Knowing Me, Knowing You: Biosignals and Trust in the Surveillance Economy

Short Paper

Christian Peukert
Karlsruhe Institute of Technology
Karlsruhe, Germany
christian.peukert@kit.edu

Marc T. P. Adam
The University of Newcastle
Newcastle, Australia
marc.adam@newcastle.edu.au

Florian Hawlitschek
Karlsruhe Institute of Technology
Karlsruhe, Germany
florian.hawlitschek@kit.edu

Sina Helming
Karlsruhe Institute of Technology
Karlsruhe, Germany
sina.helming@kit.edu

Ewa Lux
Karlsruhe Institute of Technology
Karlsruhe, Germany
ewa.lux@kit.edu

Timm Teubner
TU Berlin
Berlin, Germany
teubner@tu-berlin.de

Abstract

Technological advances in the field of smart consumer devices such as phones, wristbands, and watches facilitate real time acquisition of physiological data, for instance, for purposes of entertainment or to improve health or performance. With recent technology, even information about another person's physiological state can be acquired unobtrusively, which we refer to as foreign live biofeedback (FLBF). The behavioral effects of such information on human interactions, however, represent mostly unchartered territory. Particularly for scenarios that rely on interpersonal trust, FLBF may have a considerable influence on human behavior. Based on the well-established investment game, we present results from a controlled lab experiment considering how the availability of FLBF affects behavior – both for trustors and trustees. We find that the availability of FLBF is associated with a decrease of trust and trustworthiness as well as increased perceptions of surveillance. We discuss these findings in view of user privacy and data sovereignty, shedding light on the potential detrimental effects of FLBF as a technological feature in social interaction.

Keywords: Biofeedback, Heart Rate, Investment Game, NeuroIS, Trust

Introduction

Measurements of biosignals bear the potential to enhance the way humans interact with each other by providing them with information that would be difficult or even impossible to access otherwise (Adam et al. 2018; Roseway et al. 2015; Slovák et al. 2012; Walmink et al. 2013). However, such measurements also give rise to serious social and ethical concerns associated with the risk of involuntary surveillance, privacy invasion, and opportunistic behaviors (Fairclough 2014). Along with the rapid advancements in information and communication technology (ICT) and the emergence of business models based on personal

---

[*] Co-authors in alphabetical order

data (surveillance economy), there exists an inherent risk of privacy invasion. In addition to the involuntary disclosure of private data on social media, private data is increasingly collected in public spaces. For instance, in China's metropolis Shenzhen, facial recognition surveillance cameras are applied to catch jaywalkers and instantly fine as well as to publicly denounce them (Pomfret 2018). Importantly, human biosignals were difficult to monitor without specialized equipment in the past. However, as consumer sensor technology for measuring cardiovascular or electrodermal activity has become increasingly accessible and affordable over the last years, devices such as smart phones and wristbands enable the continuous assessment of personal physiological data in everyday life. Many people use biosensors as a source of information to improve well-being, reduce stress, or enhance workouts. Recent research has shown how physiological data can be integrated into information systems (IS) to enable *live biofeedback* (LBF, i.e., providing information on subjects' own physiological processes) as a neuro-adaptive interface element for supporting stress management and emotion regulation (Chandler et al. 2001; Al Osman et al. 2014; Riedl and Léger 2016; Al Rihawi et al. 2014). While at this stage, most applications focus on the analysis of users' *own* physiological data (online or offline), recent advances in signal processing also enable the voluntary – and involuntary – assessment of *others'* physiological data. In this regard, *foreign live biofeedback* (FLBF) refers to "a one-to-one provision of neurophysiological data from one person to another in real time" (Hawlitschek et al. 2015, p. 60). FLBF applications based on heart rate measurement, for instance, tap into the end-consumer market and promise more personal communication (Slovák et al. 2012). Moreover, technologies such as remote photoplethysmography (rPPG) enable the contactless measurement of heart rate from analyzing video data in real time (Rouast et al. 2017). Also, research has begun to use radio signals to measure heart rate without direct visual contact, even through walls (Katabi 2018). Hence, heart rate measurements no longer require skin contact and can thus be conducted without the awareness of the targeted users. Besides conceivable beneficial potentials of this technological development, this obviously raises concerns about surveillance, integrity of personal data, privacy, and discrimination (Guardian 2018; Wilson 2016).

In this paper, we pursue the question of how the availability of physiological data affects user perceptions and behavior. We consider human interaction in a well-established and fundamental scenario, namely the *Investment Game* (Berg et al. 1995). Rooted in behavioral and experimental economics, the investment game has frequently been employed for investigating trust-related behavior in human interactions. In the following, we review related work on interpersonal trust and FLBF and locate our study within this literature. We then outline the design of a laboratory experiment to assess how perceptions and behaviors are affected by the availability of FLBF. Furthermore, we present and discuss first results. In a nutshell, we find that the availability of FLBF is associated with reductions in trusting behavior and trustworthiness and increased perceptions of surveillance. With this paper, we explicitly do not intend to develop IS theory but to explore a novel user interface design element. We systematically test FLBF within a controlled experimental environment and hence contribute to the literature by exploring FLBF as an emerging technological feature. In this sense, we set the stage for further research in view of the progressing blending of e-commerce business models, sensor technology and physiological data assessment, as well as unobtrusive and continuous surveillance.

Related Literature

Self and Foreign Live Biofeedback

LBF refers to a real-time feedback response that is derived from a user's physiological state (AAPB 2011). It is based on "smart and precise instruments that measure physiological activities [...] and generate an appropriate feedback response" (Al Osman et al. 2014, p. 3145). A person's physiological state can be assessed by measuring biosignals that are sent out by the human body. Such biosignals include, for instance, pulse, brainwaves, electrical heart activity, eye movements, and respiration. While LBF was initially applied in clinical contexts, it has been used in a wide variety of domains over the last years, including Arts, Computer Science, Information Systems, Medical Science, and Psychology. While in typical LBF contexts, users receive feedback based on their *own* physiological state (Chittaro and Sioni 2014), *foreign*-LBF describes a setting in which data on *another* user's physiology is leveraged (Hawlitschek et al. 2015).

FLBF has been integrated in a variety of applications, for instance, in sports, health, and entertainment. Whereas studies on self-LBF often address self-awareness (Matthews et al. 2015; Snyder et al. 2015) and stress management (Chittaro and Sioni 2014; Reynolds 1984), research on FLBF rather focusses on aspects such as social interactions (Howell et al. 2016; Slovák et al. 2012), social presence (Järvelä et al. 2016), and social exertion (Mueller et al. 2010; Mueller and Walmink 2013). With FLBF, users gain additional information about their counterparts. Heart rate, for example, is often used to determine a person's level of arousal (Astor et al. 2013; Jercic et al. 2012; Roseway et al. 2015) and can be measured unobtrusively, that is, without body contact, for instance, visually by detecting minimal changes in skin tone and color (Rouast et al. 2017; Rubinstein 2014). Such intimate knowledge about a person's body processes (which are mostly autonomous and hence difficult to control) may be used to influence social aspects of user perception and behavior. Especially in online interactions, where users often engage in one-shot interactions with strangers, FLBF is suggested to facilitate social interaction (Howell et al. 2016; Al Mahmud et al. 2007) and affect trust-related behavior (Hawlitschek et al. 2015; Al Mahmud et al. 2007). In fact, most previous studies applied FLBF techniques to augment, support, or improve social interaction, where usually the technology was found to have a positive effect. It is important to note that there exist several perspectives on how and *why* FLBF may affect social interaction.

A first view is to consider FLBF as a "bionic" sensory extension to enhance human *emotional intelligence* (i.e., "artificial emotional intelligence"), helping the user to better recognize and understand their interaction partner's emotional state and, based on this, their motives, needs, and intentions. Roseway et al. (2015), for example, developed a FLBF device for observing and communicating emotions. The authors report that FLBF helped users to communicate with their colleagues as they dealt with the feedback signal similarly as compared to the natural display of emotions (Roseway et al. 2015). For trusting decisions, however, one line of reasoning is that the availability of FLBF could have a negative effect on trusting behavior and trustworthiness as it potentially provides clues as to why *not* to trust. In this line of thought, Al Mahmud et al. (2007) used heart rate monitoring to enable the detection of lying during a dice-role-and-bluffing game among children (where increased arousal was translated into a displayed Pinocchio's nose length). Regarding specific heart rate levels, Merrill and Cheshire (2017) found that subjects tended to cooperate less when observing an *elevated* heart rate in their interaction partner. They suggest that common associations with increased levels of body signals are anger, sickness, hot-headedness, or anxiety, which may be regarded as disadvantageous traits when it comes to trusting and cooperative decisions in social interaction. Second, FLBF may serve as a means to *oversee, control, and manage workload, stress levels,* and *task assignments*. Similar to astronauts, continuously monitored by a medical control center, future managers may employ FLBF to decide which employee to assign an extra task to and which one to grant rest (Adam et al. 2017). This appears particularly promising for tasks that involve high levels of physical activity, flow, or stress, all of which exhibit pronounced changes in physiological activity. Tan et al. (2014), for instance, studied FLBF in video-mediated collaboration. Within an instructor-worker setting in which a worker fulfilled a task based on video instructions, they found that perceived workload and stress were reduced for both workers and instructors when instructors were provided with FLBF. Martínez Fernández et al. (2013) applied FLBF for managing interactions and stress levels of entire teams in the context of financial trading. They argue that their self-aware trading system enables supervisors to monitor trading sessions more efficiently by observing the overall physiological state of the team, hence enabling better financial decisions. Third, FLBF may entail a *fun, gamified,* and *motivational* function without any other specific objective or utility. Walmink et al. (2013), for instance, proposed an augmented bicycle helmet that displayed heart rate data to other cyclists, finding that it improves "social interplay" and engagement with the activity. Magielse and Markopoulos (2009) designed a pervasive game for children in which heart rate is shared with other players when exceeding a predefined threshold. Stach et al. (2009) implemented a multiplayer fitness application in which performance is calculated relative to the individual fitness level rather than across all players. In this vein, the authors intended to avoid demotivation across players (e.g., due to different fitness levels). Although neither study could show that the application of FLBF within the games significantly increased engagement in physical exercise, Stach et al. (2009) observed a reduced performance gap between users with different fitness levels when FLBF was used. Fourth, based on the time-honored association of social presence and trust (Gefen and Straub 2004; Hassanein and Head 2007), it is conceivable that the availability of FLBF may have a positive effect on trusting behavior and trustworthiness as it provides an *additional social cue* to one's interaction partner. In this sense, FLBF could extend the set of conveyable social cues that have been considered for computer-mediated communication in the past (e.g., images, voice, gestures, or mimic). However, as we shall see later in this paper, this view is not without intricacies. For a more comprehensive review on the use of FLBF in practice and related research, we refer to Lux et al. (2018, *in press*). As outlined above, FLBF has previously been applied in a range of different areas. However, at this stage, only little research has explored its effects in trust-sensitive environments.

Trust in Online Environments and the Investment Game

Trust plays an imperative role in social interactions (Gambetta 1988). It can be defined as a "psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (Rousseau et al. 1998, p. 395). Especially in Internet-mediated socio-economic transactions, typically between strangers, sufficient levels of trust are essential. For instance, on peer-based platforms such as eBay, buyers put money at risk, as they commonly buy and pay *before* inspecting or receiving items. Moreover, peer-to-peer rental of personal belongings (e.g., houses or cars) requires mutual trust between both providers and consumers as both parties face considerable levels of economic and social exposure (Hawlitschek et al. 2016). This corroborates the relevance of IS research that investigates trust in online environments (see Gefen and Straub 2003, 2004) and has resulted in a large body of literature on different means of establishing trust in consumer-to-consumer markets (Teubner et al. 2018). Within this paper, we focus on interpersonal trust towards an interaction partner – operationalized by the corresponding trusting behavior. One of the most frequently applied means to study trust-related behavior under controlled conditions is the *Trust* or *Investment Game* (Berg et al. 1995). It has evolved as a common instrument to investigate trust in economic contexts, facilitating both the observation of a behavioral measure of trust as well as reciprocity (Fehr 2009). According to Berg et al. (1995), the mechanics of the investment game can be described as follows. Two players A and B, who do not know each other and who sit in two different rooms, are each endowed with $10. Then, player A (the trustor) decides on how much of her $10 she wants to send to player B (the trustee). The amount sent is called *investment* and can be interpreted as a behavioral measure for trust. Importantly, the investment is tripled and then credited to player B. Player B then decides on how much of this amount to keep and how much to send back to player A. The amount sent back is called *return* and can be interpreted as a behavioral measure for reciprocity – or player B's (ex post) trustworthiness.

Method

Our study investigates the effect of FLBF availability on decision making and trust. We conducted a laboratory experiment with two groups: the treatment group with FLBF and a control group without FLBF. All participants were assigned to one of the two conditions and, therein, to one of the two roles of the investment game (trustor or trustee). Participants engaged in five rounds of the investment game. All participants remained in both their role and group for the entire experiment (between-subjects design). In each round, trustors and trustees were randomly matched in pairs of two and endowed with MU10. First, the trustor decided how much of the initial endowment of 10 monetary units (MU) to send to the trustee (i.e., investment). The invested amount was multiplied by a factor of 3 and credited to the trustee. Second, the trustee decided on how much of the received amount to return to the trustor. The returned amount was credited to the trustor but this information was not communicated to the trustor until the very end of the experiment. To reduce the impact of potential learning and reputation effects from interacting with the same counterpart over time, any matching only occurred once (perfect stranger matching) and trustees' returns remained concealed to trustors until the end of the experiment. The final payoff for each participant was calculated based on the accumulated earnings across all five rounds and was displayed at the end of the experiment (MU10 = €1.50).

The displayed FLBF score was based on the participants' heart rate (measured with electrocardiography) as this parameter represents an intuitive and comprehensible measure for arousal (Astor et al. 2013). To achieve cross-subject comparability, heart rate values (averaged over the past five seconds) were divided by participants' average heart rate during a 5-minute resting period prior to the actual experiment. In the FLBF group, participants observed the FLBF values of their counterpart throughout the interaction process. FLBF was visualized by means of an "arousal meter," a bar graph displaying the other's arousal. For higher arousal, the meter's color changes from dark green, light green, yellow, orange to red. Last, participants completed a questionnaire assessing their gender, surveillance perceptions (i.e., the subjects' feeling that they are monitored and that information about them is collected or conveyed to others; Xu et al. 2012), disposition to trust (i.e., a subject's propensity to trust others; Gefen 2000), and disposition to reciprocate (i.e., a subject's propensity to engage in exchanges for mutual benefit; Kankanhalli et al. 2005) on 7-point Likert scales with 3 to 4 items each.

Participants were recruited from Karlsruhe Institute of Technology using *Hroot* (Bock et al. 2014). Altogether, 126 participants took part in this study (82 male, 44 female, mean age = 22.48 years). After arriving at the lab, participants were welcomed and filled out a consent form before they were seated in their cabin. Next, biosensors were attached. Participants then received general instructions and completed a resting period of 5 minutes to calibrate heart rate measurements. Instructions and rules were played back aloud from record. Comprehension was verified through a short quiz. Then, the actual experiment started. Last, participants filled out the questionnaire. On average, sessions took 50 minutes with a payoff of €11.65.

Results and Discussion

As a first approach to analyze how the availability of FLBF affected investment and return behavior, we consider a random effects panel regression with repeated measures (period 1–5, coded as 0–4 to make the treatment coefficient directly interpretable) per subject. For trustors, the dependent variable is *investment*, ranging from 0 to 10 (MU). For trustees, we consider *absolute returns* as the main focus variable. Note that the latter requires to control for the preceding investment i since the range of possible returns is bound to [0, 3i] (MU). Moreover, note that employing relative returns as a measure for reciprocity are problematic due to the possibility of zero-investments. In all regression models, we control for round, the individuals' disposition to trust/reciprocate, and potential gender effects. Table 1 summarizes all path estimates for trustors (investment) and trustees (absolute return). As can be seen in the table, there occurs a negative effect of FLBF availability – both for investments (b=-1.441, p<.10) and returns (b=-1.957, p<.05). This means that a) trusting behavior is lower when live biofeedback is available and b) that this reluctance in investment is well-justified since trustees behave in fact less trustworthy for the treatment group. Note that a treatment-time interaction analysis (Figure 1, left-hand side) reveals that there exists a negative time effect on investment both in the control (b=-.265, p<.05) and in the treatment group (b=-.265+.177=-.088, difference in slope not significant). This analysis reveals that the contrast between treatment and control group is particularly driven by the first rounds. This is consistent with prior findings on subjects' behavior in many economic experiments (including the investment game), where often, a distinct "end game" effect is observed and subjects tend to invest, cooperate, and trust less towards the last rounds of the experiment (Bolton et al. 2013). Moreover, we observe significant effects of individuals' disposition to trust (b=.619, p<.05) and disposition to reciprocate (b=2.075, p<.001), and no gender effects.

Table 1. Regression results (SE=Standard Error; $^{+}$ p < .10; * p < .05; ** p < .01; *** p <.001)

	Investment		Return	
	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)
Foreign Live Biofeedback	-1.087	**-1.441** $^{+}$	**-1.401** **	**-1.957** **
(Treatment Group)	(.797)	(.871)	(.608)	(.797)
Round (coded 0 – 4)	**-.175** *	**-.265** *	-.007	-.148
	(.088)	(.125)	(.128)	(.183)
FLBF × Round	—	.177	—	.277
		(.176)		(.256)
Disposition to Trust/Rec	.619 **	.619 **	2.075 ***	2.075 ***
	(.267)	(.267)	(.256)	(.256)
Gender: Female	-.145	-.145	-.242	-.244
	(.821)	(.821)	(.656)	(.656)
Investment	—	—	.469 ***	.468 ***
			(.017)	(.017)
Constant	3.874 **	4.054 **	-9.080 ***	-8.785 ***
		(1.313)	(1.259)	(1.288)
N	315	315	315	315
R^2	.034	.038	.728	.729

These first results create an interesting contrast compared to prior research that has shown that social cues embedded in online platforms (e.g., human imagery) can actually facilitate trust building. Theoretically, the availability of FLBF could be understood as such an element, conveying social information on physiological processes. At this stage, however, besides that there has only been little research on the effect of FLBF on trust, it appears that its effects on trusting behaviour and trustworthiness is rather detrimental. Note, however, that our design does not allow for conclusions on whether the availability of the *other's* arousal data or one's knowledge about the availability of *one's own* data actually causes this. Future work will have to further drill down and disentangle the underlying cause-and-effect relations. As a second step, we assess participants' levels of perceived surveillance. To this end, we conduct a two (FLBF: yes/no) by two (player type: trustor/trustee) ANOVA revealing that FLBF affects perceived surveillance significantly ($F(1,122) = 26.88$, $p<.001$), while player type does not have a significant effect ($F(1,122) = 1.09$, $p=.299$). Moreover, there occurs no significant interaction between the factors ($F(1,122) = .59$, $p=.444$). Figure 1 (right-hand side) illustrates these findings.

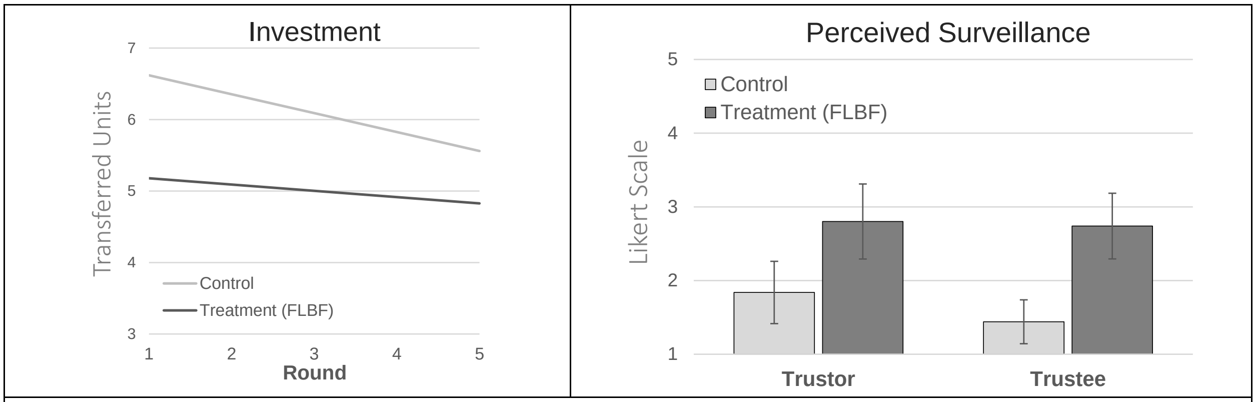

Figure 1. Left: Investment by Round and FLBF/Control group; Right: Perceived Surveillance by group (treatment or control) and player type (error bars indicate 95% confidence intervals)

While a common narrative on the effects of social cue availability is that such cues facilitate the formation of trust (Wang and Emurian 2005), there may be limits to this principle when it comes to physiological cues. Our results suggest that people experience surveillance (i.e., the perception that their activities may be watched, recorded, and transmitted to various entities, Xu et al., 2012), certainly not representing a desirable state. In line with previous literature, this may render situations such as a bio-physiologically augmented investment game, negotiations, or communication less pleasant overall and may, in turn, have detrimental effects on key behavioral variables (Curmi et al. 2013; Gervais et al. 2016). Against this backdrop, FLBF systems such as the t-shirt indicating changes in skin conductance and thereby communicating of a broad range of emotions such as joy or embarrassment (Howell et al. 2016) may appear in a different light. Depending on the specific context of course, such technological enhancements should be treated with caution.

Another aspect pertains to the interpretation of biosignals received from others. The integration of physiological data such as heart rate in terms of FLBF provides the user with additional information about their counterpart – information that is usually *not available* in face-to-face interactions for which, from an evolutionary perspective, humans did not develop the sensory and interpretative capacities to make sense of. Hence, despite the assumption that biosignals such as heart rate are easy and intuitive to interpret, the availability of FLBF within a user interface may still pose some challenges to the receiver. Specifically, given the lack of a commonly agreed-upon and intuitive benchmarks for "normal" heart rate values and fluctuations, any observed levels and variance may be considered as "high" and hence be associated with notions of anger, hot-headedness, or anxiety (Merrill and Cheshire 2017). Hence, high arousal levels may render the prospective interaction partner as inadequate for trusting decisions. The availability of FLBF also introduces novel theoretical and practical challenges for understanding the role of biosensor technology within our everyday interactions with and through information systems. In this regard, accessibility-diagnosticity theory describes how both the accessibility and diagnosticity of inputs influence the formation of beliefs, attitudes, intentions, and behaviors (Lynch and Feldman 1988). The theory predicts that decision makers consider an input for their decisions if it is accessible and perceived to be more diagnostic than other accessible inputs. FLBF may hence be discarded as a decision criterion or it may even be detrimental, similar to a person speaking to us in an entirely foreign and unfamiliar language. This *familiarity* heuristic applies to various day-to-day life situations and suggests that the familiar is favored over the novel (e.g., places, people, things). Hence, to some extent, this theory may provide some explanation as to why FLBF as a novel and relatively unfamiliar sensory input has a mitigating influence on trust and reciprocity.

Conclusion and Future Work

Within the scope of this short paper, we intend to set the stage for investigating the influence of displaying FLBF on human perception and trusting behavior in social interactions. We consider trusting behavior within a timely – some would argue – impending scenario of socio-technological development. Beyond the effect of FLBF on behavior, its availability may also be seen as an invasion into individual privacy. Concerns of surveillance may, in the long run, have unforeseeable effects on social interactions in general, and on how people use technology in particular. In this regard, the attacks against Google Glass wearers may serve as a first indication of the intricacies of such emerging technology (Gross 2014). We present experimental evidence for the effects of FLBF on trusting behavior. Specifically, we find that the availability of FLBF reduces trust and reciprocation while it increases perceptions of surveillance. We thus contribute to the discussion of social and ethical implications of ICT use by providing first empirical insights into the detrimental effects of FLBF within the context of social interaction.

Understanding the effects of FLBF is important both from a theoretical and practical perspective. So far, research on trusting behavior has mostly dealt with signals that can be assessed without technical auxiliaries (e.g., online reputation, facial expression, etc.). The outlined emergence of mobile and sensory technology has opened a door into other, previously not accessible cues (e.g., heart rate, skin conductance). This challenges our understanding of how trust forms and how formerly unavailable channels are incorporated into this process. Note that the potential practical applications of FLBF are manifold. Managers, coaches, or team coordinators may want to access their (co-) workers' or players' physiological data to plan out operating times and recreational phases. Such data would rely on voluntary provision, comparable to the medical monitoring of astronauts during space missions. However, there exist other, ethically more doubtful application scenarios. Sales persons may secretly monitor their customers' heart rate to inform their negotiation and sales pitch strategies. Such capabilities to assess one's counterpart's mood and temper in real time certainly represent a potential advantage when trying to sell a product or negotiate a deal. Counteracting such strategies, video conferencing software may use built-in filters to cancel out revealing physiological cues (e.g., variations of skin color, voice tone, etc.) as an effective guardian of individual privacy and data integrity in business settings. Our first results have demonstrated that FLBF may have detrimental effects on social interaction in certain scenarios. However, of course our study is not without limitations. First of all, the investment game covers only a small fraction of all conceivable trusting scenarios and other instruments should hence be considered to further our understanding of how FLBF affects trusting behaviors. Moreover, future research may consider the interaction partner's specific arousal values at the moment of decision making. In particular, it is conceivable that it is not only the mere availability of FLBF that affects trusting behaviors, but also the actual arousal levels displayed (e.g., where higher arousal levels may be considered as an indication of untrustworthiness; Merrill and Cheshire 2017). Against the backdrop of current developments in mobile, sensor, and surveillance technology, weighing up and discussing the opportunities and risks of FLBF availability is essential for a responsible development and use of ICT. Also, existing regulation may require ongoing modifications to respond to the intricacies of an emerging surveillance economy (Guardian 2018; Wilson 2016). Particularly as sensor technology providers increasingly tap into the end-consumer market, research on how this technology affects human perception and behavior is critical to avoid or at least mitigate potential pitfalls (e.g., detrimental influences on social interaction). In this vein, our study seeks to contribute to the ongoing discussion by exploring how the availability of FLBF may facilitate or disrupt the emergence of trust in socio-economic interactions.

References

AAPB. 2011. "About biofeedback," (available at https://www.aapb.org/i4a/pages/index.cfm?pageid=3463; retrieved July 30, 2018).

Adam, M. T. P., Gimpel, H., Maedche, A., and Riedl, R. 2017. "Design blueprint for stress-sensitive adaptive enterprise systems," *Business and Information Systems Engineering*, (59:4), pp. 277–291.

Adam, M. T. P., Teubner, T., and Gimpel, H. 2018. "No rage against the machine: How computer agents mitigate human emotional processes in electronic negotiations," *Group Decision and Negotiation*, (27:4), pp. 543–571.

Astor, P. J., Adam, M. T. P., Jerčić, P., Schaaff, K., and Weinhardt, C. 2013. "Integrating biosignals into information systems: A NeuroIS tool for improving emotion regulation," *Journal of Management Information Systems*, (30:3), pp. 247–278.

Berg, J., Dickhaut, J., and McCabe, K. 1995. "Trust, reciprocity, and social history," *Games and Economic Behavior*, (10:1), pp. 122–142.

Bock, O., Baetge, I., and Nicklisch, A. 2014. "hroot: Hamburg registration and organization online tool," *European Economic Review*, (71), pp. 117–120.

Bolton, G. E., Greiner, B., and Ockenfels, A. 2013. "Engineering trust: Reciprocity in the production of reputation information," *Management Science*, (59:2), pp. 265–285.

Chandler, C., Bodenhamer-Davis, E., Holden, J. M., Evenson, T., and Bratton, S. 2001. "Enhancing personal wellness in counselor trainees using biofeedback: An exploratory study," *Applied Psychophysiology and Biofeedback*, (26:1), pp. 1–7.

Chittaro, L., and Sioni, R. 2014. "Affective computing vs. affective placebo: Study of a biofeedback-controlled game for relaxation training," *International Journal of Human-Computer Studies*, (72:8), pp. 663–673.

Curmi, F., Ferrario, M. A., Southern, J., and Whittle, J. 2013. "HeartLink: Open broadcast of live biometric data to social networks," in *CHI 2013 Proceedings*, pp. 1749–1758.

Fairclough, S. H. 2014. "Physiological data must remain confidential," *Nature*, (505:7483), pp. 263–264.

Fehr, E. 2009. "On the economics and biology of trust," *Journal oft the European Economic Association*, (7:2), pp. 235–266.

Gambetta, D. 1988. *Trust: Making and breaking cooperative relations*, New York City, NY: Basil Blackwell.

Gefen, D. 2000. "E-commerce: The role of familiarity and trust," *Omega*, (28:6), pp. 725–737.

Gefen, D., and Straub, D. W. 2003. "Managing user trust in B2C e-services," *e-Service Journal*, (2:2), pp. 7–24.

Gefen, D., and Straub, D. W. 2004. "Consumer trust in B2C e-commerce and the importance of social presence: Experiments in e-products and e-services," *Omega*, (32:6), pp. 407–424.

Gervais, R., Gay, A., Lotte, F., and Hachet, M. 2016. "TOBE: Tangible out-of-body experience," in *TEI 2016 Proceedings*, pp. 227–235.

Gross, D. 2014. "Google Glass targeted as symbol by anti-tech crowd," *CNN*.

Guardian. 2018. "The Guardian view on Facebook: Time to tame the surveillance economy," (available at https://www.theguardian.com/commentisfree/2018/apr/13/the-guardian-view-on-facebook-time-to-tame-the-surveillance-economy; retrieved August 15, 2018).

Hassanein, K., and Head, M. 2007. "Manipulating perceived social presence through the web interface and its impact on attitude towards online shopping," *International Journal of Human-Computer Studies*, (65:8), pp. 689–708.

Hawlitschek, F., Teubner, T., Adam, M. T. P., Borchers, N., Möhlmann, M., and Weinhardt, C. 2016. "Trust in the sharing economy: An experimental framework," in *ICIS 2016 Proceedings*, pp. 1–14.

Hawlitschek, F., Teubner, T., Lux, E., and Adam, M. T. P. 2015. "Foreign live biofeedback: Using others' neurophysiological data," in *Lecture Notes in Information Systems and Organisation*, (Vol. 10), pp. 59–64.

Howell, N., Devendorf, L., Tian, R. K., Vega Galvez, T., Gong, N., Poupyrev, I., Paulos, E., and Ryokai, K. 2016. "Biosignals as social cues," in *DIS 2016 Proceedings*, pp. 865–870.

Järvelä, S., Kätsyri, J., Ravaja, N., Chanel, G., and Henttonen, P. 2016. "Intragroup emotions: Physiological linkage and social presence," *Frontiers in Psychology*, (7:105), pp. 1–11.

Jercic, P., Astor, P. J., Adam, M. T. P., Hilborn, O., Schaaff, K., Lindley, C., and Eriksson, J. 2012. "A serious game using physiological interfaces for emotion regulation training in the context of financial decision-making," in *ECIS 2012 Proceedings*, pp. 207–221.

Kankanhalli, A., Tan, B. C. Y., and Wei, K.-K. 2005. "Contributing knowledge to electronic knowledge repositories: An empirical investigation," *MIS Quarterly*, (29:1), pp. 113–143.

Katabi, D. 2018. "A new way to monitor vital signs (that can see through walls)," (available at https://www.ted.com/talks/dina_katabi_a_new_way_to_monitor_vital_signs_that_can_see_through_walls; retrieved July 31, 2018).

Lux, E., Adam, M. T. P., Dorner, V., Helming, S., Knierim, M. T., and Weinhardt, C. 2018. "Live biofeedback as a user interface design element: A review of the literature," *Communications of the AIS*, (in press).

Lynch, J. G., and Feldman, J. M. 1988. "Self-generated validity and other effects of measurement on belief, attitude, intention, and behavior," *Journal of Applied Psychology*, (73:3), pp. 421–435.

Magielse, R., and Markopoulos, P. 2009. "HeartBeat: An outdoor pervasive game for children," in *CHI 2009 Proceedings*, pp. 2181–2184.

Al Mahmud, A., Mubin, O., Octavia, J. R., Shahid, S., Yeo, L., Markopoulos, P., and Martens, J.-B. 2007. "aMAZEd: Designing an affective social game for children," in *DIC 2017 Proceedings*, pp. 53–56.

Martínez Fernández, J., Augusto, J. C., Trombino, G., Seepold, R., and Madrid, N. M. 2013. "Self-aware trader: A new approach to safer trading," *Journal of Universal Computer Science*, (19:15), pp. 2292–2319.

Matthews, M., Snyder, J., Reynolds, L., Chien, J. T., Shih, A., Lee, J. W., and Gay, G. 2015. "Real-time representation versus response elicitation in biosensor data," in *CHI 2015 Proceedings*, pp. 605–608.

Merrill, N., and Cheshire, C. 2017. "Trust your heart: Assessing cooperation and trust with biosignals in computer-mediated interactions," in *CSCW 2017 Proceedings*, pp. 2–12.

Mueller, F. F., Vetere, F., Gibbs, M. R., Edge, D., Agamanolis, S., and Sheridan, J. G. 2010. "Jogging over a distance between Europe and Australia," in *UIST 2010 Proceedings*, pp. 189–198.

Mueller, F. F., and Walmink, W. 2013. "Duel reality: A sword-fighting game for novel gameplay around intentionally hiding body data," in *IE 2013 Proceedings*, pp. 3–7.

Al Osman, H. H., Eid, M. M., El Saddik, A., and Abdulmotaleb. 2014. "U-biofeedback: A multimedia-based reference model for ubiquitous biofeedback systems," *Multimedia Tools and Applications*, (72:3), pp. 3143–3168.

Pomfret, J. 2018. "China's new surveillance state puts Facebook's privacy problems in the shade," *The Washington Post*.

Reynolds, S. B. 1984. "Biofeedback, relaxation training, and music: Homeostasis for coping with stress," *Biofeedback and Self-Regulation*, (9:2), pp. 169–179.

Riedl, R., and Léger, P.-M. 2016. "Introduction to NeuroIS," in *Fundamentals of NeuroIS Information Systems and the Brain*, R. Riedl and P.-M. Léger (eds.), Springer, pp. 1–24.

Al Rihawi, R. G., Ahmed, B., and Gutierrez-Osuna, R. 2014. "Dodging stress with a personalized biofeedback game," in *CHI Play 2014 Proceedings*, pp. 399–400.

Roseway, A., Lutchyn, Y., Johns, P., Mynatt, E., and Czerwinski, M. 2015. "BioCrystal: An ambient tool for emotion and communication," *International Journal of Mobile Human Computer Interaction*, (7:3), pp. 20–41.

Rouast, P. V., Adam, M. T. P., Chiong, R., Cornforth, D. J., and Lux, E. 2017. "Remote heart rate measurement using low-cost RGB face video: A technical literature review," *Frontiers of Computer Science*, pp. 1–15.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., and Camerer, C. F. 1998. "Not so different after all: A cross-discipline view of trust," *Academy of Management Review*, (23:3), pp. 393–404.

Rubinstein, M. 2014. "See invisible motion, hear silent sounds," (available at https://www.ted.com; retrieved August 6, 2018).

Slovák, P., Janssen, J., and Fitzpatrick, G. 2012. "Understanding heart rate sharing: Towards unpacking physiosocial space," in *CHI 2012 Proceedings*, pp. 859–868.

Snyder, J., Matthews, M., Chien, J., Chang, P. F., Sun, E., Abdullah, S., and Gay, G. 2015. "MoodLight: Exploring personal and social implications of ambient display of biosensor data," in *CSCW 2015 Proceedings*, pp. 143–153.

Stach, T., Graham, T. C. N., Yim, J., and Rhodes, R. E. 2009. "Heart rate control of exercise video games," in *Graphics Interface 2009 Proceedings*, pp. 125–132.

Tan, C. S. S., Schöning, J., Luyten, K., and Coninx, K. 2014. "Investigating the effects of using biofeedback as visual stress indicator during video-mediated collaboration," in *CHI 2014 Proceedings*, pp. 71–80.

Teubner, T., Hawlitschek, F., and Adam, M. T. P. 2018. "Understanding trust and reputation transfers on C2C platforms," *Working Paper*.

Walmink, W., Wilde, D., and Mueller, F. "Floyd." 2013. "Displaying heart rate data on a bicycle helmet to support social exertion experiences," in *TEI'14 Proceedings*, pp. 97–104.

Wang, Y. D., and Emurian, H. H. 2005. "An overview of online trust: Concepts, elements, and implications," *Computers in Human Behavior*, (21:1), pp. 105–125.

Wilson, E. 2016. "Algorithms, dictators, & the surveillance economy," (available at https://medium.com/the-graph/algorithms-dictators-the-surveillance-economy-e89139d42214; retrieved August 15, 2018).

Xu, H., Gupta, S., Rosson, M. B., and Carroll, J. M. 2012. "Measuring mobile users' concerns for information privacy," in *ICIS 2012 Proceedings*, pp. 1–16.