

# Social interaction using mobile devices and biofeedback: effects on presence, attraction and emotions

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## Abstract

In this article we describe the preliminary results of our experiment conducted with the PRESEMO. PRESEMO is a system that makes it possible for an audience to interact during a presentation. The system uses the Nokia N900 devices with heart rate monitors to create an interactive presentation and displays the heart rate of four participants in real time. Over all we measured 70 participants. During the presentation the participants were able to communicate with each other via the mobile devices and answer questions that were presented interactively. In the experiment, short movie clips were presented to the participants during which their interbeat interval, electrodermal activity and blood volume pulse were measured. Some feedbacks (chat conversation, answers to the questions and biofeedback) were visible to the participants during the presentation. We wanted to know whether it had an impact on emotions, inter-personal attraction, physical presence and social presence. We found that feedback had a positive effect on the dependent variables.

## Keywords

Psycho-physiology, biofeedback, social and physical presence, attraction, valence, arousal, dominance, affective computing.

## 1. Introduction

Recent studies in the field of human-computer interaction have proposed to replace current asymmetrical information exchange systems by smart systems that take into account the user's internal states [8]. The study and development of those new interfaces are known as affective computing [20]. Different devices that measure psycho-physiological signals, like electroencephalogram (EEG), electrodermal activity measurement (EDA) or electrocardiogram (ECG), provide information about the emotional state of the user and make it possible for the interface to adapt its functions accordingly. For instance a smart system could offer help if the user is distressed. For this reason, many studies have tried to infer emotional states from users' physiological signals [4, 15, 21], facial expression and voice [6, 19] with varying degree of accuracy.

Most of the applications that propose such biofeedback in real time have been developed for games [11, 16]. In this context, psycho-physiological responses are generally used to keep the player engaged by adapting the game difficulty according to the player's emotions: make it easier when the player is anxious and more difficult when the player is bored [5, 16]. Kuikkaniemi et al. [12] studied the effect of two different biofeedbacks on a game

play - explicit feedback where the participants are aware of the feedback effects (for example that the arousal influences the speed of the character) and implicit feedback where the players did not know about the biofeedback effects. The results demonstrated that the game play was mostly influenced by explicit feedback.

As described above the previous studies have concentrated on single user systems that provide indirect biofeedback (i.e. the physiological signals were interpreted as emotional states or commands). To our knowledge there is no study that tries (*i*) to evaluate the effect of a direct display of physiological variables such as heart rate, (*ii*) to use biofeedback in a social context. We believe that directly displaying the physiological variables would motivate users to construct their own interpretation of the signals. Compared to interpreted variables (such as emotional states) it might have two advantages in a social context: the user can have better confidence in his or her judgment than in the system's inference and it is closer to a real social exchange where people constantly interpret non-verbal messages and emotional cues of others.

Measuring the physiological activity of several people concurrently allows analyzing not only the experience of each person separately but also the joint experience of the group. Several indices of physiological compliance have been proposed in the literature to measure to which extent the physiological reactions of two people are coupled [9, 13]. These measures of joint activity can tap in social processes such as emotional contagion and empathy [14] but have also been found to increase during conflicting and negative interactions [13]. In [9] the authors demonstrated that physiological compliance is also correlated with group performance. According to those results, we believe that physiological compliance is a measure that is strongly related to social interaction. As such it could be used in mediated interaction to provide an objective measure of social presence [2](i.e. the sense of interacting and being with another).

In the experiment presented in this paper we measured the effect of two feedbacks in a playful and social system. The first feedback was called explicit and it mostly consisted of standard text conversation (chat) between the participants. The second feedback displayed the heart rates of the users and will thus be named biofeedback. We also wanted to know how physiological compliance can be used to enhance social interaction and whether it indicates interaction, social presence or inter-personal affinity (these issues are not reviewed in this paper). The research question addressed in this paper is: does the display of the

different feedbacks have an impact on attraction, social presence, physical presence and emotional experience.

## 2. Presemo

In our experiment we used PRESEMO which is a presentation system that can display overlapped multimedia material like videos, slide shows and graphs [11]. The goal of the PRESEMO is to encourage the audience to take part in the presentation and to interact with each other. This is achieved by asking questions concerning the presentation and allowing message exchanges via mobile devices.

The PRESEMO system has two main components: a main screen, where the presentation, questions and chatting messages are shown to the audience (Figure 1) and a mobile device where the participants can receive and answer questions as well as send chat messages (Figure 2). In this experiment the subjects used Nokia Maemo N900 as a mobile device (maemo is a Linux distribution developed for mobile devices). In addition a Polar band was used to measure the heart rate of the participants in real time. This information was transferred via Bluetooth to the N900 devices and then sent along with the chat messages to the presemo server. More technical information about the presemo can be found in [11].



Figure 1. The presentation view when all feedbacks are on.

## 3. Methods

### 3.1 Participants

We measured 70 participants: 23 males and 47 females. All of them were university students except one. Their age ranged from 19 to 35 years (the average age being 24.21). Most of the participants (90 %) were right-handed and none had participated in this kind of experiment before. Only three subjects had used a N900 before while 11 had used a similar device such as the iPhone. Directly after their arrival the participants were informed about the content of the experiment. Everyone gave their informed consent by signing a consent form before participation.

The participants took part in the experiment by groups of four. Two of them were in the same room and two were separated in their own rooms. Those two pairs of participants are called “partners” in this document. The participants wore wild divine finger sensors that measured their electrodermal activity and blood volume pulse. The sensors were placed on the three middle fingers of their non-dominant hand. They also wore a polar band that measured their hear rate.

### 3.2 The protocol

In this study four movie clips were used as the content of the PRESEMO presentation. Movie clips were chosen instead of a live presentation to ensure a good control over the stimuli: they were easy to edit and all participants saw the exact same stimuli. The videos lasted about six minutes each and they were about religion, poverty, parkour and climbing. Two clips were taken from the Baraka movie and two were extreme sport clips taken from the Youtube database. The criteria for the video selection were that they should be non-verbal movies and elicit different emotional states (calm, excited, negative and positive). During each video there were questions asked by the PRESEMO every two minutes (a total of 3 questions per video were asked). The questions were visible only for a limited amount of time (1 min 30 s) and had to be answered before that time was elapsed. Afterwards, everyone’s answers appeared on the screen for 30 seconds and the next question was asked.

During the video clips presentation two kinds of feedbacks were toggled on or off: explicit and biofeedback. When the explicit feedback was on, the participants could see the chat messages they and the others were writing as well as the answers to the questions. The explicit feedback was presented both on the screen and in the mobile devices (Figure 1, Figure 2). When the biofeedback was on, the participants could see everyone’s heart rates on the screen (Figure 1). They also saw their heart rate compliance: between the heart images of each participant more or less thick lines indicated the correlation between the two corresponding heart rate signals over the last 30 seconds. When the correlation between the signals of two participants was positive, the line was presented in white and when it was negative the line was presented in light blue. The width of the line indicated the strength of the correlation (Figure 1). On the bottom left corner of the screen there was the chat conversation, questions were presented in the middle and the heart beats were shown on the bottom right corner.

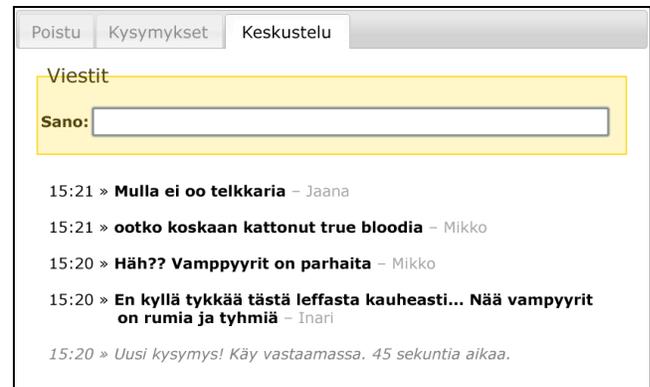


Figure 2. Chat in the mobile device.

Each group of participants saw four videos with four different feedback combinations. During the video clips they saw either no feedback, only biofeedback, only explicit feedback or both feedbacks. The four conditions were randomized so that: (i) a video clip was randomly assigned to one of the four feedback conditions for each group, (ii) the order of the feedback condition was randomized for each group. Headphones were used so that

the participants could listen to the video clips without hearing the others.

When all four participants had arrived and were ready, common oral instructions were given to them and they were introduced to each other by the nick name they chose. They were asked not to talk to each other during the experiment. Participants were told that the goal of the experiment was to test the PRESEMO system. They were encouraged to write chat messages as much as possible and answer the questions. They were also reminded to write comments even if the chat was not visible during some of the videos.

To train the participants to the PRESEMO, they participated in an interactive demonstration of the system. In this demonstration the explicit and biofeedback were on. After the demonstration, a five-minute baseline was recorded during which the participants were told to be calm and sit still. During the baseline everyone had their headphones, wild divine sensors and polar bands equipped but they were not allowed to use the mobile device.

After the baseline was recorded the participants watched the four video clips each clip being associated with one of the four feedback conditions. After each video the participants had to fill in a post session questionnaire online with a computer. They were asked to write a message “finished” with their mobile device when they were ready. During this time the chat was off so that subjects could not chat while waiting for the other participants to finish their questionnaire. The next video started when everyone had filled the questionnaire.

During the experiment, the heart rates were sometimes simulated to avoid visual incoherences in the display due to technical difficulties (temporary polar band disconnection). However, this problem did not occur too often and all the data was present in the following analyses.

### 3.3 Pre experiment and post session questionnaires

The participants were asked to fill a pre-experiment questionnaire before coming to the experiment. It contained 87 questions about personality, taken from the ZKPQ [22], the emotional contagion questionnaire [7] and the BIS/BAS questionnaire [3]. Only the neuroticism-anxiety, sociability and aggression-hostility items of the ZKPQ were selected. All the questions were 5 point Likert scales that ranged from “I disagree” (1) to “I agree” (5).

In the post-session questionnaire there were 105 questions. The participants had to evaluate social presence [1] and affinity [17] (only the attraction factor was used) of their partner and of the whole group. In the social presence questionnaire the participants evaluated the degree to which they felt as if they were together in the same space with the others. It also measured their attention, emotional contagion and mutual understanding of others in the experiment. In the attraction questionnaire subjects evaluated the others on a 5-point scale for example being interesting versus boring or warm versus cold. Post session questionnaire also contained questions about physical presence [10] and a Self Assessment Manikin (SAM) questionnaire [18] to measure the experiential impact of the PRESEMO system.

### 3.4 Statistical methods

We used the PASW 18 Statistics program and Linear Mixed Models (LMM) to analyze the data. Our repeated variables were participant ID number and session number (first presented movie clip was number one, second number two and so on). The group ID number and team ID (whether the participant was in a single or in a collocated room) were included as subject variables. The repeated covariance matrix was set as compound symmetry since it led to the lowest log-likelihood value for the model. The independent variables were the explicit and biofeedback binary variables. They were included in the model as fixed variables. One LMM procedure was used for each of our dependent variables: perceived behavioral interdependence, perceived psychological engagement, co-presence, arousal, dominance, valence, physical presence and attraction. The maximum likelihood method was used for the model estimation. Figure 3 shows the structure of our dependent variables.

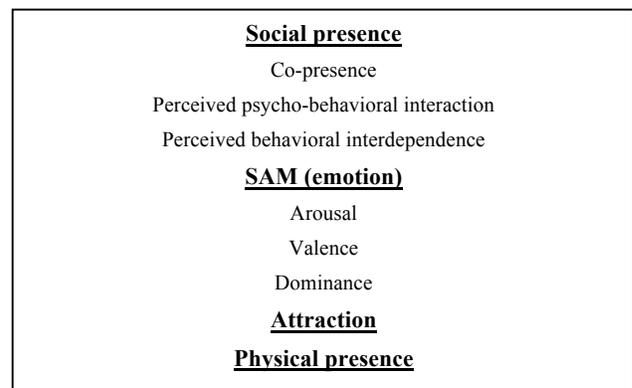
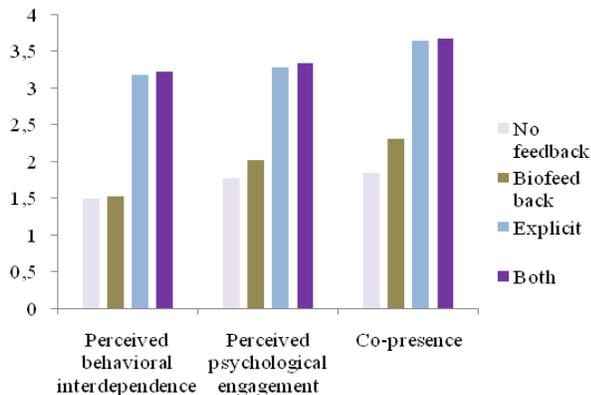


Figure 3. Dependent variables.

### 4. Results

We measured many different effects. Social presence included three different components – co-presence, perceived psychological engagement and perceived behavioral interdependence. Self-assessment manikin also had three components: arousal, dominance and valence. In addition we measured physical presence and attraction. In all these variables we wanted to see whether the explicit and biofeedback had any impact.

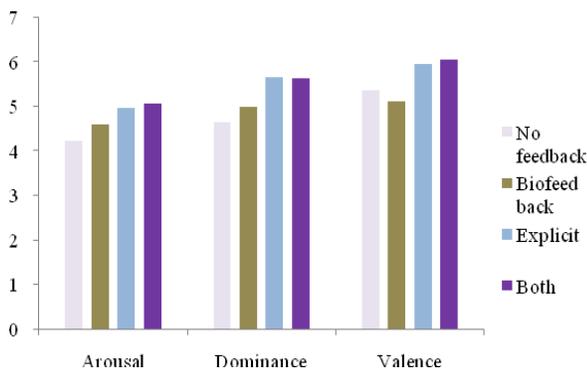
Explicit feedback had a significant effect on all of the social presence components: co-presence  $F(1;238.60)=338.48$ ,  $p<.001$ , perceived psychological engagement  $F(1;71.08)=180.20$ ,  $p<.001$  and perceived behavioral interdependence  $F(1;238.77)=301.44$ ,  $p<.001$ . That is, the participants felt that they are more aware of the others, paid more attention to them, understood what others meant and were influenced by others’ emotions more strongly when they could interact through the chatting and questions. Biofeedback had a significant effect only on co-presence  $F(1;232.90)=8.25$ ,  $p=.004$  which also was influenced by the interaction of explicit and biofeedback  $F(1;232.90)=7.03$ ,  $p=.009$ . As can be seen from Figure 4.1 the co-presence was higher when there was biofeedback. The marginal means of the social presence components are shown in Figure 4.



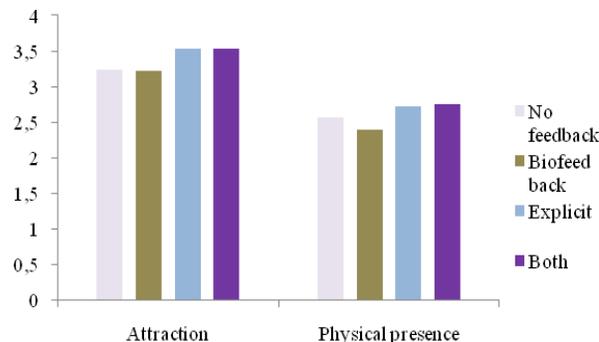
**Figure 4. The mean values in different components of social presence.**

In all three components of the SAM questionnaire the explicit feedback had a significant effect: arousal  $F(1;238.33)=8.27$ ,  $p=.004$ , dominance  $F(1;238.53)=16.14$ ,  $p<.001$  and valence  $F(1;239.31)=14.83$ ,  $p<.001$  indicating more positive and powerful emotions on a scale from one to nine when the explicit feedback was available. The biofeedback or the interaction of bio- and explicit feedback had no significant effects on these components. The means of evaluation values are shown in Figure 5.

The explicit feedback also had a significant effect on attraction  $F(1;235.97)=41.69$ ,  $p<.001$  and physical presence  $F(1;236.45)=6.32$ ,  $p=.01$ . In other words, the participants evaluated the group in a more positive way when the explicit feedback was on. Also the physical presence values were higher so the explicit feedback did not decrease participants' involvement in the video clips. Mean values are shown in Figure 6.



**Figure 5. The mean evaluation values in different self assessment manikin components.**



**Figure 6. The mean evaluation values in attraction and physical presence.**

## 5. Discussion

Explicit feedback had a positive impact on all of our dependent variables. Co-presence measured participants' awareness of each other which is obviously higher when they can write messages to each other (although the biofeedback also significantly indicated the presence of others). The significant effect of explicit feedback in perceived psychological engagement and behavioral interdependence is certainly explained by the interaction possibilities: when the participants saw the chat they paid more attention to one another, were influenced by others' actions, were able to communicate clearly and respond to each other. However the biofeedback did not have the same effects – it shows that it is not powerful enough to increase attentional engagement or being affected by others' emotions. The SAM questionnaire measured the emotional experience of the participants. Attraction values were also higher when the explicit feedback was on: the participants were able to appreciate each other better by chatting than by looking at each others' heart rates. Also the physical presence was not decreased even though the chat was on possibly because the chat directed the participants' attention more to the video clips.

These results show the important effect of explicit feedback in the presentation system: viewers felt that they understood each other better and were more engaged in the presentation. Also the attraction between the viewers was greater. The biofeedback proved to have significant effects on the co-presence factor, that is, the viewers were more aware of each other during the presentation. This demonstrates that the heart rates were considered as a reliable sign of the presence of others. The physiological data of this experiment is still to be analyzed to confirm the results obtained from the questionnaires.

The current results suggest that the direct biofeedback did not strongly impact users' experiences. However, redesigning the display of physiological variables might solve this problem. For instance it could be interesting to analyze the effect of auditory biofeedback rather than a visual one. It would also be interesting to isolate the effects of heart rate display and physiological compliance. Finally, the difference between interpreted and direct biofeedback should also be investigated in more details.

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