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Extended Senses in Responsive Environments

An Artistic Research Project on Atmosphere

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Abstract. Mobile, networked, multi-sensory systems and technologies with open and modular interfaces are about to change our established concept of technical extensions for humans. It will not be on the level of prosthesis or implants that humans are connected with machines, but rather on the level of wearable sensors and intelligent environments, which make interfaces disappear and allow "unmediated" contact between the human user and the technological systems. Departing from a notion of holistic bodily experience and media developed in current phenomenological approaches [1-3], we want to examine the affective human perception in a mediated responsive environment. By this, we aim to explore the connecting area between the human body and a sensitive environment that feels like it connects to the body as a "second skin".

Keywords: Extended Human Senses, Embodied Interaction, Responsive / Sensitive Environment, Holistic Experience, Atmosphere, Affective Computing, Media Art, Artistic/Design Research, Adaptive Architecture.

1 The Modelling of Human and Non-Human Systems

The history of computer technology is accompanied and influenced by theoretical reflections on the relation between humans and machines, or – to put it more generally – between humans and their non-human environment. Most prominently, this relation has been reflected by a movement of interdisciplinary relevance: cybernetics. As Norbert Wiener underpinned in his foreword to the second edition of his groundbreaking book *Cybernetics or Control and Communication in the Animal and the Machine,* which first appeared in 1948, cybernetics has proven to be relevant for engineering, physiology, psychology and sociology alike [4, p. 9]. The core idea of cybernetics is an epistemological rather than an ontological one: Cybernetics, and derived from it, systems theory rely on the modelling of organisms as well as machines as autopoietic systems, which are characterized by operational closure. According to the sociologist Niklas Luhmann (who adapts cybernetics to societies), systems are inherently defined by their separation from the environment: Therefore, the initial process that gives birth to a system is the recognition of differences [5, p. 45]. This means that the existence of systems is not ontologically defined by certain never-changing characteristics (*substantia*), but rather by epistemological processes,

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which construct the system's "self" through acts of separation. Consequently, it is characterized primarily by its operations: "Cybernetics marks a shift away from the building blocks of phenomena (…) to the form of behaviors, what things do and how they are observed." [6, p. 3]

Thus, the epistemological model of cybernetics views the system as an inherently self-referential and operationally closed mechanism that aims at gaining and maintaining stability. This is mainly guaranteed by feedback processes, which adapt external influences to the system's condition.

From a technical point of view, feedback loops describe how information about the current or past state of a system can dynamically influence the system in the future. They consist of a feedback signal – a measurement of the level of a parameter of interest in a system – and a feedback mechanism – a means to control or influence this parameter. Feedback loops specify how information flows through a control system, typically in the form of block diagrams.

In control theory the reference or system set point is an external input to a control loop, with the corresponding system output as the controlled variable. A sensor detects the system output to produce a measured output value that is compared to the reference to determine the measured error. This difference between the reference and the measured output is "fed back" into the controller to generate a system input that produces a desired change in the system. A controlled system is assumed to be dynamic, and inherent changes that produce variations of the system output are described as load disturbances. An objective of control theory is to calculate solutions for the proper corrective action from the controller on the system that result in overall system stability, the ability to follow changes in the reference and the attenuation of dynamic load disturbances [7].

Important but often conflicting design goals for control systems are low complexity, small deviations and quick reaction to changes in the reference signal as well as robustness – the ability to maintain stability under a variety of conditions. Unreliable sensors, long delays, nonlinear system behaviour and volatile external inputs can make real systems difficult to control.

Common examples of the technical application of closed-loop feedback systems are to constrain engine rotation speed as a servomechanism, to control heating and cooling systems with the help of thermostats, and for the implementation of cruise control in automobiles. In biology, examples of feedback loops are found in processes maintaining homeostasis. Temperature regulation in endothermic animals, the regulation of the blood pH-level, as well as the maintenance of glucose levels and the control of carbon-dioxide concentration are controlled by feedback mechanisms. Certain imbalances, such as a high core temperature, a high concentration of salt or a low concentration of oxygen in the blood, produce "homeostatic emotions", such as the sensation of warmth, thirst, or breathlessness that motivate high-level behaviour to restore homeostasis.

This concept of the cybernetic control feedback loop has been enormously influential, not only for the (isomorphic) modelling of machines and organisms, but also for the question of how human and non-human systems interact. For Wiener, machines – like humans – are connected to their environment by data exchange and

interactive processes, which can be grasped statistically [4, p. 80]. Neither cybernetics nor systems theory have a notion of semantic communication. Instead, Luhmann adopts the concept of "structural coupling" to explain interactive processes between the social system and its environment – a quite complicated procedure of adaptation, the main aim of which is to guarantee the system's stability [5].

The dualistic division of system and environment elaborated by cybernetics and systems theory has recently been challenged by alternative concepts of the human-environment relation. In contrast to Niklas Luhmann's theory of self-referential social systems, theorists like Bruno Latour propose a different approach to the formation of societies: For Latour, it is the association (in its original sense of assembly) that stands for a concept of society based on flexible relations rather than on differentiations, which emphasize processes of exclusion. Latour aims to dissolve systems and concentrates on actors, that are defined mainly through their specific actions in certain constellations. Therefore, the focus is on their activity-based relations to other actors. While systems theory defines systems through processes within systems criteria, the ANT emphasizes agency beyond systems – agencies that constitute flexible networks, where actors change their roles according to the frame in which they act [8].[1]

The influence of cybernetics on our concepts of human-computer interfaces is not to be underestimated and manifests itself in our understanding of interactivity as the core notion of the human-machine relationship. Interactivity is mostly understood as the structure that allows two ontologically different types of systems to interact with each other. While cybernetics quantifies information and thus reduces it to a pure technical transmission problem, Luhmann's system theory has no detailed concept of interactivity between different systems. On the contrary, for Luhmann communication is implausible, because we can never know what the other (system) means [9, p. 78]. Of course, there is interactivity between systems, but *how* it works has never been the main interest – neither of cybernetics nor of systems theory.

In interactive media art the problem of human-machine communication has been approached from an experimental, partly playful perspective, which adds relevant insights to the outlined question of the human-machine and the human-environment interrelation: Generally spoken, interactive installation art mainly generates meaning by entering into a dialogue with a participating visitor and therefore produces a unique expression with each human-artwork encounter. "Meaning occurs through the process of exchange, and interactivity itself is the very medium of the work" [10, p. 147]. Of course, interactive art works differ from each other according to the applied types of interaction. In the context of interactive art works Heibach distinguishes initial interactivity (the user initiates a process, which she can then no longer influence) from reactive interactivity (the user reacts to impulses from the system) and creative interactivity, which means that the user is enabled to create an output that

[1] Although Clarke and Hansen see Latour in the tradition of cybernetics and label his theory as "neocybernetic" [6, p. 7] this seems to be too optimistic in terms of theoretical continuity: There is a decisive shift from systems to networks that is performed by ANT and which needs to be analyzed thoroughly in relation to cybernetics.

is only partly determined by the technological system or might even change it [11, pp. 71-74]. Creative or "mutual" [12] interactivity requires a more complex system that does not only react to human input, but learns, adapts and makes unpredictable proposals to the human. This seems to be a contradiction to the established function of the feedback loop: Normally, for interactive systems, the model of feedback loops is applied to the ability of users to control the behaviour of a system and to reach an interaction goal or objective. A user acts in an environment to provide an input to the system and measures the effect of her action by evaluating the output from the system, comparing the result with the objective. But in responsive environments the feedback loop might fundamentally change its character: The system becomes unpredictable, irreproducible and atmospherically inspiring because of the human-in-the-loop, but also because of the intelligent-machine-in-the-loop reversing the direction of control.

2 From Systems Theory to Atmospheric Experience

Interactive art installations do not only focus on interactivity as a specific form of human-machine interaction and – to use the terms of systems theory – the coupling of two different systems. Instead, they emphasize another perspective on the human-machine relationship, which lies beyond the concepts of cybernetics: the (anthropocentric) processes of multisensory perception and bodily experience. For now, the design of human-computer interaction in interactive art installations mainly focuses on the human-machine relationship and therefore on the problem of communication between different systems: Works like Luc Courchesne's *Portrait No. One* (1991)[2] or Daniela Alina Plewe's artificial intelligence installation *Ultima Ratio* (1998)[3] confront the user with seemingly intelligent machines that challenge her standardized communication habits, although they simulate human behaviour.

Furthermore, interactive art works reflect the changes that computer technologies cause in human perception and proprioception. Marshall McLuhan has pointed out the inherent oscillation between media and epistemological structures when linking the culture of the printing press to the implementation of linear, causal and analytical (in the sense of thinking in discrete elements and not in synthesizing relations) patterns of thinking [13], [14].

While McLuhan emphasizes the co-evolution between media and the social standards of perception, recently the focus on bodily experience has intensified considerably in media theory [2], [15], [16]. Terms like "embodiment" and "atmosphere" are introduced into the discussion, thereby adopting elements of phenomenological thinking. Philosophers like Maurice Merleau-Ponty [17] and the contemporary German founder of "New Phenomenology", Herman Schmitz, develop a holistic notion of bodily experience, which lies beyond rationality and conscience. This approach neglects not only the traditional difference between body and mind, but

[2] `http://www.fondation-langlois.org/html/e/page.php?NumPage=157` (last accessed on 06.02.2014)

[3] See the documentation on http://www.sabonjo.de/ (last accessed on 06.02.2014).

also between human bodily experience and environment. Hermann Schmitz introduces a detailed description of processes that he calls "bodily communication" which rely on a continuous exchange of the human somatic apparatus with the environment [18], [19]. This concept is inherently linked to a phenomenon which has long been excluded from scientific approaches: atmosphere. For Schmitz and some other philosophers [20-22], bodily affection and atmosphere are inherently bound together, because atmospheres are sensed in a primordial, multisensory and pre-conscious process, which precedes any kind of reflection. According to Schmitz, atmospheres are feelings that are not bound to a subject, but are perceivable within a spatial area, be it a room, an apartment, a public building etc. Consequently, Schmitz concentrates on the process of sensing atmospheres, which he describes as a primordial synaesthetic process that involves the whole body and the mind and cannot be distinguished according to our traditional division of the sense organs. He speaks of "affective involvement" ("affektive Betroffenheit", [18, p. 94]), which is situated between physical instinctive re/action and pre- and subconscious feelings. Media theorists, like the Canadian philosopher Brian Massumi, pick up such concepts of unspecific feeling and classify the latter as "pure experience" that precedes any kind of mediated perception [23].

It is an interesting development that in current media-philosophical reflections these concepts of primordial, "unmediated" experiences are linked to recent developments in computer technology. This tendency seems to be another expression of the desire to transcend dualistic thinking and epistemological models that emphasize analytic differences instead of synthetic relations. New technological devices support the latter approach: "With the advent of cyberware and cyber-implants, virtual reality simulators, and mirror boxes (…) our capacity to distinguish the mental from the physical, and our perception of the real from our perception of the illusory or virtual has been made increasingly problematic." [24, p. 255] This diagnosis can also be transferred from the ontological to the epistemological level: bodily experience inherently transcends the subject-object differentiation and probably also the system-environment or even the system-system differentiation.

Nevertheless the question remains, in which way such dense and diffuse processes like "sensing" something (e.g. atmosphere) work. Without re-establishing the subject-object differentiation (or – to put it in the terms of systems theory – subject-environment differentiation) there seems to be a never-ending feedback loop between the sensing human and the space in which she experiences herself and her surrounding. This non-dualistic perspective also has a decisive impact on art and design, as the dualism of the real world and virtual reality is increasingly abandoned in favour of "a fluid interpretation of realms" [16, p. 2], supported by recent technological developments: With the miniaturization and the decline in prices of sensors and actuators, and the open source development of popular physical computing platforms, such as Arduino or Raspberry Pi, networked sensor-actor systems, that until recently were confined to development in technical institutions, can now be used for new forms of installations that turn away from the simulation on the screen and begin to experiment with interaction and experience in physical space. This development brings new dynamics into the phenomenological concept of bodily experience and the related discussion on atmosphere: Primordial sensing and atmospheric spaces seem to be the paradigm for media art that works with these new interface technologies.

3 Atmospheric Interactive Art – Some Examples

Within the philosophy of atmosphere developed by the above-mentioned thinkers, the question of media is mostly neglected. Experiencing atmospheres is a process that is inherently bound to physical presence and to an immediate exchange between the subject and her environment (which, of course, can be a complex combination of spatial arrangement, social interaction and further elements, like e.g. weather, light and temperature conditions). The impact of animated physical presence is also intriguing for interactive arts, since it breathes life into a technical installation and gives it the opportunity to leave the *black box,* which is needed for audiovisual presentations, to enter the *white cube* or even public space and everyday life. Artistic, physically responsive spaces can be set up in different contexts.

If we look for examples of interactive art that sense spatial user behaviour, we find inspiring works like *One Hundred and Eight*[4] by Nils Völker or *Rain Room*[5] developed by Random International. Both use poetically staged physical displays to represent the responsiveness of the environment, the first with the help of pixel-like arranged in- and deflatable plastic bags on a wall, the second with an immersive rainfall climate fake. They are presented in interior exhibition spaces. In contrast, *Dune*[6] by Studio Roosegaarde is an outdoor installation, though with a similar approach regarding interaction. *Dune* invites visitors to a walk of light in the black of the night in a hybrid of nature and technology at the border of the Maas River in Rotterdam. Large amounts of fibres react to the sounds and motions of passersby or flâneurs. Another example regarding the diverse applicability of interactive art concepts is the "pulse" series of Raphael Lonzano-Hemmer, in which he employs heart rate biofeedback signals for human-machine interaction. He stages the individual heartbeat of exhibition visitors with the help of the reactive hanging light bulb sculpture *Pulse Spiral* and in the form of water reflections with the installation *Pulse Tank*. *Pulse Park*[7] is the visualization of heart rates with light beams, adapted to the outdoor space in nocturnal Madison Square Park in New York.

The step from poetic expression in an interactive artwork – as briefly described with reference to *Pulse Park* and *Dune* – to an applied setting of urban planning research that focuses on energy efficiency for the illumination of a town square, is small. The Department of Architecture, Design, and Media Technology at Aalborg University Denmark carried out a full-scale research experiment to investigate the possibility of controlling urban lighting by human motion patterns [25]. Monitoring passersby's activities on a square with thermal cameras made it possible to test different lighting concepts and to examine the public's reactions to them.

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[4] `http://www.nilsvoelker.com/content/onehundredandeight/` (last accessed 06.02.2014).

[5] `http://random-international.com/work/rainroom/` (last accessed 06.02.2014).

[6] `http://www.studioroosegaarde.net/project/dune-4-2/` (last accessed 06.02.2014).

[7] `http://www.lozano-hemmer.com/projects.php` (last accessed 06.02.2014).

Furthermore, the technical accomplishments in the context of sensor-actor systems have also given the concepts of ubiquitous computing [26] and "The Internet of Things" [27] a new boost. The well-known example of the intelligent refrigerator that autonomously manages its contents and proposes menus according to the health condition of the users still serves as an example of ubiquitous computing. Accordingly, most publications in the field of architecture and ubiquitous computing still refer to building performance: comfort and energy efficiency, optimized services in buildings and urban infrastructures as well as production workflow efficiency. What seems to have been neglected so far is the human psychophysical experience within the respective space, which can only be achieved by taking into consideration her perceptual perspective. More recently established terms like adaptive architecture or responsive environment stand for an emerging field of practice and research in architecture with the aim of creating buildings that are intelligent and reconfigurable according to environmental conditions and the behavioural patterns of the residents in question. Publications like the *Situated Technologies Pamphlet Series*[8] explore the implications of ubiquitous computing for architecture and urban planning with a more human experience-centred approach. Pamphlet 4: *Responsive Architecture/Performing Instruments* by Philip Beesley and Omar Khan [28] proposes to develop "more mutually enriching relationships between people, the space they inhabit, and the environment" and discuss "key qualities of responsive architecture as a performing instrument that is both mutable and contestable." [28,] With his immersive, interactive installation *Hylozoic Ground*, Beesley creates an environment that moves and breathes around its viewers, creating an environment that can feel and care [see 28, p. 27]. He expects next-generation artificial intelligence, synthetic biology, and interactive technology to create an environment that is alive in almost every sense of the word.

4 Research Questions

The discussion on unmediated, primordial experience in media philosophy, which has a strong relation to interactive art, emphasizes the complexity of the human-environment and of course also the human-machine relationship: In contrast to the cybernetic view, the dualistic separation of system and environment is transcended in atmospheric thinking, as the subject is part of atmosphere (and also creates it) and, vice versa, the atmosphere influences the subjects in their perception, affection and, of course, also in their strategies of agency. Considering an environment of responsive technologies, which reacts to the user's feelings and actions, we suddenly face the problem that a feedback-driven technological system creates an atmosphere of immediate experience. Two very different epistemological concepts seem to meet here. With technologies of ubiquitous computing, the existing environment, which is normally controlled by the user, is 'computerized' [29, p. 77 ff.]: everyday objects become "intelligent" and gain the ability to interact with the user. The passive object becomes active, which also means that new forms of interactivity and new ranges of

[8] `http://www.situatedtechnologies.net` (last accessed 06.02.2014).

agencies emerge. While in "traditional" interactive art the user is involved in an existing feedback loop and is allowed to interact with the system in specific ways, ubiquitous computing concentrates on the needs of the user and tries to make her feel comfortable. The aim is to make the media and the mediated experience disappear: The user should have no experience of irritation and alienation.

This leads to the core idea of our artistic research project: Can a mediated physical entourage be perceived as an extended part of oneself, as an extended skin, if the parameters of design are dynamically connected and adaptable to the perception and affective response of the human? The approach is not focused on usability matters in the classic human-machine interaction context, but on the examination of the space between the self and a responsive entourage. Of course, this approach can also be critically reversed, when the environment causes irritations through a "misfunctioning" or through the development of a manipulative "behaviour".

This twofold perspective corresponds to the concepts of negative and positive feedback: In the technical definition, positive feedback increases the gain along a control loop, while negative feedback reduces it. Negative feedback tends to make a system self-regulating, it can produce stability and reduce the effect of fluctuations. Positive feedback is a process in which the effects of a small disturbance on a system produce an increase in the magnitude of the perturbation. In this situation, the feedback is in phase with the input, making an input larger. A key feature of positive feedback is that it works as an amplifier, making small differences of disturbances get bigger, thereby typically triggering a system to accelerate towards extreme output values and catastrophic system states. Positive feedback tends to cause system instability and is therefore usually avoided in technical systems.

This main research question of examining processes concerning technical adaptation (in the sense of a "second-skin-effect") and alienation (in the sense of perturbations coming from the responsive environment) needs to be subdivided into concrete research questions. We will examine the topic with a modular feedback system consisting of three component groups: sensor inputs, data processing and parametric mapping, and output media. The underlying research questions will not be examined in depth, but are expected to provide insights for the assignment of the components within the artificial setting. There will be questions that are more closely related to the anthropocentric perspective of proprioception and atmospheric sensing, and others that are more bound to technological conditions, but both perspectives will be treated as complementary. Thus, initial and rather basic questions regarding the use of biofeedback sensors already point to the creation of a specific atmosphere and the way the user may feel: What sensor data can represent which human affects? What are the characteristics of the different sensor inputs: stability, number of extractable parameters, interval, long-term progression, etc.? Which combinations of sensor data can proportion synergies or improve the notion of environmental responsiveness? How can the sensors be staged in the setting and attached to the human being?

Secondly, there is the question of agency and interaction emerging from processing and mapping, which makes it necessary to consider the following aspects: To which extend should the media response be causally linked to the human affect in order to be recognizable? Do the participants recognize long-term changes? How do the

participants interpret their interaction with the reactive entourage? How many sensor input/media output channels can be combined or synchronized to create a richer experience without creating the impression of random noise? How artificially intelligent should the system be to create mutual interaction and to generate unforeseeable input, similar to human input?

Thirdly output media selection and parameters are closely related to the generation of an emotionally immersive, responsive environment: What media types or combinations of media are appropriate, and how multi-layered and complex can the dramaturgy be in order to create a strong immersive impact?

These examinations are expected to lead to a rich artistically staged research setting providing insights into atmospheric design conditions and paving the way for critical questions regarding the interrelation of pervasive technologies and human bodily experience: What are the potential applications of the examined topic, and which possibly negative social implications are to be expected? Is it possible to draw a clear line between the prosperous, functionally and culturally extended human and one that is controlled and manipulated by the media? Does the amalgamation of the self and the environment have negative impacts on human identity?

5 Artistic Experimental Setting

In order to be able to investigate all these aspects we intend to create an artistic research setting for experiments with participants and for their evaluation. Instead of analyzing the approach and impact of existing art works, which might reveal valuable findings regarding the perception of atmosphere, we intend to build a modular networked laboratory of media and measuring components, adaptable to the methodological examinations of the proposed research questions. The Institute for Research in Art and Design HGK FHNW is equipped with a new media lab, with sufficient space for a generous research installation. In order to gain insights regarding the perception of atmosphere we will make heuristic presumptions and selections based on artistic experience. The objective of this artistic setting is to create an emotionally immersive environment; artistic authorship of a final composition is not the goal. The installation will therefore not be based on a predefining artistic script, but on conclusions gained from a series of small-scale empirical experiments on affective reactions to staged stimuli.

The setting is artistic in the sense that it does not aim to have an applicable outcome as expected in a design or architectural context. Another reason why it can be considered as artistic is that despite being inspired by research fields like perceptual psychology, neurosciences, phenomenology, media theory, human-computer-interaction, artificial intelligence and others, it is not based on scientifically documented test assemblies.

To investigate human perception on dramaturgically composed atmosphere and the resulting experience we will develop a biofeedback-actor-network laboratory. The measurement of psycho-physiological response, such as heart rate, breathing, body temperature, or skin conductance allow the real-time recording of the affective

reaction of a human subject to sensory experience generated by changes in the artistically staged environment. The environment is spatiotemporally composed of different media implementations, such as light and colour, sound, temperature, airflow and vibration, and it allows the involved participant to touch different materials, choose positions in space or to alter shapes. Since the parameters of these media implementations are connected to the processed biofeedback data of the participant, they close a (positive or negative) bidirectional feedback loops between the human and her environment: the human controls or is controlled by the surrounding system.

By isolating the participants from their routine context and audiovisual sensations the predominance of seeing (and hearing) will be equalized to other intero- and exteroceptive senses. The environment will be artistically abstract to reduce intellectual contemplation. It is not only expected to be a direct extension and representation of the subject's affect, but also a poetically stimulating and surprising part of the self. It will be immersive and beyond human scale to strengthen the spatial aspect. Movements should be smooth and non-mechanic, which is why pneumatics (e.g. inflation and deflation) will be one of the starting points.

6 Evaluation Programme and Methods

We will accomplish the evaluation with different participants that were not involved in the development process of the setting, but will be introduced to the basic research questions of the project to focus their attention. This can be achieved by means of a text, a conversation, a demo or even a short walk-through of the system. All participants will follow a sequence of comparable presets**,** which are timed and triggered by the system, the operators or by the participants themselves. In order to find a calibrating baseline the initial preset will work with random processing and consist of a noisy environmental output, followed by a series of presets with increasing in- and output complexity. To examine the border between the controlling and the system-controlled human, some settings will react to the feedback input and adapt the environment to the participants psycho-physiological input, and others will work the other way round, subtly compelling the human to attune herself to the system.

The evaluation will be based on a combination of various established approaches from usability evaluation and methods of qualitative ethnographic research. During some sequences the participants will be accompanied and invited to describe their experiences during the process (think-aloud protocols), during other sequences they will communicate with the system on their own. The setting will allow permanent field observation and the recording of biofeedback and audiovisual data. In some sequences the test persons might be given little tasks to complete, and after the evaluation a short (narrative) interview will be made and recorded, looking back and reflecting on the experience, either based on immediate memories or with the help of recorded audiovisual documents (retrospective testing). In the course of the project it might become necessary to apply additional methods or to modify the existing ones in a way that cannot yet be foreseen. Generally we aim to establish a fruitful

combination of qualitative and quantitative data to combine the analysis *and* interpretation of the technological applications and the anthropocentric perspective of bodily experience.

7 Outlook

The objective of our artistic research project is to build bridges between different perspectives: On the theoretical level it aims to bring together the different approaches to models of the human-machine/human-environment relationship represented by cybernetics and systems theory on the one hand, and by phenomenological approaches to bodily experience and atmosphere on the other. While cybernetics and systems theory ignore the individual cognitive system, phenomenological approaches do not consider factors of social and medial preformation and cultural standardization. In our opinion, these two perspectives are far more likely to be complementary than contradictory, which might point to concepts of networks, as formulated in theories of ecology. Therefore, our artistic experimental setting departs from and critically extends the classic human-machine-paradigm and the model of the interactive feedback loop. But in building a responsive environment and applying biofeedback technologies, the feedback loop becomes much more complex, because it loses its main purpose of control and moves towards surprising, unpredictable reactions, triggered by the technological system and the human being alike. The core question from the phenomenological perspective will be, whether and in which way such technologies change the user's perception of the self in relation to the environment (epistemological level), as well as her exchange with the environment (level of agency). From a technological point of view it will be of interest, how the medial settings are able to generate certain atmospheres and how the biofeedback data influence the responsiveness of the environment. This finally leads us to the meta-level of cultural critique and the relation between responsiveness and manipulation.

The interdisciplinary approach of this project involves a combination of methods – both qualitative and quantitative– that challenge the scientific tradition. In addition, the abstract but nevertheless immersive environment created by the artistic setting will open new perspectives and provide valuable insights. This combination of different approaches and new perspectives – so we believe – can be regarded as an essential characteristic of "artistic research".

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