process for wearable computing is also regarded as a set of procedures to solve a problem with various types of information [13]. Moreover, researchers developed a design methodology for wearable computing and indicated that authenticity may inform the design process [14]. Furthermore, they explored the role of the prototype in user-centered design processes for wearables. And some studies reported important design principles to guide such design decisions as aesthetics, affordance, comfort, contextual-awareness, customization, ease of use, ergonomics, wearability, and fashion [15].

## 3 Phenomenal Research to Gather Requirements

The purpose of our design is to help people become more aware of their emotions in a group environment and also to help them enhance positive emotions and mitigate negative ones. To understand the lived phenomenal experience of users, we have relied on phenomenological research to focus on user needs, especially IPA (Interpretative Phenomenological Analysis). The aim of IPA is to examine how users are experiencing and feeling in a group environment.

### 3.1 Participants

We recruited 12 participants through a snowball sampling method: 8 males and 4 females, 1 listed undergraduate student, 7 listed Master's students, 3 listed Ph.D. students, and 1 listed faculty member. Their ages ranged from the 20 s to the 40 s, and no participants were color-blind.

### 3.2 Data Collection and Analysis

The guided semistructure interview allowed us to understand and gather participants' descriptions of their lived phenomenal experiences, including feelings, thoughts, images, and memories. The essential open-ended interview questions were to learn user attitudes toward wearable objects and their emotional state within a group environment. We encouraged participants to describe what their bodies had experienced in terms of

stressful situations, depressed situations, and over-excited situations in a group context and how their feelings had been affected in such a phenomenon. The interview felt like a natural exploratory conversation.

The interview questions are listed as follows:

- What are the things you wear that are able to cheer you up?
- What are the things you wear that are able to calm you down?
- What are the things you want to wear when feeling depressed or overexcited?
- Do you have any favorite wearable product? If so, can you describe the reason why you like it the most?
- Which materials below will make you comfortable? Woolen, cotton, nylon, fiber, silk, others?
- Can you describe a situation that would make you depressed or overexcited?
- Can you talk about how you shared or experienced emotions in a group environment?
- Will the mood of the group environment change your current feeling? How would the group environment affect you when you feel depressed or overexcited?
- Have you ever been in a group situation where you wanted to cheer up the group members or calm them down? How would you do that? How did your emotions affect the others' emotions?

After the interview, we read the transcripts and transformed the initial notes into emerging themes. A thematic analysis was applied to systematically classify the qualitative data. In the theme analysis, three researchers picked up the most prevalent and important issues that contributed most to the analysis and deleted some overlapping items. Researchers then referred back to the transcription to reach a consensus that those selective codes were the most important ones affecting the overall emotional experiences. In the end, researchers refined the final categories by combining some relevant subcategories.

### 3.3 The Main Findings

To set up the guidelines of our design, we concluded with the following three requirements based on the interview study.

**Style: Wearable Products Should be Soft, Light, and Comfortable.** Wearable products are the extension of human bodies and perceived as a second skin. Because of the close interaction with our body, physiological pleasure such as softness, lightness, comfort, and smoothness could affect people's choice of wearable products. Most participants loved cotton and woolen, which gives people pleasant sensations.

Participants cared about how other people perceive the product. One female student said, "When I am very excited, I wear a beautiful light dress. It makes me feel good and proud. I really care about how my friends perceive me. If I am judged harshly, my life will be miserable." Color is strong visual information and can relate to different perceptions and moods. This finding inspired us to create a comfortable cotton garment that can enhance psychological pleasure with color changing.

**Aesthetic Emotions: Recognizing Emotions in an Aesthetic and Subtle Way Instead of Naked in an Emotional Expression.** In the interview, a female user had this to say:

“I was once angry with my roommate and totally out of control. I am not always aware of my negative emotions. I know it is important to understand and manage emotions, but I don’t want to wear a band or a necklace to monitor my mood...it’s like your inner state is exposed in public. Everyone will know your emotions. Why not influence my emotions directly?”

A male student told us that with this product he was concerned about looking like an alien to group members. He expected the product would be normal and acceptable.

Their words show that users may not be aware of their negative emotions and have the ability to control them, but they do care about the emotional states of their bodies. However, sometimes people want to hide their real emotions instead of showing them openly in public. They are more willing to silently influence their emotions rather than to translate emotional expressions frankly in a group environment. There are some privacy concerns about emotions. This inspired us to consider that people may want new technology to help them control their feelings in an aesthetic, subtle, and silent way.

Moreover, the smart wearable product should look normal to others, not obvious and strange. Fashionable products are also to be favored when they are able to convey their emotions subtly and unobtrusively.

**Social Emotions: Emotional Empathy in Social Relations Makes People Feel Pleasure and Becomes a Distraction to Their Inner State.** We asked participants several short questions pertaining to the phenomenon when they felt depressed or overexcited and what affected their experience of body in a group environment. Most were college students, and they admitted always feeling depressed because of exams, deadlines, presentations, singing, and win-lose situations. When they were depressed, they preferred a brighter environment rather than dim light. Some participants would like to go out and do something like shopping, singing, and drawing with their friends to distract their emotions. They also preferred a calm place with few people around. More people would cause more pressure.

Another interesting thing about negative emotions is that people usually dislike talking too much to the group members if they are in a depressed situation. They would rather talk less and create a relaxed environment so that their friends will feel good. These findings encourage us to explore a new interactive way to communicate non-verbal emotional expressions in a group. Emotions can be transmitted through a wearable garment and enhance social bonds among people without invading privacy.

All participants revealed that environment greatly affects overexcited emotions. One participant said, “When I am among excited people and talking about things I like, I’ll get excited.” Another one mentioned, “When I hang out with my friends or my family, we do too many things that make me laugh so much or make me lose control of my own laughing.” People tend to express their excited emotions and are rarely aware of their harm. Before they reach the state of burnout, people want empathic interactions and let the other people feel the same way they do. They seek intimacy, attachment, and social interaction among people. This finding led us to use emphatic interaction to increase emotional wellbeing. Viewers’ bodies are also an interface for the wearer. We

can find ways to connect people and change people's emotions through other people's bodies. Emotional empathy in social relations makes people feel social pleasure and also become a distraction to people's inner state. A wearable garment can be a social medium to create new social interaction from private to public, intrapersonal to interpersonal.

## 4 Design Process

Given the interview results, we defined our design goals as using wearable and unobtrusive technology to affect their extreme emotions. The artifact needs to be physically and socially acceptable. We went through a series of brainstorming and sketching activities and came up with different concepts with regard to the wearable technologies and design forms.

### 4.1 Technology Options

**Wearable Sensors.** A wide range of technology options is available to detect emotional information. Emotion recognition using biosensors is an effective way to monitor human physiological signals, including heart rate variability (HRV), skin conductance (GSR), skin temperature, respiration, body volume pulse (BVP), and brain waves (EEG). As mentioned in the literature review, heart rate and skin conductance are the most reliable metrics to measure emotions. These sensors need not monitor wearers for a long time. The traditional way to measure heart rate is to attach wearable sensors to a person's chest. Previous work also demonstrated that it was possible to monitor the heart rate of an individual within one meter by use of the electric potential sensor [16]. Skin conductance is a highly important tool to measure emotional arousal. Studies indicate that feet, fingers, and shoulders were the most responsive positions of skin conductance [17]. We decided to use heart rate sensors and skin conductance sensors to measure emotions. The most important feature of the wearable sensors is reliable reading of body data and fast signal processing. The sensors should be also light in design and make wearers feel comfortable [18].

**Wireless Communication.** Wireless technologies have effectively infiltrated our everyday lives involve the transmission of data between different nodes over the air. There are four popular types of wireless technologies – infrared, Bluetooth, Wi-Fi, and Zigbee. Wi-Fi is mostly used for computer communications to access the Internet. Bluetooth is intended to support communications among connected devices, such as smartphones communicating to wireless headphones. Zigbee is ideal for low-power consumption and short-range communications. Infrared technology is widely used for device communications in short- and medium-range device communications. It can send or receive location information and decode signals. Considering the long transmission distance as well as the inexpensive cost, we chose the infrared receiver to receive the emotion data from the other wearers' sensors and to pass the raw data to the LilyPad controller for processing and analyzing the information.

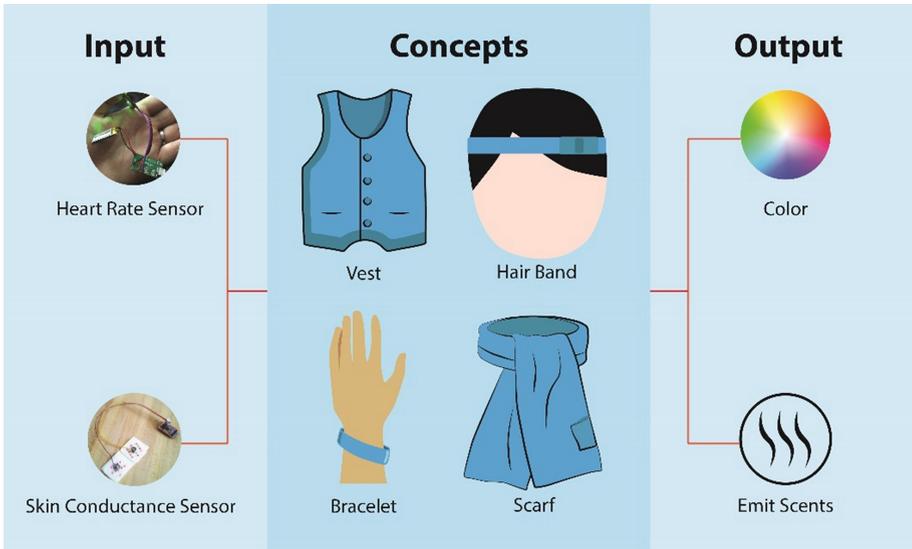
**Dynamic Output.** Our concept is to influence people's emotions in a group environment. If one person is depressed or overexcited, the other individuals in this group will create a happy or calm environment with the use of wearable devices to affect his or her feelings. Bearing in mind the concept of group emotional interaction, we want to address emotions with sound, light, color, vibration, temperature, and olfaction. However, feeling the vibration and temperature are always from self to self instead of from others to self. They conflict with our design concept. Playing sound can make people feel happy or sad. Lighting in a room also has an effect on people's feeling. But these actuations are too obtrusive for wearers and may cause uncomfortable feelings. Thus we decided to use color and olfaction as the way to change emotions.

Color has psychological properties and conveys emotions biologically and culturally. Different colors are linked to different emotions. For example, blue may make people feel calm and peaceful; red is usually related to the feelings of optimism, energy, and passion. Olfaction is another powerful sense to enhance or reduce people's emotions. Smell plays an important role in social interaction and effectively triggers emotional memories deep inside the brain. The smell of lavender calms anxiety, and the scent of jasmine eases depression. The LilyPad controller will be used to process the raw emotion data from wearable sensors and display the visual and olfactory outputs in the wearable device.

## 4.2 Design Alternatives and Rapid Evaluation

After addressing the technology issues, we used brainstorming to generate ideas of design forms and proposed four possible solutions – a woolen vest, a plastic hairband, a cotton bracelet, and a cotton scarf (Fig. 1). All these four products will be incorporated with heart rate sensors and skin conductance sensors. Thus the devices will be able to monitor heart rate and skin conductance. In a group, if one wearer's smart object detects high heart rate and high values of skin conductance response (SCR) data, an infrared receiver in the device will send a signal to the other devices in this group. Once receiving the signal, the LilyPad controller of the other devices will process the data and determine the emotional index. Overexcitement usually raises heart rate and SCR values; depression is always associated with low heart rate and low SCR values. Once the extreme emotions are detected, the other individuals' smart devices will change their colors to cheer up or cool down the individual with negative emotions. In the meantime, the scent capsules of the other smart devices controlled by LilyPad Arduino will emit jasmine to cheer up or lavender to help calm down.

We presented the four low-fidelity prototypes to the same 12 participants recruited in the previous user study. The goal of the evaluation was to gather user feedbacks and investigate design improvements. Participants were asked to express what they felt about wearing the products. They had some concerns about the hairband and bracelet. No male participants wanted to wear a hairband, and it also seemed awkward for some female participants. The bracelet was simple and easy to wear, but it was not noticeable when worn. It was hard to detect the bracelet's color changes on people's wrists. Some participants were quite interested to see what the vest would look like to address emotions. They would be excited to wear such a vest to influence the other people's



**Fig. 1.** Four different concepts of our design

feeling. However, a color-changing vest may draw too much attention, and they were worried about wearing it every day.

The cotton scarf concept received the more-positive feedbacks from participants. Participants felt comfortable when they wore a scarf every day. As a great accessory for both men and women, scarves are fashionable and affordable. They can be worn either indoors or outdoors. These findings led to the key insight that we would like to make a smart scarf that can change its color in a silent way based on people's negative emotions. Wrapped around the neck, a scarf is suitable for both men and women. It is usually accepted as part of our clothes. Therefore we decided to use a color combination (colors of scarves and clothes) for emotion regulation. Participants also mentioned that they wanted the smart device to influence their own emotions when they were alone. But the scarf concept will bring problems to self-regulation, since the wearer needs to look down to notice the changes.

During the interview, we also asked participants to connect their emotions to color. Blue was the favorite color for most male participants. Their preferences were mostly blue, navy blue, light blue, yellow, and light orange to cheer them up. Females preferred brighter and soft colors, such as light pink, red, orange, and yellow, to cheer them up. Concerning the favorite color to make people calm down, most males chose dark colors, such as gray, dark blue, green, and teal; the females loved blue, green, white, and light gray.

### 4.3 The Final Concept

We finally chose cotton scarf as the solution to transfer wearer’s negative emotions to positive ones (Fig. 2). A heart rate sensor and a skin conductance sensor will be attached closer to the middle of the scarf. Wearers need to make sure the skin conductance sensor will touch the shoulder so that the responses will be more accurate. Sensors will send extreme emotion data to the IR transceivers in the group, and they will pass the raw data to the LilyPad controller. Then LilyPad will process the most negative emotion first and change the scarf’s color to cheer up or calm down individuals. When the wearer is alone, the scarf will measure only his or her emotion to make people feel good.

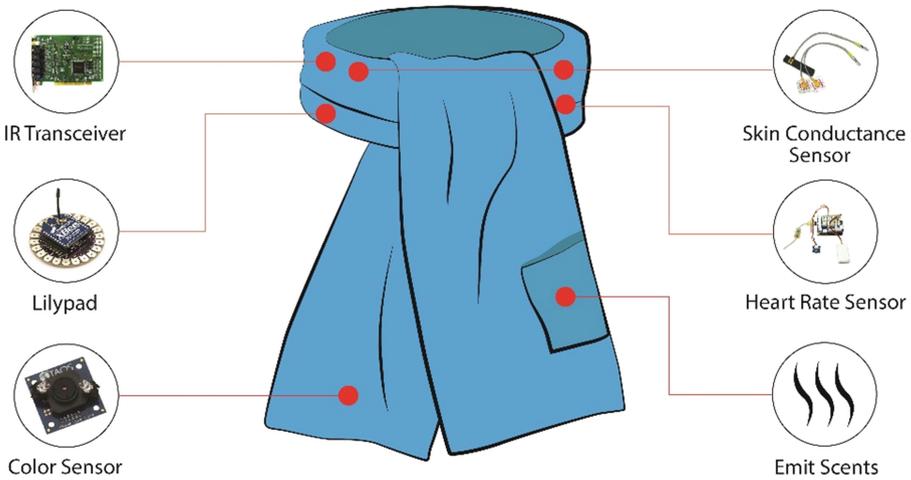


Fig. 2. The final concept of the smart scarf

In regard to color changing, scarves will be painted with thermochromics inks, which can change their hues with the use of electrical conductors heating up the surface. By controlling the temperature, thermochromics inks can show a wide range of colors. In general, we will use blue to cool down wearers and orange to cheer up them. In consideration of the unobtrusive appearance of scarves, their colors will vary to match wearers’ clothes. Instead of passively perceived colors, wearers can actively change colors to affect different emotions.

## 5 Discussion and Conclusion

Using colors to change emotion is a valid solution. Wearers from different cultures interpret color differently. Sometimes misunderstanding may develop during group interaction. One possible solution to solve this issue is to create a mobile app connecting to the scarf. The app will ask the wearer to enter demographic information.

Wearers can also change scarf color settings. Thus the smart scarf is able to help customize the display color under user preference.

The limitations of heart rate sensors and skin conductance sensors may cause inaccurate readings. Moreover, the two sensors couldn't differentiate all of the body emotions. We may therefore consider using multiple channels, including respiration and blood volume pulse, to recognize emotions.

The purpose of our design is to regulate people's emotions in a group environment with the use of a wearable and acceptable product. As human beings, our emotions are easily affected by those of others. The user study shows that people don't want to be exposed to unwanted attention, and they do care more about emotional privacy. By taking advantage of emotional contagion, we designed the system hardware and proposed four different concepts to influence emotions. According to user feedbacks, wearing a scarf outweighs the other forms.

In future work we will conduct an evaluation with the high-fidelity prototype to refine the final design concept. We are also going to build a working prototype of the system with engineers.

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