Behavioral and physiological measurement of connectedness

Joris H. Janssen
Eindhoven University of Technology &
Philips Research
Den Dolech 2
5600MB Eindhoven NL
j.h.janssen@tue.nl

Wijnand A. IJsselsteijn
Eindhoven University of Technology
Den Dolech 2
5600MB Eindhoven NL
w.a.ijsselsteijn@tue.nl

Joyce H.D.M. Westerink
Philips Research
High Tech Campus 34
5656AE Eindhoven NL
joyce.westerink@philips.com

CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-930-5/10/04.

Abstract
Currently, connectedness assesment is primarily done through questionnaires. Although questionnaires are good for tapping into the user experience, they also have drawbacks, like memory biases, proneness to social masking, and lack of mental access. Now that sophisticated sensors are becoming cheaper, less obtrusive, and more widely available, this opens doors to more objective continuous measures of connectedness. We explain how nonverbal behavior and physiological properties of our bodies can be exploited to augment connectedness measurements.

Keywords
Connectedness, Psychophysiology, Nonverbal behavior

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

General Terms
Experimentation, Measurement, Performance, Human Factors

Introduction
Over the last years, the interest for digital devices that can improve the feeling of connectedness between people has rapidly grown. This interest is founded on

evidence from psychology that humans are, above all, social animals. Care and support through close relationships are essential for our well-being and health [1]. Extensive evidence shows the devastating effects when this feeling of belongingness is jeopardized [2]. Hence, it makes sense to research devices that can support our intimate social relationships.

One of the essential prerequisites for research on connectedness devices are measurement tools that can capture the performance of such new devices. Currently, evaluation of connectedness devices relies heavily on questionnaires. Although questionnaires can be useful to tap into the subjective user experience, they are also prone to social masking and the limitations and biases of introspection. Moreover, social desirability effects are particularly salient when reporting on privacy-sensitive thoughts or emotions as involved in connectedness research. Therefore, very often, more objective behavioral and bodily measures are not in line with results from subjective data. Furthermore, questionnaires only provide data at discrete moments, whereas behavioral measurements can be done continuously. Moreover, the process of asking questions itself probably has an influence on the user experience. Finally, questionnaires may give away the objective of the researcher leading to a confirmation bias in the user's responses. Hence, it is likely to be beneficial to also employ objective measures to be able to better assess the effects of new connectedness devices and solutions.

In this paper, we will provide an overview of possible behavioral and physiological measures of connectedness[1]. This is especially relevant now that many sensors are becoming cheaper, more widely available, and less obtrusive. In the next section, we will go into physiological measures that are influenced by connectedness and give references to unobtrusive physiological sensor developments. Next, we will elaborate on behavioral measures that are affected by connectedness.

Physiological measures

When communicating with someone, physiology is heavily influenced by the connectedness or intimacy[2] we feel in a situation. We will discuss intimacy-related arousal and respiratory sinus arrhythmia as a measure of social emotion regulation.

The basic idea of arousal theory is that when a situation becomes more intimate our physiological arousal increases [3]. These increases in arousal can most directly be measured through skin conductance. Several studies have shown the robustness and validity of this measure; e.g., in measuring the arousal associated with social proximity [4]. Skin conductance measurements requires two electrodes to be positioned somewhere on the body. Traditional sensors are often placed on the fingers, but, more recently, skin conductance sensors have also been integrated in an

[1] Of course, physiological and behavioral measures can also be used to try and enhance the connectedness itself, e.g. by keeping your loved-one aware of your heart beat. This type of use of physiological and behavioral measures is not included in this overview.

[2] We sometimes refer to connectedness with the word intimacy because many of the literature that we discuss uses this concept. Intimacy can be compared to the feeling of connectedness one has with one specific person [6].

unobtrusive wireless wristband [5]. This way we can continuously assess how intimate the interaction through a connectedness device is for a user. We can measure which aspects of the interaction are more intimate than others and we can measure how the feeling of intimacy changes with more experience with the device. Furthermore, it will also allow us to compare intimacy across alternative connectedness devices.

Another interesting physiological component for connectedness researchers is respiratory sinus arrhythmia (RSA). RSA refers to periodic fluctuations of the heart rate linked to breathing [7]. First, resting levels of RSA are associated with individual differences in emotional reactivity to stimuli. People with lower resting RSA are less emotionally flexible [8]. For connectedness researchers, this means that the impact connectedness devices will have on the feeling of connectedness will therefore probably be lower for people with low resting RSA than for people with high resting RSA. Hence, RSA is an objective measure to better understand individual differences in reactions to connectedness devices. More importantly, RSA changes with shifts in emotional experience [8]. In other words, fluctuations in RSA show when the impact of the connectedness device is the largest. This allows the connectedness researcher to objectively test different features of the device and investigate temporal fluctuations while using connectedness devices. RSA requires heart rate and respiration measurements. These can, for instance, be integrated in an unobtrusive elastic band positioned around the chest [5]. Heart rate can also be acquired from a wrist-worn photopletysmograph.

Behavioral measures

Our nonverbal behavior towards someone is heavily influenced by the bond we feel with the other person. Therefore, behavioral measures not only are powerful tools to objectively quantify the user experience when interacting with a connectedness device, they are also very relevant for objectively quantifying the bond two people feel towards each other. Most connectedness devices are targeted at increasing the bond between two persons. With behavioral measurements, these increases in closeness between two connected users can be objectively assessed to evaluate the device.

The relation between our nonverbal behavior and the bond between us and another is founded in equilibrium theory [9]. Equilibrium theory poses that all our nonverbal behavior towards another person is targeted at keeping the intimacy equilibrium we have with that person. This mechanism is so strong that the different forms of nonverbal behavior compensate each other to keep the intimacy equilibrium. For instance, when stepping into an elevator with a group of people, interpersonal distance might suddenly be inappropriately close. In effect, people might look at the walls, floor, or ceiling instead of at each other, reduce their smiling, and turn sideways or away from each other. Because we hold different equilibriums with different persons, our nonverbal behavior differs from person to person. Connectedness researchers can exploit this relationship and see if nonverbal behavior becomes more intimate during and after use of the connectedness device.

Our nonverbal behavior consists of a plethora of different aspects that can be measured. Smiling, mutual gaze, touch, interpersonal distance, body

orientation, and posture are some examples of intimate signals (see [10] for a review). When doing such investigations in the lab, it is sometimes possible to take just one of these aspects as a measurement and keep the others constant. A good example of such an approach comes from [11], who investigated the effect of a new connectedness device by measuring the interpersonal distance people keep between each other while the device was turned on or off.

The recent advances made in wearable sensors also allow for continuously measurements of a lot of our nonverbal behavior in daily life. For instance, Pentland [12] has developed sensors with small cameras worn around the neck that would allow measuring things as mutual gaze, smiling, interpersonal distance, and body orientation. Such sensors allow the connectedness researcher to reliably assess our nonverbal behavior towards other persons in real life settings.

Conclusion

Rapid advances in sensor developments allow the connectedness researcher to more objectively assess the impact of new devices and solutions. By exploiting the effects of connectedness on physiological and behavioral parameters we can come to more reliable evaluation tools. In the end, the goal of connectedness research should be to come to consistent results and general guidelines. Therefore, objective measurements are essential to compare different research efforts and establish connectedness research as a field. Hence, combining subjective and objective measures can significantly improve evaluation procedures.

Citations

[1] Baumeister, R.F. & Leary, M.R. The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. *Psychological Bulletin 117,* (1995), 497-529.

[2] Cacioppo, J. T. & Patrick, W. *Loneliness: Human and the need for social connection.* W.W. Norton & Company, New York, NY, USA, 2008.

[3] Patterson, M. L. An arousal model of interpersonal intimacy. *Psychological Review, 83*, (1976), 235-245.

[4] McBride, G., King, M. G., & James, J. W. Social proximity effects on galvanic skin responses in adult humans. *Journal of Psychology, 61,* (1965), 153-157.

[5] Westerink, J.H.D.M., de Vries, G.-J., de Waele, S., van den Eerenbeemd, J., van Boven, M., & Ouwerkerk M. Emotion measurement platform for daily life situations. In *Proc. ACII2009*, IEEE Press (2009).

[6] Aron, A., Aron, E. N., Tudor, M., & Nelson, G. Close relationships as including the other in the self. *Journal of Personality and Social Psychology, 60,* (1991), 241-253.

[7] Grossman, P., & Taylor, E. W. Toward understanding respiratory sinus arrythmia: Relations to cardiac vagal tone, evolution and biobehavioral functions. *Biological Psychology, 74,* (2007), 263-285.

[8] Butler, E. A., Wilhelm, F. H., & Gross, J. J. Respiratory sinus arrhythmia, emotion, and emotion regulation during social interaction. *Psychophysiology, 43*, (2006), 612-622.

[9] Argyle, M., & Dean, J. Eye-contact, distance, and affiliation. *Sociometry, 28,* (1965), 289-304.

[10] Andersen, P. A., Guerrero, L. K., Buller, D. B., & Jorgensen, P. F. An empirical comparison of three theories of nonverbal immediacy exchange. *Human Communication Research, 24*, (1998), 501-535.

[11] Kuling, I.A., Janssen, J.H., & IJsselsteijn, W.A.. The intimacy of heart beat communication. *CHI2010 Workshop on Designing and Evaluating Affective Aspects of Sociable Media to Support Social Connectedness*.

[12] Pentland, A. *Honest Signals: How they shape our world.* MIT Press, Cambridge, MA, USA, 2008.