Get up, move on! Using Electromyography to Explore the Relationship of Experience and Motion

Johann Schrammel
CURE
Hauffgasse 3-5
1110 Vienna, Austria
schrammel@cure.at

Eva Ganglbauer
CURE
Hauffgasse 3-5
1110 Vienna, Austria
ganglbauer@cure.at

Manfred Tscheligi
1) CURE (postal address see above)
tscheligi@cure.at
and
2) HCI-Unit, ICT&S
University of Salzburg
Sigmund-Haffner-Gasse 18
5020 Salzburg, Austria

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

Abstract
Understanding the role and consequences of movement for emotional experiences is crucial for designing compelling interactions. In this paper we present initial results of an exploratory study targeting some of the open issues in this area. Questionnaires, interviews and electromyography were used to compare experiences and emotions evoked in conditions where participants were in motion respectively while being seated.

Keywords
Movement, Emotions, Psychophysiology, IAPS

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Common sense and results from UX research suggests that the interaction with products, tools, and artifacts can be enriched by allowing people to move naturally and unrestrictedly [1, 17]. If people can express themselves with their whole body, they immerse into another world more naturally and easily. Results show that even engagement and social interaction are

encouraged by controllers that afford movement [14]. Izard et al. describes neural, sensorimotor, motivational and cognitive processes that can influence emotions. Body posture and movement can activate emotions by afferent processes [12].

To be able to study these relationships between experience and motion in detail unobtrusive measures to assess the experience and emotional content of a moment are needed.

Trying to "measure the experience" is a nontrivial task by definition as User Experience (UX) is embedded in a situational, temporal, individual and product context [11] and is characterized by sensual, emotional, compositional and spatio-temporal threads [16].

Traditional approaches to assess experiences and emotions include self-report methods such as questionnaires, interviews, narrative techniques, contextual inquiries or sensual evaluations [11]. These methods provide the possibility to gather insight into the subject's feelings and preferences, but also require the subject to take explicit actions to provide the data and therefore interrupt the ongoing interactive process. Approaches to automate the recognition of the expressive and emotional content of speech, faces or gestures [6] that avoid this disadvantage have been developed, and combinations of these automatic expression recognition methods result in a broader spectrum of emotions that now can be detected successfully [4, 7].

Using Electromyography to Assess Experience and Emotion

Another promising approach to assess and research experiences in motion is Electromyography (EMG). EMG measures muscle activity by detecting surface voltages that occur when a muscle is contracted. Typically this is done by use of surface electrodes. EMG was used in a lot of studies to access the valence of emotions successfully [8, 15]. Especially the muscle activity of the zygomaticus major muscle (the "smile" muscle) and the currogator supercilii muscle (the "frown" muscle) in the face have been used frequently. Results show that emotions can be assessed by EMG, sometimes even more accurately than from face observations [2]. During negative events, the currogator EMG was found to be significantly higher, respectively zygomaticus EMG during positive events [8]. Partala et al. found a recognition rate of 60-80% to distinguish between positive and negative experiences [18].

Research Questions

EMG seems to have great potential to assess emotions in UX research, but concerns remain whether and how it can be used in realistic contexts. Especially the practicability of the technology as well as the quality of the recorded data has been questioned. A second focus of our research is to analyze the relationship between the situational experience and the users movement patterns.

In detail we want to answer the following two questions: (1) Can electromyography successfully be used to estimate a user's emotional experience in motion contexts? And (2) is a more embodied way of controlling the interaction actually amplifying experience as expected?

Method

Six female and six male subjects participated in the study. Participants were between 20 and 36 years old and had extensive experience in computer game playing. Each participant brought a friend of the same sex along, against whom they were playing in the gaming session of the study. The study was divided into two major parts.

The main stimulus of the first part consisted of different pictures taken from the International Affective Picture System (IAPS) [13]. Participants had to watch 10 pictures per condition for 5 seconds and afterwards rate the experienced emotions using the Self Assessment Manikin (SAM) [2]. Pictures were shown in two different conditions: when participants were seated and while walking stationary. IAPS provides standard values for valance induced on average by the pictures. Care was given that valence values of the pictures where the same in both conditions. Ordering of tasks and used picture set was switched between participants and conditions to even out possible confounding factors.

In the second part participants were playing two different tasks (food tracing and cow tossing) from the game “Rayman Raving Rabbids” on the Sony Playstation 2 (seated condition) and on the Nintendo Wii (motion condition). Play time to finish the tasks on either type of console typically was between 10 and 15 minutes. Amount of Movements of the player was tracked by use of a second Wii Remote attached to the dominant arm. Participants played against the friend they brought with them. “Rayman Raving Rabbids” has very similar graphics on the two consoles and gaming sites give them the same rating. Half of the participants started with the Wii, and half with the Ps2.

After each condition, participants were asked to rate their average experience during playing by use of Emocards [5]. Additionally, participants were asked to describe the emotionally most outstanding situation during play. They were also asked to fill out a questionnaire using Likert-scale items regarding perceived agitation and emotions. After completion of both condition participants were asked to explain which platform they preferred for playing and why.

EMG data was collected during both parts of the study. The Flex Comp Infinity System from Thought Technologies was applied with two electrode-sets for currogator and zygomaticus EMG [20]. Data was recorded with 2048 Hz, but downsampled to 32 Hz for faster data processing. Data manipulation was carried out in Matlab filtering raw EMG data with a butterworth filter. Thresholds for zygomaticus and currogator activation were assigned manually based on a visual inspection of the recorded curve per participant. EMG-data was used to calculate an estimation of valence of the current emotional situation of the user. Zygomaticus was modeled as positive and currogator as negative when activated.

Results

To answer the question whether the electromyographical measures provide a viable indicator for different aspects of the users' experience we correlated the recorded and processed data with self-reported measures of the users both in the IAPS setting and in the game play situation.

Comparing IAPS Conditions

In the IAPS condition self-reported data of the users using SAM as well as the average ratings of the typically induced levels of valence using IAPS pictures as provided by [13] were correlated.

Our data indicate that there is only a weak correlation ($r=0.175$, $p<0.01$) between the valence value expressed by the participants and the EMG-derived valence using information from the currogator and zygomaticus. We think this rather low r-value is caused by the fact that IAPS pictures only have the ability to evoke weak emotions witch corresponds with a lower activation of the muscles. Very small values are likely to fall below the threshold values and therefore to be masked in the data.

As expected SAM-based valence values strongly correlated with the IAPS-Standard-values ($r=0.618$, $p<0.01$).

We also compared whether there was a difference in the amount of activation of the two muscles tracked by EMG. Using paired samples t-test comparing the activation did not show a significant effect of the movement condition on the amount of either the zygomaticus ($t_{11}=1.24$, $p=0.24$) or the currogator ($t_{11}=-1.39$, $p=0.19$).

This result might sound like a contradiction to our expectation that movement actually amplifies the experienced emotions. However, regarding the movement condition for the IAPS task with stationary walking, the motion of the participants was not a natural extension of the interactive situation but an arbitrary addition.

Comparing Gaming Conditions

Users reported more positive experience when using the Wii compared to the Ps2. Two-way repeated measures ANOVA with sex and game condition as independent variables showed a significant main effect for self-reported experience.

As described EmoCards were used as means for collecting self-report data on valence and arousal during the two gaming conditions. Again, two-way repeated measures ANOVA was used to analyze the data. We did not find any significant differences in the reported valence depending on game condition ($F_{1,10}=2.358$, $p=0.156$), sex ($F_{1,10}=2.753$, $p=0.128$) or an interaction of these two factors ($F_{1,10}=2.358$, $p=0.156$).

The analysis of self-reported arousal showed a significantly higher level for the Wii-condition ($F_{1,10}=4.957$, $p=0.05$). No main effect for sex ($F_{1,10}=2.358$, $p=0.156$) and the interaction of factors ($F_{1,10}=3.670$, $p=0.084$) was found.

EMG-based calculation of valence did not show any significant differences between the two gaming conditions. However, as a positive gaming experience also involves tricky situations and challenges, valence alone is not a good measure. Therefore also patterns for the individual muscles were analyzed.

For the activation of zygomaticus no main effect can be found, however the interaction between sex and gaming condition is significant ($F_{1,10}=5.692$, $p=0.038$). An increase in activation of muscles can be found for male gamers, females do not show this effect.

When looking at the data for the currogator the means show a similar pattern, however here the interaction is only marginally significant ($F_{1,10}=3.358$, $p=0.097$).

Correlation of Motion and EMG
Situational motion data (as provided by the Wii) and EMG data was correlated to further analyze the relationship of these two data sources. The motions of gamers show a highly significant correlation with both, the EMG-values of the zygomaticus ($r=0.139$, $p<0.01$) and the currogator ($r=0.256$, $p<0.01$). One might suspect that this correlation is caused by a slight activation of the tracked muscles related to an overall increased tension during movements. However, several arguments point against this interpretation. First, in this analysis only a binary representation of EMG data was used and threshold values were manually assigned to the data taking care they are set high enough to only detect meaningful activation. Second, several random samples of video data from different study participants were analyzed regarding the plausibility of the binary EMG-outputs. No indication for erroneous data was found. And third, in the IAPS condition no such differences between the moving and the stationary condition could be found in the EMG data.

Qualitative Results
We asked participants about their preferences regarding Ps2 or Wii. A majority of the participants (9) preferred playing with the Wii. Those participants (3) that preferred playing with the Ps2 mentioned that they know the platform better, i.e. their reasons are not related to the interaction style but familiarity.

"Playing on the Wii is more fun, the whole body is in movement and not only fingers and thumbs."

"I liked the Ps2 better, I don't know the Wii enough, and what I know seems suspicious to me."

"I preferred playing on the Wii better. You have to do more with the arm and move more. If you are allowed to do this, you can better feel the game play"

"This is strongly depending on the game […] Although I lost [against the partner] on the Wii today, I liked it better to play."

Discussion
In overall our results indicate that EMG measures indeed are suitable for the usage in motion contexts and provide reliable data. Signals are not inferred substantially, although we recommend to apply sufficiently high thresholds in motion contexts. This also implies that EMG becomes less sensitive for the detection of weak signals.

With regard to the differences between stationary and moving conditions, both EMG-based and self-report data from the gaming session support our expectation that involving natural body movements intensifies the users' experience, and that arbitrary motions do not have such an effect. It seems to be very important that the body movement is in accordance with the activity and follows a natural pattern.

Johann Schrammel has been active in the field of HCI-Research for about ten years. He has been continuously interested in researching different aspects of user experience. Early work focused on using narrative approaches and conversation analysis to analyze experiences when interacting with technology. Recently he focused on complementing these qualitative understandings of experience with quantitative data from psycho-physiological measures and motion trackers.

Eva Ganglbauer holds a master degree in computer science and media from the University of Technology in Vienna. Her research interests cover various aspects dealing with energy feedback, mobile and advanced interfaces, emotions and user experience. Trying to delve deeper into the role of emotions, motion and user experience research on the possibilities of psychophysiology for HCI became evident.

Manfred Tscheligi is professor for Human-Computer Interaction & Usability at the University of Salzburg and director of CURE. Since several years he is active the international research scene (e.g. as General Conference Co-Chair of CHI2004, Conference Chair of the MobileHCI 2005 or co-chairing the ACE 2007 conference). He is also member of different editorial boards such as Springer series on Human-Computer Interaction.

References

[1] Bianchi-Berthouze, N., Kim, W. & Patel, D., Does Body Movement Engage You More in Digital Game Play? and Why?, Affective Computing and Intelligent Interaction, LNCS 4738, Springer,, 2007, pp. 102-113

[2] Bradley, M.M. & Lang, P.J., Measuring emotion: the Self-Assessment Manikin and the Semantic Differential., Journal of Behavior Therapy and experimental psychiatry, 1994, Vol. 25(1).

[3] Cacioppo, J.T., Petty, R.E., Losch, M.E. & Kim, H.S., Electromyographic activity over facial muscle regions can differentiate the valence and intensity of affective reactions. Journal of personality and social psychology, 1986, Vol. 50(2).

[4] De Silva, L., Audiovisual emotion recognition Systems, Man and Cybernetics, 2004 IEEE International Conference on, 2004, Vol. 1.

[5] Desmet, P.M.A., Overbeeke, C.J., Tax, S.J.E.T. (2001). Designing products with added emotional value: development and application of an approach for research through design. The Design Journal, 4(1).

[6] Glowinski, D., Camurri, A., Volpe, G., Dael, N. & Scherer, K., Technique for automatic emotion recognition by body gesture analysis, Computer Vision and Pattern Recognition Workshops, 2008. CVPRW '08. IEEE Computer Society Conference on, 2008.

[7] Gunes, H. & Piccardi, M. (2006), 'A Bimodal Face and Body Gesture Database for Automatic Analysis of Human Nonverbal Affective Behavior', Pattern Recognition, 2006. ICPR 2006.

[8] Hazlett, R.L., Measuring emotional valence during interactive experiences: boys at video game play, In CHI ’06.

[9] Healey, J. A. Affect Detection in the Real World: Recording and Processing Physiological Signals. Affective Computing & Intelligent Interaction, 2009.

[10] IJsselsteijn WA, Kort YAW de, Poels K, Jurgelionis A, Belotti F (2007) Characterising and Measuring User Experiences. In: Proceedings of the international Conference on Advances in Computer Entertainment Technology.

[11] Isbister, K. Höök, M. Sharp, and J. Laaksolahti. The sensual evaluation instrument: developing an affective evaluation tool. In CHI ’06.

[12] Izard, C. E. (1993), 'Four systems for emotion activation: cognitive and noncognitive processes', Psychological review 100(1), 68-90.

[13] Lang, P. J., Bradley, M. M. and Cuthbert, B. N., International affective picture system (IAPS): Technical Manual and Affective Ratings, Center for Research in Psychophysiology, University of Florida 1999

[14] Lindley, S.E., Le Couteur, J. & Berthouze, N.L., Stirring up experience through movement in game play: effects on engagement and social behavior. in CHI '08

[15] Mandryk, R.L., Inkpen, K.M. & Calvert, T.W.,Using psychophysiological techniques to measure user experience with entertainment technologies, Behaviour & Information Technology, 2006, Vol. 25(2), pp. 141-158

[16] Mccarthy, J. & Wright, P., Technology as Experience, MIT Press, 2004

[17] Moen, J., From hand-held to body-worn: embodied experiences of the design and use of a wearable movement-based interaction concept. In TEI ’07: Proceedings of the 1st international conference on Tangible and embedded interaction.

[18] Partala, T., Surakka, V. & Vanhala, T., Person-independent estimation of emotional experiences from facial expressions, IUI '05.

[19] Picard, R.W., Affective Computing, The MIT Press, 1997

[20] Thought Technology Ltd. 2180 Belgrave Avenue, Montreal, Quebec, Canada H4A 2L8.