EMS Icons: Conveying Information by Analogy to Enhance Communication Through Electrical Muscle Stimulation

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Abstract
Electrical Muscle Stimulation (EMS) has recently received an increased amount of attention from the HCI community. It has been used to remote control users for navigation and instrument playing, but also as a method to convey haptic feedback in VR, for example. As EMS devices become commercially available and application research continues, we explore EMS as a modality to convey information through actuation and as a means to induce and communicate emotions and moods. In this position paper, we present the results from two focus groups on using EMS for interpersonal communication as a way to send and receive emoticons through electrical stimulation. We argue that so-called "EMS Icons" have the potential to become part of multimedia experiences and more broadly of User Interfaces as a haptic variant in analogy to visual and auditory icons.

Author Keywords
EMS Icon; EMS; Emoji; Emoticon; Remote Communication; Immersion

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H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces

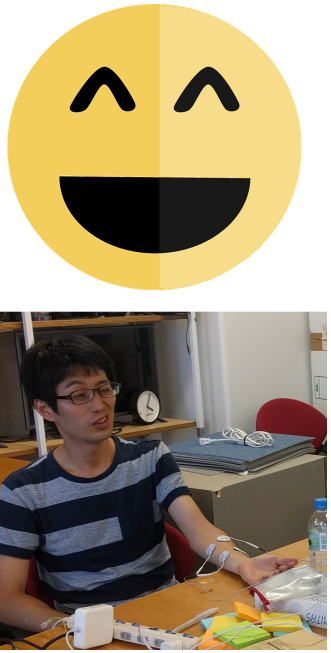

Figure 1: EMS Icons enable a new output modality for communicating information, conveying emotions, triggering moods, and supporting immersive experiences.

Introduction

First found on Japanese mobile phones, the late 1990s gave birth to a new tool to communicate emotions, moods, and sentiments: emotional icons, so called "emoticons", combined mostly alphanumeric characters and punctuation to create simple face-like expressions depicting feelings, moods, and sensations. Even though emoticons opened up various new ways of conveying moods, their simplicity limited the expressive range and breadth of usage. In contrast, the pictographic characteristics of the "emoji" (*i.e.*, "e" from Japanese "Picture", and "moji" from Japanese "character" or "letter") promised much wider reaching explanatory qualities. Not only could facial expressions be transmitted, but depictions of hand gestures, images of food, flags of countries, activities etc. became cornerstones of a new ubiquitous language.

While emoticons are universally intelligible with the ability to stress and support verbal expressions, conveying emotional sentiments is mostly restricted to conventional output modalities, such as visuals and sometimes audio. Therefore, we propose "EMS Icons" as a new output modality that utilizes Electrical Muscle Stimulation (EMS) to communicate information, convey emotions, trigger moods, and support immersive experiences. Simple icons, such as emoji or emoticons can be used to trigger the transmission of a set of electrical stimulation patterns that cause the creation of a smile, frown, or specified posture on the receiving person. Emoji typically show simplified facial details that depict expressions of emotions, such as happiness, sadness, or anger. These could be used as templates for applying EMS technology to key regions in the recipient's face, limbs or upper body.

To investigate the notion of sending emoticons and actuating recipients' body parts, we conducted two focus groups, in which we explored combinations of facial expressions and body postures to express, among others, the six basic human emotions (anger, happiness, surprise, disgust, fear, sadness) [2]. In this paper, we explore a first set of EMS Icons that represent respective emotional expressions to be applied to remote communications through emotions, moods, and sentiments. The application scenarios presented push the boundaries from sole emoji usage for emotion transmission and communication to multimodal entertainment experiences (concerts, cinemas, theaters) through mood induction and use in computing systems more generally. Based on the discussions in our focus groups we conclude this paper by presenting a broader range of EMS Icons and where they can be implemented in future User Interfaces (UIs) and applications.

Related Work

EMS uses electric impulses to mimic the action potential that comes from the central nervous system, therefore causing a muscle to contract. Commonly, EMS is administered using electrode pads placed on the muscle group to be contracted. Researchers apply EMS mostly to influence physical movements of users: from triggering hand movements to play an instrument [11] to altering the user's walking path, a "cruise control" for pedestrians [9]. Lopes *et al.* investigated the use of EMS as an output modality to guide the user's hand while drawing or giving haptic feedback in VR environments [5, 6]. EMS has also been used to encode notifications in an embodied manner [10]. Yen *et al.* [13] looked into stimulating a smile using EMS: they evaluated electrode locations and described a setup to test whether a stimulated smile could affect people's mood. The positive impact of electronic smile stimulation on the emotional and mental well-being of people with major depressive disorders was presented as a possible alternative to medication by Zariffa *et al.* [14] in 2014. Other indications

Figure 2: Focus group participant trying out EMS on her forearm for demonstration purposes.

for the tight connection between physiology and psychology can be found in a study concerning the embodiment of power through non-verbal displays conducted by Carney *et al.* [1].

The results showed that different poses (low-power or high-power poses) tend to induce psychological, physiological, and even behavioral changes accordingly. One method to communicate the emotions encoded in the embodiments and physiological expressions is presented by Hassib *et al.* [4] in form of a sender-receiver system, whereas Electroencephalography (EEG) is used on the sender's side to read characteristics of the current emotional state and EMS is used to receive the information and actuate the recipient's body. An explicit way to communicate mood and personalize communication is the use of so-called emoji.

Emoji have been studied by Lu *et al.* [7] showing their wide use to convey moods, emotions, and information about emotion. And even though they can be understood as a ubiquitous language, their study shows that different cultural backgrounds lead to differently preferred emoji. Moreover, Lu *et al.* found that culture plays an even more important role than language when it comes to the preferences for certain emoji. But instead of modifying the sentiment in notifications, emoji are mostly used to amplify the content and sentiment expressed in words [12]). Furthermore, the application used to send and receive emoji seems to have an influence on the type of pictogram used, *e.g.* Twitter, Facebook, WhatsApp, where private messages are dominated by faces, but public posts by decorative emoji.

Icons are representative symbols that are widely used in UIs as a means to communicate system or application information in a metaphorical way. Visual icons were first used on a Desktop PC for the Xerox Star 8010. Invented by Davis Smith and designed by Norm Cox, these little application icons used metaphors from everyday life to convey their functionality to users in a familiar way. Gaver [3] then adopted this concept and introduced auditory icons, the audio equivalent to visual icons in computing systems. Nowadays, such icons can be found in almost every UI—on tablets, mobile phones, watches *etc.*—due to their intuitive nature, resulting learnability, memorability, and therefore their ability to augment the user experience. While the use of haptic icons has also been explored for UIs [8], we focused our investigation on the use of EMS to provide sensations stimulated through electric currents, so called "EMS Icons".

Focus Group

We conducted two focus groups with the goal of identifying and mapping emoticons and emoji to electrical stimulations of different body parts. Therefore, we recruited 14 participants (3 female) through university mailing lists and invited them to our lab in two groups of 9 and 5 respectively. Participants had a mean age of 27 years ($SD = 4.2$) and were mostly graduate students with backgrounds in design and engineering. We discussed seven central questions about EMS including application use cases in general, identifying appropriate body parts for stimulation, and its potential to be used for communicating information with a focus on transferring emotions and moods.

Procedure

After signing a consent form explaining the participation and allowing us to videotape the session, we started off introducing the purpose of the focus group. We presented the concept of EMS by showing a live-demo, during which we placed four electrode pads on the forearm of a volunteer to form a closed hand through electrical stimulation (Figure 2).

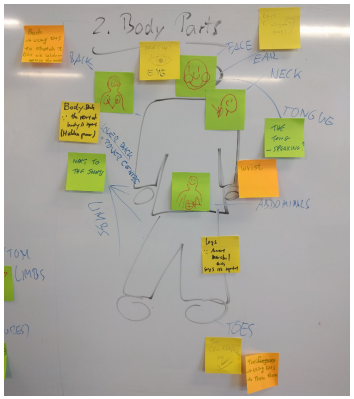

Figure 3: Body parts as identified by our focus groups participants through which emotions and moods could conveyed through.

Then, the moderator guided the group discussion by subsequently posing questions with regard to four aspects of EMS:

1. General application areas for EMS and more specifically using EMS for communication purposes.
2. Listing different body parts feasible for stimulation.
3. The use of EMS to communicate/invoke different emotions and moods, especially the six basic human emotions as defined by Ekman [2] (see Table 1).
4. Replacing emoticons and emoji commonly used in text communication with their EMS equivalent.

For each question, participants were given a few minutes to write down ideas on sticky notes, which were subsequently discussed and grouped by the entire group. Each focus group lasted about 90 minutes, for which participants received candy as compensation.

Results

The first round of the discussion focused on defining general use cases for EMS and identifying appropriate body parts, where emotions and moods could be conveyed on. The most prominent application themes included learning scenarios (skill transfer, N=12), use in therapy or rehabilitation programs (N=8), remote control and performances (N=9), communication (N=7), immersive experiences (N=4)), and transfer of emotions (N=5). Further applications included haptics as an output modality, a system for enforcing safety postures in emergency situations, and the creation of phantom limbs. The most prominent body parts to be stimulated for communication purposes were facial muscles, neck, shoulders, diaphragm, and limbs, such as wrists, fingers, knees, and toes. Figure 4 depicts

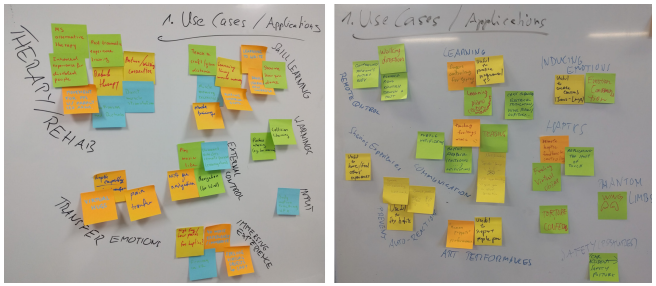

Figure 4: Participants developed general use cases for EMS and grouped them by themes in discussions.

application use cases grouped by themes, while Figure 3 shows the identified body parts, which muscle stimulation could be performed on.

Next, we discussed in particular how emotions could be communicated through EMS. Participants debated the stimulation of muscle groups in order to move entire limbs as well as how to induce facial muscle motion through micro-muscle stimulation. Micro whole-body muscle stimulation was suggested to be used to induce tingling sensations, shivering, and goosebumps, which could represent sensations and emotions, such as fear, and excitement. At this point, discussions moved from how to convey basic emotions such as joy, sadness, fear, and anger to more complex and eclectic states, such as nervousness and contempt through, for example, finger and leg tapping as well as triggered eye blinks. Moreover, stimulating respiratory muscles was suggested to be used to train and induce breathing rhythms appropriate for specific situations, *e.g.* inducing a calm rhythm panic attacks are impending, whereas certain tingling sensations in the abdominal region could induce sensations of affection or joy.

Figure 5: Most used emoji as stated by participants, for which we asked them to design equivalents as EMS Icons.

Figure 6: Second set of emoji and their translation to muscle stimulations.

Subsequently, we posed the question on how the specific set of Ekman's six basic human emotions [2] could be communicated through EMS. On that note, we also discussed which body parts would be most expressive for conveying these emotions. In the following, we summarize the results of the discussion around using EMS in relation to emoji and inducing emotions and moods.

EMS Icons

Table 1 lists different options of body parts for each basic human emotion as well as stimulation types that could represent these emotions. Most emotions were assigned to parts of the upper body, which shows a rather direct than metaphorical allocation. Obviously, aspects of technical feasibility and social acceptability were neglected for this discussion, so we find stimulations that represent effects as they appear as a direct result of an emotion felt. Thus, a triggered smile was suggested by most participants as a happy face, but for a more comprehensive emotional sensation, body parts such as the torso, arms, and hands were to be involved, too. Shoulders, for example, can be used to express sadness through hunching, so can anger by applying greater tension. Participants also agreed on the importance of subjacent muscles, such as can be found in the abdominal region, which could complementary be stimulated to trigger disgust. Stimulation of the hand and those muscles responsible for breathing could be done to express anger through forming a fist and adjusting the breathing frequency (shallow: fear, deep: anger).

We further explored an EMS set of emojis by asking participants for voicing their most used emoji (see Figure 5 and 6) and finding an EMS equivalent for each of them. One of the most popular was the *wink* emoji. Participants agreed on its equivalent EMS Icon as a one-sided triggered blink. A similar agreement could be found for gestures of apologetic nature, such as the *bow*. The respective EMS Icon was clearly defined as a change in posture of the upright back into a bow. Another expression both groups agreed on was that of happiness or smiles. Participants thought that triggering the cheek muscles to slightly move up and the eyes to stretch are the appropriate way to express joy. The biggest difference between both groups could be found in the selection of preferred emoji. Whereas the first focus group came up mostly with facial expressions as their dominantly used emoji, the second group presented several choices for non-facial expressions of emotions, such as the thumbs-up gesture, or a sudden random touch as an EMS Icon for fear.

Emotion	Body Part	Stimulation
Happiness	Face, upper body, arms, hands.	Forming a smile using mouth, eye squinting, increasing heart-rate, straightening upper body posture, throwing arms and hands up.
Sadness	Face, neck, shoulders.	Activating lacrimal gland, hunching shoulders, head bending down.
Fear	Head, upper body.	Body shiver along neck, quick breathing contractions of upper body, quick diaphragm contractions, increasing heart-rate, creating goosebumps.
Anger	Head, shoulders, arm, hands, lower legs.	Jaw clenching, frowning brows, creating tension in shoulders, closing hands to fists, clenching teeth and jaw, deep and quick breathing, tension in calfs.
Surprise	Face, upper body, hands.	Eyes widening, mouth opening, single sudden whole upper body contraction, tingling in stomach, sudden breath, throwing hands up.
Disgust	Face, upper body.	Stomach contractions (vomiting sensation), leaning back, mouth warping, closing mouth with tongue, stretching nose.

Table 1: Participants were asked to select appropriate body parts for stimulation and conveyance of six basic human emotions as defined by Elkman [2].

Following this part of the discussion, we lastly analyzed possible scenarios, for which the use of communication enhanced through EMS would be feasible. The predominant application scenario was emotion conveyance. In particular, the potential to send exact feelings and their physical expressions to people close to the user, such as close friends, family, or the partner. The use of EMS was therefore seen as rather intimate. Participants further proposed exceptions,

however, such as bridging differences in body language that arise from different cultural backgrounds or creating empathy with people in different situations to improve mutual understanding. The groups also discussed the potential for developing communication interfaces with autistic patients and people with anxiety issues. Not only human-human interaction could be augmented with EMS Icons, but also human-computer interaction. Especially in the gaming domain, EMS Icons would allow for new immersive experiences and communication modalities.

Discussion

In the focus groups presented, we explored a possible transfer of emoticons and emoji to representative EMS expressions. A notable discussion evolved around the observation that sending an emoji and stimulating the recipient's body through EMS may change the communication itself as the recipient rather feels or acts out the sender's emotion. This seems inherently different from simply receiving a visual emoji as confirmation of an emotion felt on the sender's side. While currently available EMS Devices do not necessarily provide the sufficient finesse to stimulate complex muscle groups, there are obvious limitations as to where electric pads can be applied to (from a technical, social acceptance, but also safety point of view). Also, a proliferation of EMS technologies bears a range of risks: erroneous application of the actuators could lead to uncontrolled stimulation of muscles, specifically critical when it comes to vitally essential muscle systems such as the respiratory tracts or heart muscles. Moreover, there should be limits to frequent stimulations of certain muscle groups, such as facial muscles. Would frequent stimulation lead to muscle growth and deformation and therefore cause aesthetic issues? Further, how can we prevent abuse of remotely triggering affect? Could there even arise bigger picture implications, such as emotion control and consolidation by third parties? Our focus group participants pointed out the intimate nature of communication that EMS presents, but also identified scenarios that would involve strangers, *e.g.* for communication with autistic people and bridging cultural differences. Besides being used for interpersonal communication, EMS Icons further show potential to be applied in Human-Computer interactions considering the broader application of icons. In the following, we outline three application scenarios, which partly emerged in our focus group discussions and which we see subsequently come into fruition with increasing adoption of EMS technology.

Augmenting Media Experiences through EMS

In cinema, the combination of film music and moving images create an emotional experience for the viewer, which could not be fully conveyed by visuals only. The use of EMS Icons in a cinematic context would allow film makers to include an additional dimension to induce and emphasize film moods and evoke emotions. Inducing shivers or muscle tension, for example, could be used to emphasize sensations of fear in a horror movie or theater piece. Nervousness could further be underlined by shaking the viewer's leg. Hence, actuators built into cinema chairs, for example, could stimulate viewers and provide a more immersive film experience. Similarly, live music events and music recordings could be enhanced by triggering song-specific emotional responses, *e.g.* making a ballad even more heart-wrenching by causing the listener's shoulder to hunch down. Media experiences can thus be shared by transferring emotional states across viewers and locations.

EMS Icons in Software UIs

Besides providing entertainment value, EMS Icons could also be utilized by application programmers in Software UIs. Just like auditory icons are commonly used to communicate

system status messages or trigger warnings, EMS Icons present an additional modality to inform users. Instead of hearing an alarm sound, the user's hand could twitch when attempting to delete a file or close a program. In games, EMS Icons could be used to support immersion, while web sites could induce a tingling feeling when hovering over a hyperlink. Therefore, EMS Icons could provide designers and application builders with an additional output channel.

Home desktops, but also workplaces could be augmented by integrating EMS actuators in furniture, such as chairs and desktops. They could be used to avoid slouching during long work sessions and initiate a healthy posture from time to time. Moreover, augmented workspaces could help to keep tensions high in meetings and during tiring tasks. In order to avoid an unfriendly and unproductive working climate, sentiments of joy and happiness could occasionally be triggered.

EMS in Smart Garments

While augmenting media experiences poses the obvious next step for incorporating EMS in more consumer experiences, EMS Icons in UIs requires consumer products to be introduced to home and office environments. Continuing the thought of EMS becoming more ubiquitous, the final step would be an integration into our everyday environments. We have already mentioned furniture augmented with actuators, but for EMS Icons to be completely mobile and pervasive, we would need to integrate them into the very fabric of our clothing itself. The currently developing field of smart garments could, therefore, be extended by EMS devices that allow their wearer to receive EMS Icons anytime and anywhere. Such EMS-actuated garments can turn our daily clothing, specific functional wear, or even seat covers—*e.g.* in cinemas, therapy chairs, and sport stadiums—into receivers for EMS Icons and wirelessly communicate with whatever application we are currently using, be it on the cinema screen, on our laptop or mobile phone in our hand. Multimodal sensations can, for example, be induced when messages are received and read so that visual emoji can be felt on the user's body as the message is being read. EMS-actuated garments also have the potential to be used to influence breathing rates and heart rates on-the-fly in order to create immersion on the one hand or calm a person down on the other hand during emerging stages of fright, panic or anxiety attacks.

Conclusion

In this position paper, we explore EMS as a modality to convey information through actuation and as a means to induce and communicate emotions and moods. Therefore, we propose EMS Icons as a new output modality that can be applied to augment multimedia experiences and more broadly in User Interfaces as a haptic variant in analogy to visual and auditory icons. We present results from two focus groups, in which we explore the extension of the emoji concept through EMS away from a purely visual form of communicating mood and sentiment towards a highly immersive physical experience. Insights from the discussions on application use cases, body parts feasible for EMS stimulation, and ways of communicating moods and sentiments, eventually lead us to the formulation of a broader application space for EMS Icons including multimedia experiences, Software UIs, and smart garments. While research in the coming years will need to focus on technicalities and aspects of social acceptance of EMS, this paper presents a long-term vision of the concept of EMS Icons and their pervasive use in future computing interfaces.

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