Exploring Physiology-Based Interactions in Performing Arts Using Artistic Interventions

Taavet Jansen, Aleksander Väljamäe

Abstract: Technological innovations like physiological computing offer new possibilities when exploring audience-performer interaction. To avoid technological solutionism that often accompanies biosensor applications in performing arts, an artistic interventions approach was used. This paper describes a recent art-science residency consisting of three artistic experiments: the audience's electrodermal, activity-driven soundscape in a dance improvisation, a "lie detector" applied to the actor just after the performance, and a heart-rate-driven personal discotheque installation. Both artist and scientist provide reflections on future development of this transdisciplinary field from the performing arts perspective.

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Introduction

Contemporary interactive theatre heavily relies on technological innovations, and its content is often generated on the fly. However, new technologies such as wearables that sense viewers' physiological reactions or stream online theatre are far less frequent. During an art-science residency at Tallinn University in 2019, the performing artist Taavet Jansen experimented with physiological computing concepts and technologies in relation to new ways of audience participation. The art-science collaboration residency took place over six months in Tallinn, Estonia where Mr. Jansen and Human-Computer-Interaction (HCI) scientist and art-science practitioner Dr. Aleksander Väljamäe worked together to explore the potential of physiological computing technologies in performing arts settings. This article uses a mixed methods writing approach (Zhou and Hall 2018, 1) in which the artist's and the art-science practitioner's first-person autoethnographic reflections (marked in italics) provide personal insights into the working process. The overall scientific discourse, however, is given in a traditional, non-personalised text. This mixed writing method allows one to highlight individual narratives within the context of the art-science collaboration and more fully represent its multifaceted nature. A detailed account of the transdisciplinary collaboration process and the time structure of the residency is detailed by Hanna-Liisa Pender and Taavet Jansen (2020).

The artist: *I am interested in people on stage in front of other people. It bugs me that I don't know what happens 'inside' of them. I realise we don't understand what the other person thinks or feels, but we can get small indications of these processes. If we can measure these and smartly visualise this data, it could become an instrument to measure the artistic project's success or become a part of the artwork itself. But what kind of data could we extract from people in this wild, uncontrolled environment? In this art-science residency, I had a chance to study the audience's reactions, analysing their electrodermal activity and heart rates. I was looking for the artistic stimuli triggering the reactions and for new ways to meaningfully visualise this data.*

The residency's art-science collaboration can be best described by the practice-based research model of Ernest Edmonds and Linda Candy (2010, 471), which distinguishes different trajectories between three main elements of practice (art works), theory (design strategies and frameworks), and evaluation (results). The residency's methodological approach was closest to "artistic intervention in research" as described by Baptiste Caramiaux and Marco Donnarumma (2020, 2). In this approach, the artistic process acts upon specific scientific frameworks and HCI design strategies. This allowed us to explore different artistic concepts during the residency without relying on a specific research topic. Instead, every artistic experiment focused on different ways of using the physiological computing technology. From the HCI perspective, artistic intervention helps to address a problem (or study a phenomenon) in radically new ways (Benford et al. 2012). Also, artistic intervention helps to avoid the problem of technological solutionism (Caramiaux and Donnarumma 2020, 5). Technological solutionism refers to the technological push and "solution-driven design" (Blythe et al. 2016, 4968) where social or cultural contexts are often ignored. A critical artistic intervention can question the role of technology and its meaning-making capacities, forcing artists and researchers to face the inner beliefs that ultimately motivated their choices (Caramiaux and Donnarumma 2020, 5).

The scientist: *Since 2008, I have been involved in the art-science productions that have been triggered by researchers, e.g., the Multimodal Brain Orchestra performance in 2009 in Prague (Le Groux et al. 2010) or the mixed-reality interactive installation 'The Synthetic Oracle' presented at the European Science Open Forum (ESOF'08 in Barcelona (i Badia et al. 2009)). One of the common shortcomings in these productions was a strong technological push where the possibilities of new technologies were demonstrated to the public, but the artistic concept was weak or not situated in a wider social context. Over the years, this convinced me that true art-science productions should start not from the technology side but from the artistic concept or artistic enquiry.*

In physiological computing, human-computer interaction relies on measuring human physiological signals, such as brain or heart activity, and then adapting the system to these signals, usually in real-time (see Fairclough 2009 and references therein). Changes in physiology reflect the cognitive, perceptual, and emotional processes of the user interacting with a digital system. Importantly, such physiology-based interaction can be both explicit, in that the user is aware of his or her control, or, more importantly, implicit, where interactions between human and computer happen on subconscious and symbiotic levels (Kosunen and Väljamäe 2020). Physiological-computing technologies that focus on the monitoring of a user's affective states are referred to as affective computing (Picard 2000). In recent years, the research on affective processes has demonstrated its importance for understanding and predicting how people think and behave, giving rise to "the era of affectivism" (Dukes et al. 2021). Therefore, it is not surprising that affective computing technologies are becoming increasingly widespread in all domains of human life, including theatre and performing arts at large.

At the beginning of the residency, the fields of physiological and affective computing were new to the artist, generating several artistic questions regarding both hardware and software tools in terms of their simplicity, reliability, and, finally, their added value in the performing art context. Embracing the scientific agenda, the leading research question for both the artist and scientist became: "How can physiological computing tools extend and deepen the performing artist's practice beyond simple technological augmentation?" Three distinct artistic experiments focused on different aspects of using physiological computing tools in the performing arts context. The first experiment explored what sensory feedback can be given to the audience about the emotional arousal state of selected members and how this can complement the performance experience. The first experiment explored what sensory feedback can be given to the audience about the emotional arousal state of selected members and how this can complement the performance experience. The second experiment tapped into the actor's own emotional experiences immediately after the performance. The third experiment focused on how to create an interactive audio-visual space that adapts to the individual visitor's heart rate.

> The artist: *People don't understand the advantages that technology use can bring to art. People tend to integrate technology into an artistic event so that the performance would be more attractive, but technology could be used more delicately – using human micro-movements, physiological reactions, and brain processes. In other words, the use of technology can now give a voice to our organism that others can hear.*

The scientist: *In my art-science practice, I am interested in how to shape viewers' or users' experiences over time, their 'affective waveform', its dynamics. I find the physiology-based interaction fascinating since it allows the artistic content to adapt to the individual or collective reactions, therefore maximising the potential emotional impact of a cinema or theatre piece. Bringing various sensors into the performing art context also allow us to unite the audience, the performers, and the stage into a complex, interconnected, bio-cybernetic system that may bring to life new experiences and new forms of art.*

This paper is organised as follows: Sections 2 to 4 describe each of the three artistic experiments, detailing their artistic, technical, and scientific aspects, followed by key observations. Section 5 provides a more general summary of the lessons learned from the residency. And, finally, Section 6 contains the general discussion and concluding remarks.

2. Artistic experiment 1: *Neurochoreography experiment nr. 4*

2.1. Physiology, theatre, and audience engagement

Wearable technologies and biomedical sensors are not an exception and are becoming increasingly integrated into the theatre domain (for a recent review, see Rostami et al. 2017). Particular attention has been given to the audience's cognitive and emotional reactions, which represent a dynamic "waveform" of unfolding theatrical experience. These can be detected using both behavioural, such as viewers' facial expressions or their movements (Theodorou et al. 2019), or physiological data (Latulipe et al. 2011; Vicary et al. 2017). Ideally, physiological computing technologies should allow, even in real time, redesigning of the structure or the content of the performance to have artistic impact on the audience, e.g., emotional impact and engagement or a new understanding of the theatre piece, as well as to open up new artistic possibilities.

2.2. The initial artistic idea

The first artistic experiment was a contemporary dance performance *Neurochoreography experiment nr. 4*. It stemmed from the previous neurotheatre works of Väljamäe and his colleagues in collaboration with the dance collective FINE5, where the audience's physiological reactions were an integral part of the show either as visualisations (*Demultiplexia*[1], 2017; Väljamäe 2017) or sonifications (*Trisolde*[2], 2019).

1 *Demultiplexia* (2017), directed by Yury Didevich and Aleksander Väljamäe. Bozar, Brussels.

2 *Trisolde* (2019), directed by Rene Nõmmik. Sakala 3 Teatrimaja, Tallinn.

Neurotheatre is an emerging type of interactive theatre, in which the audience – spectActors – and actors can communicate via brain-neural computer interaction using motion and physiological sensors and multisensory actuators, including touch, sound, and visuals (Väljamäe and Didevich, in preparation). The primary interest in this experiment was to convert the audience's immediate affective reactions into a meaningful soundscape even if such sensory feedback would be very simple aesthetically. Sonification, or, in a more general terminology, the perceptualisation of data, is the process of converting a data stream into sound or another perceptual modality (Jovanov et al. 1999). One of the key issues in the sonification of physiological signals is finding the right strategy of feedback to strike a balance between aesthetic quality and public perception of the feedback (Väljamäe et al. 2013).

> The artist: *Sound design is an organic part of every mise-en-scène. From the music design to the organic sounds of the space – all sounds are artistic decisions. I am interested in how to use the implicit processes of the spectators in sound design. The majority of people don't know how the sensor technologies work, and, therefore, too complicated of a relationship between the sensor's data and the sound can confuse the spectator. I was curious about what could be the most straightforward data mapping. I decided that the audience's reaction should modulate the volume of the sound design so that everybody could understand the relationship.*

2.3. The performance

The performance took place on a 6m x 6m black box type of stage where both performers (Liis Vares and Liisbet Horn) were on stage for the entire time. The performance lasted precisely 20 minutes. When the audience entered the space, the performers were already performing a "warm-up" sequence. The performance began with the performers leaving the stage and coming back with intensive movement. Both performers were tasked with taking choreographic impulses from each other, accounting for the overall intensity, and not consciously reacting to the sound. Dramaturgically, they had a mission to meet three times during the performance and restart their improvisation with a new theme. Henri Hütt's track "taeva altaril" was used for the soundtrack, which was manipulated by the artist.

To monitor the audience's emotional response, four electrodermal activity (EDA) sensors were used. EDA is a common biometric signal that measures conductivity from sweat on the skin that is secreted in response to autonomic nervous system arousal (Andreassi 2010). So, the arousal of four members of the audience was registered when they saw something exciting on stage. A simple sonification approach was used, which reflected arousal changes via the loudness modulation of the accompanying soundtrack. The performance was designed in such a way that the dancers avoided any interaction with the sound (the audiences' response) because the goal was to create the condition for the sound design and the dancers to be observed separately. In terms of the performance "space," separating the dancers and the soundtrack created an additional tension between the visual and auditory "spaces."

Figure 1. Left panel: two dancers in physical interaction. Right panel: two dancers performing a movement sequence separately. The video of the full performance is available online: https://youtu.be/JuqL79vdOLY.

2.4. Observations

The dancers (Liis Vares and Liisbet Horn) shared several observations after the performance. First, they claimed that it was not difficult to ignore the soundtrack since they both concentrated on the dance improvisation. However, long pauses or rapid changes were noticeable, and a lack of a single sound source (a sonification of a single user affective state) created a feeling of randomness. In other words, the composite feedback from four different people was more difficult to "associate" with. Second, it was not more complicated than a usual dance improvisation, but the presence of the audience added a new layer: "[. . .] we were moving through it together, no place to hide." The "active" presence of the audience felt as if the control over the choreography became distributed between the dancers and the audience. Both dancers agreed that having a software tool that allowed them to revisit both the video and the underlying affective reactions of the audience would be very interesting for similar future work. A member from the audience noted that the most intriguing element for them was following the physiological data mapping and witnessing the discrepancies between what was happening on the stage and its effects on the music level. There was a very intense moment when the two dancers were touching each other, but the sound went completely silent, creating an additional level of tension. The full analysis of the performance will be provided by Jansen and Väljamäe (in preparation).

The artist: *I mostly see the artistic potential in neurochoreography – sensor technologies making visible what is currently invisible – the internal processes of the performer and the audience are expressed in numerical values. It is not clear at all what these numbers represent, but I see the potential of these technologies for finetuning the audience to a state where they are the most responsive to my artistic challenge. These numbers represent something – we just have to figure out how to use them*.

The scientist: *This experiment revealed the great importance of a 'performance space' dimension when choosing the right sonification strategy. It was clear that the artistic setting, the atmosphere, the pretext, and the dramaturgy, influenced the audience's perception of a rather simple, if not primitive, sonification based on the music loudness modulation. While the initial mapping between the viewers' reaction and the sound was very clear, the moments of mismatch between the tension on the stage and the sound intensity added a completely new layer to the performance. Viewers were trying to follow 'the logic' of the mapping and this added to the overall tension created by the performance.*

3. Artistic experiment 2: *The "Interrogation" of Macbeth*

3.1. Acting and the use of physiological sensors

An actor's profession is tightly linked to emotional dynamics and self-control of underlying physiological processes. Many studies show that strong emotional experiences that actors live out during a scene can lead to emotional burnout (Robb et al. 2018). While the debate about whether actors experience true emotions on stage can be traced back to the 18th century's "Paradox of the Actor" by Diderot (Beck 2000, 264), there are various acting training methods stemming from Stanislavsky's early ideas about "psychophysiological authenticity" and his interest in yoga practice in the 1910s (Tcherkasski 2012, 10). For example, in the Alba Emoting method (Bloch et al. 1987; Bloch 1993), actors train triadic, respiratory-postural-facial patterns to create and control real emotions. Another important training technique for actors is the use of emotional imagery (Gollnisch et al. 1993), which sometimes evokes stronger physiological reactions than real life events. Antonin Artaud compared the process of actor training to sports, calling it "affective athleticism" (Gardner 2003; Artaud 2018).

The scientist: *During my research stay in Saint Petersburg in 2013–2014, I learned about extensive experiments that the Institute of the Human Brain at the Russian Academy of Sciences conducted together with the State Academy of Theatre for a number of years in the joint neurophysiology lab led by the theatre director, Larisa Gracheva (Gracheva 2019). This interdisciplinary research extensively studied topics like non-verbal creativity and actors' psychophysiological dynamics. Conversations with Larisa sparked my interest in actors' physiology training and qualitative assessment of their emotional experience. Interestingly, the field still is very conservative when talking about the adoption of new physiological computing tools and mainly relies on exercises that do not involve sensor technologies.*

3.2. The initial artistic idea

The second artistic experiment was done in collaboration with actors from the Tallinn City Theatre and involved ideas using lie detection techniques based on recorded electrodermal activity.

> The artist: *The initial idea came from the Estonian actor Tambet Tuisk – he was interested in acting while connected to a "lie detector." He was intrigued about whether he could lie without the lie detector identifying it using his skills of acting. The proposal was interesting for me for two reasons: a) figuring out how to build a technologically reliable equivalent to a lie detector, b) exploring the artistic potential of the situation where the actor's skills can be actually measured.*

Originally, the idea was to use sensor technology while the actor was on stage (a performance of *Macbeth* by the Tallinn City Theatre[3]). The visualisation of biological signals, or their processed output, to the audience would, in theory, allow viewers to believe the emotional authenticity of his acting. Even if the sensor did not work, this would still give room for the alternative interpretation that the actor was so good that he deceived the technology. However, due to time, organisational, and budget constraints, we decided not to interfere with the ongoing performance, since the introduction of sensor technology would break the scenography of the performance and creating a new performance was not an option. As an alternative, it was decided to "interrogate" the actor after the performance in front of the audience from the main show.

3.3. Technical realisation

A lie detector or a polygraph infers deception through the analysis of physiological reactions to a structured series of questions. This technique has become a popular cultural icon even though its effectiveness in detecting deception has been questioned (American Psychological Association 2004). While there are no specific physiological correlates of deception, the anxiety associated with a sensation of guilt can be picked up by peripheral physiology sensors. The typical polygraph instrument simultaneously measures several physiological indexes, such as blood pressure, pulse, respiratory patterns, and the electrodermal response, which are not under the direct voluntary control of the test subject (Steinbrook 1992, 122). A customised BITalino R-IoT microcontroller board with an EDA sensor was used to record physiological signals from the actor's left and right palms. While such a simplified version of a polygraph was not enough to detect deception, it still allowed us

3 *Macbeth* (2017) by William Shakespeare, directed by Antti Mikkola. Tallinn City Theatre Põrgulava, Tallinn.

to see the peripheral arousal reactions of the actor. The final experiment setup included a prepared "interrogation" just after the performance (*Macbeth,* but without the audience to avoid putting additional pressure on the actor (Mr. Alo Kõrve, who plays the role of Macbeth)). The interview questions were created together with Steven Hristo Evestus – a professional prosecutor – and were based on the actor's decisions on stage. The main research question was whether the actor was aware of the artistic decisions he made on stage and how much these affect his real life and work. The professional maturity of the actor and the complex role allowed for in-depth questions about how and why he made artistic decisions (e.g., "Were your stage partners today as focused as you were?", "Were you mentally exhausted?", "Were you satisfied with your work tonight?"). The "interrogation" took place on 25 May 2019 and took about 30 minutes, with recorded physiology and videos.

Figure 2. Snapshots from the *Macbeth* experiment process. Left panel: the prosecutor S. H. Evestus. Centre panel: the setup at the Tallinn City Theatre. Right panel: the actor Alo Kõrve connected to electrodermal activity sensors.

3.4. Observations

The media took great interest in this artistic experiment because the people in the team – Tambet Tuisk, Steven-Hristo Evestus, and Alo Kõrve – are well-known in Estonia. The lie detector topic and the use of sensors greatly contributed to this interest. The process of setting up the experiment at the theatre went very smoothly, and the idea of a specific show after the main performance attracted attention from both the administration and the creative team of the theatre. The main participants, Evestus and Kõrve, found strong artistic potential in this format for development into a post-performance event. However, such an event's dramaturgy had to be carefully developed with the actor since it was an intimate experience that goes beyond the play's character and tapped into the actor's real life. The experiment also showed that the peripheral physiological responses alone were not enough to decipher the decision-making process happening on stage or the subjective feelings experienced by the actor. Perhaps a wearable EEG (Electroencephalography) or fNIRS (functional Near-Infrared Spectroscopy) device recording the actor's brain activity during the performance could complement this approach (see, for example, a recent brain-driven camera solution by Mann et al. 2021). Some of the questions resulted in stronger emotional arousal reactions than others, intruding the private space of the actor. From a conceptual perspective, it was interesting to see how the "theatre miracle" could be deconstructed, where instruments from reality questioned the imaginary world created by actors. Hence, such technology could be used to detect aspects of the performance that are personally important to the performer. The idea of the actor being aware of his decision making and emotions during the performance has great potential for both teaching acting and educating the audience.

The artist: *I'm sure that I would believe the actor even if I saw from the polygraph that he is lying. The research process with Tambet and Steven uncovered more for me than I was initially expecting. I realised that sensors do not help me to 'decode' the art of acting. The use of sensors on the actor during the performance could be seen itself as entertainment – visualisation of the actor 'lying' can be entertaining and fun rather than adding extra artistic value to the performance.*

The scientist: *Working with a professional actor was rewarding. Observing an 'emotional athlete's' reactions confirmed my conviction that affective dynamics should be studied using professionals, as they exhibit a variety and strength of emotional reactions that are not similar to naïve participants. It was also clear to me that psychophysiological hardware and software tools can and will be integrated in the actor training process once they can be used without professional assistance.*

4. Artistic experiment 3: *Interactive installation "Heart-rate Party"*

4.1. Scientific background

Heart rate and, especially, pulse, are physiological signals that are rather simple to measure. This has already led to many commercial uses of heart-activity monitoring in sports and well-being applications. Heart rate can be easily affected by external rhythmic stimulation where, for example, false heart-rate sounds can modulate the real heart activity and underlying emotional and cognitive states (Valins 1966; Tajadura-Jiménez et al. 2008). Interactive systems where a user gets heart-rate feedback can be seen as positive (training up) or negative (training down) feedback (Pope and Stephens 2012). One important aspect of heart-rate use in art and well-being applications is that, due to its simplicity, collective scenarios can be deployed monitoring a group's physiological synchronisation and social coherence (McCraty 2017). Such collective scenarios are specifically relevant for the theatre domain when monitoring a performance's impact on the audience.

4.2. The initial artistic idea

The third artistic experiment was realised as an interactive installation. Its idea originated from a collaboration with Sasha Mirson, DJ and media artist, who proposed a sound installation with a modulated musical tempo, where the rhythm of the dancer's heartbeat would enforce the dancing rhythm. While artistic instances of such physiology-based interactions are not new (for a recent review, see Dikker et al. 2019), the focus here was on the technical and physical realisation of such a system, its reliability, and its perception by visitors.

> The artist: *An interactive artwork is a complex concept. Artwork that adapts to the spectator decreases the possibilities of meeting something that would make you see the world differently. If the spectator becomes a narrator, the dialogue between the artwork, the spectator, and the environment becomes one-sided and narrow.*

4.3. Technical realisation

The audio-visual installation "Heart-rate Party" was shown on June 6, 7, and 8 in Püha Vaimu SAAL, Tallinn. The installation was built and programmed by Taavet Jansen and Aleksander Mirson, a student at the Viljandi Culture Academy. The heart-rate sensor (R-IoT) was used to measure the pulse of the user. It synchronised the frequency of the pulse to the sound tempo or, in other words, its beats per minute (BPM), including the light design. The user's pulse was measured when she held her finger on the sensor for 10 seconds. The software then registered the visitor's heart rate, and the frequency of her heartbeat was used to modify the BPM in Ableton Live and Video and the light mapping software MadMapper. The graphic instructions for the user were generated and rendered in Max MSP software. The idea was that visitors would be engaged with the installation, trying to change their heartbeat by moving more, thus making the music play faster.

Figure 3. Left panel: a spectator interacting with the installation. Centre panel: the heart-rate sensor and the microcontroller BITalino R-IoT. Right panel: the light modulated by the user's heart rate.

4.4. Observations

Several technical questions arose from this work, including which software framework to use, the sensor's reliability, mappings of biosignals to light and sound, the physical arrangement of the space, and the artistic context of the installation (how to instruct the visitors). Over 20 people experienced the installation. Participants' experiences helped to understand the importance of the installation setting. Visitors were a bit intrigued by the complexity of the installation. Even when they understood how it worked, they found it technologically complex and were surprised when their heart rate was captured and the music actually started to change. Since most efforts were put mainly into getting the technology to work, the context and artistic "packaging" was very weak. The installation itself was not sufficiently "inviting" or "intriguing" and its "invitation to start moving" addressing the visitors did not work at all. Almost nobody started to move to control the BPM of the installation. However, almost all visitors agreed that if the concept would be developed further and designed properly, it could be an interesting (art)work. All visitors had many questions about the technical details and the process of creating the installation.

> The artist: *I couldn't enjoy the installation myself because of the stressful preparation period. Also, I felt more like a technician, explaining to the spectators what to do, what was going on and how it worked, and why it was such a great idea.*

> The scientist: *The installation clearly showed that ideas that are valid in controlled laboratory conditions may not necessarily work in a public installation. The context and the "packaging" of the experience became as important as the technical realisation of the simple biocybernetic loop. Perhaps the idea would have been more effective in a real discotheque as not all visitors were prepared to dance in the exhibition room.*

5. Lessons learned from the artistic experiments of the residency

The three artistic experiments concentrated on the specifics of what one could physically record from a performer-viewer relationship. Importantly, after these experiments, it was clear to the scientist and the artist that the captured spectator experiences expressed in physiological data did not necessarily represent a conscious, subjective reaction to the presented content. The work process was also different for the artist, since the artistic practice develops in a different way, independent of the science or technology involved. In other words, the artistic expression was almost side-lined. For the scientist, it was a very good example of research-in-the-wild, with every artistic experiment providing a seed for a more methodologically elaborate scientific experiment.

Physiological data is highly idiosyncratic, and generic classifiers that rely on a predefined set of signal features, even for such a simple signal as EDA, may fail, especially in the theatre and out of the lab context. Some of the experiences may be entirely new for spectators (e.g., complex mixed emotions, see Kreibig and Gross 2017), and the artistic concept of the performance could rely precisely on these new physiological patterns. Importantly, the physiological reactions of the audience could be a result of a complex and carefully directed interplay of both cognitive and emotional manipulations. Reliable classification of such mixed reactions is in opposition to the standard challenges of the affective computing domain, which currently gravitates towards using simple solutions with the few basic emotions at hand. Ideally, one should be able to build and adapt classifiers for a dedicated performance and the related cognitive and physical context (e.g., similarly to the co-adaptation of a prosthetic control algorithm and a user strategy in the rehabilitation domain, Couraud et al. 2018).

> The artist: *This residency gave me the basic understanding of affective computing paradigms and it also opened up a new sense of spectator-performer relationship analysis in the theatre environment. Developing and executing the concepts of interaction helped me to understand better what happens between a spectator and a theatre performer. I understood that there are more 'measurable' things going on during the performance than I had imagined. The whole focus on people's physiological and emotional reactions was new for me. Artists don't usually worry about how the spectators will physically and psychologically receive the artwork – I realised how affective computing tools and methodologies could bring an angle in understanding the performing art process.*

> The scientist: *During my work with Taavet, I started to grasp how a performing artist works and the strength of a true art-science collaboration. Using the artistic interventions allowed us to explore, discuss, and play with many scientific concepts and technological solutions – almost like walking through a garden and picking the most exotic fruits. Each of these topics – neurochoreography, measuring collective audience engagement, evaluation of the actor's emotional state, or heart-rate-based interaction with audio-visual content – definitely forms a separate topic for in-depth research. However, the presented work allowed me to map the potential foci of these future studies.*

The use of physiological sensors in the theatre may bring a new dimension into the creative process. For that, it is essential to:

- Experiment with sensor technology in the theatre from the beginning of the artistic creative process so that the sensor technology is an integrated part of the performance;

- Allow enough breathing room for the artists to get used to the new technologies, to fully grasp the new possibilities, and to experiment with these freely, having a strong technical and scientific support;
- Systematically study "implicit interaction aesthetics" similarly to the aesthetics of more common, explicit interactions, since the exploration of "uncomfortable" interactions is very important for bringing moments of discomfort into the overall experience leading, sometimes, to the climax of the performance (Benford et al. 2012);
- Create an opportunity for an ethical debate on the ways to use physiological sensing with the audience in the theatre so that it is both accepted by viewers and conforms to the ethical standards of human experiments (consent form, anonymisation of the data, etc.);
- Ensure the artist knows the technology in advance and has the possibility to experiment with it during the rehearsal periods, and preferably that the developers or technical support work together with the creative team to allow constant development and modification (e.g., testing sensory feedback mapping solutions);
- Provide the creative team with a stable link to an expert who can support them with the necessary scientific knowledge, examples, and references, and also facilitate the translation of this knowledge into a different domain.

6. Discussion and concluding remarks

There is still a lot of exciting research to be done on how to interpret and make perceptible the data collected from viewers and performers. One may call this research area "quantified theatre," in parallel with quantified self-movement. At the current moment, rather straightforward approaches are used to translate biosignal data into changes within audio-visual parameters, so called data mapping. This gives a perfect synchronicity and an instant effect for data perceptualisation. However, it misses the most important thing – what this data means, what it expresses, and what should be done with these results in an artistic context. Artists often lack the theoretical knowledge underlying the technologies that are used. The transfer of this knowledge to art and, specifically, to the world of theatre would open new directions and opportunities for interpreting art as well as science in richer ways.

Directors and stage artists are skilled at energising the space, composing the emotions of the audience with active dramaturgy, and igniting and directing the audience's imagination. The viewer is made to forget reality and enter an imaginary world where different rules and laws apply. Such knowledge is appreciated in many other fields where the user's / viewer's experience is at stake – in HCI, marketing, virtual reality journalism, to name a few.

The theatre experiments described above used sensors and software specifically tailored for artists and creators. However, new technological tools for theatre experimentation are yet to be designed and created. There is a clear need for a common scientific conceptual basis and language that can be used for collaboration in different formats, mentoring programs, multidisciplinary think-tanks, etc., to help create the necessary ecosystem for online theatre and neurotheatre experiments. Specific methodological innovations are emerging from art-science projects interested in experimental research outside the lab, research-in-the-wild, and particular tools for training performers and creative processes. And, finally, such technological innovations will inevitably speed up and intensify the public debate on technology-infused futures, since theatre can be used as a part of the fiction design practice that has become popular in the HCI community (Dunne and Raby 2013). Technology should not be seen as something external but rather as something that helps humans to know themselves better and to build deeper connections within one's consciousness.

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Aleksander Väljamäe – a visiting scientist at Centre for Advanced Studies, Science and Art, Join Research Center, European Commission, working on neurosecurity and experimental communication. He received his PhD at Chalmers University of Technology, Sweden, in 2007. His research addresses multisensory media influence on cognitive and emotional levels, with a particular stress on new applications (brain-computer interfaces, neurocinema, neurotheatre). He actively participates in art-science projects, being also an artist-in-residence at EC. He authored over 30 journal articles and book chapters.
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SUMMARY

Kunstiliste sekkumiste kasutamine füsioloogiapõhiste interaktsioonide uurimiseks etenduskunstides

Taavet Jansen, Aleksander Väljamäe

Võtmesõnad: etenduskunstid, kunstiresidentuur, interaktsioonidisain, neurofüsioloogia, neuroteater

Tallinna Ülikoolis toimus 2019. aasta veebruarist juunini kunstiteaduse residentuur, kus etenduskunstnik Taavet Jansen ja neuroteadlane Aleksander Väljamäe töötasid kunstilise sekkumise kontseptsiooniga, analüüsides võimalusi, kus publiku ja esinejate füsioloogilised reaktsioonid looksid uusi tähendusi etenduskunstide kontekstis. Selles artiklis analüüsivad ja kirjeldavad autorid sooritatud eksperimente ja avaldavad omi isiklikke mõtteid toimunud sündmuste kohta.

Kunstilises eksperimendis „Neurokoreograafia nr 4“ uuriti interaktiivset improvisatsioonilist tantsuetendust, kus neljale vaatajale kinnitatud sensorid mõõtsid nende erutuse taset (*electrodermal activity*) ja saadud andmed manipuleerisid reaalajas sama etenduse helikujundust. Sellise interaktiivse lahenduse tekitatud tagasiside-efekt lõi olukorra, kus vaatajate tahtmatud reaktsioonid mõjutasid omakorda nende saadavat kogemust, tekitades lavastuse mõju intensiivsuse spiraali, kus nähtu mõjutas järgmisel hetkel juba kogemust ennast.

Kunstilises eksperimendis „Macbeth“ kasutati erutust mõõtvaid sensoreid, salvestamaks näitleja reaktsioone intervjuu vältel, kus esitati küsimusi tema rolliloome kohta vastlõppenud etenduses „Macbeth“. Näitlejaga läbi viidud intervjuu eesmärgiks oli mõista, milliseid tehnikaid kasutab näitleja oma rolli luues, ja tehnoloogiat kasutades tuvastada, mil määral on näitleja teadlik oma laval tehtud kunstilistest ja tehnilistest otsustest.

Interaktiivses heli- ja valgusinstallatsioonis „Heart-rate Party“ kasutati külastaja südamerütmi, mõjutamaks installatsiooni heli- ja valguskujunduse tempot. Eksperiment tõi teravalt välja kriitilised küsimused piisava tehnilise võimekuse, kujunduse ja raamistuse olulisuse kohta, mis on vajalikud interaktiivse installatsiooni õnnestumiseks.

Kõik kolm eksperimenti otsisid kontseptsioone, kuidas oleks võimalik salvestada võimalikult täpselt esineja-vaataja omavahelisest suhtest loetavaid andmeid. Oluline on välja tuua, et kogemused salvestatult füsioloogiliste andmetena ei pruugi väljendada teadlikku, subjektiivset reaktsiooni nähtud kunstilisele sisule. Sellised „uurimistööd võsas“ (*research-in-the-wild*) võivad luua uusi võimalusi, kuidas tõlgendada füsioloogilisi andmeid mitte ainult laboratoorses kontekstis. Läbi kunsti prisma vaadatuna võivad need andmed omandada mitmeid uusi tähendusi. Inimeste füsioloogilised andmed on isikupärased, teatriruumis võivad need aga olla keerulise kognitiivse ja emotsionaalse manipulatsiooni tulemus. Seetõttu üldised klassifikaatorid, mis töötavad laboris, võivad olla etenduskunstide kontekstis kasutud.

Füsioloogiliste sensorite kasutamine teatris võib tuua uusi dimensioone ka loomeprotsessidesse. Selleks tuleks aga luua võimalused, kus kunstnikud saaksid eksperimenteerida sensortehnoloogiatega juba loomeprotsessi algusest peale. See annaks kunstnikule piisavalt hingasmisruumi, et saada ülevaade tehnoloogia pakutavatest võimalustest ning eksperimenteerida sellega piiranguteta. Oluline on tagada kunstnikule ka tugev tehniline ja teaduslik tugi eksperimenteerimise vältel. Samuti oleks oluline algatada arutelu füsioloogiliste andmete eetilise kasutamise kohta etenduskunstide kontekstis, nii et see oleks akt-

septeeritud nii kunstnike kui ka vaatajate poolt, aga oleks ka vastavuses inimestega tehtavate eksperimentide eetiliste standarditega.

Väga palju põnevat uurimistööd ootab ees: kuidas interpreteerida ja teha mõistetavaks esinejatelt ja vaatajatelt kogutud andmed. Praegusel juhul kasutatakse interaktsiooni visualiseerimiseks andmete otsest ülekandmist audiovisuaalseteks parameetriteks. See tagab küll perfektse sünkrooni audiovisuaalses efektis, kuid selles puudub peamine – teadmine, mida need andmed tähendavad nii teaduslikult kui ka kunstilises kontekstis kasutatuna. Kunstis jääb tihti puudu teoreetilistest teadmistest, mis aitaksid intuitiivselt tehtud kunstilisi otsuseid raamistada. Selline teadmiste ülekandmine kunsti ja teaduse vahel avaks uusi võimalusi kunstiteoste interpreteerimisel ja looks uusi perspektiive mõlema valdkonna arenemiseks.

Taavet Jansen töötab etenduskunstide väljal üle kahekümne aasta – tantsija, koreograafi, lavastaja, helikunstniku ja videokujundaja, interaktiivsete lahenduste programmeerijana. Praegu õpib Eesti Kunstiakadeemia doktorantuuris, uurides kohalolutunde loomist vahendatud kunstisündmuse kontekstis. Samuti töötab ta TÜ Viljandi kultuuriakadeemias multimeedia lektorina. Jansen on ka üks pool-virtuaalse, poolfüüsilise platvormi e¯lektron (https://elektron.art) algatajatest.
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