Evaluation and Analysis of Experience in Responsive Atmospheric Environments

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To investigate the atmospheric potential and the affective connection between humans and their instrumented, responsive environments, we have designed an abstract, cocoon-like, responsively mediated space. Our aim is to develop design strategies and to investigate the potential of responsive spaces from a critical perspective, beyond pure application and usefulness. We have evaluated our environment in a series of controlled experiments in a lab environment with a total of 17 participants. Results show that participants experience affection, a coupling between themselves and the designed environment, and show strong cognitive engagement to understand and structure the environment through patterns of situation awareness and sensemaking. In this contribution we give a perspective on the further methodological development we plan to apply in future studies.

Couplings between people and responsive spaces in closed feedback loops have the potential to create an immediacy that produces specific affective and cognitive effects on participants experiencing these spaces. In our designed environments we combine a responsive space with biofeedback technologies to immediately and affectively connect an artistic environment with a person being related to it. We consider both sides – the human and the technological system – equal actors (Latour 2005) that are connected and interplay in real-time in a human-in-the-loop system. The system's responses follow dynamic mappings to physiologic human reactions, manifested through light, sound and motion/wind. These responses are expressive and can cause new psycho-physiological reactions, that in turn change the appearance of the space, creating a human-machine interdependency.

We built a large environment of about 4 meters wide, 8 meters long and 5m high. It is composed of a single type of white, semi-transparent, non-woven textile with interesting texture and tactility, hanging loosely from the ceiling, shaping a cocoon-like isolated space resembling organic natural structures. The resulting homogeneous and abstract, yet responsively mediated space, removed participants from their familiar context. We decided to not implement any distractive features of affordance as they appeared to imply behaviors and tasks that appeared suggestive and obvious. This reduced design was intended to make participants attentive but also self-aware of their situation in the environment. We measure body movement, breathing and heart rate of the participants that are coupled to the appearance of the space to enable varying degrees of interactive control.

Evaluation

We have conducted a series of experiments with a total of 17 participants (9 male, 8 female, ages between 22 and 54 years). Before participants enter the installation setting, we briefly inform them of the procedure, without explaining technical details or the goal of the evaluation. We ask them to take off their shoes and to put on socks, which improves the sense of tactility and serves as a small "rite de passage". They put on the sensor chest belt with an elastic breathing sensor, a motion sensor and the wireless transponder. A photoplethysmograph, for measuring blood volume pulse (BVP), is attached to the index finger of the right hand.

We explained to participants that entering the room they are free to behave as it suits them, that there was nothing they had to achieve or that could go wrong and that they could leave the space at any point. The exposure lasted between 7 and 12 minutes and was video recorded. We also recorded the sensor data, synchronized with the video, allowing us to analyze the sensor measurements and the recorded behavior, together with the appearance and sound of the installation at a glance.

After exposure we conducted 15 minute semi-structured interviews asking participants to recount their experience. During the interview we encourage them to talk further about feelings and emotions connected to the experience. At a later point in the interview we would ask if they saw a connection between their actions, their body and the space, if they felt like they could interact, and asked them to describe relationships and correlations they recognized.

Results

Participants are affected by the environment and vice versa – in the sense that they change each other's behavior. This relation proved to be inherently bound to the question of power. As long as participants didn't realize that they were able to control the environment, they often felt uncomfortable and alienated. As soon as they discovered the options of influence, they began to feel at ease. The interviews produced insights concerning the transfer of control and emotion. Some participants identified their surroundings as a feedback system or as an encounter with something affective. One participant noticed: "the pulse I recognized a bit later, in the sound, that there is a feedback of the pulse that the light reacts to it." Another participant explained that the experience was: "calming and enjoyable because of the heartbeat; When I noticed that I could control it myself, I quite liked it. It was fun to play with it. It became more joyful, because oneself was in charge… then that frightening, abrupt, heteronomous part – there is something coming towards me and I have to react – changed into: I can control and influence the situation."

A number participants described their experience as ambivalent and therefore interesting. They would name specific media components (light, sound, air stream, tactility) that over the course of the experience they conceived as pleasing, frightening, boring or irritating. Changing associations were

Scene view 1

Scene view 2

also caused by the interplay of the media components and changed the participant's state of mind. It was a state that could switch very quickly from "very pleasant" to "rather uncomfortable", but exactly this made it interesting. "Concerning the light, it changed from friendly to hostile, concerning the movement of the noises, also from friendly to hostile, then dark-bright and smooth-hard, I found that interesting". The interplay with other media components caused varying associations. Participants interpreted the sound as sound of the sea, water, wind from the Antarctica, or similar. In two cases the relaxing sound of water changed into the noise of a highway. In one case the bright light source at the ceiling without an association was first considered a dazzling technical device. When the participant laid down on the floor and looked at it while the wind from the axial fan moved the textiles and the water noises came in, the lamp all of a sudden became a romantic star.

The transcribed interviews were further analyzed to retrace the temporal structure of the participants' behavior and experience. To extract chronological order, we used video and data recordings together with the statements from the interviews. From the chronological sequence patterns of activities across participants can be identified. Situation awareness (SA) formulates three stages that form a basis for planning and action in complex situations (Endsley 1995). The patterns exhibited by the participants distinctly match the three phases of situation awareness. We also observe a more complex, interwoven structure: McCarthy and Wright (2007) use sensemaking to describe experience as a continuous, active engagement with a designed environment. They identify six connected processes: Anticipating, Connecting, Interpreting, Reflecting, Appropriating, Recounting. Statements, themes and structures from our interviews clearly show that participants execute the six processes of sensemaking to understand and model the environment. The chronological order revealed a surprising amount of structure that was not apparent from the original interviews, revealing that participants invest significant cognitive effort when they encounter our responsive environment.

Methodology

In an unfamiliar, ostensibly sparse and reduced environment, in particular in a "taskless" situation, participants become very sensitive to signals from the surrounding situation. They are especially conscious of and react strongly to the sense of being observed, directly or through a camera. The immediacy and chronology of events and experiences appears

crucial for the analysis and understanding of experience and behavior in responsive environments. This is remarkably difficult (or otherwise impossible) to extract from interviews.

To evaluate the attitude and the reactions of participants as they explore and experience an environment, we can combine three complementary approaches: behavioral studies, inquiry and the use of psycho-physiological sensor measurements. A behavioral approach records and evaluates the observable behavior and actions of participants as they are inside of the environment. Behavioral studies use controlled observation and account in real time for participants' interactions (e.g. conveying attention through posture and view direction). However, they can be hard to interpret: observable measures and coded interpretations may be ambiguous and are often not specific to a single construct or cause. Behavioral studies may not provide much information on a person's motivations or their internal state. The process of direct observation or recording e.g. with cameras is often obtrusive and can thereby influence and substantially change a person's behavior and the experience in a setting.

While it is possible to infer participants' thoughts through a behavioral study, it can be more straightforward to record their impressions and opinions through inquiries from interviews and questionnaires. Unfortunately, inquiries are discrete and retrospective and are therefore not ideal for real time assessments. The "think aloud" protocol is a way to circumvent this, yet it influences participants through divided attention (Ogolla 2011). Resulting measures may reflect (social) pressure and are subject to participants' recall, in particular when answers are not oriented toward experimenters' expectations or if participants glean the goal of a study.

When people interact in an environment, measurable bodily reactions co-occur with mental changes. Psycho-physiological signals can be used in order to account for such body changes as a participant experiences an environment, in real time. Sensors need to be unobtrusive, reliable and robust against environmental conditions. Heart rate variability (HRV), respiratory volume and rate, together with the variation in skin conductance (SC, GSR) are indicators for changes in attention and arousal (Godin et al. 2015). The transition events in these signals can be correlated with events in the environment. These signals can also be directly interpreted and attributed to mental states: low HRV can indicate a state of relaxation, whereas an increased HRV can indicate a potential state

of mental stress or frustration. Fast and deep breathing often indicates excitement such as anger or fear but sometimes also joy. Rapid shallow breathing can indicate tense anticipation including panic, fear or concentration. Slow and deep breathing indicates a relaxed resting state while slow and shallow breathing can indicate states of withdrawal, passiveness like depression or calm happiness. Electrodermal activity (EDA/GSR) is a fast and relatively reliable indicator of stress as well as of other intense stimuli and also helps to differentiate between conflict/no conflict situations or between anger and fear.

Motion tracking sensors allow the detection of activity (Olivares et al. 2012), in particular of rest and active body motion, and even the recognition and classification of behavior (Zhu et al. 2014). Sensing body motion supports the calibration and interpretation of psycho-physiological measurements. The body worn sensors are inconspicuous and appear much less noticeable than the use of cameras for observing subject behavior. The application of inertial sensing (IMU) allows the tracking of subject behavior over a wide area, without the need for extensive preparation of the tracking environment. Motion sensors can, within certain limits, replace cameras or direct observation techniques, making body motion tracking a useful and much more acceptable technology for subject activity tracking over large areas, long durations and in sensitive or more private settings.

Current results show that there is a need to minimize intrusion and to capture experiences in real-time and over long durations. We propose to develop novel, hybrid forms of inquiry and analysis to improve the accuracy of the timeline representation of events and of associated experiences, and to increase the granularity of captured events – with the ability to register increasingly subtle changes of affect and experience. Our current aim is to capture rich data and combine this with improved sensor technologies, specifically using sensor measurements as a scaffold to improve relevant shortcomings of behavioral studies and inquiry.

References

Endsley, M. “Toward a theory of situation awareness in dynamic systems.” Hum. Factors J. Hum. Factors Ergon. Soc. 37(1), 1995, pp. 32–64.

Godin, C., Prost-Boucle, F., Campagne, A., Charbonnier, S., Bonnet, S., & Vidal, A. “Selection of the Most Relevant Physiological Features for Classifying Emotion.” Emotion, 40, 20, 2015.

Latour, B. Reassembling the Social: An Introduction to Actor-Network-Theory. Oxford University Press, New York, 2005.

McCarthy, J., Wright, P. Technology as Experience. MIT Press, Cambridge, 2007.

Ogolla, J. A. 2011. Usability evaluation: Tasks susceptible to concurrent think-aloud protocol. Master thesis, Linköping University.

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