The role of physiological computing in counteracting loneliness

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CHI 2011, May 7–12, 2011, Vancouver, BC, Canada.
ACM 978-1-4503-0268-5/11/05.

Abstract
With loneliness spreading rapidly through Western societies, we need technologies that can help people share emotions and create deep intimate connections. We propose that physiological computing is in a key position to create such meaningful interactions. We first present a short requirements analysis, showing that physiological signals are promising as communicative tools. Subsequently, we briefly discuss four experiments that we have done that support the important role physiological computing can play in to improve social connectedness. We end with directions for further research.

Keywords
Psychophysiology, telecommunication, heart beat

ACM Classification Keywords
J4 Psychology, H5.1 Evaluation/methodology.

General Terms
Experimentation, Measurement, Performance, Human Factors

Introduction
Beside the climate and economic crises, there is a social crisis going on in Western societies [1]. This fact

is illustrated by various statistics. For instance, people in 2004 were three times more likely to report having no one with whom to discuss important matters than respondents in 1985 [1]. Moreover, in the US alone, there are now more than 22 million people living entirely alone [1]. Our need to belong is such a profound motivation that loneliness reduces happiness, increases our chances of depression, and even influences our physical health [2]. For instance, married individuals are known to have a higher survival chance when confronted with cancer than singles [3].

Many of the new innovations in social media allow to share information about ourselves with people around us. For instance, one can share thoughts (e.g., Twitter), location (e.g., Foursquare), photos (e.g., Flickr), or documents (e.g., Google Docs). Nonetheless, such information is not what shapes and improves social bonds. Instead, it is the sharing of feelings and emotions rather than facts that create deep intimate connections [4]. Currently, there are very few technologies that actually help us to empathize with the people around us or share feelings with them.

In this paper, we propose that the recent developments in physiological computing have the potential to form a key part in reducing the loneliness prevalent in Western societies. It is our hope that physiological computing can help people to get more emotionally in touch, improve empathy, and thereby create happier societies [5]. In the following sections, we will support this thesis by an overview of requirements and four experiments that we have done around such propositions. We end with some directions for further research and a conclusion.

Requirements

A successful tool for sharing emotional signals has to fulfill several requirements. In this section we will discuss some of these, and how physiological computing tools can embody them.

First of all, as noted already, emotions must be at the core of the communication as they are of great importance for social interaction and especially social connectedness [4]. Physiological signals are very strongly related to emotions [6]. Moreover, perception of physiological signals is related to experience of emotions [7].

Second, the communication should be possible in an automatic and unobtrusive fashion (similar to existing forms of emotion communication like posture or facial expressions). Technical developments allow physiology to be captured continuously with unobtrusive sensors [8]. Combining this with the wireless technology becoming available around the world ensures that physiological computing can also fulfill this requirement.

Third, the captured emotional signals are privacy sensitive and should not directly be shared with all of your friends and connections. Instead, they should be communicated to a select group or only one specific person. This can, for instance, be accomplished by indicating a selected group of receivers (e.g., your partner), and by using dedicated wearable actuators that allow only the wearer to perceive the communicated signals.

Empirical work

We have started to explore different aspects of the use of physiological signals as communicative tools. We wanted to test if these signals are experienced as intimate cues that tell us something about others' emotions and feelings.

First, in two experiments, we tested whether or not physiological signals are themselves experienced as intimate signals [9]. For this, we focused on heartbeat sounds as this appears intuitively related to emotions and auditory representations of heartbeats are commonplace. We found that hearing someone else's heartbeat not only influences self-reported intimacy, it also influences nonverbal behavior (in our case: kept interpersonal distance) towards the person whose heartbeat is displayed. These findings convincingly show that heartbeats can be perceived as intimate cues.

In the third experiment, we were interested to see if physiological signals can also influence perception of emotional states. To test this, we presented two levels of heart rate with videos of people in angry or neutral states. We included the videos to be able to compare the effect of the heart rate with that of well-established communication of emotions through facial expressions. The results showed that the effect size of the heart rate display/sound on emotional judgments was just as large as the effect of facial expressions. Hence, we concluded that physiological signals can also influence our emotion perceptions.

Fourth, Kuikanniemi and Janssen [10] constructed a system to test the effects of real-time communication of skin conductance level. In this case, they used the automotive application domain to create an empathic link between a driver and a caller. The hypothesis was that physiological feedback in the form of haptic stimulation helps the caller to adapt to the driver and make the driving safer. They simulated constant demanding discussion situations using a word game. A first pilot study shows that physiological communication can be quite easily manipulated to convey information about changes in driving challenge to caller. Moreover, it showed that participants experienced the physiological feedback as a close intimate signal.

Future research

Taking these results together shows that physiological computing can potentially form a very useful and powerful contribution to the social crisis we are in. Nonetheless, we believe this is only the tip of the iceberg and there are many questions begging to be further explored. Below we give some suggestions to further research.

First of all, it is unclear which physiological signals are best to use as communicative tools. We have focused on heartbeats for their intuitive properties. Nonetheless, based on the psychophysiological literature and our own work, other signals like skin conductance might be more emotionally informative. On the other hand, heartbeat perception has a large influence on our personal emotion experiences (experiment 1 and 2). Hence, it is worthwhile to look into which signals are best for communicating intimacy and emotions.

Second, the rendering of the physiological signals can be done in many ways. So far, we have used sounds for the heartbeat experiments and haptic feedback for the skin conductance feedback. Haptic feedback has the advantage that it can only be perceived by the one wearing the haptic actuator. This makes it a very private communication tool that might be necessary in the case of physiological communication. Nonetheless, it is so far unclear how physiological signals are best perceived and how such tools can be incorporated in wearable systems.

Third, physiological signals have the advantage that they can be measured continuously. Nonetheless, for the communication it might not be ideal to continuously communicate these signals as this might be distraction and too obtrusive. Moreover, the intentionality inherent in non-automated communication acts may be lost to an extent, potentially impoverishing the perceived meaning of a message. Hence, there is a clear challenge to figure out at what moments communicating these physiological signals can be most beneficial.

Conclusion

Based on our experimental explorations, we believe that physiological computing has a significant potential as communicative tool. Research in this area is only beginning to develop and there are many conceptual and technical issues still to be resolved. Nonetheless, including physiological computing in communication applications can have profound effects on human communication. It will likely boost empathy, creating closer bonds. This way, physiological computing and communication could become a possible solution for the social crisis we are living in.

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