Situated Aesthetics: Interaction and Participation in Biofeedback Performances

Vikram Kaushal

PhD 2019

Biofeedback Performance: Interaction, Participation and Artistic Production

Vikram Kaushal

A thesis submitted in partial fulfillment of the requirements of
Manchester Metropolitan University
for the degree of Doctor of Philosophy

Department of Architecture
Manchester Metropolitan University
2019

Acknowledgements

I would like to express my sincere gratitude to my advisors Professor Toby Hayes, Dr Laura Coucill and Dr Atif Waraich for their insights over the course of my PhD study and for their patience and motivation. I am also grateful to the staff and students of the Manchester School of Architecture who have been a constant source of imagination and inspiration. Thank you also to Dr Richard Brook for kindly reading and offering invaluable feedback on this thesis.

Three experiment-performances took place in the formation of this thesis and were only possible through the support of a great many colleagues. A big thank you to Matt Lee, Dr George Khut, Dr Jason Taylor and Dr Aspasia Paltoglou for their practical help in realising certain aspects of the artwork's performances. I must also extend this gratitude to the commissioners of the work Charlotte Corrie, Dr Lewis Sykes, The Everyman Theatre, The Arts Council, John Moores University, Openculture.org and the Science and Industry Museum Manchester.

I also offer a special thank you to Orlando Edmonds whose continued help and invaluable advice have been instrumental in producing this document. He enabled me to crystallize and develop my research through his patient and generous support, not only as a mentor but also someone who became a friend. This thesis would not have been possible without his input.

Finally, I must acknowledge my family and friends for their unwavering support and love over the course of the creation of this thesis. This achievement is partially yours. Thank you.

Portfolio

This thesis accompanies the online portfolio which can be found here: www.loganandwilcox.co.uk.

The portfolio presents the three experiment-performances along with audience testimonies and interviews with the participants, peer educators and spectators. The portfolio should not be read as the artwork itself but rather as a complementary record of the events which took place.

Table of Contents

List of Figures

artist (red). As the audience is not involved in any substantial capacity in the performance, its relationship to the artist remains purely reactive and unidirectional.

Figure 9: Teitelbaum, R. (1976). Diagram of *In-Tune* (1976), in *Biofeedback and the Arts: Results of Early Experiments*. Vancouver: Aesthetic Research Centre of Canada, p. 34.

Figure 10: Kaushal, V. (2015). The spatial arrangement of Teitelbaum's *In-Tune* (1976) as a variation on paradigm '2. Stage b)' with participants (green) and an artist (red). Between the participants, the relationship is unidirectional reactive as they simply listen to each other's sonified data. Between the participants and the artist, the relationship is reactive but bidirectional as the artist modulates the sounds as they receive the readings in real-time.

Figure 11: Moore, P. (1970). The performance of *Ecology of the Skin* by David Rosenboom at Automation House, New York (1970). Available at: http://4columns.org/dayal-geeta/david-rosenboom (Accessed 14th October 2019).

Figure 12: Kaushal, V. (2019). The spatial arrangement of Rosenboom's *Ecology of the Skin* (1970) as another variation on paradigm '2. Stage b)' with spectators, participants and an artist. Between the participants, the artist, and one another the relationships are interactive. Between the spectators and the artist, the relationship is bidirectional reactive.

Figure 13: Mori, M. (2001). Participants inside the *Wave UFO* (1999-2002) installation. Available at: http://www.digiart21.org/art/wave-ufo (Accessed: 14th October 2019).

Figure 14: Kaushal, V. (2019). The spatial arrangement of Mori's *Wave UFO* (1999-2002) as a variation on paradigm '1. Artefact b)' with participants. Between the participants and the artefact, the relationship is bidirectional reactive because the participants influence the graphic signature, but only to a limited degree.

Figure 15: The spatial arrangement of Lozano-Hemmer's *Pulse Index* (2010) as a variation on paradigm '1. Artefact b)' with participants and spectators. Between the participants and the artefact, the relationship is bidirectional reactive, whilst the relationship between the spectators and the artefact is unidirectional reactive. This is

because the participants can influence the artefact, but only to a limited extent, whilst the spectators are simply observing it without influencing it.

Figure 16: Science Gallery (2010). Rafael Lozano-Hemmer's *Pulse Index* (2010). Available at: https://opencall.sciencegallery.com/pulse-index (Accessed: 13th October 2019).

Figure 17: Glynn, R. (2010). *Performative Ecologies* installation (2010). Available at: https://www.researchgate.net/figure/Ruairi-Glynn-Performative-Ecologies-2008_fig4_281365606 (Accessed 13th October 2019).

Figure 18: Kaushal, V. (2019). The spatial arrangement of Glynn's *Performative Ecologies* (2010) as a variation on paradigm '1. Artefact b)' with participants and spectators. Between the participants and the artefacts, the relationship is interactive because the two roles are able to engage with one another in the manner of a conversation, where each is reciprocally influenced by the other, learning and adapting its behaviour. Between the spectators and the artefacts, the relationship is unidirectionally reactive as they simply observe the performance taking place between the other roles.

Figure 19: Khut, G. (2012). Video portrait from *Distillery: Waveforming* (2012). Available at: https://vimeo.com/62140271 (Accessed: 13th October 2019).

Figure 20: Kaushal, V. (2019). The spatial arrangement of Khut's *Distillery: Waveforming* (2012) as a variation on paradigm '1. Artefact a)' with a participant. Between the participant and the artefact, the relationship is bidirectional reactive because the participant influences the graphic signature, but only to a limited degree.

Figure 21: Kaprow, A. (1959). *18 Happenings in 6 Parts* (1959). Available at: http://www.medienkunstnetz.de/works/18-happenings-in-6-parts/images/3/ (Accessed 14th October 2019).

Figure 22: Kaushal, V. (2019). The spatial arrangement of Kaprow's *18 Happenings in 6 Parts* (1959) as a variation on paradigm '4. Hybrid' with participants and multiple artists. Between the participants and the artefacts, the relationship is unidirectional reactive because the participants don't have an influence on the artefacts. Among the participants

themselves, the relationship is either bidirectionally reactive or interactive as they are able to engage with one another with varying degrees of agency. Between the artists and the participants, the relationship is interactive because they are able to mutually influence one another.

Figure 23: Staeck, K. and Steidl, G. (1974). Joseph Beuys's lecture at SAIC in 1974. Available at: https://www.pinterest.com/pin/504966176944206539/ (Accessed 13th October 2019).

Figure 24: Kaushal, V. (2019). The spatial arrangement of Beuys's lectures as a variation on paradigm '2. Stage a)' with participants and spectators. Between the participants and the artist, the relationship is interactive as they engage through questions and answers in the manner of a conversation. Between the spectators and the artist, the relationship is simply reactive as they are simply listening to the other roles speak.

Figure 25: Kaushal, V. (2019). The spatial arrangement of a typical community arts project as a variation on paradigm '3. Participatory' with participants and multiple artists. Between all the roles, the kinds of relationships formed should be interactive as they should involve mutual learning, engagement and conversation.

Figure 26: Price, C. (1964). Diagram showing different interactions within the InterAction building. Available at: https://medium.com/@agrimgrg22/drawing-notation-influenced-by-fun-palace-of-cedric-price-6a08676cba43 (Accessed 13th October 2019).

Figure 27: Nelson, R. (2013). Multi-mode epistemological model for practice as research, in *Practice as research in the arts: principles, protocols, pedagogies, resistances*. London: Palgrave Macmillan.

Figure 28: Ragan, S. M. (2013). Arduino heart rate sensor circuit diagram. Available at: https://makezine.com/projects/ir-pulse-sensor/ (Accessed 13th October 2019).

Figure 29: Kaushal, V. (2015). This Processing sketch illustrates an example of the graphic signatures created by visualising the biometric data.

Figure 30: Jensen, Ole & Spaak, Eelke & Zumer, Johanna. (2014) EEG tracings by Hans Berger, in ‘Human brain oscillations: from physiological mechanisms to analysis and cognition’. Available at: https://www.researchgate.net/figure/An-early-EEG-recording-performed-by-Hans-Berger-Prior-to-the-arrow-the-subject-is_fig1_267748206 (Accessed 13th October 2019).

Figure 31: Kaushal, V. (2015). Screen capture of Neurosky software.

Figure 32: Kaushal, V. (2015). Screen capture of Brainwave OSC.

Figure 33: Kaushal, V. (2015). Studio setup of *System* (2015). See the section on the first experiment-performance for the diagram.

Figure 34: Kaushal, V. (2015). Screen capture of Modul8 processing brainwave data.

Figure 35: Kaushal, V. (2015). Diagram of *System* (2015) data-flow.

Figure 36: Kaushal, V. (2019). The spatial arrangement of *System* (2015) as a variation on paradigm ‘1. Artefact b)’ with one participant and one artist, as well as a key to the symbols in this diagram and later diagrams.

Figure 37: Edmonds, O. and Kaushal, V. (2018). A diagram visualising the integration and situatedness of humans, technology and nature. Telephone conversation with Orlando Edmonds, 15 December.

Figure 38: Kaushal, V. (2016). *Neu-collective Consciousness* (2016) performance at the Everyman Theater.

Figure 39: Kaushal, V. (2019). The spatial arrangement of *Neu-Collective Consciousness* (2016) as a variation on paradigm ‘2. Stage b)’ with participants, spectators and artists.

Figure 40: Kaushal, V. (2016). Graphic signature for *Neu-Collective Consciousness* (2016).

Figure 41: Kaushal, V. (2017). Participant plugged in to *Zugzwang* (2017) at the John Lennon Theater.

Figure 42: Kaushal, V. (2019). The spatial arrangement of *Zugzwang* (2017) as a variation on paradigm ‘1. Artefact a)’ with participants, spectators and artists.

Figure 43: Kaushal, V. (2017). Graphic signature in *Zugzwang* (2017).

Figure 44: Kaushal, V. (2017). Participant in *Verrfast* (2017).

Figure 45: Kaushal, V. (2019). The spatial arrangement of *Verrfast* (2017) as a variation on paradigm ‘4. Hybrid’ with participants, spectators and artists.

Figure 46: Kaushal, V. (2017). Graphic signature in *Verrfast* (2017).

Figure 47: Kaushal, V. (2017). Workshops at Talbot Mill, Manchester.

Figure 48: Kaushal, V. (2017). Workshops at Talbot Mill, Manchester.

Figure 49: Kaushal, V. (2017). Workshops at Talbot Mill, Manchester.

Figure 50: Kaushal, V. (2017). Final setup of *Verrfast* (2017).

Figure 51: A diagram illustrating the simultaneously integrated and situated relationships between humans, technologies and nature.

Figure 52: A diagram illustrating the simultaneously integrated and situated relationships between artists, audiences and artworks.

I. Abstract

This practice-based PhD explores how the implementation of biofeedback in audio-visual performances can challenge the traditional divisions between the roles of the artist, the audience and the artwork. This was achieved by designing a system to accommodate these performances and iterating the system across three performances. At the centre of the system is the use of biometric devices to collect real-time data from audience participants. Their brainwaves and heart rates were interfaced with audio-visual outputs which were made both visible and audible to them, thereby influencing the original data and creating a biofeedback loop. The first of the four experiments took place in a controlled studio environment without an audience and served to establish which technologies were most suited to this end. The technologies were tested for their prospective reliability and accessibility in a live performance environment, with the ultimate aim of enabling the greatest level of interaction between the roles of artist, audience and artwork. The following three experiments took place between 2015-18 and were funded by commissioning bodies to be hosted in galleries and exhibition spaces with an audience present. Each of these latter three performances continued to iterate the system's design, implementing changes in response to the obstacles and opportunities presented at each stage of the process.

The research question took as its starting point the principles of practice as research and the fields of social practice and cybernetics. Broadly defined, social practice is a field of art whose theory and practice foregrounds participation and an awareness of context and process in the production of artworks. Cybernetics is a field of science and philosophy which studies how systems self-regulate within, and adapt to, their environments through mechanisms of feedback and circularity, exploring principles of situatedness, embodiment, interaction and control. By drawing on the respective theories and practices of these fields, this thesis will document how they each informed the experiments in addressing the research question. Little research exists on the points of contact between social practice and cybernetics. Considered together, they mutually inform one another and present a number of illuminating points of departure when considering the embedded hierarchies and relationships between the roles of artist, audience and artwork.

II. Introduction

1. Overview

a) Research Question

How can the implementation of biofeedback in audio-visual performances challenge the traditional divisions between the roles of the artist, the audience and the artwork?

b) Thesis Structure

This thesis documents my practice across six chapters which detail the theory and practice of the experiment-performances, identifying the key practitioners, thinkers, artworks and literature which informed the process. The ‘Literature Review’ outlines the purview of the project, providing the historical and philosophical context in which it is located, with subsections dedicated to the respective threads of cybernetics and social practice. Throughout the project in general, the study of social practice and cybernetics served as a means of analysing the experiment-performances in relation to the research question. Additionally, doing so also functioned as an end in itself as I identified how they intersected and complemented one another in ways which had not been explored previously. Alongside each subsection on cybernetics and social practice are sections detailing relevant pre-existing fields and discussions. These serve to further contextualise the project and provide links between its two principal fields and critically engage with the key theories and literature written on the subjects of social practice, cybernetics, and the interrelationship between the roles of the artist, artwork and audience, providing examples of projects which inform and forecast further developments in these areas. The fourth chapter, ‘Methodology’, provides a record of the technical and logistical routes by which the practice-element of the project developed and grew, specifically focussing on how the software and hardware were tested, iterated, and implemented. Following this, the fifth chapter comprises four subsections, each of which is dedicated to providing an overview and analysis of each of the four experiment-performances. This is followed by the ‘Conclusion’, which surveys the successes, failures and opportunities for development, and makes more explicit suggestions for future projects which might address questions following from this work.

c) Research Context

To explain what led me to this research question, I will briefly survey my own practice to date from being a youth worker in the community arts sector and studying architecture to working as a visual jockey (VJ) in real-time performance contexts.

In 1999, I was one of a group of youth workers commissioned by the UK Government's Department for Education to assist in the aftermath of the Oldham Riots—a series of racially motivated attacks which took place in the town of Oldham, Greater Manchester—which involved running a programme of community arts projects to help the town's younger residents. This experience introduced me to the theory and practices which fall under the broader umbrella of social practice. In turn, I studied architecture during the period in which social practice had begun to dominate much artistic production during the 1990s and 2000s. In this time, art was increasingly treated by governments as an instrument of social change, with community arts projects becoming a source of feedback and a site for evaluating the wellbeing of certain communities and demographics.

During my time at the Manchester School of Architecture I discovered the work of the Architectural Machine Group, a multidisciplinary research group founded by Nicholas Negroponte that eventually became the MIT Media Lab (Pertigkiozoglou, 2017). The group's emphasis on bringing together art, design, social sciences and philosophy to ask questions about the role of the citizen in the age of new computer technologies appealed to both my social concerns and design sensibilities. It was through Negroponte's work and his collaborations with cyberneticist Gordon Pask that I was introduced to cybernetics—an entire field engaged in these topics. Together they experimented with ways of interfacing humans and machines in interactive environments, producing tools and methodologies that would allow 'conversation' between humans and intelligent learning technologies. As Theodore Spyropoulos explains, Pask and Negroponte built 'dynamic and engaged environment[s] in which the co-evolution of the architect and his machines would produce new paradigms of design (Spyropoulos, 2008, p. 144)'.

Whereas my design and community arts work focused on questions of participation, process, and the user-producer dynamic, it was VJ-ing which galvanised my interest in live performance and a performance-oriented focus on how the relationships between the artist, audience and artwork could be modulated to produce more interesting dynamics and reduce passivity by distributing authorship. Regularly playing in nightclubs, festivals and galleries using live-performance technologies contributed to my understanding of these roles and how the two fields of cybernetics and social practice

could be combined to produce performances which explored their interaction. It is notable that, in the early days of VJing, for the very heterogeneity of technologies and skills it required, VJing was categorised under a variety of different genres of production; it was not confined to any single conventional role of artist, producer, designer, coder. This had an influence on my awareness and interest in the blurring between the roles of the artist, audience and artwork and the conditions under which this takes place.

Between these interests, I was led to discover the concept of biofeedback, especially as it was pioneered by David Rosenboom and Richard Teitelbaum (whose influence on my work I detail below). In its own right, whilst biofeedback does not necessarily unite social practice and cybernetics, its quality of blurring the limits between body and environment and performer and performance disposes it to challenging the divisions between the roles of artist, audience and artwork. Seeing social practice and cybernetics in relation with one another allowed me to imagine how the implementation of biofeedback could make this blurring apparent.

d) Practice as Research

This project draws from the model of research methods and critical approaches developed by Robin Nelson in the book *Practice as Research in the Arts: Principles, Protocols, Pedagogies, Resistances* (2013). In it Nelson proposes an approach of cross-referencing testimonies, data, and evidence in the manner of a dialogical, multimodal process (see diagram 2.2). This was how the project was approached, whereby the data collected from the participants was combined with the personal testimonies of other audience members to shape and influence the ongoing iteration of the system, ultimately culminating in this write-up and the analysis of the experiment-performances in the proceeding sections. The following diagram is taken from Nelson's book:

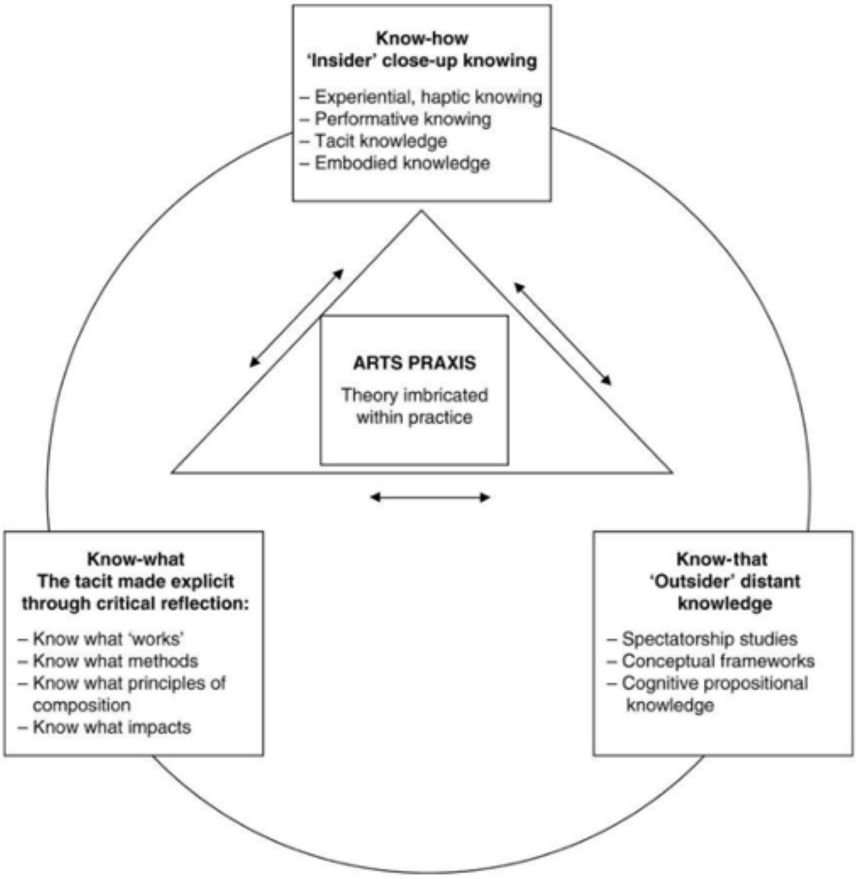


Figure 27: Nelson, R. (2013). Multi-mode epistemological model for practice as research, in *Practice as research in the arts: principles, protocols, pedagogies, resistances*. London: Palgrave Macmillan.

Praxis, as a hybrid of 'theory integrated within practice', sits at the center of a triangle, the corners of which comprise:

- *Practitioner Knowledge*

  This involves tacit knowledge, embodied knowledge and (phenomenological) experience. The concept of practitioner knowledge is premised on the notion that practitioners, enculturated by their training and experience, have 'embodied within them' the 'know-how' to make work.

- *Critical Reflection*

  This involves practitioner 'action research', explicit knowledge, and the idea of

being located in a tradition. The concept of critical reflection describes a conscious strategy to reflect upon established practice as well as to bring out ‘tacit knowledge’.

- *Conceptual Framework(s)*

  This involves traditional theoretical knowledge and cognitive-academic knowledge. Creative practice becomes innovative by being informed by theoretical perspectives, either new in themselves, or perhaps newly explored in a given medium.

Nelson’s diagram offers the opportunity of seeing the process of art production as itself knowledge producing. In other words, the separation of theory and practice is not clean. Forms of practice can themselves be thought of as theories in their own right, and in turn, the artwork itself can be thought of as research in its own right. This project is practice-based as the creative artefacts form the basis of the contribution to knowledge. However, ‘the process’ and its ‘evidence’ are also intended to be read as knowledge producing and not just ‘means’ to an end or merely as a form of documentation. The art object, its constitutive methods and the mediums used all interact in feedback loops. This document exists alongside these experiments not only as an explanation of the method, but as a way to contextualize and place the practical work within the contemporary discourse on the interrelation between the roles of artist, audience and artwork. Throughout, I will detail the various ways in which the different forms of knowledge correspond to the dimensions of the project and how each experiment-performance exhibited them and to what extent.

e) Research Aims and Objectives

Building on my youth work experience, architecture degree and VJing background, the four experiment-performances attempted to address different aspects of the research question.

The first experiment-performance, which I will simply call *System*, involved setting up the framework which I would then use in the following three experiment-performances. The goal was to create an open-ended system which included possibilities for interaction between the audience and the audio-visual outputs. This was achieved through the use of

biofeedback, and at this stage in the process the predominant focus was on establishing the advantages and disadvantages of each possible biometric device and therein which was most suited to the purposes of the overall project. At this early stage, given the lack of both an audience and a completed piece of work, the role explored in the most depth was that of the artist. As the system was explicitly designed to encourage the co-creation of the artwork with the audience, the role of the artist was being prepared to be distributed and dispersed across the participants attending the future performances.

The second experiment was the first 'performance' of the system insofar as it took place with an audience present. Entitled *Neu-collective Consciousness*, the emphasis was on involving other groups and individuals in the process as a collective activity.[1] This meant both negotiating the commissioning brief, managing the expectations of the organisation who commissioned us, and testing the system in an uncontrolled environment in real-time. As such, here, the roles of the audience and the artwork came to the fore. The spatial arrangement was such that the audience were included on the ‘stage’, and members of the public were invited to wear the biometric devices which translated their data into graphic representations on screens hanging in the middle of the room. However, there was still a limit to how integrated the audience, artwork and artist were as these same screens divided the spectators in the audience from those of the participating audience members wearing the devices. Following its completion, we took the opportunity to integrate the audience’s opinions and feedback into the system, modifying its design and presentation to improve the level of interactivity between the roles in the following performances.

In the third experiment, *Zugzwang*, the emphasis was placed on further reducing the limits between the artist(s) and audience, but this accompanied a reconsolidation of the artwork as an ‘object’. By removing the screen and replacing it with a pyramid hanging in the centre of the space, the border separating the artist and audience was lifted, but it reintroduced a more definitive and demarcated object as the central focus of the performance. Alongside this, instead of keeping the data taken from the participants separate, I combined it together to form mean averages. These average readings were then visualised and sonified together to produce singular real-time representations, thereby further homogenising the outcome and yet further interconnecting the participants who took part in the performance.

The issues experienced in the third experiment-performance were approached in

[1] Please refer to the corresponding section on each experiment later in the document for elaborations on the respective significance of each title.

the fourth and final one by drawing upon more conventional social practice methods. *Verrfast* attempted to redress the lack of knowledge participants had in previous instances of using the system by introducing experts in the field of neuroscience and psychology to explain how the data was being collected by the biometric devices. This involved hosting a series of discussions and educational workshops in the lead up to the performance-proper. As such, this part of the process became part of the outputs of the experiment-performance rather than simply its pretext. Whilst this constituted a widening of the role of the artwork-as-object to become more process-oriented, it also involved a return to the more traditional paradigm of the artist-as-expert. This was due to the fact that we tried to explain in greater depth to the participants how the system worked in order to get the most out of it and allow for the greatest level of interaction between the audience and the artwork.

In summary, the objectives which accounted for this process as a whole were as follows:

1. Design a system capable of connecting audience biometric data with audiovisual material
2. Implement a feedback loop between the data and the performance software
3. Iterate the design across multiple experiment-performances
4. Implement changes based on knowledge gained in each respective experiment-performance

f) Key Terms

Before attempting to show how the divisions between the roles of artist, audience and artwork can be challenged it is important to define how I will use each term in relation to one another and the subroles which emerged. In each case, the roles of the artist, audience and artwork rest upon at least one essential characteristic. For example, when I use the word artist, I am always referring to the condition of being a creator, facilitator, producer or practitioner. Additionally, the roles also designate other non-essential characteristics. For example, when I use the word artwork, I am referring to either the system, the artefact, the performance or the process as a whole. In all cases of using the terms artist, audience or artwork, I refer to at least one essential characteristic and, depending on the context, at least one other variable characteristic.

I will show how this applies in each specific case.

Though the status of the artist is subject to debate, I attempt here to detail some of its characteristics which are prerequisites and some of those which are incidental, depending on the context and specifics. An artist must fulfill at least one or more of the following roles of ‘creator’, ‘facilitator’, ‘producer’ or ‘practitioner’ in relation to the work of art. The nonessential but nonetheless operative subroles which came up during this project include but are not limited to: ‘author’, ‘designer’, ‘performer’ and ‘entertainer’. Whilst it is of course possible to be an author, designer, performer or entertainer without necessarily being an artist, the role of the artist does necessarily designate the role of creator, facilitator, producer or practitioner. In this respect, the role of the artist is contingent upon formal, practical and aesthetic criteria, the details of which I will explore and critique with reference to other practitioners and my own experiment-performances.

I define the role of the audience by its status as the sensor or perceiver. Its subroles relevant to this project include but are not limited to: spectator, observer, listener and consumer. Similar but distinct from the role of the artist, it is not necessary to be, all at once, a spectator, observer, listener or consumer to fulfill the role of being an audience, nor does being any of these necessarily mean you are an audience member, but it is impossible to be a member of an audience without sensing or perceiving some object or event. Something that is distinct to the role of the audience compared to the roles of artist and artwork, where the existence of one implies the existence of the other (there is no artist without an artwork and vice versa), is the fact that it can exist independently of artists and artworks. For instance, one can be audience to a lecture without the lecture being considered an artwork. However, to this last point, as I will explore in the Literature Review, this also depends on how one defines the limits and criteria of artworks, as in some cases which I will detail lectures might indeed be considered artworks.

What is interesting between the first two roles are the categories which exist between them. As was the case in my experiment-performances, there are roles which explicitly trouble the distinctions between artist and audience. A central aspect of the exercise undertaken by this project is in observing the points at which the roles of participant, peer practitioner, coauthor, cocreator, and co-producer exceed the role of audience, entering into the territory of artist. For our purposes, at this stage it is sufficient to state that, contained within the role of the audience, there were two distinct subroles which warrant being defined. In each case of an audience member wearing a biometric device, they are referred to as ‘participants’ as doing so meant they partook in the production of the work and were able to influence it to a significant degree through their interactions with the system. In the case of audience members simply being present and

observing the performances, they are referred to as ‘spectators’ for the fact that they observed the experiment-performances but did not influence them to a significant enough degree to constitute describing them as ‘participants’ (which connotes a more active involvement). The reason for describing them as ‘spectators’ and not simply ‘observers’ was to distinguish their role from that which is fulfilled by the more passive observation of a ‘system’ or an ‘experiment’, neither of which necessarily connote the durational, actively engaging qualities of a performance.

As with the role of the artist, the role of the artwork rests upon both prerequisite qualities and, in turn, possible contingent characteristics or ‘subroles’. I define the role of the artwork by its status as the object created / produced / facilitated / practiced by the artist and sensed / perceived by the audience. It is important not to confuse ‘object’ as an artefact, process or concept with simply an artefact alone (for instance, an image, sculpture or painting). A process is still an object insofar as it is perceived or sensed as the object of the artist’s and audience’s attention. This distinction is what allows the expanded definition of the role of the artwork to include processes and concepts, and it is this definition which is employed here. The subroles of an artwork are as diverse as instances of art, but broadly speaking include paintings, sculptures, plays, novels, videos, etc. There are two subroles which feature in this project that warrant clarification in advance as they comprise distinct but eventually combined parts of the overall work. First, there is the artwork as 'system' which refers to the hardware and software used to produce the biofeedback loop. Second, there is the 'performance' which refers to when the system is used in the context of an audience, the space in which these performances took place, and the participants whose biometric data was fed into the system to produce the biofeedback loop. The term ‘experiment’ is also used throughout to describe the fact that the system design was iterated from the initial test (the first 'experiment') and the subsequent live performances (the 'experiment-performances'). Without an audience and the subsequent interaction between the artist and the participants, the three following experiments would have remained experiments alone and not experiment-performances. Depending on the stage of the process, when I discuss ‘the role of artwork’, I refer to any one or more of these objects (as either the artefact of the technology, the process of the performances or the overarching concept of a biofeedback performance).

These definitions should not be taken as the final word but rather an introduction to some of the questions and factors involved in defining the roles and the divisions between them. One of the advantages presented by the project is the fact that it draws upon different intellectual frameworks to make its case. For instance, where cybernetics

discusses ‘observers’, ‘users’ and ‘systems’, social practice discusses ‘artists’, ‘participants’ and ‘artworks’. Each of these terms intersect and overlap depending on the person using them and the context in which they’re used. My interest was in harnessing these and other fields of knowledge to try to identify these ambiguities and explore how they contribute to the research question. In doing so, the project entered into the tradition of artists who have challenged and developed the role of the artwork as it relates to the roles of artist and audience.

III. Literature Review

1. Introduction

This chapter is divided into four sections: ‘Historical Context’, ‘Philosophical Context’, ‘Cybernetic Aesthetics’, and ‘Social Practice’. The two former sections situate the project within its sociopolitical history and the context of ideas that informed the works which precede it. The two latter sections overview artworks produced during the 20th and 21st centuries which had the most influence on this project. In the spirit of Nelson’s model of PaR, the literature review serves the function of establishing both the know-that and know-what of the project by locating the conceptual frameworks in which it is situated whilst also identifying ‘what works’ with reference to previous projects and artworks in the tradition it inherits.

2. Historical Context

a) Cybernetic History

The respective developments of cybernetics and social practice as disciplinary frames are able to be contextualised in a variety of historical events and key moments. However, I will limit myself to describing only those events which are most relevant to the project and which shed light on their previously unacknowledged points of reciprocity.

The history of cybernetics is complex, but for our purposes it is sufficient to limit our scope to three parts: the rise of what is known as ‘first-order’ cybernetics in the 1940s-60s, its inheritance and modulation by ‘second-order’ cybernetics in the 1960s-70s, and its contemporary practice from the 1970s to the present day being carried out by a number of old and new institutions which have adopted the name ‘cybernetics’ to describe what by now are a diverse array of theories and practices.

First order cybernetics begins in earnest with the work of Norbert Wiener. Wiener coined the term in his book 1948 book *Cybernetics: Or Control and Communication in the Animal and the Machine* (2013), building on the word *kybernētēs*, first used in Plato’s *The Alcibiades* to refer to the governance of people (2001). As contemporary cyberneticians Stuart Umpleby and Louis Kauffman explain, Wiener’s book was inspired by a series of lectures sponsored by the Josiah Macy Jr. Foundation from 1946 to 1953, eventually referred to as simply the conferences on cybernetics following its publication and subsequent influence (2017, p. 3).

The conferences had as their purview the subject of how natural, social and technological systems are grounded in circularity. As opposed to the traditional paradigms of modern science which emphasises linearity, rationalism and logical positivism, cybernetics takes as its starting point the principles of circularity in the form of feedback, regulation, and reciprocity, positing that systems of knowledge are in fact situated and contingent. Indeed, as contemporary cybernetician and philosopher of science Andrew Pickering observes, among the early implementations of cybernetic thinking was Wiener's design of a military system which would track the movement of airplanes, allowing artillery guns to shoot ahead of them, thereby anticipating their position by the time the bullets reached them (2014). Whilst born out of a military context of control, it did not remain so; first-order cybernetics ultimately was engaged in disrupting the modern paradigm of linearity, not to entirely rid it of its place in modern thought, but to reveal what it had forgotten. As Umpleby and Kauffman identify,

> Given the vital role that circularity plays in biological and social systems, it is surprising that so much of science focuses on linear causal relations. Probably this happens because scientists seek certainty in their knowledge (2017, p. 4).

First-order cybernetics invited openness and uncertainty back into the fold of scientific discourse, recognising the patent inaccuracy such restrictive impositions would inevitably cause.

As first-order morphed into second-order cybernetics, what began as a military-funded science of control and circularity grew to embrace an explicitly social framework. This 'social basis' of cybernetics is articulated by physicist and philosopher Andrew Pickering in his book *The Cybernetic Brain* (2010, 389), one of the key texts I will draw upon throughout this discussion. Pickering describes how often the work of cyberneticians in the 1960s took place outside the academy or formal institutional contexts and rather was homed by a more amorphous and broader sphere of 1960s counterculture. Throughout its history, he explains, we encounter

> the marks of a continual social marginality of cybernetics: its hobbyist origins outside any institutional frame, its early flourishing in tenuous and ad hoc organizations like dining clubs and conference series, its continual welling-up outside established institutions and its lack of dependable support from them. […]More generally, the counterculture, while it lasted, offered a much more supportive environment to cybernetics than did the organs of the state (2010, p. 389).

From living rooms and garages to brief stints in progressive university departments, 1960s cybernetics took place on the fringes of the academy, mirroring the extent to which its theory and practice ventured perspectives from outside the established frames of scientific

thought. Practitioners like Walter Grey attempted to model consciousness by building mechanical tortoises, whilst Stafford Beer attempted to envision the management of factories by integrating them with the ecosystem of ponds (Pickering, 37-90; pp. 215-308). Stafford Beer's Viable Systems Model (VSM), a model of an adaptive, self-regulating system which could be applied to any organisation or structure, was attempted to be implemented to Salvador Allende's socialist government in the 1970s (Glanville 2008, p. 21).

Stafford Beer anticipated the benefits of interfacing these different typologies of knowledge to enhance participation within complex systems. Beer recognised that the body could be used as a model for other social and political systems, bringing together biofeedback aesthetics and neurocybernetics. Andrew Pickering details this in the text *Science of the Unknowable* (2006) in relation to Beer's Viable Systems Model (VSM):

> Beer's idea was therefore to read biological organisms as exemplary of viable systems in general—we should transplant their key features to the structure of the firm. In particular, as I hinted a minute ago, Beer chose the human nervous system as his model. If his original idea was that the firm needed to contain an artificial brain (made of magnetic *Daphnia* or leeches), the idea of the VSM was that the firm should *become a brain,* a cyborg brain with human brains lodged within it (p. 15).

The crux of this vision was the principle of 'reciprocally vetoing homeostatic interactions' (p. 16), whereby the VSM came to be considered 'a kind of *techno-social diagram* of an adaptive democracy' (p. 22). In this respect, the body provided a way of imagining how one could account for black boxes by integrating feedback loops into each level of organisation in the manner of a recursive function:

> Each component […]of any viable system was supposed to be itself a viable system. Thus, under higher magnification, each system[…] was supposed to consist of its own five element system, and so on, both up and down the scale. Since the body has mind and consciousness, this implied, for Beer, that different levels of consciousness could be traced down to the individual cells of the body, and upwards beyond the body, to a kind of group consciousness that arose in syntegration (p. 27)[.]

Rather than being organised by an unquestioned command line, the internal components of the body each consist of their own recursive processing which feed out into other networked processes. In turn, these contain their own internal recursive forms of organisation. If second-order cybernetics was housed by any broader historical framework, it was the confluence of countercultural movements that proliferated 1960s artistic, social and political thought.

Cybernetics has branched out since its expansion in the '60s and '70s. Nicholas Negroponte's Architectural Machine Group produced a set of research projects which

brought together theories and practices of art, design, social sciences, science and philosophy to ask questions about the role of the citizen among new media and computer technologies. The Architectural Machine Group is where cybernetics was first formalised within the academy as a legitimate framework of theory and practice. Negroponte worked with Gordon Pask on networks and systems theory, sharing the view that the complexity of the world, with all its feedback loops and circular systems, must be preserved when studying it (2011). One of the foremost examples of contemporary U.K.-based work on cybernetics was the Cybernetic Culture Research Unit which operated out of the University of Warwick in the 1990s-2000s. Headed by Nick Land and Sadie Plant, the outfit's most famous outputs include the theory of accelerationism (capitalism must be replaced by its rapid advancement rather than halted) and a wide array of cross-disciplinary post-structuralist critiques of rave music, biomechanics and 1990s drug culture (Fisher, 1998). Cybernetics also continues through the American Society for Cybernetics (asc-cybernetics.org) and the International Academy for Systems and Cybernetic Sciences (iascys.org) which hosts annual conferences and curates articles and books for publication.

Across this 80 year history, it is cybernetics' experimentalism and commitment to performance which have remained consistent, as has its occupancy at the margins of the academy and formal institutions. Not only its theories and practices, but precisely this marginality appealed to me and shaped the project by offering a sense of validation to many of the methods employed in carrying out the work which often took the shape of something in between work, life and play—the interstices of ongoing experiments.

b) Social Practice History

Social practice offers a framework for thinking through collective authorship in the production of art outside the formal settings of the academy or artist's studio. The principle of participation is fundamental to social practice. Social practice oversees a shift away from the goal of the artist as producing 'high art', whereby art is considered an elite or special cultural object created for its own sake, towards thinking through how the co-creation of artworks can be used as an instrument for social change. As such, the history of social practice intersects with various changes in how sociopolitical life was organised, including the role of the arts in society and the relationship between the individual and the collective. Some of these changes took the shape of how art's ability to create social change was measured. Because of the collaborative and participatory nature

of social practice as it emerged from community arts programmes, there were budgetary requirements which necessitated the involvement of outside roles, often but not exclusively in the shape of the state. As such, numerical and quantitative metrics were introduced to funding criteria. However, this form of appraisal inevitably changed the internal composition of the roles involved in the production of the artworks as I will detail below.

Social practice tracks the dispersion of the role of the artist across a wider number of participants and commissioning bodies, thereby designating new responsibilities under its remit. As a community arts worker, I had first hand experience of helping with the government-sponsored response to the Oldham Riots. It was in this forum that I first encountered the shifting role of art in society, and the difficulties this presented in terms of the decisions concerning how funding was allocated and the benefits were measured. A report was commissioned by the government, the Metropolitan Borough of Oldham and the local police authority in the aftermath of the riots to try to establish their causes and propose solutions. The Ritchie report, named after the chairman of the review, David Ritchie, outlined a series of measures to address ethnic tensions, segregation and proposals for greater integration among the wider community:

> In looking for solutions, the Panel's guiding principle is that every recommendation, and every development in future for youth provision, must have at its core whether or not it will promote integration (Ritchie, p. 48).

What is interesting about the Ritchie Report and its detailing of the response to the Oldham Riots is this focus on 'integration' and how it was costed and measured. Integration obviously encompassed a wide set of concepts and metrics: ranging from ethnic and social forms of integration along demographic lines, to simply referring to opportunities for conversations between residents who might previously existed in isolation of one another, segregated by historical divisions. In view of achieving this somewhat amorphous goal, the report sought to harness the unique qualities of artistic projects to form opportunities for interaction between participants:

> The Panel were very impressed with Unity in the Community, a project promoted by Greater Manchester Police, Oldham Athletic Football Club, the Council's Sports Development Team and marketing company M2M. The project will help young people aged 9-11 over a full academic year to understand the different communities in Oldham. They will work through three themes: sport, which will involve professional coaching in football, team matches and a tournament ending in March 2002; academic achievement using poets working in primary schools, and the aim being production of a children's poetry book; and arts, involving children collaborating to produce large pieces of artwork. We are excited by this work, and any project which brings together young people from all cultural groups to learn and have fun together is a positive step for Oldham. There is funding for only one year currently (Ritchie, p. 51).

This brief passage from the report evidences the concerns which structure social practice as it grew out of community arts. During this shift, art also came to be used as a source of feedback in its own right—a barometer of the communities in which the projects took place, measuring the social wellbeing, interests and persuasions of those who took part. In this respect, on the one hand, art is instrumentalised a means for social change, but on the other hand its funding is contingent upon being able to measure and cost its effectiveness in doing so. The application of the quantified measurements to qualitative experiences posed various difficulties in attempting to adhere art into the practices of means-testing government policy. In this respect, the adoption of art as a means of producing different forms of interaction had the effect of dispersing the roles of artist, audience and artwork to become more collective, foregrounding the processes of participation over the aesthetics of any object produced. However, in turn, the logic of commissioning which grew out of this, whereby funding streams are contingent upon costing the value of the work in quantified terms, had a significant impact on the nature of the roles themselves—both in terms of their autonomy and integrity (by introducing preconceived requirements) and in terms of the goals of art itself (away from producing aesthetic experiences towards producing participation for its own sake).

This process of relating artistic production to measurable social benefits follows from a wider ideological shift beginning in the 1970s. Michel Foucault explains in *The Birth of Biopolitics: Lectures at the Collège De France, 1978-79* (2008) how this process emerges out of a theory of economics which sought to introduce activities traditionally not conceived as economic 'into the field of economic analysis' (p. 217). This was achieved by inventing the concept of 'human capital' as a means of remapping qualitative aspects of social life into quantifiable forms of value (p. 224). As such, Foucault explains,

> on the basis of this theoretical and historical analysis we can thus pick out the principles of a policy of growth which will no longer be simply indexed to the problem of the material investment of physical capital, on the one hand, and of the number of workers, [on the other], but a policy of growth focused precisely on one of the things that the West can modify most easily, and that is the form of investment in human capital. And in fact we are seeing the economic policies of all the developed countries, but also their social policies, as well as their cultural and educational policies, being orientated in these terms (p. 232).

In other words, this 'analysis of non-economic behavior through a grid of economic intelligibility' directly feeds into how art production (a social, amorphous and qualitative process) is conceived of in terms of quantifiable and measurable outputs (p. 248). Emerging out of the socially-focussed community arts movement, social practice inherited this line of thinking.

In many respects, the trajectory of social practice in relation to art in general is an inverse mirror of the relationship between cybernetics and the history and philosophy of modern science. Where cybernetics sought to supplement the ontology of rationalism and empiricism which characterises the modern paradigm, focussing instead on a ‘nonmodern’ circular logic and recognition of the expanded field of observation, social practice is symptomatic of the shepherding of modern quantitative analysis into a nonmodern field of qualitative, experiential form. Arguably, this was not only the result of the type of funding requirements detailed above, but was also augmented and extended by the sheer amount of data which would soon become available in such situations due to the proliferation of digital media and online communication platforms.

Due to changes to the roles of art and artists in society, both of which extended to include the role of the audience in the production of the work, the systems surrounding artistic production also changed. The task of measuring and evaluating the work became increasingly numerical, producing a set of issues concerning whether qualitative experiences can be assigned quantitative metrics. In turn, if so, this raised the question of how the application of such quantitative metrics would change the nature of the work for better or worse, further reformatting the relationship between the roles of artist, audience and artwork in the process.

3. Philosophical Context

a) Nonmodern Ontology

As before, this section on the philosophical context of the project will be divided into three subsections. The former introduces the ontological concerns which underpin the research question and join the theories of cybernetics and social practice. The latter two cover their respective philosophies directly. It should be acknowledged that this is just one way of framing the philosophical history of the work undertaken for this PhD, and the choices of what to include are informed by decisions about what makes the research and the contribution to knowledge most clear.

Both cybernetic philosophy and social practice philosophy intervene in traditional philosophical paradigms which create divisions between nature and culture and science and aesthetics. To the extent cybernetics and social practice challenge the borders between the roles of artist and audience and art-as-object versus art-as-process, they can be thought of as symptomatic of what Pickering calls ‘nonmodern ontology’. Ontology describes the first principles of being. Where epistemology focuses on the content of ideas

and objects, ontology is concerned with the relationships between them—where the limits of an object begins and ends, and where the links become part of the object itself or remain an interface. My interest in social practice and cybernetics as frameworks to analyse the experiment-performances stems from their shared concern for such relationships. At their core, social practice and cybernetics diverge from the ontological presuppositions preserved by philosophers since René Descartes wherein the world is cleanly bifurcated between 'mind' and 'body', the immaterial and the material, and the observer and the observed.

To arrive at a 'nonmodern ontology' we must first establish what is meant by a modern ontology. In We Have Never Been Modern (1991), Bruno Latour argues that 'modernity is coextensive with a certain dualism of people and things', and in turn, 'that key features of the modern West can be traced back to dichotomous patterns of thought which are now institutionalized in our schools and universities.' Using the example of the debate between the political philosopher Thomas Hobbes (1588-1679) and the natural scientist Robert Boyle (1627-91), Latour observes how

> Boyle and his countless successors go on and on both constructing Nature artificially and stating that they are discovering it; Hobbes and the newly defined citizens go on and on constructing the Leviathan by dint of calculation and social force, but they recruit more and more objects in order to make it last. Are they lying? Deceiving themselves? Deceiving us? No, for they add a third constitutional guarantee: there shall exist a complete separation between the natural world (constructed, nevertheless, by man) and the social world (sustained, nevertheless, by things) (1991, p. 31).

'Against this backdrop', Pickering contends that 'cybernetics thus stages for us a nonmodern ontology in which people and things are not so different after all' (2010, p. 18). Rather than progressing linearly, the relationship between the natural, the mechanical, the cultural and the political exist in dynamism, their borders repeatedly redrawn. It is precisely the very constitution of these borders which cybernetics interrogates through its study of circularity and feedback. Social practice, in turn, explores how they function in the production of art with respect to the roles of artist, audience and artwork. By using biofeedback technologies in audiovisual performances, this project sought to continue the challenging of these limits, bringing together what are otherwise deemed separate fields of knowledge. Using neuro headsets and heart rate monitors to interface the participants and their environment, I attempted to blur the borders between the human subject, technical objects, and the spaces which host them. As such, the project is positioned to identify the interrelation between fields, e.g. between neurology and philosophy and between science and aesthetics.

Against these historic tendencies, many of these new conceptual forms were being

worked through by philosophers under the rubric of ‘phenomenology’. Phenomenology began in earnest with the work of Edmund Husserl, specifically his text *Logical Investigations* published in two-volumes in 1900. Broadly defined, phenomenology takes as its focus the study of consciousness, defining itself against the classical Cartesian mind-body split. Instead, phenomenology understands consciousness as situated, the mind instantiated in a network of social and material relations. In turn, the body is retrieved from being treated as merely a technology of mind to becoming seen as coextensive with it (Merleau-Ponty 2002, pp. 77-234). My project attempted to harness biofeedback as a way of challenging the bifurcation between mind and body and between the body and technology, and therein between the roles of artist, audience and artwork.

Heidegger is instrumental in steering phenomenology from being understood as a branch of philosophy to a way of practising it. In his magnum opus *Being and Time* (1927), he describes it in the following terms:

> The term ‘phenomenology’ is quite different in its meaning from expressions such as ‘theology’ and the like. Those terms designate the objects of their respective sciences according to the subject-matter which they comprise at the time. ‘Phenomenology’ neither designates the object of its research, nor characterizes the subject-matter thus comprised. The word merely informs us of the “how” with which what is to be treated in this science gets exhibited and handled (2001, pp. 58-9).

In effect, Heidegger challenges Descartes’ maxim—*cogito ergo sum* (‘I think, therefore I am’), suggesting that what is missed by such a starting point is the very concept of being itself, or ‘the *meaning of the Being of the* '*sum*'.’ In response, Heidegger ventures a distinction between being as a quality of objects and being ‘as becoming’, or what Simon Critchley describes as ‘being-in-the-world’ (2009). The word Heidegger uses for this is *Dasein*, a term which invests a greater sense of emergence, openness and the interaction between processes in flux (Heidegger 2001, p. 46). Rather than subjects and objects existing in static, linear relation to one another, they grow, morph and change in feedback, ‘becoming’ one or the other depending on the given context. In the second experiment-performance, by using a transparent screen for the visual projections, the audience were able to see one another literally through the artwork, blurring the limits between them as both 'perceiving' subject and 'perceived' objects of the work.

This fundamental distinction underlies what Pickering means by a ‘nonmodern ontology’ and is what phenomenology describes and cyberneticians attempted to act out through experiments, as detailed below. This emphasis on practice and method—the ‘how’—makes cybernetics appear as its logical extension, especially given the focus on the blend of both philosophy and science. In turn, the focus on process over object and on

blurring previous dualisms between subjects, objects, people and things, aligns phenomenology with the purview of social practice.

In the work of Maurice Merleau-Ponty, the question of art and aesthetics takes centre stage in responding to these theoretical propositions. In *Phenomenology of Perception* (1945), Merleau-Ponty elaborated on the investigations of Heidegger and Husserl in an examination of the situatedness of perception:

> In so far, then, as there is consciousness of something, it is because the subject is absolutely nothing and the 'sensations', the 'material' of knowledge are not phases or inhabitants of consciousness, they are part of the constituted world (1962, p. 276).

Once again we encounter the notion of being as 'being-in-the-world' rather than being as a static quality. The focus here is on the interaction between sense and matter and their commingling through the act of perception. In turn, this extends to the body for, as Merleau-Ponty has it, 'to be a body, is to be tied to a certain world, as we have seen; our body is not primarily in space: it is of it' (p. 171). The concept of aesthetics anchors both the sense of embodiment and social situatedness, which Merleau-Ponty identifies, writing that 'it is in this sense that our body is comparable to a work of art. It is a nexus of living meanings, not the law for a certain number of covariant terms' (p. 175). In other words, rather than absolute or fixed, bodies—like artworks—are co-authored and exist in flux. Both are part of emergent processes and subject to ongoing interaction with other bodies and their environment, redefining their roles in the process. For example, as I will detail later, the decision to project the graphic signatures onto translucent screens such that the audience could see each other through them, blurring the distinction between the subjects and objects of the work, was informed by and attempted to enact these concepts. The work was designed such that each participant and spectator were not just 'in' the performance space, but rather one 'of' its constitutive parts.

Cybernetics and social practice channel this history of nonmodern ontology. 'As well as' (not 'instead of') this, they posit the centrality of interaction and participation to supplement the modern paradigms of linearity and clearly defined limits between 'things'. Therein, the roles within a given system are always contingent upon their respective contexts. It was this very contingency and interfacing of roles which the system I designed attempted to model.

b) Cybernetic Philosophy

To make explicit the links between cybernetics and this nonmodern ontology of situatedness and embodiment, let us consider some of the main theories which were explicitly developed by its practitioners. Cybernetics is animated by the attempt to supplement a linear model of understanding systems with a circular one, as well as also foregrounding the concepts of emergence, integration and situatedness. By reflecting on these concepts it becomes possible to imagine how the circular relationships produced by biofeedback in live audiovisual performances can cause the roles of artist, audience and artwork to become either integrated with (as represented by the Venn diagram), or situated within (as represented by the concentric circles), one another.

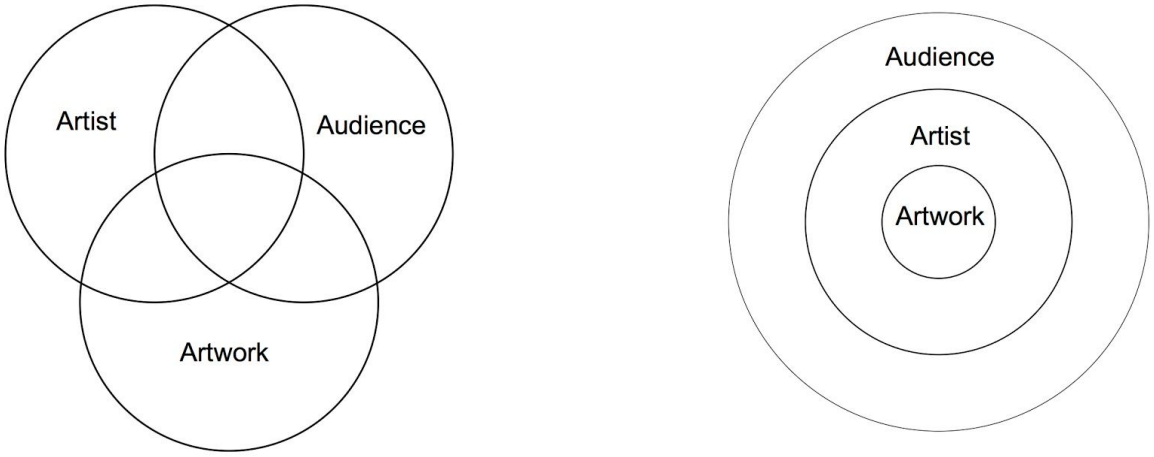


Figure 1: Edmonds, O. and Kaushal, V. (2018). A diagram visualising the difference between the integrated and situated relationships between the roles of artist, audience and artwork. Telephone conversation with Orlando Edmonds, 15 December.

Whilst Norbert Wiener is accredited with instigating cybernetic philosophy, the Macy Conferences on cybernetics (1946-53) with which his work is associated played host to a number of important theorists, practitioners and scientists, each of whom contributed to the ongoing discussion of these issues. One conference discussion involved Norbert Wiener alongside the eminent scientists, physicians and theorists, Ralph Gerard, John Von Neumann, Walter Pitts, Julian Bigelow, Warren Sturgis McCulloch, and Frank Fremont Smith talking on the subject of, in McCulloch's words, the 'distinction between analogical and digital' systems and 'the question whether information be continuously coded or discretely coded' (Gerard 2016, p. 193). It begins with Von Neumann offering the following analogy:

> [I]f I toss a coin there is every possible position for the landing of the coin, a certain region where the coin stands on edge and one where it does not. That is the thing which makes

> the coin essentially a digital possibility. The | dynamic probability of the coin standing on edge is very small. In other words, we convert; in every analogical system we have a certain region that corresponds to a number in one way or another. In the digital systems these are made so that they consist of fields of attraction. We try to make the regions corresponding to the number, corresponding to the fields of attraction with indeterminate regions, as small as possible in between them so that the particle will develop itself in one position or another (2016, p. 178).

A coin toss conjures the image of a binary set of options, but in reality this is a simplification. In Gerard's words, 'there are gradations, as in non-Aristotelian logic, where a proposition can have shades of truth and falsehood' (p. 178). This is the basis of first-order cybernetic philosophy: the reality that, as Pitts describes, 'the physical system in general is a [33] complex of variables which can be continuous or discrete and connected by various dynamic relations which cause the variables to change as time changes, a complex which can be altered and affected by external inputs' (p. 185). Describing an observed system, for instance, as digital or analogue constitutes a reduction of complexity insofar as, quoting Bigelow, 'the statement that "something is digital" implies that you have as a referent something else which is continuous' (p. 187). The decision to describe a system as one or another bears an explicit relation to how we imagine its limits. While the coin is in the air, it is continuous (or what Heidegger might describe as 'becoming'), whereas if it is stationary and heads / tails, it can be described as 'being', 'digital', or 'discrete'. What cybernetics attempts to address is that neither is 'correct' as such, but simply constitute one possible way of drawing a line around an otherwise indeterminate set of possible relations to make the information able to be coded (i.e. to assign discrete, categorical values to what previously would have been non-discrete, continuous information). Such concerns structured the decisions involved in transferring the biometric data between softwares and in translating the biometric data into graphic and sonic signatures, particularly in knowing when to reduce the complexity of the information and when to retain it, preserving sufficient variety for it to be perceptible to the participant wearing the devices. Indeed, as Wiener explains:

> the whole habit of our thinking is to use the continuous where that is easiest and to use the discrete where the discrete is the easiest. Both of them represent abstractions that do not completely fit the situation as we see it. One thing that we cannot do is to take the full complexity of the world without simplification of methods. It is simply too complicated for us to grasp (p. 193).

First-order cybernetic philosophy foregrounds this abstraction when considering the nature of systems. It attempts to supplement the modern scientific paradigm by reintroducing circularity into the equation, revealing that linear and discrete systems often rely upon reductions of complexity to make them able to be coded but at the risk of forgetting their

originary and underlying continuity and situatedness. This applies, of course, as much to mechanical computer systems as it does to neuroscientific studies of consciousness and the brain (198). By creating a system which interfaced the neurological, 'continuous', 'analogue' data of brainwaves with the discretely coded graphic and sonic signatures, but then feeding these back into the room of participants, I attempted to expose and explore the complexities of these fundamentally distinct but intimately linked paradigms of organising knowledge. Where the graphic and sonic signatures amounted to simplified, digital objects, the system as a whole constituted merely a part of a wider system of interaction nested within other systems. The former amounted to a reduction of this complexity of the system's situatedness, but their presence exposed this very complexity by making clear the influence of the unseen, unconscious activity of the participants and therein, by extension, the audience and space itself.

Second-order cybernetic philosophy reflects upon the role of the observer in deciding upon these limits, and in turn this paves the way for regarding the social context of cybernetics. Second-order cyberneticians ventured a new 'performative' vision of a world composed of 'black boxes' with which we interact. In *The Cybernetic Brain*, Pickering thinks through how the cyberneticians of the 1960s crossed disciplinary boundaries to produce models of their theories in such a way that allowed for the openness and serendipity of uncertainty that the first-order cyberneticians had articulated but not yet put into practice. Pickering argues that this 'ontological theatre' presented a view of the brain as a performative rather than representational organism:

> cyberneticians[…] conceived of the brain as an immediately embodied organ, intrinsically tied into bodily performances. And beyond that, they understood the brain's special role to be that of adaptation. The brain is what helps us to get along and come to terms with, and survive in, situations and environments we have never encountered before. Undoubtedly, knowledge helps us get along and adapt to the unknown, and we will have to come back to that, but this simple contrast (still evident in competing approaches to robotics today) is what we need for now: the cybernetic brain was not representational but performative, as I shall say, and its role in performance was adaptation (2010, p. 6).

As Pickering goes on to elaborate, 'the sixties and cybernetics shared an interest in the performative brain, with the technologies of the decentered self as a point of exchange' (p. 82). In this respect, as itself a technology of this 'nonmodern self' (p. 83), biofeedback is of interest. By 'reading out "autonomous" bodily parameters such as brain rhythms and displaying them to subjects, thus making them potentially subject to purposeful intervention', biofeedback 'brings us face to face with a form of decentering of the self into a technosocial apparatus' (p. 85). In other words, biofeedback exposes the brain as but another blackbox: one which responds and interacts with its environment through the body

and whatever technologies are appended to it. Indeed, the first time the participants in the experiment-performances were introduced to the biometric devices, these too appeared and functioned as black boxes, their internal workings unknown to them. Even when they were explained, they remained relatively mysterious, such was the complexity of the technical knowledge required to understand them fully. The participants simply had to ‘perform’ with them to make them 'work' in the experiment-performances.

This discourse of black boxes and performance bears an explicit relation to the role of the observer in studying such systems. As Ranulph Glanville explains,

> what is vital, for the development of second order Cybernetics, is that the Black Box is essentially and crucially a construct of the observer. When we use this concept, we bring the observer into the process, rather than denying him (2008, p. 5).

For Glanville, it is in second-order cybernetics ‘in which the role of the observer is appreciated and acknowledged rather than disguised, as had become traditional in western science: and is thus the Cybernetics that considers observing, rather than observed systems’ (p. 1). In the system I designed, certain pieces of the software remained black boxes insofar as I was unable to ascertain the algorithms which translated the biometric data into categorical values at certain points in the process.

Beer’s theory of the VSM operates on the basis of trying to present points of contact between the observers and observed parts of a system, interfacing what might otherwise remain as black boxes. The VSM describes a structure of systems capable of balancing their autonomy with the capacity to reproduce themselves and remain viable (adapt) in a changing environment. In Pickering’s words, ‘the VSM offers a considered topology of social locations and relations, information flows and transformations that, to a considerable degree, promises a dispersal of autonomy throughout social organizations’ and is identified by its ‘adaptive, homeostat-like couplings between the various levels of the VSM’ (2010, p. 273). Beer’s theory of cybernetic organisational management informed how I used certain pieces of software when designing how particular parts of the system interacted. Specifically, rather than organising the nodes of the software’s functions and components in a hierarchical formation, I designed the relationships in such a way as to allow information to flow in both directions at any given point. Broadly speaking, second-order cybernetic philosophy faces outwards to the social world, foregrounding interactivity and ‘conversational’ (rather than monological) modes of approach. Beer’s thinking, therefore, became even more pertinent when applied to the live performance contexts for their involvement of participants and the literally conversational relationships which this induced.

Cybernetics contributes to this consideration of biofeedback and the roles within artistic performance by rethinking how systems are as much situated, integrated and circular as they are linear, separable, and discrete. The movement between first-order and second-order emphasises this by turning the lens onto the observer, expressing the extent to which all attempts to represent a given system always involve a reduction of complexity: the context is never wholly contained.

c) Social Practice Philosophy

The philosophical basis of social practice is multilayered, but chief among these layers are questions of definition.

Rather than to designate a set of thematic concerns or recurrent stylistic features, to discuss the 'aesthetics' of social practice is to describe a common set of approaches to making artworks and the processes involved, largely focussed around the principle of participation. This emphasis on participation has led certain critics and practitioners to call the genre of work I describe as social practice as 'participatory art' (Bishop, 2014; Matarasso, 2018). Rather than there being a correct answer as to which is the containing genre, how one chooses to frame their relationship simply positions them in relation to one another within slightly different histories and focuses. Having come to social practice by way of social work, the term social practice was more intuitive as I was interested in the context and value of the work as vehicles for social change. Matarasso positions the aesthetics of social practice within a longer history of the term aesthetics itself, tracing it back to when it was used to designate an elite category of creative production (in distinction to work of popular appeal) (2018). This definition and use of aesthetics, in Matarasso's eyes, bore an explicit relationship to certain philosophical presuppositions of the Enlightenment:

> the downside of the fine arts as defined by Kant and other Enlightenment philosophers was that they mistook the elite culture of their time and place for a universal form of supreme value and power; this idea has remained, sometimes unspoken and often unconscious, throughout Western culture until the 1960s (2018).

It is within the lineage of artists and movements which have resisted this paradigm of thinking about art that social practice is found, and its principles reflect this.

Nonetheless, the question of how to evaluate social practice for both its social outcomes and internal, experiential qualities persists, and there is a diversity of opinion in how these concerns are best addressed and what the consequence of this ethos has been on the quality of work produced. In *Use or Ornament* (1997), Francois Matarasso

describes a metricised aesthetics of social practice wherein the value of the artwork is quantified by its calculable material ends, e.g. improving participants' employability following their involvement in a given project. In *Relational Aesthetics* (1998), Nicolas Bourriaud describes an aesthetics of relationality which responds to changes in communication through new media technologies and globalisation. Finally, in *Artificial Hells – Participatory Art and The Politics of Spectatorship* (2014), Claire Bishop reviews the history of social practice, focussing on how its emphasis on participation has come to dominate evaluations of work within the field. This project is positioned somewhere in between these three works and the theories each thinker outlines. Whilst participation and interaction were central, as in Matarasso's ethos, I did not attempt to measure and cost each input and output in numeric terms. Bourriaud's interest in relationality and how the internet and new technologies have reformatted the art object to become process-oriented dovetailed with my work insofar as the technology I used hailed from both real-life friendships and online collaborations with software developers and the maker community. Bishop's retrieval of the 'aesthetic' as a category interested in sensory experiences derived from formally meaningful objects also describes a key aspect of this project. My interest was not in producing purely 'aesthetic' objects but in facilitating a hybrid of interactive, relational work which was process-based but still retained the value of meaningful experience derived from the formal qualities of the experiment-performances.

If the term 'aesthetics' describes the broader framework for analysing the whole of the artistic production process and its constitutive parts, then it is the word 'role' itself which must be thought through in order to establish the limits separating the parts themselves. The idea of a role evokes a performance (to 'play a role') and therefore something temporary. It also suggests a function (the 'role of 'x' in 'y''). As such, it is situated on a scale between an object and a process and does not rely solely upon the 'concept of the thing' (Merleau-Ponty, p. 63) in the sense of the strict separation which Latour identifies in the modern scientific paradigm (1991, p. 31). For our purposes, rather than attempting in vain to define the three roles upfront, let us simply note the subdivisions of the roles we are interested in. The micro-roles of author, creator, spectator, participant and actor are what we must reflect upon in order to grasp what, taken together, they amount to: varying degrees of artistic responsibility and the limits of the artwork itself. It is not enough to simply ask: 'what do each of these roles mean?'; rather we must ask 'what do each of these roles involve?' and 'where, when and how do they share features?'

Social practice describes a mode of artistic production which foregrounds process, participation and an emphasis on contextual considerations (ranging from audience to

site), but it also rests upon an often unstated presupposition of what the 'social' aspect of its practice is. Stefano Harney and Fred Moten's *The Undercommons: Fugitive Planning and Black Study* (2013), outlines a vision of social practice by repurposing the terms 'planning' and 'study'. To 'plan', by their proposed redefinition,

> is to invent the means in a common experiment launched from any kitchen, any back porch, any basement, any hall, any park bench, any improvised party, every night. This ongoing experiment with the informal, carried out by and on the means of social reproduction, as the to come of the forms of life, is what we mean by planning; planning in the undercommons is not an activity, not fishing or dancing or teaching or loving, but the ceaseless experiment with the futurial presence of the forms of life that make such activities possible. It is these means that were eventually stolen by, in having been willingly given up to, state socialism whose perversion of planning was a crime second only to the deployment of policy in today's command economy (2013, pp. 74-5).

The often overlooked question of what is distinctly 'social' about a given form of art production applies as readily to the 'social basis' of cybernetics which we outlined earlier. And 'study', as Moten's puts it, locates such activity in already existing social life: 'study is what you do with other people' (2013, p. 110). By introducing the system I developed into a live performance environment and inviting the audience to participate in it, the work immediately became invested with the dynamism and serendipity which becomes possible when people are introduced into the work as unplanned interactions are able to take place.

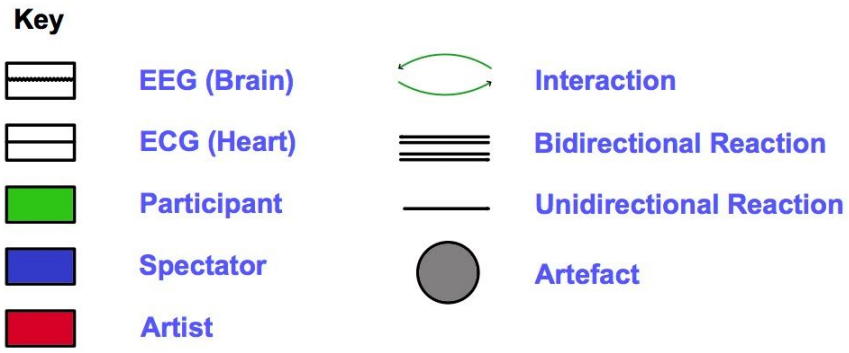
Whilst social practice cannot be adequately summarised under a unified mantle of philosophical principles, hopefully by foregrounding these three aspects—'aesthetics', the concept of 'roles', and the 'social'—it will be more apparent how the experiment-performances attempted to address the research question.

Between the philosophies underlying and produced by cybernetics and social practice, a common interest can be identified in challenging previous limits between categories and insisting on the social contexts in which these categories are formed. Taken together, they propose a set of counter-narratives to the traditional modern conceptions of how systems of production are defined and the nature of the roles they involve.

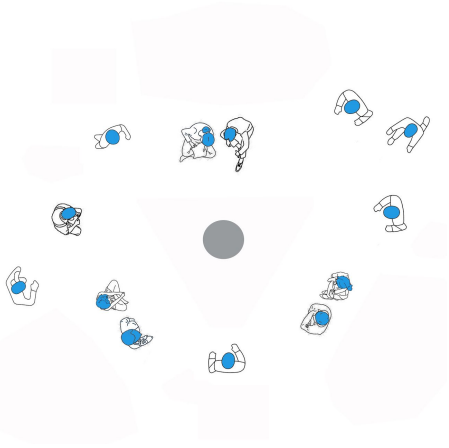
4. Aesthetic Context

a) Spatial Paradigms

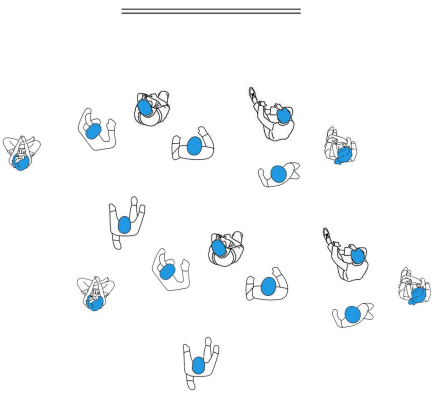
I will now discuss the aesthetic context of my experiment-performances, detailing the artists and artworks which informed my own practice. Before going into depth, I will first outline the different paradigms of presenting artworks which each example models and modulates. These should not be taken as fixed rules which the artworks strictly adhere to, but rather serve as guides of the spatial particularities of certain ways of organising the roles of artist, audience and artwork. In each case, throughout, what is noticed beyond their spatial organisation is the degree to which the divisions between the roles are challenged by varying levels of interaction and participation. The three paradigms denote either the presence of an artefact, a stage and performer(s), and a dispersed, 'participatory' model of creating artworks. Within the former two paradigms, there are two variants of the spatial organisation of the work in relation to the audience and, in the latter case, the artist. As the literature review proceeds through this aesthetic context, each considered work develops or subverts the paradigms to varying degrees, occasionally forming hybrid structures which combine all three. It is through this hybridity, where the roles of artist, audience and artwork are most dispersed, that the divisions between them are most challenged. In each spatial paradigm, a combination of audience members (either spectators or participants) are present, and, in some cases, alongside the artist. The relationships between these are either reactive or interactive, the latter defined by the ability for the relationship to be reciprocally influenced by the roles it connects. In certain cases, reactive relationships are only unidirectional insofar as they describe a one-way response, for example of an audience member to the artwork (the latter of which remains unaffected by the audience member's engagement with it).



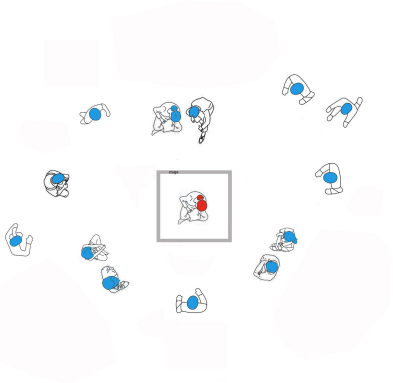
1. Artefact a)



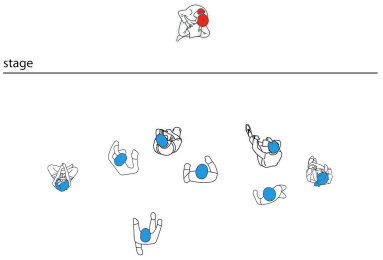
1. Artefact b)



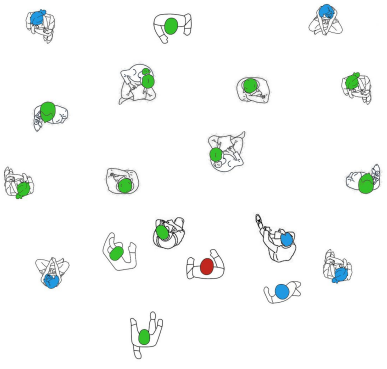
2. Stage a)



2. Stage b)



3. Participatory



4. Hybrid

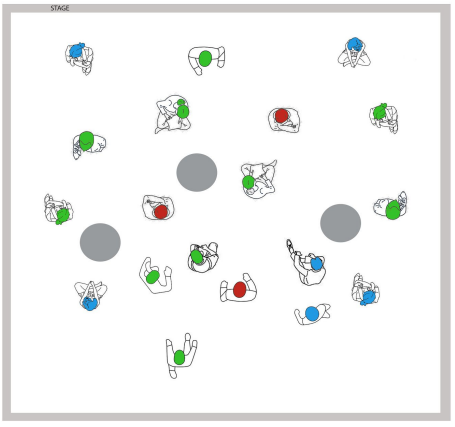


Figure 2: Kaushal, V. (2019). Paradigms of spatial arrangements of artworks and a key to the symbols used.

b) Cybernetic Aesthetics

i) Introduction

Cybernetic aesthetics can be separated into two categories:

1. works that are made knowingly under the rubric of cybernetic theory
2. works that model cybernetic principles consciously or unconsciously

Works falling under the latter category are not inherently less ‘cybernetic’; indeed, they can often extend cybernetics in serendipitous ways, supplementing oversights in the branch of self-identifying cybernetics. The following sections explore both: works which were made by self-identifying cyberneticians as explicit attempts at putting theories of cybernetics into practice as well as a repertoire of works which employ biofeedback to explore similar concepts of human-machine ‘conversations’ in artistic performances. It is this latter category of biofeedback aesthetics which assumes the role of supplementing and extending self-identified cybernetic art by focussing on the application of a particular set of technologies which tangibly model its core principles of circularity and feedback. I will detail the key instances in which biofeedback has been specifically used to manifest these principles, from its early use in the 1970s to the present day.

ii) 1950s - 1970s

In 1953, second order cybernetician Gordon Pask presented *Musicolour Machine*, a machine resembling a musical organ which when played would respond to the music by emitting light in varying intensity and colours. However, if the keyboardist’s playing became too repetitive, the machine would become bored and stop responding, plunging the room into darkness. The machine Pask created wasn't merely an instrument but rather approached the role of co-author of the performance. Neither the keyboardist nor the machine controlled the situation alone, rather, as Pask commented, ‘the performer trained the machine and it played a game with him’ (Pask 1971, p. 78).

Figure 3: Kerr, H. (1953) Gordon Pask with the *Musicolour Machine* (1953). Available at: https://we-make-money-not-art.com/molly_wright_steenson_is_a/ (Accessed 13th October 2019).

Figure 4: Kaushal, V. (2015). The spatial arrangement of Pask's *Musicolour Machine* (1953) as a variation on paradigm '1. Artefact a)' with the participants (green) among the spectators (blue). Whilst Pask's goal was to provide for the possibility of true 'conversational' interaction between the participants and the artefact, the reality was that the relationships should be considered as 'reactive' as the machine didn't have the ability to adapt its own behaviour beyond the ways Pask designed it to.

This work and the piece which followed modelled the features of one of Pask's key theories. 'Conversation theory' describes the mechanisms by which participants in a given situation enter into 'conversations' as a process of negotiating novel experiences, internalising information as new knowledge and committing it to memory by responding in real time. Conversation, in this sense, is not linguistic but behavioural, denoting a reciprocal interaction of learning and knowledge production between two or more participants. To articulate how this theory could be modelled by experiential aesthetic objects or situations, Pask (1971) coined the term 'Aesthetically Potent Environments', with which he referred to 'environments designed to stimulate pleasurable interactions' (Fernández 2009, p. 54). According to Pask, an artwork

which exhibited these features would ‘respond to a man, engage him in conversation and adapt its characteristics’ (Pask 1971, p. 76). By his definition, ‘conversation’ occurs within any adaptive system made up of mechanical and / or human actors. In turn, Pask wasn't interested in the content of the conversation but the process of the conversational act—specifically how it could be replicated and extended from human to machine and machine to human:

> Let us turn the design paradigm in upon itself; let us apply it to the interaction between the designer and the system he designs, rather than the interaction between the system and the people who inhabit it. […] [T]he designer does much the same job as his system, but he operates at a higher level in the organizational hierarchy[…]. Further, the design goal is nearly always underspecified and the ‘controller’ is no longer the authoritarian apparatus, which this purely technical name brings to mind (Pask G., 1969, p. 495).

In 1968, Pask presented the *Colloquy of Mobiles*, an installation made up of conversational machines at the *Cybernetic Serendipity* exhibition at the ICA, London. The work was a collection of what Pask described as ‘male’ and ‘female’ machines with which he developed a cybernetic model for interaction between the viewer and the artwork. These machines were suspended from the ceiling and ‘communicated’ with one another by transmitting rays of light towards adjacent machines which, in turn, affected their performative behavior. Made up of sensors, mirrors and torches, the light would strike a mirror located inside one of the mobiles, causing the mobile to move and rotate, reflecting the light onto other mobiles. The audience was also able to interact with the installation using handheld flashlights, creating an even greater variation in the performance of the mobiles. Pask wrote:

> Man is prone to seek Novelty in his environment & having found a novel situation, to learn how to control it[...], […]these propensities are at the root of curiosity and the assimilation of knowledge. They impel man to explore, discover & explain [...]. [T]hey lead him into social communication, conversation and other modes of partially co-operative interaction [...]. My contention is that man enjoys performing these jointly innovative & cohesive operations. Together they represent an essentially human and inherently pleasurable mode of activity (Pask G., 1971, p. 76).

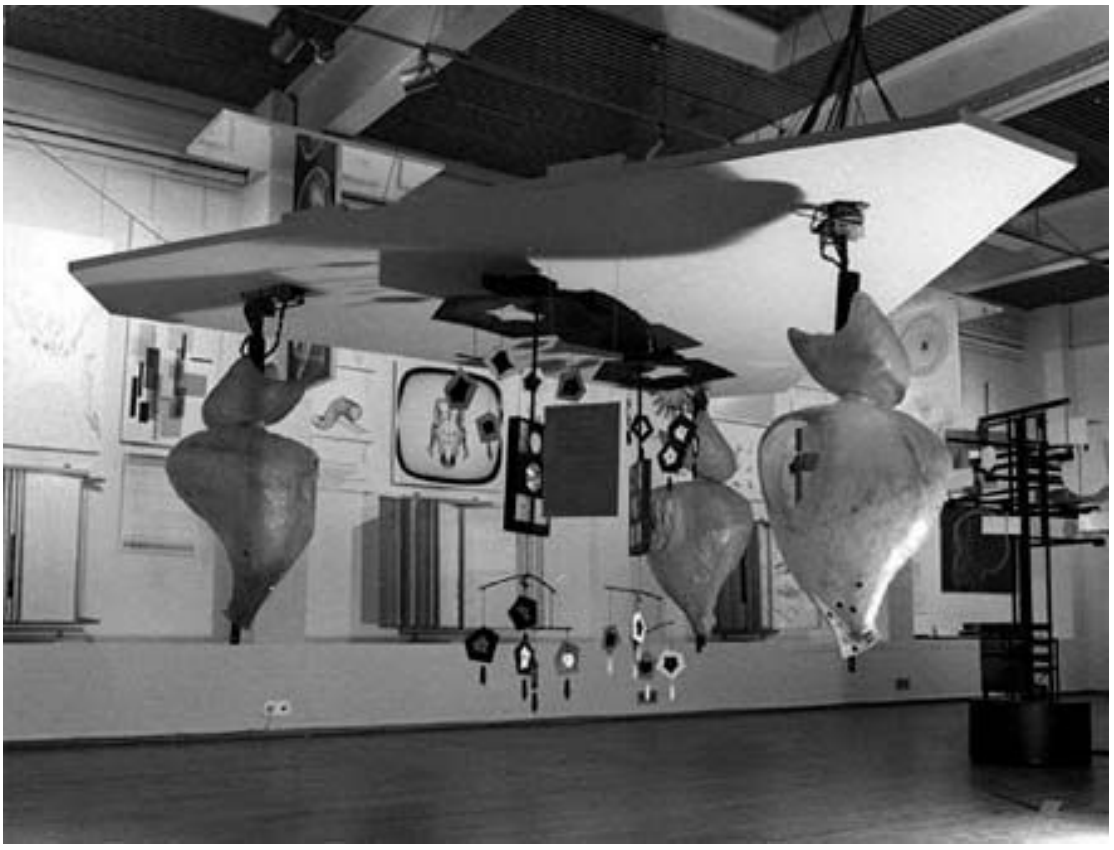


Figure 5: ICA London (1968). *The Colloquy of Mobiles* by Gordon Pask (1968). Available at: http://www.medienkunstnetz.de/works/colloquy-of-mobiles/images/8/#reiter (Accessed 13th October 2019).

Pask noted a distinction between the two works. *Musicolour* was less sophisticated—an example of a merely 'reactive' environment as it didn't develop new goals for its own performance. Meanwhile, through the development of *Colloquy of Mobiles*, Pask understood that the introduction of human participants allowed for a more open-ended range of 'interactive' performance possibilities. This distinction, between reactive and interactive, is integral to this research and in developing an adaptive system capable of mediating biometric data and aesthetic outputs. During the design of the experiment-performances, I attempted to model these principles of having characteristics of 'living' systems which would morph and change rather than simply respond in simple, linear ways.

Figure 6: Kaushal, V. (2015). The spatial arrangement of Pask's *Colloquy of Mobiles* (1968) as another variation on paradigm '1. Artefact a)' also with participants (green) and spectators (blue).

Since the 1970s second order cybernetician Roy Ascott has developed work which deals with the relationship between art and computer technologies. Perhaps most acclaimed for coining the term 'telematics' to describe the use of computer networks as an artistic medium, Ascott contrasts what he terms the '[visual] channel of communication' of traditional artworks with new aesthetic 'modalities' which induce 'the intimate involvement of the spectator':

> Although in painting and sculpture, the channel of communication remains largely visual, other modalities—tactile, postural, aural—are employed, so that a more inclusive term than "visual" art must be found, and the one I propose is "behavioral." The artist, the artifact, and the spectator are all involved in a more behavioral context. […]A feedback loop is established, so that the evolution of the artwork / experience is governed by the intimate involvement of the spectator. As the process is open-ended, the spectator now engages in decision making (Ascott R., 2008, p. 110).

Ascott suggests that such intelligent instruments form a 'living' ecology that the human body can engage with, such that subsequent physiological responses are manifest and formalised in the artwork. This 'cybernetic stance invites both a change in the nature of art as object and, once more, a shifting in the power relation between artist and audience, somehow entraining the audience in their production and evolution' (Pickering 2010, p. 324). Specific examples of Ascott's work will be explored in the chapter on the Experiment-Performances.

Between Pask and Ascott, we can see how the original preoccupations of cybernetics—feedback loops, circularity, interactivity and conversation—were modelled through the adoption of new technologies and innovative systems design. From Pask, the key takeaway is the importance of modelling his concept of 'conversation', i.e. distinguishing between simply reactive and truly interactive engagement between the roles of audience and artwork. Ascott extends and elaborates upon this sentiment by calling for the use of technologies to enable the 'intimate involvement of the spectator', suggesting a level of engagement in which influence is reciprocally felt and imprinted on each actor within the performance of a work. During the planning and design stages, I attempted to extend the logic of the question of how the system could be set-up in such a way as to change and respond to behaviour by testing different configurations of biofeedback loops on myself.

The other dimension to 'cybernetic' aesthetics which is necessary to explore is the genealogy of biofeedback. Whilst not explicitly or exclusively practised by self-identifying cyberneticians, its process and function is characteristically cybernetic in principle as it connects the mind and the body with their environment through the use of technologies which extract and represent data from them.

It is in the work of Alvin Lucier that this technique begins. Lucier's *Music for Solo Performer* (1967) is the first known instance of brainwave data being used in the performance of a piece of music, and indeed in any artform. The system consisted of two electrodes attached to Lucier's forehead used to read alpha waves which were then translated into audio frequencies and amplified via a mixing desk. These frequencies were then routed to loudspeakers placed next to various percussion instruments, causing them to vibrate. This seminal use of the biofeedback loop offered new insights into the relationship between artist, artwork and audience by harnessing technology to intervene in the perceived separation between the performance artist and the performance object. During the first public performance, I borrowed from this idea of a top-down hierarchy where there is a performer controlling performance instruments by connecting single data streams to single participants. Notably, whilst Lucier's work was innovative in its use of biofeedback, its spatial arrangement modelled a traditional artist / stage / spectators paradigm (Figure 7). It was only by the second experiment-performance, *Neu-collective Consciousness*, that the data streams were combined, moving beyond Lucier's structure by inviting the spectators to participate.

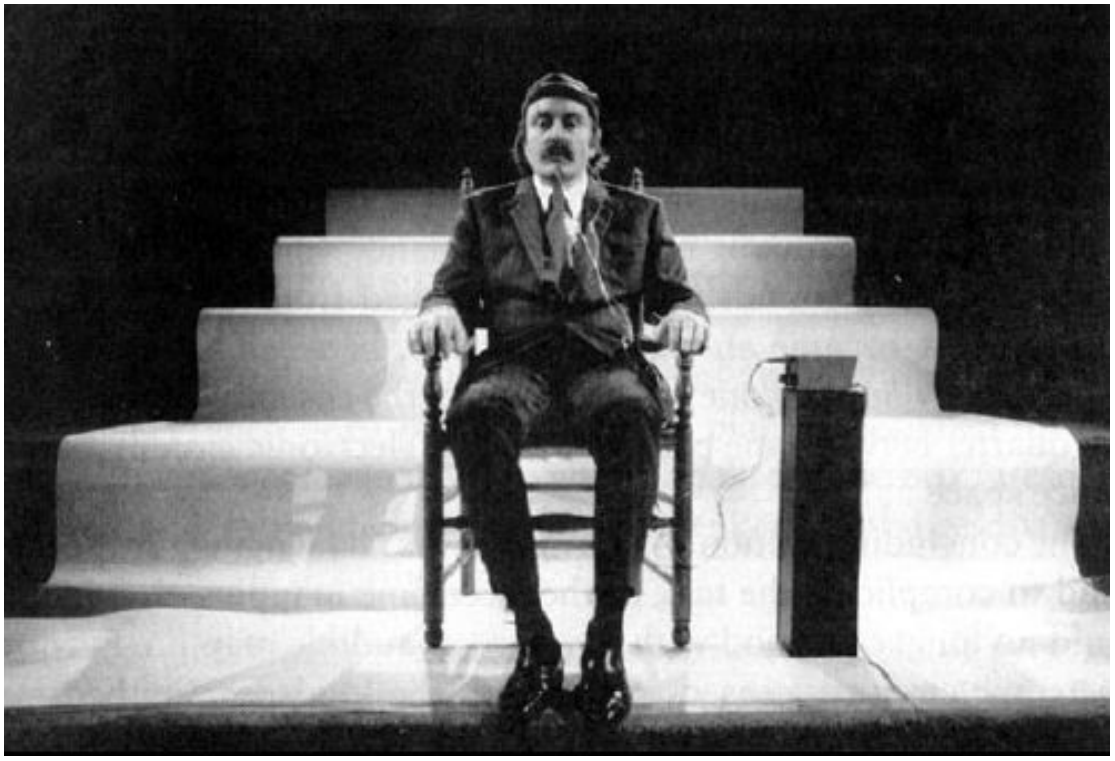


Figure 7: Lucier, A. (1965). Alvin Lucier's performing *Music for A Solo Performer* (1965). Available at: https://www.theguardian.com/music/musicblog/2014/jun/25/sitting-in-a-room-with-alvin-lucier Accessed 13th October 2019).

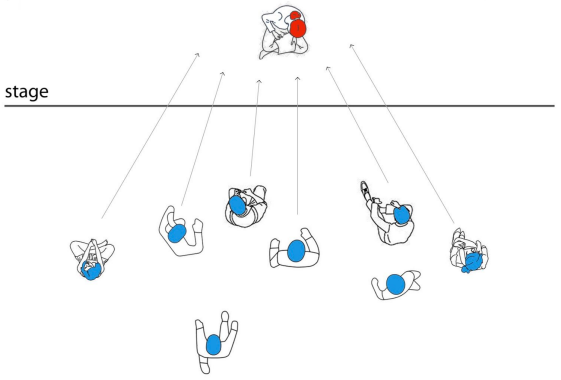


Figure 8: Kaushal, V. (2015). The spatial arrangement of Lucier's *Music for Solo Performer* (1965) as a variation on paradigm '2. Stage b)' with spectators (blue) and an artist (red). As the audience are uninvolved in any substantial capacity in the performance, their relationship to the artist remains purely reactive and unidirectional.

Building on Lucier's work, Richard Teitelbaum also explored biofeedback in his performance *Spacecraft* (1967) by using electroencephalographic (EEG) and electrocardiographic (EKG) recordings to control MOOG synthesisers. Each musician's thoughts and the images they conjured were translated through electronic instruments (contact microphones, synthesizers and others) into highly amplified sounds fed back from spatially distant loudspeakers—an electronically transformed "double" which mirrored the performers' internal subjective states. Teitelbaum updated the original system by introducing a second performer. This performance of the same year, entitled *In-Tune*, assigned different sounds to the signals from both performers within the composition to produce a network of microphones and EEG electrodes which were used to sonify the performer's heart rate, breathing and brain waves. Teitelbaum, acting as conductor, then manually played with the sounds generated. Interestingly, in this respect, a hierarchy was formed within the performance as the performers were guided by the conductor. Teitelbaum describes the moment he conceived of the installation:

> One night I had a dream, or a hypnagogic vision, in which I saw three reclining figures spaced along the perimeter of a round, diaphanous "tent", all bathed in a soft blue light and all wired together in a loop so that one person's brain waves controlled strobe lights and sounds perceptible to the next, he in turn passing this alpha signals similarly on to a third, and the third back to the first to close the loop. This image haunted me, and I decided to try and realize it electronically and musically (Teitelbaum, 1976, p. 35).

Figure 9: Teitelbaum, R. (1976). Diagram of *In-Tune* (1976), in *Biofeedback and the Arts: Results of Early Experiments*. Vancouver: Aesthetic Research Centre of Canada, p. 34.

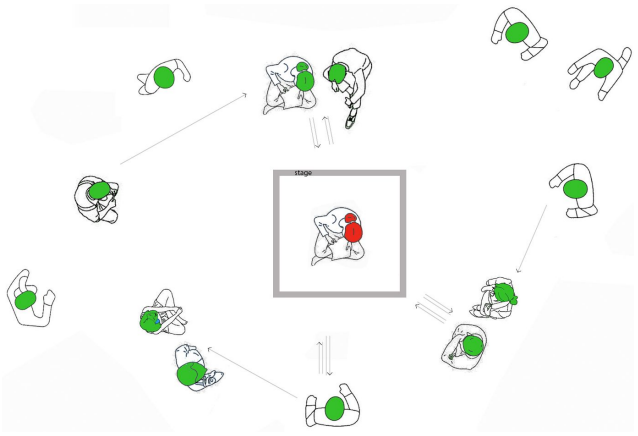


Figure 10: Kaushal, V. (2015). The spatial arrangement of Teitelbaum's *In-Tune* (1976) as a variation on paradigm '2. Stage b)' with participants (green) and an artist (red). Between the participants, the relationship is unidirectional reactive as they simply listen to each other's sonified data. Between the participants and the artist, the relationship is reactive but bidirectional as the artist modulates the sounds as they receive the audience readings in real-time.

It is interesting that Teitelbaum was the first biofeedback performer to foreground the audience-artist interaction by demonstrating how each individual present affected one another. My project builds on this work by deploying cybernetic methods to create a system that collects biometric data from the audience before rendering that data available for the artist(s) to use in the performance. Not dissimilar to *In-Tune*, I also attempted to evolve the hierarchical distribution of the outputs generated within the interrelation of the roles of audience, artwork and artist. What is more, Teitelbaum's diagram of *In-Tune* provided me with inspiration for my own spatial diagrams of the experiment-performances. By the second public performance, I attempted to incorporate this idea of combining the biometric data of participants to see the effect it had on the performance.

Teitelbaum's work would go on to inspire the work of David Rosenboom, who coined the term 'biofeedback'. He defined it as follows:

> [t]he presentation to an organism, through sensory input channels, of information about the state and / or course of change of a biological process in that organism, for the purpose of achieving some measure of regulation or performance control over that process, or simply for the purpose of internal exploration and enhanced self-awareness. Normally, this information will be of a type not otherwise available to that organism. It does not presuppose, however, that such an external indicator could not, through disciplined practice, be replaced by an internal mechanism of which the subject can achieve awareness without the aid of an artificial monitoring system (Rosenboom, 1976).

Defined in this way, biofeedback presents a clear and useful way of putting cybernetic principles into practice, especially for its applicability to questions concerning the brain and consciousness.

Rosenboom described his work as an extension of the human nervous system as the systems he designed recognised and responded to measurable neural aspects of music perception. He synthesised the work of experimental psychologist Leo DiCara and Neal Miller, whose research into the nervous system demonstrated that animals had the capacity to influence the behaviour of their own bodily functions such as heart rate, blood pressure and other metabolic processes which were previously thought to have been immune from conscious influence.

Ecology of the Skin (1978) was, in Rosenboom's words, an 'environmental - demonstration - participation - performance' event (1990, p. 49) in which he recorded the brainwaves and heart rates of performers and audience members also by using EEG and EKG recordings. The signals generated were translated into music and light. Ten participants held a small box which recorded their individual brain activity. This data was used to trigger a single tone specific to each individual, creating a rich percussion of varying tones. The volume of the tone produced correlated with the length of time the participant was able to sustain the same brain wave (1990, p. 50). Rosenboom saw the collaborative nature of the biofeedback loop as an opportunity to better understand ourselves mentally and physically, enhancing and extending the connection between the audience and their environment.

Figure 11: Moore, P. (1970). The performance of *Ecology of the Skin* by David Rosenboom at Automation House, New York (1970). Available at: http://4columns.org/dayal-geeta/david-rosenboom (Accessed 14th October 2019).

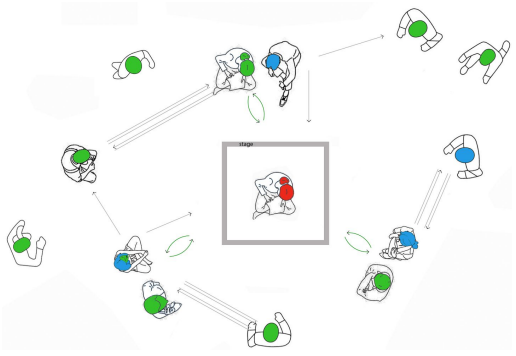


Figure 12: Kaushal, V. (2019). The spatial arrangement of Rosenboom's *Ecology of the Skin* (1970) as another variation on paradigm '2. Stage b)' with spectators, participants and an artist. Between the participants, the artist, and one another the relationships are interactive. Between the spectators and the artist, the relationship is bidirectional reactive.

Rosenboom's work greatly informs this research as he is responsible for setting out the parameters and framework of biofeedback. There are many parallels between Rosenboom's live event portfolio and what I attempted to achieve. Rosenboom retains the role of conductor whilst nevertheless distributing authorship across other participants, therein building upon the narrower distribution of authorship in Teitelbaum's work which involved fewer performers and participants. My project attempted to mediate a similar distribution of authorship, and by the final experiment-performance, an even further degree of authorship was relinquished by the role of the 'conductor' than had been by both Rosenboom's and Teitelbaum's works. My work also borrowed from the logic of a stage in the round, where in the third experiment-performance I introduced the pyramid projector in the middle of the room.

These examples demonstrate a specific insistence on the performative aspect of the technologies. In each case, this was achieved by the creation of a biofeedback loop which unites the mind and body and, in turn, both of these with the environment they are

in. As such, those involved are made conscious of their embodiment and situatedness within an environment, and therein their connection to one another. In this way, none of Lucier, Teitelbaum or Rosenboom were in the business of directing biofeedback towards some further, outside use, but rather were focussed on the artistic value of the performance itself as capable of producing meaningful experiences in its own right.

iii) 2000s – Present

During the period of the 1980s to the 1990s, the interest in Cybernetics receded amidst a surge of interest in AI and the birth of the home computer which focussed research on systems thinking away from its early areas of study. It was not until the 2000s that the original strains of thought resurfaced, characterised by a series of attempts to implement these tools and concepts to continue reformatting the roles of artist, audience and artwork as well as the divisions between disciplines and their subcategories.

Artist Mariko Mori explored the use of biofeedback loops in her work *Wave UFO* (1999-2002). In this instance, three participants' real-time brain waves were projected onto the internal surface of a teardrop-shaped 'spaceship'. The participants are connected to electrodes which record their brainwaves, and this biometric data is then translated into projected images of varying shapes and colours which change depending on the types of brain activity being generated. In this example, the most dominant and active participant's biometric data is used to generate the audio-visual environment.

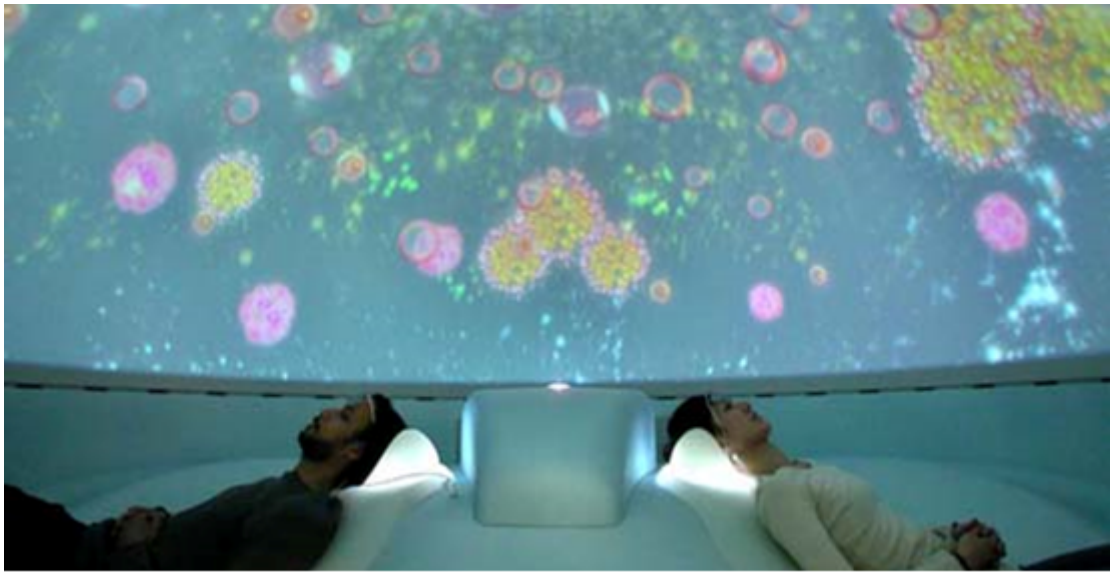


Figure 13: Mori, M. (2001). Participants inside the *Wave UFO* (1999-2002) installation. Available at: http://www.digiart21.org/art/wave-ufo (Accessed: 14th October 2019).

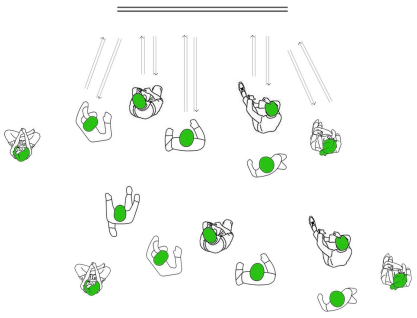


Figure 14: Kaushal, V. (2019). The spatial arrangement of Mori's *Wave UFO* (1999-2002) as a variation on paradigm '1. Artefact b)' with participants. Between the participants and the artefact, the relationship is bidirectional reactive because the participants influence the graphic signature, but only to a limited degree.

Mori describes the work as an exploration of 'oneness' through 'a truly connected audience' (Kortbek & Grønbæk, 2008). Artworks like *Wave UFO* mark a shift from earlier works like Teitelbaum's *In-Tune* insofar as they no longer have a conductor. Instead, the approach is bottom-up: the three participants' brainwaves freely form the entirety of the audio-visual experience without direct influence by an artist-as-conductor. Whereas Teitelbaum engaged the audience but maintained overall control, Mori enables three participants to directly create the audio-visual experience through a form of conversation without an artist present and in control of the audio-visual objects. Spatially, Mori's work builds upon the logic of viewing an artefact by having the artefact itself be a rendering of the spectators' biometric data, thereby producing a level of reactivity and making the spectators into participants. During the execution of the experiment-performances, I extended Mori's commitment to cultivating an environment which is sufficiently immersive as to allow for and enhance greater participation in the authorship of the work by further introducing an audience to the space rather than reserving or limiting attendance for those who are explicitly participating through the devices.

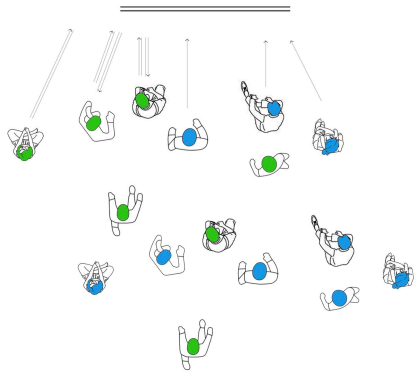


Figure 15: The spatial arrangement of Lozano-Hemmer's *Pulse Index* (2010) as a variation on paradigm '1. Artefact b)' with participants and spectators. Between the participants and the artefact, the relationship is bidirectional reactive, whilst the relationship between the spectators and the artefact is unidirectional reactive. This is because the participants can influence the artefact, but only to a limited extent, whilst the spectators are simply observing it without influencing it.

Rafael Lozano-Hemmer has created a number of works, which have explored the use of the body and its biorhythms, the heart in particular. One such work is *Pulse Index* (2010): a large-scale installation that records participants' heart rates and simultaneously collects fingerprints. The fingerprints immediately appear on a 10-meter video wall, pulsating to the participant's heartbeat. The piece collects, stores and displays data of any participant who has interacted with the installation. Having created a tapestry of archived

fingerprints and heart rates, the collected data is made visible to any further participants entering the performance space. Spatially, *Pulse Index* occupies a traditional 'artefact' paradigm, with the focus of the audience's attention being the screen upon which the biometric data is visualised. As with Mori's work, however, the innovation lies in the fact that the visualisation is produced by the participation of audience members and, in this respect, transforms the artwork to include the space and presence of the audience. Because the inputs and outputs of the work are relatively rudimental (a simple registry of fingerprints), the qualitative nature of the relationship between the participants and the artefact is reactive rather than interactive.

Figure 16: Science Gallery (2010). Rafael Lozano-Hemmer's *Pulse Index* (2010). Available at: https://opencall.sciencegallery.com/pulse-index (Accessed: 13th October 2019).

Pulse Room (Lozano-Hemmer, 2006) was a spatial installation, occupying a room with evenly-distributed, hanging incandescent light bulbs which used a sensor to record audience heart rates. The light bulb closest to the participant pulses to the rhythm of their heart rate. When the sensor is released all the lights turn off and the flashing sequence advances by one position along in the grid of light bulbs. At any given time, the room represents the heartbeat of the 100 most recent participants. Hemmer's installations are spectacular and engaging, however they are not explicitly concerned with the effect of biofeedback on the participant as the effect of immersing yourself isn't fed back into the artwork. During the planning of the system, I incorporated Hemmer's idea of archiving the data captured to feed back into its later iterations. Beyond this, Hemmer's work was also the first to inspire me to introduce heart rate into the system as well as brainwaves. Moreover, unlike Mori's work where the audience is synonymous with the participants, Hemmer's work was also the first to imagine how the participants' biometric data (rather

than the artist's, as in Lucier's or Teitelbaum's work) was transformed into a performance for an audience.

More recent examples of cybernetic aesthetics include Ruairi Glynn's interactive installation *Performative Ecologies* (2008). In this piece, a cybernetic system is created which draws upon Pask's conversation theory by enabling robots to monitor the attention of the participants. The robots have cameras which record facial expressions and attribute these to an associated level of engagement in the viewer. The robots compete for their attention by becoming increasingly 'expressive' in order to attract the most attention from the viewer. This behaviour isn't predetermined but is rather generated via the feedback loop. Individual participants, both human and robot, operate as performative agents, each acting independently but continually negotiating their choreography with each other to create a social system through feedback. As the robotic dancers gain experience, they share their knowledge with the larger ecology, dancing for each other, exchanging their most successful techniques and collaboratively negotiating future performances.

Figure 17: Glynn, R. (2010). *Performative Ecologies* installation (2010). Available at: https://www.researchgate.net/figure/Ruairi-Glynn-Performative-Ecologies-2008_fig4_281365606 (Accessed 13th October 2019).

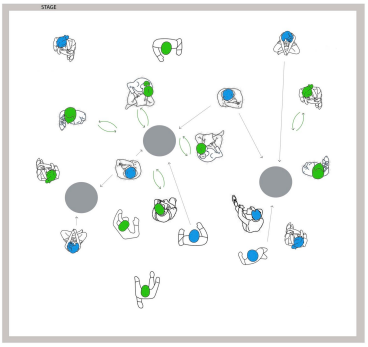


Figure 18: Kaushal, V. (2019). The spatial arrangement of Glynn's *Performative Ecologies* (2010) as a variation on paradigm '1. Artefact b)' with participants and spectators. Between the participants and the artefacts, the relationship is interactive because the two roles are able to engage with one another in the manner of a conversation, where each is reciprocally influenced by the other, learning and adapting their behaviour. Between the spectators and the artefacts, the relationship is unidirectionally reactive as they simply observe the performance taking place between the other roles.

Performative Ecologies expands on more conventional, linear systems of simple reactive installations such as Rafael Lozano-Hemmer's *Pulse Room* (which only has a predetermined response to system inputs). Glynn has uniquely developed an adaptive

system with the ability to share knowledge to the wider community of robots and human participants through ‘conversational feedback loops’. The system has the ability to change and develop as a result of their own learned behaviour. Glynn comments:

> Each operates autonomously, but as part of the larger ecology, share their knowledge and contributes to the performative qualities of the environment as a whole (Performative Ecologies 2012).

It is in this respect that Glynn explicitly inherits and pays homage to Gordon Pask insofar as his performative ecologies model the principles of Pask’s *Aesthetically Potent Environments*. Moreover, here Glynn emphasises the distinction between merely reactive and interactive (in other words, ‘conversational’) aesthetic systems (Glynn, 2016, p. 1). Glynn’s work was the first to introduce me to imagining how the principle of learning could be incorporated into the system design. However, instead of the system ‘learning’, it was I who learnt more about what influenced higher levels of participation and interaction, feeding this knowledge back into later iterations of the system. Spatially, the layout of the artwork models a hybrid of all three traditional paradigms: there is a level of dispersed, ‘participatory’ interaction between moving roles, ‘artefacts’ which participate in the interaction and are the focus of the spectators’ attention, and, by virtue of these interactions, the whole work becomes a performance wherein the entire space in which it takes place adapts to become a kind of ‘stage’.

Most recently, artist George Khut has explored the use of the biofeedback loops in medical applications. Khut’s *Heart Library Project* (2009) linked heart rate to visual stimuli as participants were asked to lie down on a table in a dark room holding a heart rate sensor while looking up at a projected image of an orb, the color of which changed depending on the frequency of their heart rate. In this way, participants learned to mediate their psychophysical condition through awareness and engagement with the biofeedback loop.

Khut’s subsequent work, *Distillery: Waveforming* (2012), explored the link between heart rate and pain control, specifically how controlling the rhythm of the heart had a positive impact on reducing physical pain. Khut developed software which graphically mirrored an individual’s heart rate to help children going through painful and anxiety inducing procedures. As soon as the patient began to control their heart rate, the graphics on the screen would start to transform and become more elaborate and hypnotic, thereby encouraging the patient to focus on controlling their experience, distracting them from their pain. Unlike Teitelbaum and Rosenboom, Khut’s work deviates from biofeedback for pure artistic performance, instead using the biofeedback loop as a medicinal tool in the manner

outlined above (georgekhut.com). It is also in this respect that Khut's work is exemplary of the theory of somaesthetics (Shusterman, 2012; Grammatikopoulou, 2016) which I will detail later. Spatially, Khut's work transforms the traditional audience / artefact paradigm into a personal, scaled down, individual experience with one participant per artefact.

Figure 19: Khut, G. (2012). Video portrait from *Distillery: Waveforming* (2012). Available at: https://vimeo.com/62140271 (Accessed: 13th October 2019).

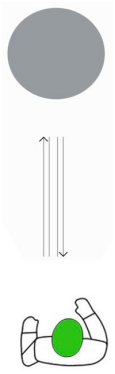


Figure 20: Kaushal, V. (2019). The spatial arrangement of Khut's *Distillery: Waveforming* (2012) as a variation on paradigm '1. Artefact a)' with a participant. Between the participant and the artefact, the relationship is bidirectional reactive because the participant influences the graphic signature, but only to a limited degree.

Offering an audience the ability to engage with real-time biometric data is a powerful way to experience the body, regardless of the form through which it is manifested—either as sound, image or another sensory object entirely. This is only made possible by the use of sensory instruments to mediate the bodies' responses. This cybernetic system of audience, machine and the visualization / sonification of data creates a new synergy between the artist-artwork-audience, offering new possibilities for co-authored performances.

iv) Summary

The artworks and practitioners listed above can be summarised in the following way. Gordon Pask introduces the concept of conversation to produce works which enable a level of interaction between the performer, the performance object, and the audience. This is later taken up and updated by Ruairi Glynn who evolves the concept of conversation by identifying a distinction between reactive and interactive artworks. Ascott's focus on behaviour also provides an interesting point of departure to think about the levels and

depth of true interactivity by investing the aesthetic principles of cybernetics with a social dimension. Once we arrive at Lucier, Teitelbaum and Rosenboom, the focus shifts to the technologies of biofeedback as a way of connecting with 'the self'—distinct from the previous practitioners who see their work as interfacing individuals with machines and vice versa. Mori and Lozano-Hemmer develop the focus on the environment and performative aspects of cybernetic aesthetics, continuing the interest in creating opportunities for interfacing with the self, but branching out to think about the sensory qualities of the environments in which such artworks take place. And finally, Khut's work harnesses the power of biofeedback technology to develop objects which serve a dual function as both artworks and medicinal tools, maintaining an interest in psychology, neurology and self-awareness.

The value of these works to my own project is twofold. On the one hand, Pask and Glynn's works introduced me to the application of conversation theory and, specifically in Glynn's case, the possibilities of developing complex coding to produce bespoke systems capable of modelling the questions I was interested in. The likes of Mori and Lozano-Hemmer, on the other hand, encouraged my interest in the more performance side of the production process, illustrating the importance of creating an atmosphere and environments in which such interactive processes would best be fulfilled.

Going forward into the aesthetics of social practice, the emphasis shifts onto the dimension of the 'performance' and what happens when the concept of participation is added to the discussion. Moreover, in departing from cybernetic aesthetics into social practice, the artworks themselves shift increasingly from an object-focus to being process-oriented, which in turn allows for different kinds of interaction between the roles.

c) Social Practice

i) Introduction

I will now provide examples of key social practice works and practitioners from its development in the 1970s to present, identifying its point of contact with cybernetics and exposing their shared conceptual frameworks. Doing so will aid me in addressing the research question by bringing the dimension of 'performance' to the fore and focusing in greater depth on the roles of artist, artwork and audience in light of social practice's concern with audience participation and interactive modes of artistic creation. To begin, I will situate the project in a longer history which includes practitioners not explicitly operating under the name 'social practice', such as Allan Kaprow and Joseph Beuys,

before going on to explore the community arts movement and the work of Francois Matarasso. The works considered here will serve as examples of, whilst building upon, the theories of social practice already outlined above in the work of Matarasso, Bourriaud, and Bishop. Running throughout each discussion is a continued interest in the words which comprise the aesthetic category itself: here, ‘social’ and ‘practice’ assume many forms and definitions, the heterogeneity of which contributing back to the sense in which the roles of ‘artist’, ‘audience’ and ‘artwork’ are not cleanly divisible under certain conditions of artistic production and, in particular, performance. One change which is interesting to note is the way in which the different venues for the performances and artworks have an effect on the expectations of the audience. In many of the works detailed below, rather than the works themselves, it is their setting and context which challenge the roles involved.

ii) 1910s - 1970s

Any discussion on challenging the divisions between the roles of artist, audience and artwork is indebted, if only indirectly, to the work of Marcel Duchamp. Though such a challenge could be traced back further, it is the inauguration of the 20th century’s concern for these divisions which is symbolised in the work of Duchamp, whose concept of the ‘readymade’ and found object sculptures are touchstones of contemporary art history. Perhaps the most succinct of Duchamp’s own statements on the subject can be found in his 1957 essay ‘The Creative Act’:

> All in all, the creative act is not performed by the artist alone; the spectator brings the work in contact with the external world by deciphering and interpreting its inner qualifications and thus adds his contribution to the creative act. This becomes even more obvious when posterity gives its final verdict and sometimes rehabilitates forgotten artists (Duchamp 1975, p. 140).

For Duchamp, the creative act is situated not just in the act of production, but in its reception by an audience who, in turn, participate in the production of the work by their very engagement in interpreting and evaluating its meaning and the aesthetic experience induced.

Following Duchamp, another early innovator who challenged the divisions between artist, audience and artwork through performance was Allan Kaprow. Kaprow is famous for a genre and process of art production known as ‘Happenings’. These events were curated by him and involved working alongside others to produce staged performances of experiential, theatre-like artworks. However, rather than following a strict script, these works were improvisational, following cues and steering rather than being determined by a

set of strict roles. The earliest and one of the most famous examples of these experimental performances was the eponymously titled *18 Happenings in 6 Parts* (Kirby, 1995). Hosted by the Reuben Gallery in New York, the work took place over the course of several days in 1959. Spread across multiple rooms, the audience were given cards on entry instructing them of the evening's course of events; multiple performances took place simultaneously as the audience moved between rooms to view the next in the sequence. The 'actors' were credited on cards, handed out on arrival, along with reference to the audience themselves (credited as performers in their own right) for their presence and subsequent participation in various of the event's activities.

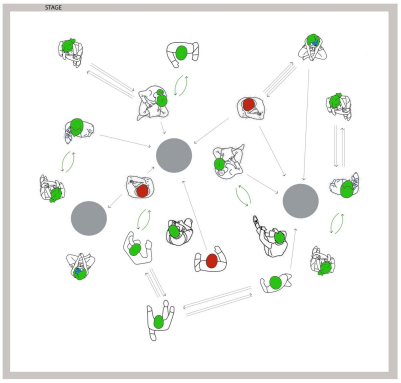
Figure 21: Kaprow, A. (1959). *18 Happenings in 6 Parts* (1959). Available at: http://www.medienkunstnetz.de/works/18-happenings-in-6-parts/images/3/ (Accessed 14th October 2019).

Through these Happenings, Kaprow interrogated the hierarchy separating the artist from the audience, the artwork coming to function instead as simply a site of experience. Jeff Kelley attributes this belief of Kaprow's to his inheritance of pragmatist philosophy from John Dewey. In an introduction to a collection of Kaprow's writing, Kelley writes:

> If a central theme runs through Kaprow's essays, it is that art is a participatory experience.

> In defining art as experience, Dewey attempted to locate the sources of aesthetics in everyday life. In defining experience as participation, Kaprow pushed Dewey's philosophy—and extended his own measures of meaningful experience—into the experimental context of social and psychological interaction, where outcomes are less than predictable (Kelley, 1993, p. xviii).

Figure 22: Kaushal, V. (2019). The spatial arrangement of Kaprow's *18 Happenings in 6 Parts* (1959) as a variation on paradigm '4. Hybrid' with participants and multiple artists. Between the participants and the artefacts, the relationship is unidirectional reactive because the participants don't have an influence on the artefacts. Between the participants and one another, the relationship is either bidirectionally reactive or interactive as they are able to engage with one another with varying degrees of agency Between the artists and the participants, the relationship is interactive because they are able to mutually influence one another.



By reframing art as a stimulus and vehicle of experience rather than foregrounding its object status or its capacity for knowledge production, Kaprow intervened in the degree to which the border of its role can be clearly delimited. However, each Happening still abided by some steering; control and influence of a given work's events were never totally relinquished, such that Kaprow's work becomes an example of how the divisions between the roles of the artist, audience and artwork are made porous rather than disappear entirely. Within this history of social practice, the expectations of the audience as to their role and its relation to that of the artist and artwork begin to be most challenged by the setting of the performance and its grounding in participation. Spatially, Kaprow's work is typical of early participatory artworks whereby the audience are interspersed throughout the work alongside the artist(s) and artefacts which serve as both props and part of the work in their own right (Figure 22). In this particular case, Kaprow's work also harnessed the capacity of theatre to produce 'performances', hence the sense in which the work also takes place on a 'stage', much like in Glynn's work some decades later. Due to the fact that the performance was steered but not entirely scripted, the qualitative nature of the relationships between the human roles would vary between being simply reactive and, in cases of greater 'conversational' depth, interactive. During the execution of the fourth experiment-performance, I extended this idea of the importance of participants being able to steer their own experience by introducing crib sheets which provided them with a set of instructions which by following them they would better understand how to influence the system.

Joseph Beuys introduces a further dimension to the longer history of social

practice through his contributions to the theme and function of pedagogy within and by art production and performance. Beginning as a more traditional performance artist, Beuys's career eventually comprises multiple threads each of which arguably fall under the same mantle of his artistic practice, but where their very heterogeneity challenges the definition of such a mantle. Beuys's earlier work is typically framed in the tradition of performance and conceptual art movements of the 1960s and '70s and is associated with the late Dada and Fluxus movements. In *How to Explain Pictures to a Dead Hare* (1965), hosted by the Galerie Schmela in Dusseldorf, Beuys appeared in a glass container cradling a dead hare, pacing around and muttering to it. In *I Like America and America Likes Me* (1975), Beuys flew to America to spend a few days living in a room with a coyote, equipped with only a felt blanket and a shepherd's crook. Emerging from the more explicitly conceptual performance art, among other ventures, Beuys would go on to be one of the founders of the Free International University for Creativity and Interdisciplinary Research (1974) and the German Green Party Die Grünen (1980).

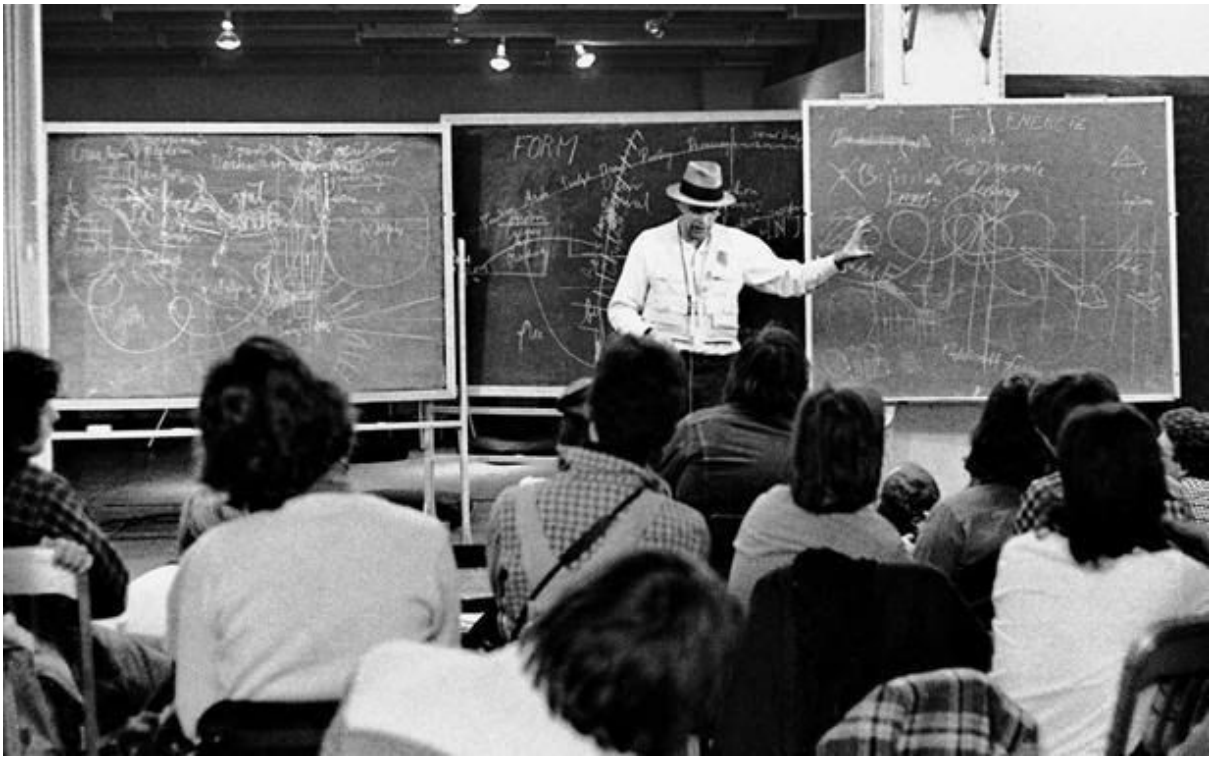


Figure 23: Staeck, K. and Steidl, G. (1974). Joseph Beuys's lecture at SAIC in 1974. Available at: https://www.pinterest.com/pin/504966176944206539/ (Accessed 13th October 2019).

What is interesting and instructive in Beuys's career is his own grappling with categories to describe his own artistic output. Across his practice and the multiple decades and geographies it occupied, Beuys elected to use terms ranging from 'social

sculpture' and 'action' to describe his earlier conceptual performance work to eventually stating that he believed his pedagogy was what he felt was his aesthetic contribution:

> To be a teacher is my greatest work of art. The rest is the waste product, a demonstration. If you want to express yourself you must present something tangible. But after a while this has only the function of a historic document. Objects aren't very important any more. I want to get to the origin of matter, to the thought behind it (Beuys, 1969).

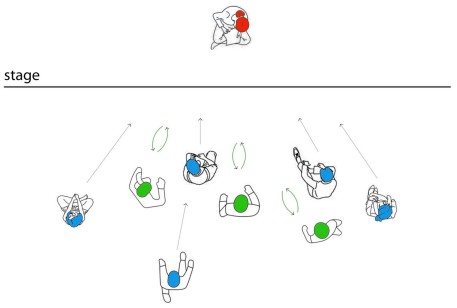


Figure 24: Kaushal, V. (2019). The spatial arrangement of Beuys's lectures as a variation on paradigm '2. Stage a)' with participants and spectators. Between the participants and the artist, the relationship is interactive as they engage through questions and answers in the manner of a conversation. Between the spectators and the artist, the relationship is reactive as they simply listen to the artist speak.

Ultimately, Beuys contributes to the development of social practice by emphasising the contextual elements of participation and co-creatorship that eventually become its cornerstones. Notably, Beuys' spatial organisation resembles that of a traditional performer on a stage, much like Lucier's *Music for Solo Performer* (1965). The difference here being that, with Beuys, the lectures invite open-ended dialogue. Unlike Kaprow's work which, whilst harnessing participation and relinquishing a degree of control, still retains an element of predetermination guided by props, in Beuys' lectures the participant can steer the direction of the work literally by engaging in conversation. Throughout the experiment-performances, I tried to model his expanded definition of the artist's role to include the importance of pedagogy. This was especially the case in the final experiment-performance in which outside experts from the fields of neuroscience and psychology were involved in order to educate and support the participants through workshops which were devised to provide them with a deeper understanding of how to influence the system.

iii) 1970s - Present

Beginning in the 1960s-1970s, community arts is another contributor to the development of social practice and site at which the divisions between the roles of artist, artwork and audience are challenged. In Claire Bishop's extended historical critique of participatory art, the community arts movement is included as one of the other key contributors to the development of the field (2012, 163-93). The work produced by any instance of

community arts has an inherently dispersed authorship. Bishop identifies The Artist Placement Group, which began in 1966 and was run principally by Barbara Steveni and John Latham, as one such example of a distributed practice. Its focus was on coordinating artists being placed into work settings, often in managerial offices in the industrial sector, where their presence could invite an exchange of knowledge between non-artists and artists. This was a unique take on the division of roles since, in Bishop's words, 'instead of pulling the audience into the work[…], APG operated on the inverse principle of pushing the artist *out* into society' (Bishop, 2012, p. 166).

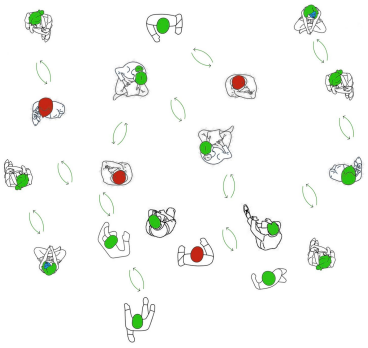


Figure 25: Kaushal, V. (2019). The spatial arrangement of a typical community arts project as a variation on paradigm '3. Participatory' with participants and multiple artists. Between all the roles, the kinds of relationships formed should be interactive as they should involve mutual learning, in-depth engagement and conversation.

Two further examples Bishop offers are the organisations known as The Blackie (1966) and Inter-Action (1972). The Blackie, based in Liverpool, offered local residents the opportunity to participate in performances under an 'open door' policy, whereby all interested were welcome to join. In Bishop's words, The Blackie was premised on a

> commitment to showing 'high' art alongside everyday productions of local people; early visitors included choreographer Meredith Monk and the jazz musician Jon Hendricks, while many of its workshops and social games have taken their initiative from avant-garde culture (John Cage, Merce Cunningham, Samuel Beckett, Liliane Lijn, John Latham) (Bishop, 2012, p. 179).

The Blackie was neither itself an artist, nor an artwork, nor an audience but rather a space where all three could meet, emerge, and combine together. This was also the model of Inter-Action based in Kentish Town, North West London. Among its various creative projects, the space coordinated public performances whereby actors would dress up as historical figures, such as the playwright William Shakespeare, and spend time in public places, inviting curiosity from passers by with a view to sparking discussion and encouraging learning about the character's historical context. Inter-Action and The Blackie also typify one feature of much community art in the form of the use and function of games and 'play' to invoke creativity, learning and participation (p. 182). As such, much of their activity was underscored by a commitment to cooperation and collaboration as key features of successful artistic endeavours, but also to the more therapeutic and political dimensions of their socially-facing work. Taken together, these three cases mark the start

of the period when participatory art begins to be regarded as a credible genre of art on its own terms. Spatially, this is the first time in which the arrangement of the roles is no longer organised around or in relation to a stage or artefact (Figure 25). Instead, participation becomes its own object of the work, and with the removal of any mediating objects, conversation becomes the principle medium of expression and communication, therein increasing the level of interactivity by investing each person involved with a greater degree of agency and open-ended possibilities for engagement. My approach to the project as a whole mirrors many aspects of these examples of community arts projects, particularly their principles of non-exclusivity and the value of bringing together professional and non-professional artists to collaborate together on each level of the design, implementation and performance. Testifying to this was the fact that each experiment-performance was billed as the work of the artist collective Logan and Wilcox, of which I am a founding member, rather than to me alone. More tangibly, this was apparent in the inclusion of the academics and commissioning bodies in the design of the performances, as well as the very fact of including the audience through the use of biometric devices.

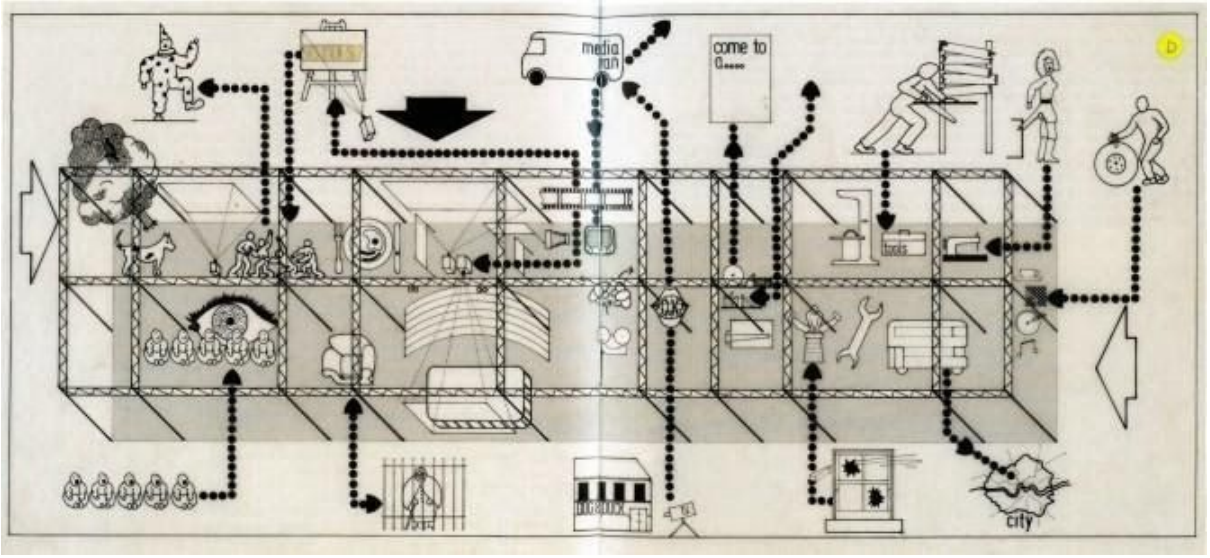


Figure 26: Price, C. (1964). Diagram showing different interactions within the InterAction building. Available at: https://medium.com/@agrimgrg22/drawing-notation-influenced-by-fun-palace-of-cedric-price-6a08676cba43 (Accessed 13th October 2019).

Bringing us into the more recent past of the 1980s and 1990s, Francois Matarasso is a key figure in social practice for his work both in facilitating and theorising works. Matarasso is also useful as someone who has attempted to define participatory art in general. For Matarasso, participatory art is distinct from community arts which instead

designates the organisations, groups and spaces which involve people in a given locality in the production of artworks. Participatory art, by contrast, is for Matarasso a ‘useful catchall term’ which includes a variety of subfields including but not limited to: community art, relational aesthetics, socially engaged practice, arts and health, applied theatre, and art activism. As such, Matarasso defines participatory art as simply ‘the creation of art by professional and nonprofessional artists’ (Matarasso, 2018). In turn, Matarasso also distinguishes between participatory art and art which simply involves participation; participatory art is distinct in that social change is central to its concerns, rather than artworks which position the social benefits as secondary (Matarasso, 2018).

In a seminal study on the field and its various offshoots, *Use or Ornament* (1997), Matarasso details a series of attempts made by the research body Comedia to evaluate the ‘social benefits’ of arts initiatives in Britain. Broadly speaking, here Matarasso’s interest was thinking beyond assessing art in either purely aesthetic or economic terms, assessing instead its ability to produce both meaningful experiences through its form and, simultaneously, measurable social outcomes. Crucially, Matarasso attempts to set himself apart from those who seek ‘monetarist’ defences of the ‘creative industry’ (where art is instrumentalised as a palliative or replacement to a shrinking welfare state), nor does he advocate that ‘participation in the arts’ should be thought of as ‘a form of, still less an alternative to, social policy’ (Matarasso, 1997). Instead, Matarasso details a variety of both qualitative and quantitative methods of measuring the ‘work’ produced by artworks insofar as they are able to contribute to a community’s cohesion, empowerment, image, identity and well-being. In other words, whilst Matarasso maintains that ‘the intangible and magical aesthetic of art[…] is its greatest use’, in assessing the various case studies overseen by Comedia, he concludes that ‘usefulness can be beautiful, and beauty useful’ (Matarasso, 1997). In other words, here, the roles of the artist, artwork and audience are not only expanded into an explicitly social realm of evaluation and influence, but are redefined precisely in their relation to being able to enter into this space. This expanded field of what we are referring to as ‘social practice’ allows for a clearer interrogation of how particular technologies and styles of performance enhance this theory of, and approach to, art production.

iv) Summary

Social practice contributes a unique perspective on the ways in which the particular form assumed by an artistic performance has a consequence on how we think about the division between the roles of artist, audience and artwork. Cybernetics lacks this precise

focus. The two fields share the features of interactivity and non-object oriented thinking as well as an emphasis on participation. However, social practice uniquely contributes to the ‘performance’ aspect of the research question. From its predecessors in the work of Duchamp, Kaprow and Beuys and to its earliest iterations in the community arts movement, right the way through its living practitioners such as Matarasso, social practice has continuously challenged the divisions between the roles in question if only by virtue of expanding the media and sites through which art making takes shape. This expanded field of artistic practice and the new mediums which come with it inevitably feed back into how the comprising roles are conceived and delimited.

IV. Methodology

1. Introduction

This section describes the process by which the system was originally planned and iterated, detailing the various technologies which were tested and identifying how existing practitioner knowledge was deployed alongside the new practices and frameworks discovered while doing so. Throughout, it defines the key terms used in discussing the system and the subsequent public experiment-performances. The methodology draws together ideas and approaches from a diverse array of subjects and forms of cultural production, ranging from neuroscience to interactive systems theory. The result is a system of networked biofeedback loops between participant data and audiovisual outputs. Together, this formed the basis of the three commissioned live performances.

2. Method

Across each stage of the development of the system and subsequent iteration of the performances, in accordance with the epistemological model of practice as research I was guided by a commitment to playful experimentation. Once I began testing the devices, I adapted and changed the system in accordance with what I discovered. The different instruments varied greatly in flexibility and how they affected the mobility of the participants using them. Certain of them were less accurate and reliable when it came to collecting the biometric data. Certain sensors had been developed to be open-source, while others operated within a closed source system. Instruments and software developed under both protocols were examined in order to identify their advantages and disadvantages. The instruments and systems were tested for factors such as what data is collected, how it is distributed, wearability, their robustness and reliability, and their level of accuracy, including latency.

a) Heart Rate: Devices and Data

I first set out to measure heart rate. All heart rates are unique as the heart muscle varies in size and shape, as do the orientation of the valves and the influence of an individual's general physiology. Measurements can be achieved in very simple, uncomplicated ways. For instance, doctors measure auscultation of the heart using a stethoscope to listen to the sounds of the heart caused by blood flow and closing valves or by pressing a finger against one of the major arteries on the wrist or the neck. There are other more accurate,

sophisticated clinical methods such as phonocardiograms (PCG), electrocardiograms (ECG), and pulse meters. However, these methods require expensive and large apparatuses which are difficult to obtain. Moreover, their physical characteristics are such that they would reduce the mobility of participants. As such, I decided I needed to develop my own version of a heart rate monitor based on other commercially available monitors, making adjustments where necessary.

The Arduino Microprocessor is an open-source platform of user-friendly microcontrollers commonly used to prototype instruments and devices similar to the ones we were testing. Used extensively by both the 'maker' community and professionals, Arduino allows users to build digital devices which interact with their environment through plugins which control physical devices.[2] Arduino has an extensive community of users who share and support each other's projects by offering advice, 'cookbooks', and libraries of code (Arduino Stack Exchange 2019).[3] These forums proved invaluable in the development of this project, especially during the creation of the heart rate monitor.

Following extensive research into the various applications of the Microprocessor, I identified the best way to assemble the hardware with the use of a plug and play sensor. This pulse sensor, which consists of an infrared LED and a light detector mounted side-by-side, extracts the heart rate data through contact with the fingertips or earlobes by measuring the difference in the amount of light being reflected back from the blood under the skin. It does this by transforming the mechanical pulsing action of the heart into an electrical signal, such that when the heart pumps, the blood pressure rises and the respective amount of infrared light emitted increases, reflecting this back to the detector. Subsequently, the detector creates more current as it receives more light, causing the voltage entering the amplifier circuitry to drop.

[2] The term 'maker' was originally coined by Dale Dougherty (2012, p. 11) to refer to members of the internet generation interested in producing tangible objects as opposed to creating objects entirely in the digital realm. The maker community is characterised by its DIY values of sharing tools, skills and indeed sometimes computer code to design and make instruments and devices for personal and collective purposes, often publishing such information on blogs, forums or a number of publications which serve the community.

[3] According to the coding website DevDungeon (*Cookbook*, 2019), 'a cookbook in the programming context is a collection of tiny programs that each demonstrate a particular programming concept. The Cookbook Method is the process of learning a programming language by building up a repository of small programs that implement specific programming concepts.'

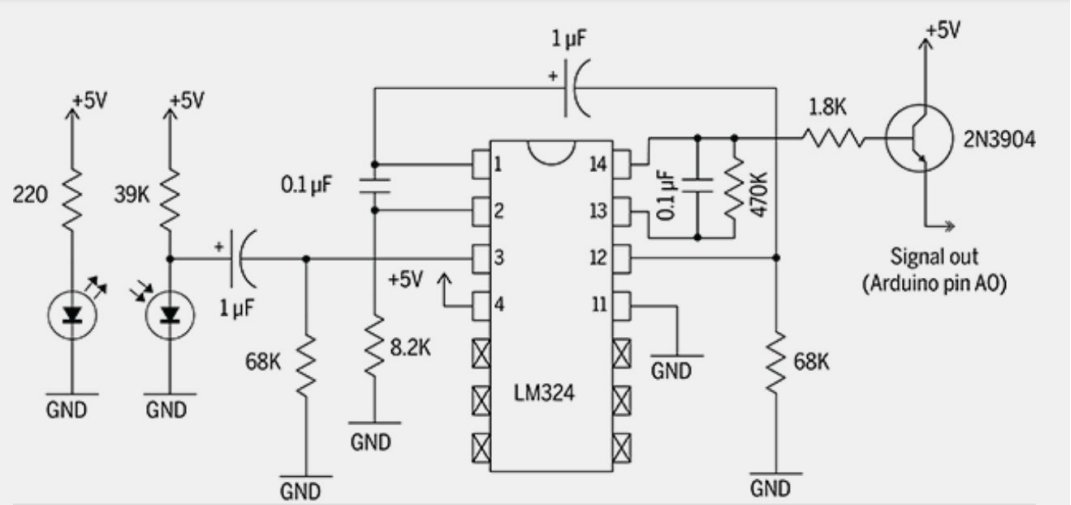


Figure 28: Ragan, S. M. (2013). Arduino heart rate sensor circuit diagram. Available at: https://makezine.com/projects/ir-pulse-sensor/ (Accessed 13th October 2019).

The sensor sends this data to the Arduino Pro which registers it in the Arduino's software. From here, the data is passed to a connected computer running the Java-based programming environment Processing where it is visualised.

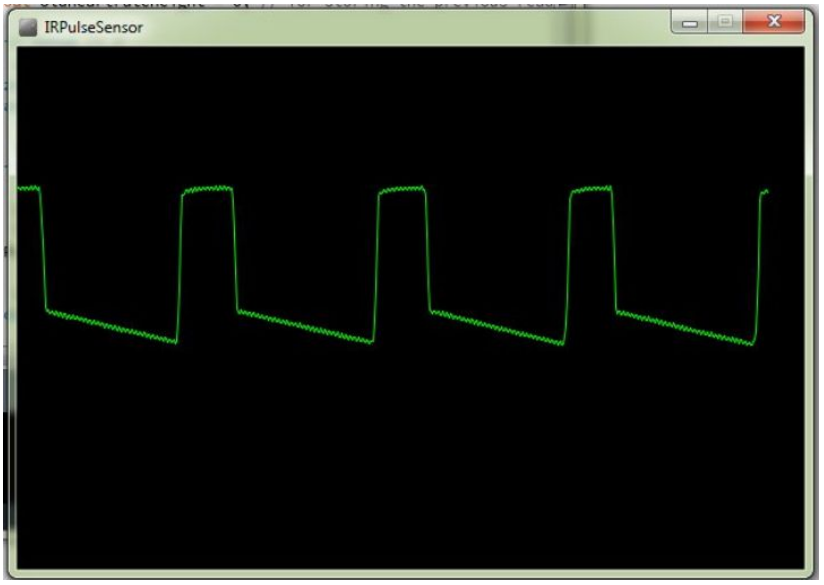


Figure 29: Kaushal, V. (2015). This Processing sketch illustrates an example of the graphic signatures created by visualising the biometric data.

The heart rate monitor required the participant to be physically connected to the computer which was undesirable as this limited their mobility. To overcome this, a Bluetooth module was implemented to allow the device to work wirelessly so the participant could move more freely. Having implemented this modification, the data was passed to the Arduino. From the Arduino it travelled via Bluetooth to the computer running the visualisation

software. This method was largely effective, but, whilst the system did not experience latency issues, implementation was not seamless. For instance, the hardware and software required to manage the data ended up needing to be custom built. Having tested the original hardware over the course of a number of days, it became apparent that it was insufficiently reliable for use in a live performance environment (detailed later) as the software intermittently crashed for no apparent reason, even after extensive debugging. Given the limited time scale of this research project, I was unable to adequately ensure the hardware was sufficiently robust for public use as we would have needed to have successfully tested the hardware for comfort, reliability and safety. My practitioner experience from previous installations had taught me that this kind of bespoke hardware would often fail after very little usage with issues typically arising from the quality of the assembled parts or low manufacturing standards.

Despite these obvious limitations and obstacles, this approach provided me with a richer knowledge of the data being generated and the available hardware and software, including what to look for when selecting components. The process brought me into contact with a wealth of well documented commentaries on the variety of options available when undertaking this kind of project. Indeed, it drew attention to the pertinent issues in this particular workflow, such as the phenomenon of transforming mechanical functions into electrical signals.

In contrast to the maker community's methods and techniques of sharing and DIY making, there are a number of commercially developed 'off the shelf' systems which offer comprehensive and robust hardware and software. These fall into two methods of developing systems: the 'electrical' and the 'optical'. The 'electrical' method predominantly uses a wireless chest strap to measure electrical activity generated by the heart, sending the data to a monitor worn on the wrist or to a device loaded with the monitoring software. The 'optical' method uses light sensors and emitters similar to the devices developed by the maker community. Many of the heart rate monitors were identified as 'fitness trackers' and had accompanying software which allows users to monitor their physical activity—from the number of steps walked to body temperature, heart rate and blood pressure.

As trackers like the MioLink and Fitbit are targeted at the fitness market, they tended to be ergonomically designed for usage during sport with greater emphasis on durability and wearability. On the whole, they were much more elegantly designed than the open-source devices. The hardware was largely constructed from durable materials and manufactured to a high standard. As commercial products, they were marked with the standard CE signatures, certifying the products conformed to safety standards required

within the EEA (European Economic Area). This expedited the process of developing a safe and reliable hardware to be used within the system as it presented the advantage of having been extensively and professionally tested for comfort and safety.

There were nevertheless a number of barriers to accessing the data from the device. A number of these developers did however offer access to an Application Program Interface (API) which provided a limited set of functions allowing for the creation of additional applications within the device. Access to the APIs within each of these software applications was critical to harnessing the real time data.

Once the data was in a format that could be understood by the audiovisual software, the aim was to use it to trigger audio and video information. Whilst closed-source software such as iHealth and Vitasigns were able to do this with greater legibility, they didn't provide the desired response from the participants as the graphical format of the visualization led participants to try to 'study' the visuals, attempting to ascertain what the peaks and troughs meant. However, my intention was for participants to spontaneously adjust their breathing and heart rate with the ECG rather than study the data.

b) Brainwave EEG: Devices and Data

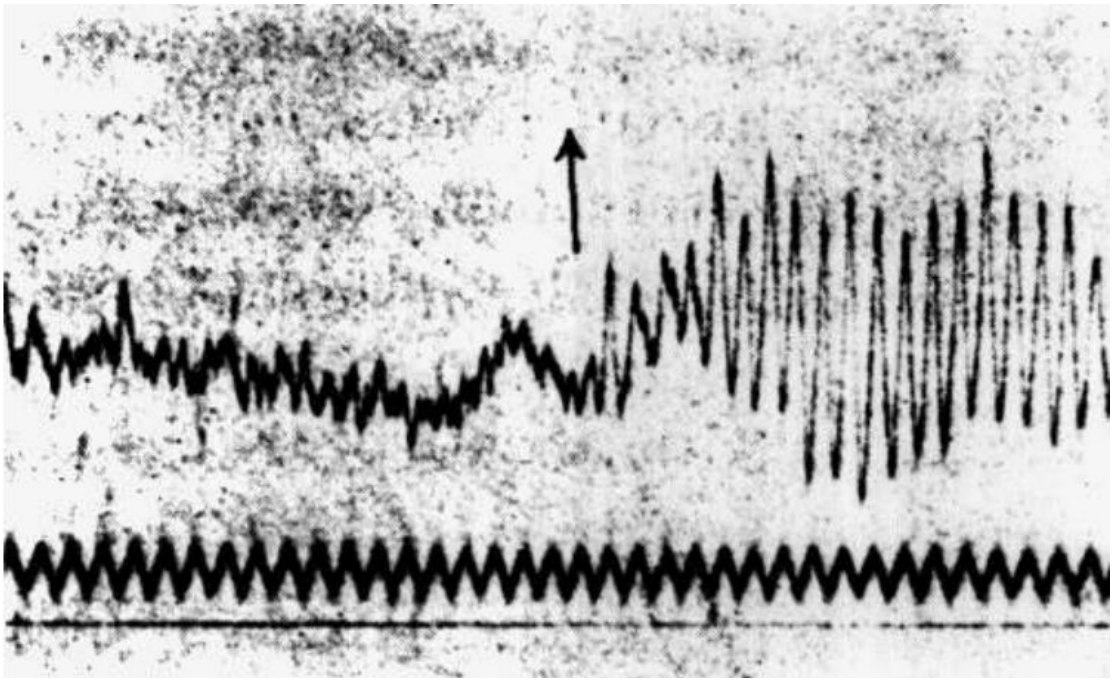


Figure 30: Jensen, Ole & Spaak, Eelke & Zumer, Johanna. (2014) EEG tracings by Hans Berger, in 'Human brain oscillations: from physiological mechanisms to analysis and cognition'. Available at: https://www.researchgate.net/figure/An-early-EEG-recording-performed-by-Hans-Berger-Prior-to-the-arrow-the-subject-is_fig1_267748206 (Accessed 13th October 2019).

Brain imaging has a relatively short history. Electroencephalography (EEG) was invented in the mid-1920s by German psychiatrist Hans Berger (Holmes, 2014, pp. 89-92). Berger invented a technique that revolutionized clinical neurology and psychological research and served as a catalyst to developing our understanding of psychology and the physiology of the brain (p. 97). EEG uses sensors to record the electrical signals produced during the brain's messaging process (Niedermeyer and da Silva, 2005). By tracking and recording brain wave patterns, one is able to better understand neural oscillations in relation to other cognitive processes. At the outset, the majority of my research was focused on exploring neurobiological activity. It was only later that it became apparent there was a lack of knowledge, so a study was conducted on the psychological aspects of the system once the first experiment-performance had been carried out.

As discussed, the use of DIY instruments was inappropriate for this particular research. Instead, I used a commercial device called a NeuroSky MindWave headset. This device monitors the brain's electrical activity via a single electrode placed along the scalp.

Alpha, Beta, Theta, and Delta brain waves are captured and monitored to ascertain the participant's 'Attention' and 'Meditation' levels. The analysis of this was provided by the *NeuroSky* software and is represented in percentage levels of 'Attention' and 'Meditation' as seen below.

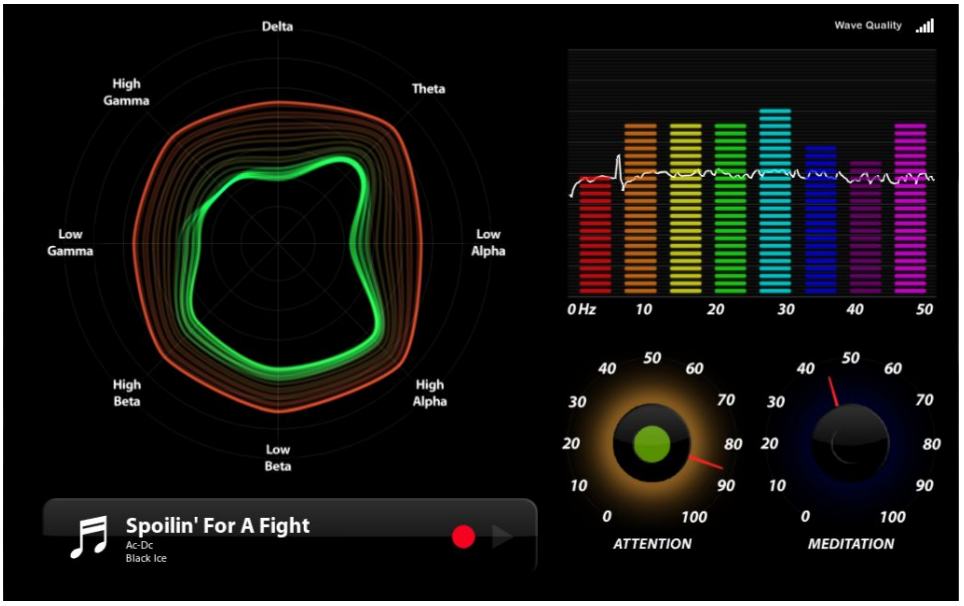


Figure 31: Kaushal, V. (2015). Screen capture of Neurosky software.

The headset is connected to the computer via Bluetooth. Data is then received by Brainwave OSC which translates it into a format which Isadora can understand. Isadora is a graphical programming language. From Isadora, the data is sent to Modul8 which creates the graphic signature. No cables are required which allows for greater mobility and a good level of comfort and usability within the context of this research.

The ‘Attention’ and ‘Meditation’ categories were of most interest as they provided a greater level of legibility insofar as one could readily identify how and what activity by the wearer affected the readings. From a participant’s perspective, it is crucial to the establishment of a truly interactive system that the effects of one’s actions are apparent.

The ‘Attention Meter’ algorithm indicates the intensity of mental focus on a scale of 0 to 100. The reading increases when a participant focuses on a single thought or external object and decreases when the participant is distracted. The ‘Meditation Meter’ algorithm indicates the level of calmness or relaxation also on a scale of 0 to 100. Here, the reading increases when a participant relaxes their mind and decreases when they are uneasy or stressed. These two attributes (‘Attention’ and ‘Meditation’) are what we assigned to the video channels.

The use of Brainwave OSC allowed us to bypass the accompanying visualisation software which had proved too cumbersome for use during this experiment. Brainwave OSC allowed us to capture the real-time raw data and assign it as an output to video or audio channels. Brainwave OSC does not perform any filtering or analysis; its function is purely to transfer the data collected by the MindWave headset. Data within each of the EEG bands is updated every second.

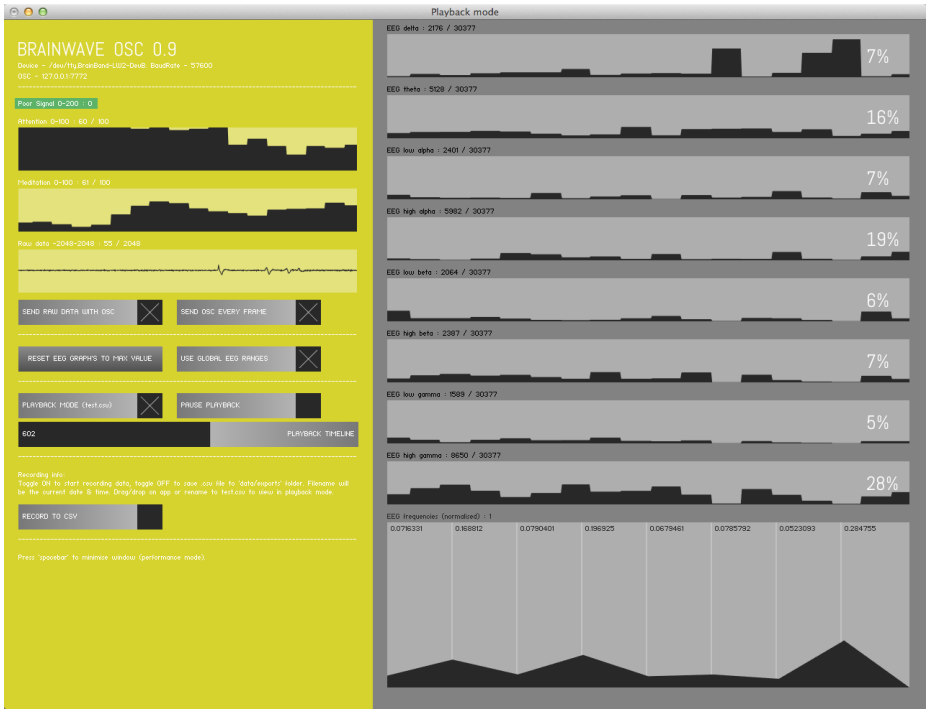


Figure 32: Kaushal, V. (2015). Screen capture of Brainwave OSC.

A piece of software called *Isadora* acted as the 'mission control' where all the data received from the headset via Brainwave OSC could be manipulated in order to make it usable. The attention or meditation data was then passed in real time to the motion graphic software Modul8. The graphics were then projected into the environment in real time, establishing a biofeedback loop between the participant and their biometric data.

Figure 33: Kaushal, V. (2015). Studio setup of *System* (2015). See section on Experiment-performance #1 for diagram.

In setting this all up, the first step was connecting the headset to the server via Bluetooth. This worked without issue for six hours (each of the upcoming performances would only

last for approximately five hours, so this was more than sufficient). However, whilst the headset was fairly comfortable to wear and did not reduce mobility, I experienced issues with the range of the Bluetooth connection which only extended to as little as 2-4 meters.

This experiment was carried out in the Logan and Wilcox design studio. The participant was asked to wear the headset and focus on the screen which was projected on one of the walls. The data remained within a stable range and therefore so did the graphics it produced. The participant commented that they felt as if they were indeed directly affecting the content on the screen. However, this took a number of attempts. Overall, the test showed that, in order for the experiment to meet my intended goal, the participants required a basic level of knowledge of what the system was doing and their role within it. Alongside this, I was also affirmed in my belief in its potential for interactive performances.

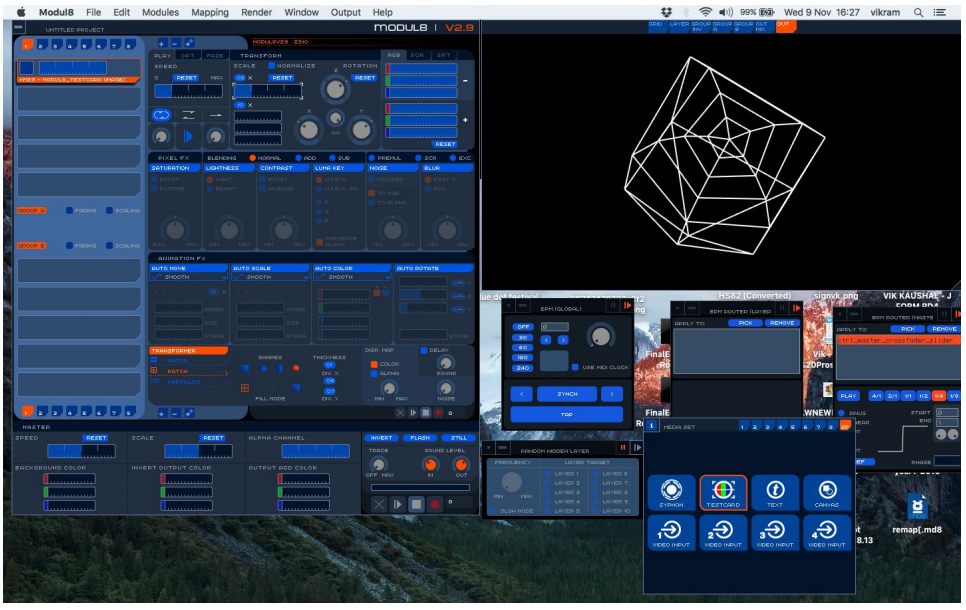


Figure 34: Kaushal, V. (2015). Screen capture of Modul8 processing brainwave data.

c) Representing the Data: Sonification and Visualisation

It is important to distinguish between the different uses of the data within the project. The primary use was to trigger the sonic and graphic signatures which correspond to the participant's brain activity and heart rate, establishing a biofeedback loop. In order to advance from purely analysing the data to influencing it, there must be a possibility for interaction and goals must be agreed upon, whilst nevertheless allowing for play and serendipity. I envisioned the system's interface as producing an opportunity for participants to communicate through their own biometric data. The decision as to how and

what connections would be made between datasets determined the design of the visualisation and sonification.

At the outset, I had only intended to use visualisations, with sonifications only being considered afterwards. I had experience working with visual media, making it the natural choice when considering how to represent the data. Sonification and visualization share basic principles, except where visualizations employ elements such as lines, shapes, and colours to represent certain datasets and variations within them, sonification relies on sonic properties such as volume, pitch, and rhythm. Temporality is a defining feature of sound as all sound occurs in time, much as images / video occur in space. The decision to also sonify some of the data followed from the fact that sonification is well suited to representing temporal or sequential data, e.g. a heart rate, as it provides a sense of the way in which events unfold over time and in a format which would be familiar to participants. Participants' experience of the different components contributing to the system is inherently multimodal and made up of the different sense organs. Rather than participants focussing on trying to understand the graphics, sonifying the heart rate generates a feedback loop without detracting from the collection of the other biometric data.

3. Summary

The next section details how and why these changes were made to the system, elaborating on this original experiment and then proceeding through the following commissioned live performances. Across the entirety of its iterations, the system and its subsequent performances allowed me to address the research question and, in turn, identify how the frameworks in which I was operating (especially cybernetics and social practice) complement one another as different modes of 'praxis'. In each of the following experiment-performances, a combination of Nelson's conceptual foundations were deployed: the 'know-how' of the participants as they sensed the relationship between their embodied experience and the audio-visual signatures; the 'outsider' knowledge of experts in neuroscience and psychology; and my own critical knowledge gained through iterating the system to find out 'what worked' from one instance to the next.

V. Experiment-Performances

One – *System* (2015)

1. Summary

Title: ‘system’

Aim: To develop a system that gathers and represents biometric data both sonically and visually.

Venue / location: Logan & Wilcox Design Studio

Number of Participants: 1

Number of Audience Members: N/A

Hardware: Arduino pro, Mio Link heart rate monitor, MacBook pro, Iphone 6, NueroSky headset, screen and projector, speakers and amp

Software: Modul8, OSX, BrainWave OSC, Isadora, nRF Toolbox for BLE app (OSi)

Portfolio: www.loganandwilcox.co.uk

2. Introduction

As outlined in the methodology, the first experiment-performance was developed to test the hardware and software processes which would go on to facilitate the production of a system that could collect and represent biometric data sonically and visually. The experiment was conducted with a variety of both ‘off the shelf’ closed source systems and bespoke open-source systems such as DIY microprocessors and plug-in sensors. Each of these options were evaluated on the basis of their utility when creating the initial iteration of the system. This first stage was conceived of as the ‘base’ which underwent improvements and refinements as each proceeding experiment was carried out. As the first experiment in the series, the kinds of knowledge involved circulated around the choice of what technologies to test, the results of the testing and the subsequent decisions as to which technologies should be brought forward into the following experiment-performances.

3. Description

a) Overview

This experiment-performance was carried out in a controlled studio environment in order to test the robustness of its different iterations before being implemented in a performance environment. This was carried out over the course of two sessions. The first session involved using a custom-assembled version of the open source microcontroller board Arduino Pro in conjunction with a heart rate sensor. The Arduino presented various structural and engineering concerns regarding its build quality, encouraging us to attempt the process with other hardware. As such, in the second session I used a closed source system called a Mio Link heart rate monitor. I observed and recorded the movements and responses of the participants during the testing in order to gauge the participant's experience. In turn, these observations were fed back into the system design process, forming a 'conversation' between the system and the participant's experience. Allowing this feedback to inform and contribute to the design process helped us to refine and develop the system in accordance with the research aims.

In both sessions, the data generated by the participants wearing each of the devices was subsequently mapped in real-time to responsive audio and visual channels using the software Modul8. The audio and video was then played back through video projection and synchronised audio into the environment, establishing a feedback loop between the participant and their biometric data. The collected biometric data was analysed through screen captures and recordings of the audio-visual outputs in order to evaluate the system's limen and how it could be developed in general. This helped to establish the usability of each technology and possible ways of collecting and representing the data. I established two different possible ways of collecting heart rate. First, I used an electrocardiograph (ECG) which uses electrodes placed on the skin to measure the electrical activity of the heart over a period of time. Second, I tested out pulse oximetry which comprises: an LED to shine light through the wearer's body tissue; a sensor which determines the pulse by measuring the light which passes through the tissue; and a monitor which displays the data (World Health Organisation, 2011).

b) Details

i. Technical setup

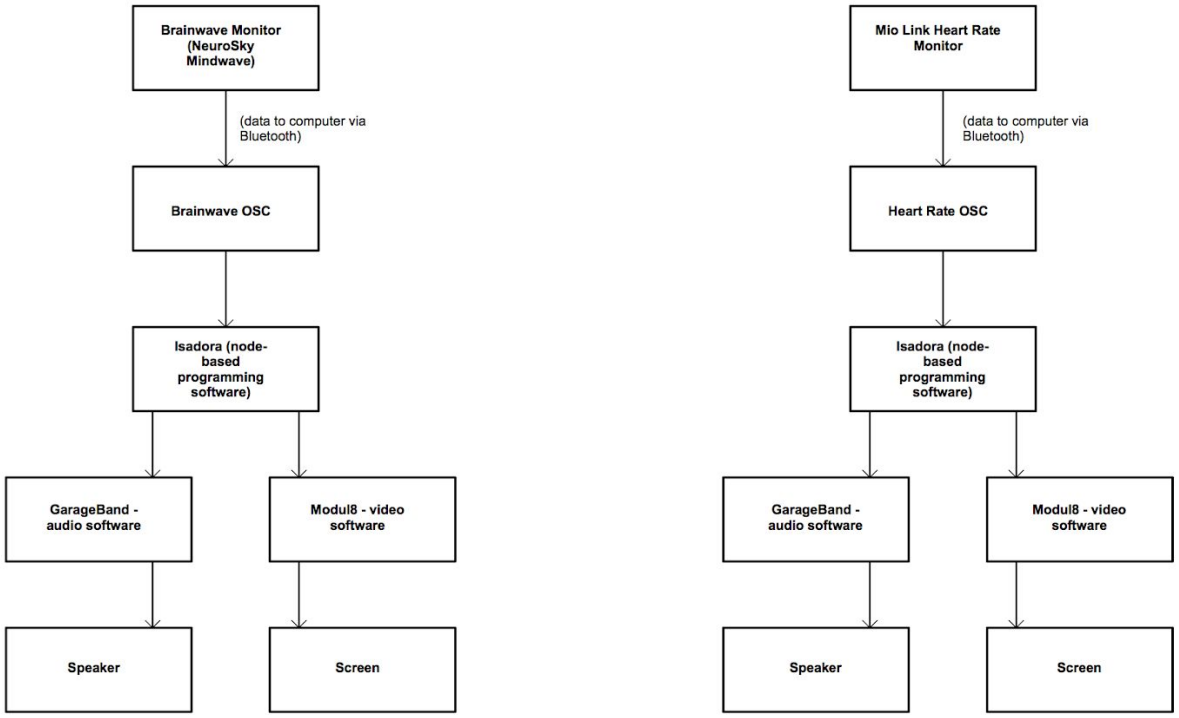


Figure 35: Kaushal, V. (2015). Diagram of *System* (2015) data-flow.

The Mio Link heart rate monitor uses pulse oximeter technology. The data is able to be sent via Bluetooth to a receiving device, in this case Heart Rate OSC. Heart Rate OSC visualised the data and converted it into the protocol called Open Sound Control (OSC). In the developer's own words, OSC 'is an open, transport-independent, message-based protocol developed for communication among computers, sound synthesizers, and other multimedia devices' (OSC, 2019). From Heart Rate OSC, the OSC data is sent to Isadora where it is curated and organised to be intelligible to the software used to visualise and sonify it (Modul8 and Garageband, respectively).

My use of Isadora was limited to converting the numeric data to be more readily integrated into the video and audio software. However, Isadora is in its own right an interactive media playback platform with a visual programming environment and a video and audio processing engine—arguably, it could have managed most of the work done by each piece of software on its own. However, I was less familiar with it so opted to harness my expertise in what I already had experience using. Instead, I used Isadora simply to tidy and split the OSC data into two signals, one of which was sent to Modul8 and the other of which was sent to Garageband. Each of these pieces of software received their respective

OSC signals, triggering the corresponding visual and sonic signals. Modul8 is the software I was most familiar with, and its interface and performance options can be much more readily harnessed and implemented without having to design bespoke modules for processing and representing the data as the case would have been using Isadora. Finally, Garageband was used to simply slow down and speed up the tempo of an MP3 loaded into it (also corresponding to certain readings from Isadora) as this was the clearest and simplest way of ensuring the participant noticed the correlation with the speed of their heart rate. The respective visual and sonic information was then sent out into the room via a projector and monitor speakers.

The process for the brainwaves signal path was almost identical but with minor differences. First, rather than reading heart rate with the Mio Link, I collected brainwave data using a NeuroSky Mindwave electroencephalogram (EEG) monitor which measures and outputs the EEG power spectra (alpha waves, beta waves, etc.)—what it refers to as 'NeuroSky eSense meters (attention and meditation)'—and eye blinks. Rather than Heart Rate OSC, the data is then sent to Brainwave OSC (also commissioned by George Khut) to be converted into OSC and processed in the same way as the heart rate data. The only oddity which arose from this was that both the branded NeuroSky software and George Khut's software presented the brainwave data only in terms of values of three invented categories ('Meditation', 'Focus' and 'Concentration') without disclosing what each category's scale corresponds to in terms of the original brainwave data.

Spatially, the goal of the first experiment-performance was to ensure the participant was at the centre of the performance and the artist was at the periphery (Figure 36). This way, the participant becomes the point of focus. Alongside this, it was essential that the layout still ensured the technical aspects (such as the connectivity range for the server) were working. At this early juncture during the testing phase, the result was that the experiment produced an individual rather than a collective experience. In a certain sense, it modelled Khut's work *Distillery: Waveforming*, from which some of the software had been inherited. However, the layouts in subsequent experiment-performances quickly moved away from this.

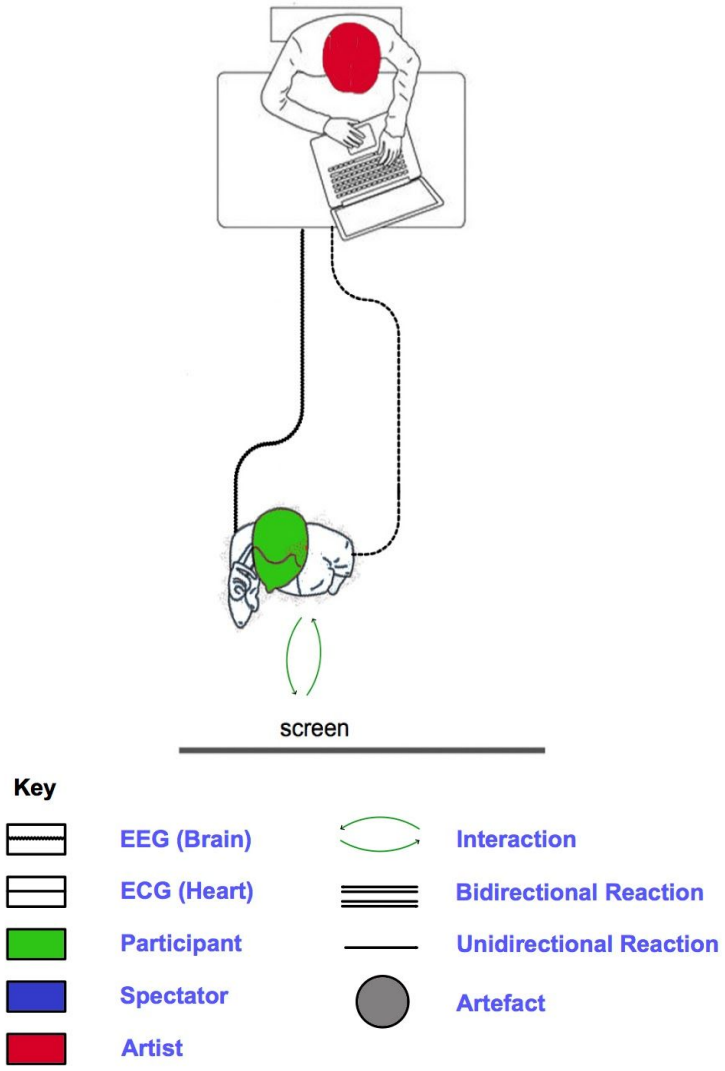


Figure 36: Kaushal, V. (2019). The spatial arrangement of *System* (2015) as a variation on paradigm '1. Artefact b)' with one participant and one artist, as well as a key to the symbols in this and later diagrams.

ii. What did it do?

After iterating various potential devices to establish what would optimise the system, I eventually decided on the following setup. The MioLink heart rate monitor was connected to the participant to read their pulse. This data was then sent via Bluetooth to the software Heart Rate OSC which simply translated the data into an OSC format to be read by Isadora. The artist George Khut had commissioned this software to be made for a project he had developed involving the heart rate and brain wave data of medical patients. Isadora is a graphic programming environment which focuses on the real-time manipulation of digital video designed by Mark Coniglio (Troikatronix, 2019). Isadora then sent the data to Modul8, a programming language used to create experimental systems often involving audio and visual information. The visualisation of the data in Modul8 was

then projected into the room onto a screen, creating a feedback loop with the participant. In turn, the brainwave monitor received the alpha, beta and gamma waves. This data was then sent via Bluetooth to the software Brainwave OSC which, once again, translated it into an OSC format to be read by Isadora, sent to Modul8, and also projected into the room, forming a feedback loop.

From the point of view of the participant's experience, the effect was that they became conscious of their unconscious biological states as they felt they were able to effect change in their environments. In turn, they felt a certain level of frustration when they lost control as it takes time and practise to fully grasp the correlation between the devices, the data and their experience.

4. Analysis

a. Theory & Practice Reflections

i) On George Khut

Comparisons can be drawn between our experiment-performance and George Khut's *Distillery: Wave Forming* (2012) which formed the basis of the conceptual framework of this initial experiment. In Khut's work, the heart rate of audience members was also rendered as audio-visual outputs to produce a feedback loop.

A meeting on the 3rd March 2015 with Khut helped me to identify alternative routes to developing the system. Khut brought our attention to two pieces of open source software which he had been involved in developing: HeartRate OSC and BrainWave OSC. Each of these were developed in the Openframeworks programming language by the programmer Trent Brooks and are available to download from the website GitHub (Brooks, 2018). The HeartRate OSC software gathers data from any 'off the shelf' heart rate monitor (HRM) provided it conforms to the 'Heart Rate Profile' (HRP) specified in the Bluetooth GATT developer portal (Bluetooth, 2019). This presented the advantage of being able to use the 'off the shelf' HRMs which my equipment survey had indicated were more reliable and robust.

In Khut's interactive artwork *Distillery: Waveforming* (2012), data collected by monitoring the audience member's breathing and heart rate was also used to produce graphic, morphing, geometric forms (see figure below). The work invited audiences to 'explore connections between mental, emotional and physiological phenomena', by making the mind conscious of the individual's unconscious activity (georgekhut.com, 2019). In this respect, my research focus deviated from Khut's work; whereas Khut's work

connected individuals to themselves exclusively via their own biometric data, my intention was to establish a connection between the bodies of participants, exploring new forms of collaborating and performing within a multi-modal approach.

The philosophical context of Khut's work intersects with that of my own. By making participants aware of their unconscious activity and thereby providing an experience of the embodied nature of the mind, Khut's work gestures towards one of the most important dyads of Western philosophy: the (perceived) separation of mind and body. Cartesian mind-body dualism is the notion that the mind is non-physical, operating in conjunction with but ontologically distinct from the body and, specifically, the brain (Rozemond, 1998). Christina Grammatikopoulou's article 'Breathing Art – Art as an Encompassing and Participatory Experience' (2016) makes a connection between these philosophical issues and Khut's work. Grammatikopoulou develops this connection further to the biofeedback loops present in certain rituals or ceremonies which involve focussed breathing and meditation. She explains how

> the breathing practices that are present in different religious and medical traditions around the world are based on the easily observable fact that there is a correlation between our emotional state and our breathing rhythm. In these traditions, especially the ones originating in India, one can find detailed instructions on how to let the air enter the body and how to let it out. After following these practices for some time, one experiences the connection of body and mind and the connection of oneself to the world. This approach has certain similarities with phenomenology, but within a more practical frame. Expanding one's consciousness through such practices means that the sense of the "lived body" is enhanced (Grammatikopoulou, 2016, pp. 45-6).

Connecting such unconscious activity, for example the processes which determine the rate of our heartbeat and perspiration, provides a deeper awareness of one's physicality and embodiment. George Khut's work is directed to such an end, and I drew upon this in developing the system.

Contrary to the perception of technology as 'external' to the human body, in both my own and George Khut's work, the biofeedback loop creates an interface between the invisible, unconscious internal processes and explicitly surface technologies. As such, the work challenges this assumption by creating an awareness of the physical happening of our unconscious behaviours. This action of using technology to access these internal mechanisms to see how they affect us and how we can consciously affect them in turn was explored throughout the remaining experiment-performances.

ii) On 'Collective Production' & / vs. 'Collective Authorship'

I anticipated to collaborate with a number of actors throughout the creative process—whether it be the commissioning institution or specialists I commissioned to assist with parts of the work. There was no univocal, master plan to adhere to; serendipity and cross-pollination were all welcomed features of the process.

Collaboration and collective production operate on many levels and between different actors in the creative process. The concept of 'commissioning' illustrates this insofar as it can describe either the action undertaken by an individual or institution to solicit a work's production or an artist outsourcing tasks / steps in the production of a work to individuals or institutions. In other words, commissioning is something that is done both to and by artists. The implications of this relationship have contributed to the ongoing debate over the concept of authorship. In their article, 'Commissioning the (Art)Work: From Singular Authorship to Collective Creatorship', (2016), Katerina Bantinaki argues that the question is essentially one of intention. They observe that, 'in standard (if not all) cases of commissioning', it could be argued that

> the intentions of collaborators (other than the artist) that guide their activities in the production process "substantively figure only as a proxy for the artist's intentions": that is, their intentions only derive from the original intentions of the artist, and their activities are geared toward materializing the artist's conception. Although these collaborators are responsible for the production of the work, they bear indirect and not direct responsibility for the work as an [artwork of a particular nature], so they cannot be credited with authorship (Bantinaki, 2016, p. 19).

Bantinaki delineates between being 'responsible' for a work and being its author. Bantinaki's argument draws upon the philosophy of Christy Mag Uidhir, specifically their article 'Minimal authorship (of sorts)' (2011) which Bantinaki quotes above. According to Mag Uidhir's logic, a participant can be creatively involved whilst only contributing to a very limited extent to the overarching intention of a given work. In this way, they outline a distinction between what they refer to as 'collective production' and 'collective authorship':

> prima facie, collective authorship entails collective production, and that to be collectively produced is to be the product of activities with multiple, distinct intentional sources. Collective production, however, should neither entail nor suggest collective authorship. Most films are collectively produced, and while I suppose that key grips fulfill crucial production roles, key grips are not thereby authors of films[…]. [W]e regard the activities in which key grips and print technicians engage, though complex and highly skilled, as being broadly directed by—or facilitating those activities directed by—the intentions of others (Mag Uidhir, 2011, p. 377).

However, the distinction between individual and collective authorship is made ambiguous by the use of technologies. When I designed the system, each software option presented

varying levels of control and opportunities for modulation. As such, each piece of software shapes and determines the project to varying degrees, and therein could be thought of as channeling, in turn, the respective software developers' authorship / creatorship to varying degrees. In theory, I could have used Isadora for much of the process, a piece of software which offers a much higher degree of control and modulation. However, we elected instead to use the software we were more familiar with, Modul8. By extension, we relinquished control, allowing our production to be influenced by the limitations and steering imposed by the more streamlined Modul8. Indeed, open source projects and software are very much rooted in the principle and practice of co-authorship. In theory, whoever contributes to an open source platform—founder or newcomer—can morph it to suit their intentions. However, the degree of flexibility or autonomy afforded by a given tool is determined by the parameters set up by previous developers. Furthermore, as the biometric data (including the 'intentions') of the participants influenced the graphic and sonic signatures, it could be argued that the participants became coauthors of the work insofar as they were given the ability to influence the work.

b. Personal Observations

i) Implementation of Cybernetics

Included within the purview of cybernetics are certain questions regarding the binaries of human / technology, technology / nature, and self / world. Setting up the system during the first experiment-performance provided opportunities to experience the contingency of the borders between them since I was forced to reckon with the overlap between the participant, their environment, and the technologies involved. Christina Grammatikopoulou (2016) identifies this blurring in Khut's work generally, and my project attempted to extend this logic, developing the social dimensions which had been left unconsidered by previous cybernetic artworks through attempting to connect a greater number of participants.

Broadly speaking, the motivation behind framing the work in this way stems from the belief that cybernetic artworks which innovate upon such technologies have the potential of reimagining the ontological bifurcations between the categories of human, environment and technology. Indeed, in their article 'Co-evolution, neo-cybernetic emergence and phenomenologies of ambiguity: Towards a framework for understanding interactive arts experiences' (2016), Carlos Castellanos contends that

> artworks can go further and actually provoke or enable a bodily, felt sense of this co-emergent dynamic, and thus bring into greater consciousness what can be described as the co-evolutionary nature of our relationship with our technological environment (Castellanos, 2016, p. 160)

Such concerns underlie much of the project and were attempted to be provided for in the initial design of the original system. Simon Penny's article 'Art and robotics: sixty years of situated machines' discusses the historic roots of this bifurcation of mind and body, identifying it as the original cybernetic problem *sine qua non*:

> the deep ontological bifurcation in the ideologies of robotics and computing extend a fault line leading back to Plato and Aristotle. We believe that either knowledge resides in abstraction, or that knowledge resides in the word. In other words, knowledge as derived or inferred from the world, or imposed upon and framing the world, based on non-material archetypes. This tension between regimes of abstraction, such as the mathematized sciences, and the realm of the senses or at least the sensorial, as exemplified by the arts, is a paradox at the core of robotics (Penny, 2013, p. 152).

Cybernetics presents one possible framework for understanding and alleviating this tension. What it makes explicit is that the categories of human, nature and technology are each 'situated' (represented by the Venn diagram), 'integrated' (represented by concentric circles) and / or both, within / with one another (Figure 37). It highlights the continuum between the body and the mind, and then between these both and the environment and technology. As Castellanos has it,

> cybernetics offers us a different way of looking at the world, one where the sharp Cartesian divide between people and things does not exist; where humans and their environment exist in a constant co-emergent interplay (Castellanos, 2016, p. 162).

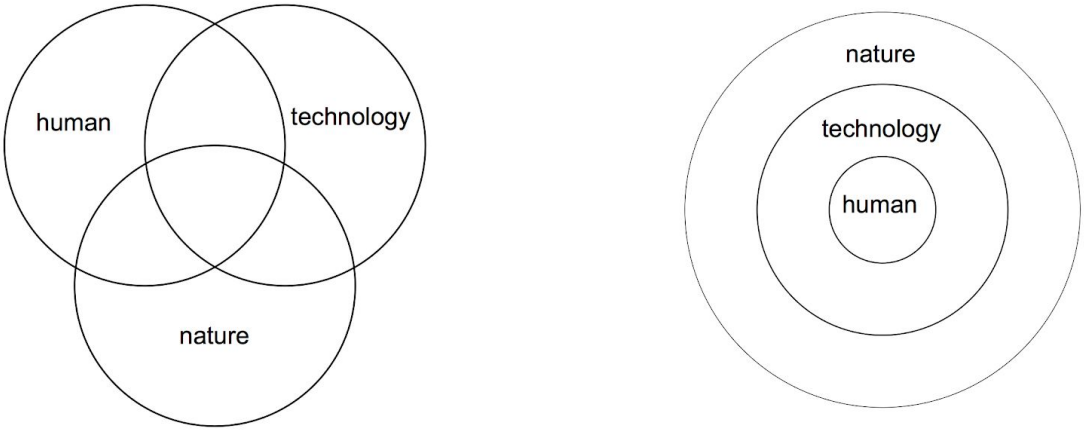


Figure 37: Edmonds, O. and Kaushal, V. (2018). A diagram visualising the integration and situatedness of humans, technology and nature. It eventually became apparent that these relationships were best represented by embedding the diagrams inside one another as represented and discussed in the 'Conclusion'. Telephone conversation with Orlando Edmonds, 15 December.

ii) Implementation of Social Practice

Castellanos observes that artworks which integrate these principles into their process thereby provide opportunities for collaborative, emergent, and discursive processes of learning about our relationship to technology itself. In their words,

> certain forms of interactive art, what I call the ‘emergent arts’, facilitate or amplify a construction of a reality that is active, dynamic, collaborative and co-evolutionary with our increasingly technologized environment (Castellanos, 2016, p. 160).

In the spirit of posthumanism, cybernetics examines how we have co-evolved within and alongside our technological environment; far from being distinct, humans have always existed in feedback loops with what we might otherwise perceive as mere 'objects' and 'things' (Nayar 2014, 10). Castellanos invents the term ‘sybiogenic’ to account for this concept:

> Symbiogenic experiences are those that give rise to a sense that we are co-emergent, that is, that we exist in mutually influential relationships with our increasingly technological environment (Castellanos, 2016, p. 160).

The first experiment presented an opportunity to reflect on how I would measure the success of the project in relation to the principles of social practice I deemed valuable. Broadly speaking, the variable I prioritised securing was the degree of interaction and ‘symbiogenesis’ enabled by the system. Moreover, this extends beyond merely my own use of the system: I was interested in devising a mechanism of making it available to others, whether by incorporating people into the experiment-performance or through making the software freely available following the event.

5. Synopsis

a. Reflections on Theory

i. George Khut

The work of George Khut was instrumental to this project. Following a meeting with him, Khut personally provided me with a link to the software on Github, handing off the baton for the next iteration of the loose collection of principles and practices which his own work had coalesced. What was striking about the particular nature of the technology, specifically the visualisation of biometric data, was that it invited the participant to think about their brain in an unusual way. There was something intrinsically difficult to pin down about the experience of wearing the technology and interacting with one’s own data in that

form, although it's inherently ubiquitous. The human brain functions via a set of uniform processes. These processes are constantly operating, whether or not we are 'aware' of this in any explicit and direct manner. The first experiment-performance provided me with an opportunity to engage with this unconscious activity by rendering it visible and audible.

ii. Collective production vs. collective authorship

In turn, with respect to the discussion of commissioning, there is an interesting synergy between the notions of collective production / authorship and Matarasso's distinction between participation in art and participatory art as detailed in the Literature Review (Matarasso, 2018). Authorship is a requirement for a work to be considered participatory art insofar as the latter is premised upon involving the participants in the decision making process and encouraging their direct influence on the fundamental nature of the work. Respectively, collective production describes something more akin to participation in the process of making the work but does not necessarily entail an explicit level of direct influence on its direction—at least, not to the extent that the individual producers' contributions would be identifiable by someone engaging with the work. Through subsequent experiment-performances, these distinctions and pairings also bear resemblance to and inform the distinction between reactive art and interactive art. This synergy was something I was actively interested in exploring and directly impacted the steer of the following experiment-performances.

b. Testing and development

The first experiment-performance followed on from having already secured the commission to produce the work for a public audience. Its purpose was to design and test the system in a more controlled environment before introducing a live audience. It was my own personal decision to iterate the system across them (rather than produce discrete, separate works). This decision to iterate the system is what led me to think of it in terms of a set of experiments. However, this was then consolidated by the fact that the first commission's theme was precisely that: 'experiments'—giving me license to explore this more explicitly. During the first iteration, the work was more defined by the experimental aspect rather than the performative as the only people present were myself and one person to help me test the equipment. These sessions were more exploratory, whereas the first public experiment-performance required it to be more streamlined. One crucial detail I discovered in this first experiment which I took forward with me was that the

computer and the headsets had to be in close proximity in order to register a signal. This meant that the technology would have to be present in the performance space and therein became part of the visual aesthetic presentation of the work.

With respect to the objectives in addressing the research question, I managed to achieve the first two of four:

- Design a system capable of connecting audience biometric data with the audiovisual material

- Implement a feedback loop between the data and the performance software

As such, I was able to begin thinking through how the use of biometric devices in a live performance setting could invest the audience with an ability to influence the artwork, thereby challenging the traditional divisions between the roles of artist, audience and artwork. However, it was not until the first public performance that these roles would come fully to the fore and become able to be challenged.

Two – *Neu-collective Consciousness* (2016)

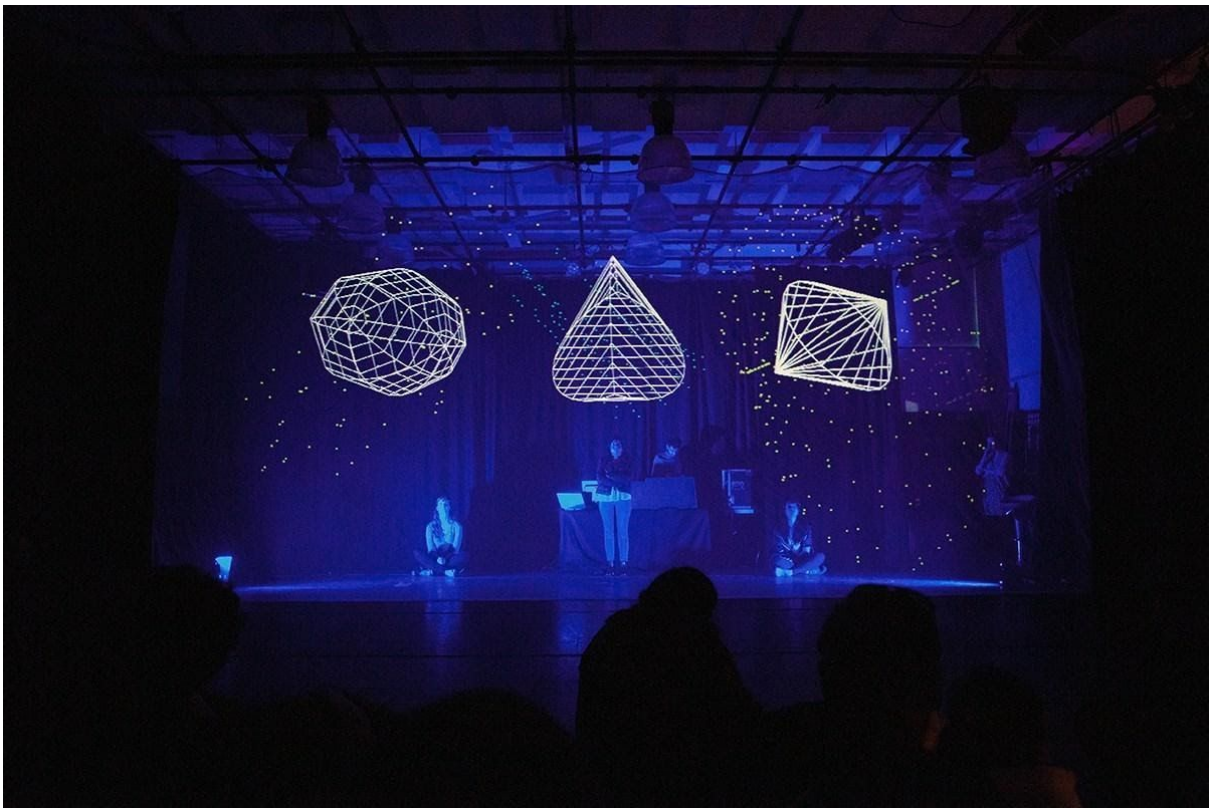


Figure 38: Kaushal, V. (2016). *Neu-collective Consciousness* (2016) performance at the Everyman Theater.

1. Summary

Title: Neu-collective Consciousness

Aim: to increase the number of participants and therefore the number of inputs to the audiovisual outputs of the system whilst introducing it into a live performance context, thereby also introducing an ‘audience’ into the work.

Venue / location: Everyman Theatre, Liverpool

Commissioning Bodies: openculture.org, the Arts Council, and Everyman Theatre, Liverpool

Number of Participants: 3

Number of Audience Members: 2,000

Hardware: MacBook Pro, transparent gauze, speakers and amplifier, MioLink, NeuroSky Mindwave

Software: Modul8, OSX, MidiOSC, Modul8, Brainwave OSC, Isadora, Bluetooth

Portfolio: https://www.loganandwilcox.co.uk/neu-collective-consciousness

2. Introduction

Neu-collective Consciousness took place in May 2016 and was attended by over 2,000 people. It was commissioned and funded by openculture.org, the Arts Council, and Everyman Theatre, Liverpool. It was performed as part of Light Night Liverpool, an annual event which takes place in multiple venues across the city. This was the first public performance where the system developed in the previous experiment was used in a real-world scenario. It had taken one year of technical development and refinement for the system to be ready. Its use in a live performance environment allowed me to explore different hierarchical relationships between the roles of artist, artwork and audience. In this sense it was also the first experiment which introduced further levels of 'know-how' in the shape of the curators' and audience members' involvement.

3. Description

a) Overview

The experiment aimed to provide a deeper understanding of how the system described above could be used in a live performance context to create a conversation between the conscious and unconscious activity of the participants, and between the participating audience members and those simply present in the performance space.

b) Details

The lights in the room which hosted the performance were turned off in order to allow participants and the audience to become fully immersed in the artwork. I also looped a piece of ambient music to help generate an atmosphere within the performance space. Spatially, the use of a transparent and translucent screen allowed both the participants and spectators to view each other in a conventional relationship between artist and audience (Figure 39). Doing so placed the participants at the centre of the performance, but by simultaneously having the stage be at ground level, they were not elevated 'above' the spectators. Instead, the only elevated element was the graphic signatures which, projected onto a translucent screen, acted as a distinguishing but connecting medium

through which the roles were intermingled as they were transposed onto one another from the perspective of each respective role.

Those who volunteered to partake in the performance were given very simple instructions of what the system did. Participants were then left to their own devices to explore and interpret what they were doing. If they sought further information, I was happy to explain in more detail what data was being collected and how we were using it within the system. This allowed some participants to gain greater control over their digital signature. However, some participants managed to do this on their own without any additional information. A number of the participants described the act of controlling the graphical interface as ‘difficult’, particularly due to the fact of it taking place in a performance space with people talking and walking in and out. Nonetheless, whilst I had only intended for people to come and review the performance for 5-10 minutes, spectators ended up staying anywhere between 15-45 minutes, many of them sitting on the floor to observe the performance at length. Having conceived the work from the first experiment as merely testing the system, it was at this point that I became cognisant of it as an actual performance.

As to the system, participants controlled their own 3D signature, and their data varied greatly between them. 12 full bands of data were able to be received from the headset, and the different data readings corresponded to different actions in the 3D graphic signature. The greater the focus, the less variation in data, and the slower and more consistently the floating 3D signature moved and changed. If the data became erratic, this indicated less focus, and the graphic would mirror this by moving more erratically in turn. The 3D graphic signature of each participant remained static until such time as data was received by the software, generating the 3D graphics. This proved to be an important part of making the participant actually feel involved in controlling the objects in front of them.

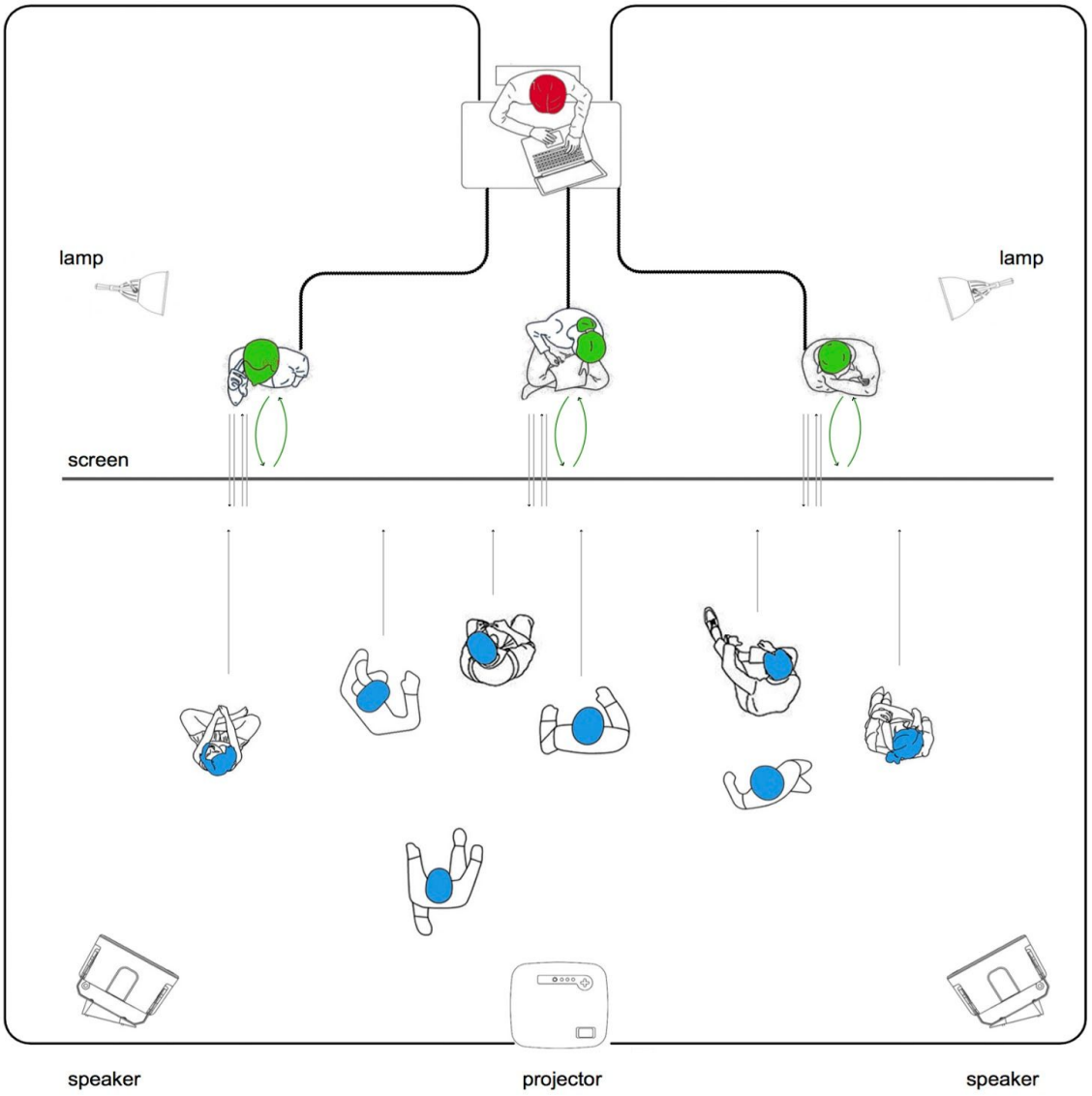


Figure 39: Kaushal, V. (2019). The spatial arrangement of *Neu-Collective Consciousness* (2016) as a variation on paradigm ‘2. Stage b)’ with participants, spectators and artists.

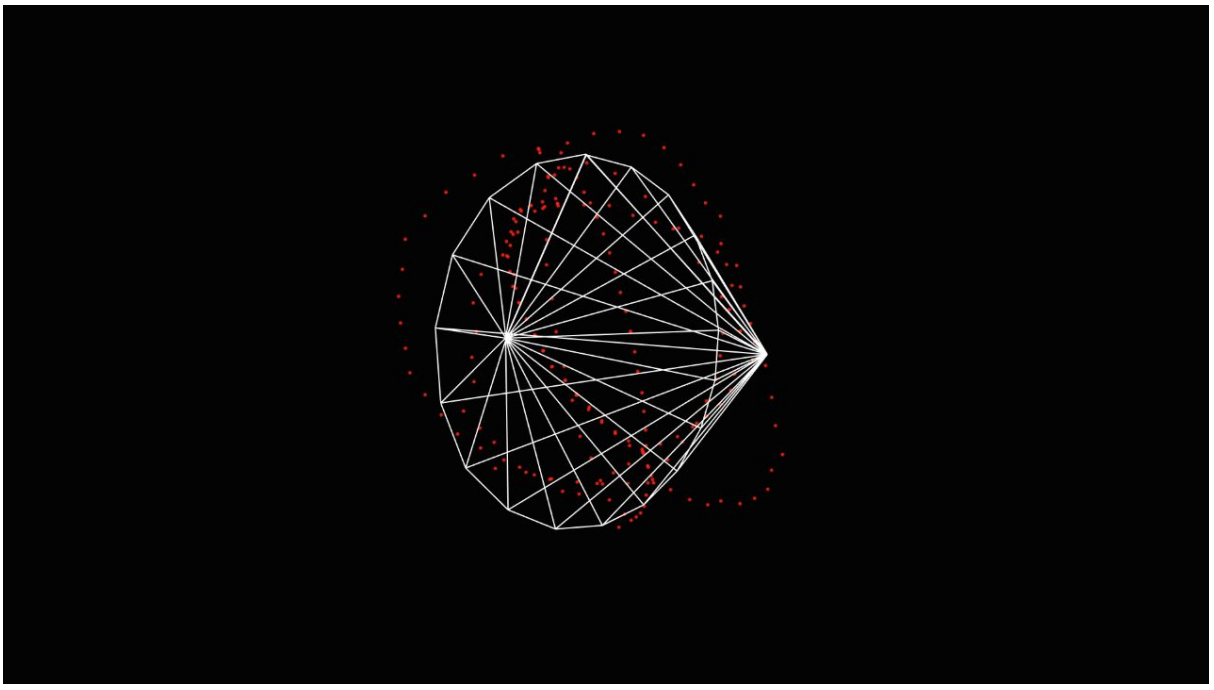


Figure 40: Kaushal, V. (2016). Graphic signature for *Neu-Collective Consciousness* (2016).

4. Analysis

a. Theory and Practice Reflections

i) On First-order versus Second-order Cybernetics

This first live performance of the system modelled a midpoint between first order and second order cybernetics. Arguably this initial lack of second order principles (e.g. reflexivity and the inclusion of the observer) was due to the fact that the second experiment almost just served as a test of the system which had been designed in the first experiment. The reflexivity implied by second order cybernetics only entered into play once I had established the system could work in its most basic form within a social environment. It was only in hindsight, thinking back on the experiment-performance, that a degree of self reflection came into play. In this respect, in accordance with Nelson's model of PaR, the second experiment-performance offered an opportunity for greater critical reflection. Moreover, this analysis section of the write-up provides a further degree of reflexive accounting of how the experiment is situated in certain conceptual frameworks and debates about terminology.

This reflexivity is the key distinction. Referring to the pre-eminent cybernetician and cofounder of second-order cybernetics, Heinz von Foerster, Wolfram Lutterer observes in his article 'Systemics: the social aspects of cybernetics' that 'it would probably indeed be better for Heinz von Foerster's "second-order" if—as Scott suggests – this

“non-trivial” and “relativistic” cybernetics was described as reflexive cybernetics’ (Lutterer, 2005, p. 499). Whilst cybernetics is already premised on an idea of a feedback loop, ‘reflexive’ second order cybernetics constitutes a feedback loop in which the observer regards their own observation as part of the process. Second order cybernetics arises as the reflexive ability to converse with the process itself, as in Pask’s theory of conversation. Lutterer develops this distinction between cybernetics and its ‘reflexive’ counterpart through a linguistic analysis of the etymology of the words ‘pattern’ and ‘matrix’:

> For the pattern, which is inherent in our interactive world, von Foerster plays a queer kind of a gender-scientist: *pattern* is from the Latin *pater*, father. Therefore, a rather masculine attitude toward these things would be associated by this term. He would rather like to think of a woman, and therefore, the *pattern that connects* becomes a *matrix that embeds* (*matrix – mater – mother*). There had to be some kind of bed, or context, in which the various ideas could be a pattern (von Foerster and Broecker, 2002, p. 314).

If first-order cybernetics observes a pattern, second-order extends its observation outwards to encompass a wider matrix of processes. Where ‘pattern’ connotes linearity within a system or sequence of repetition and deviation, matrix expands upon this to connote a situated or embedded set of patterns within patterns, forming a dimensional network. In this respect, this experiment-performance exemplifies first order cybernetics insofar as it involved someone producing the graphic signature as and while they observed it changing. However, it could be said to be second order due to the fact that there were people present who influenced the environment purely by virtue of being present and thereby having an influence, however variable, on the participant, therein becoming more adaptive and situated within a wider network of influence.

ii) On ‘Double Description’

This experiment-performance introduced the difficult question of having to assign a descriptor, either in the form of ‘experiment’ or ‘performance’. The employment of a double-description was based on the decision to iterate the system across multiple performances (as an experiment) and to do so in front of a live audience.

Instead of settling for one term, I opted simply to hybridise them in the manner of cybernetician Gregory Bateson’s concept of ‘double description’. Double description challenges the idea of singular truths by refusing to reduce scenarios to binary oppositions. Another of the British branch of cyberneticians, Bateson’s work brought together anthropology with linguistics to support his study of living systems in both the biological and sociocultural spheres. In an introduction to the book *A Legacy for Living*

Systems: Gregory Bateson as Precursor to Biosemiotics, Jesper Hoffmeyer outlines a particular facet of his notion of the double description:

> Bateson claimed that the product of double description belongs to a higher logical type than the phenomena that were abductively compared. The similarities reached by abduction are here seen as cases on which to build an inductive inference that brings us to a higher logical type (Hoffmeyer, 2008, p. 5).

Whilst the action of abduction involves the identification of shared patterns across different forms, the notion of the higher logical type evokes a sense in which there is a relation that structures and precedes the complex, indeterminate, multiplicitous dynamics which extend from it, much like the relationship between a tree's trunk and its rhizomatic root structure. Reflecting on this natural phenomenon as an example of the complex non-deterministic structure of systems was one of many reasons why I approached the experiment as I did, i.e. respectful of the complexity of social systems and non-deterministically. As unpredictable as the rhizome is, it nevertheless congregates around a single point. Though it is this endpoint which is readily visible, it is based in all these other strands. The experiment-performance operated in this way, and as such, it would have been reductive to form descriptions purely in terms of a single point. The concept of the rhizome was employed as a framework for my practice as it extends the sense of a natural form of knowledge generation. Rather than as an 'absolute' science, I conducted the process through qualitative observations. Double-description allows one to retain complexity and nuance by deploying multiple terms rather than reducing the object to a singular concept.

To elucidate the thinking between the choice of terms, it is helpful to acknowledge each term's variety of official definitions. The *Oxford English Dictionary Online* defines 'performance' as follows:

1.
    a. The accomplishment or carrying out of something commanded or undertaken; the doing of an action or operation.
    b. The quality of execution of such an action, operation, or process; the competence or effectiveness of a person or thing in performing an action; spec. the capabilities, productivity, or success of a machine, product, or person when measured against a standard.
    […]
4.
    a. The action of performing a play, piece of music, ceremony, etc.; execution, interpretation.
    b. A ceremony, rite, or ritual.
    c. An instance of performing a play, piece of music, etc., in front of an audience; an occasion on which such a work is presented; a public appearance by a performing artist or artists of any kind. Also: an individual performer's or group's rendering or interpretation of a work, part, role, etc. In extended use: a pretence, a sham (*Oxford English Dictionary Online*, 2018).

Foremost, performance is defined as the carrying out of a task as well as a way of thinking about the 'success' of a task's 'performance'. Respectively, once we reach the fourth definition we encounter the notion of performance as entailing the observation by an 'audience'. What is also noteworthy is the introduction of the concept of experimentation with respect to performance as 'an individual performer's or group's rendering or interpretation of a work', and, beyond this, the notion of performance as deception as 'pretence' or 'sham'.

The term 'experiment' suitably describes the methodological approach of developing the system across various iterations, though it ultimately lacked the explicit aspect of observation. This first definition immediately seemed reflective of how I envisioned the process we were undertaking, needing only to be supplemented by the implication in 'performance' of the audience's presence:

1.
    a. The action of trying anything, or putting it to proof; a test, trial; esp. in phrases, to make (an) experiment, †to take (an) experiment. Const. of. Now somewhat arch., and conveying some notion of sense.
    b. An expedient or remedy to be tried.

The second also presented useful distinctions and qualifications:

2. A tentative procedure; a method, system of things, or course of action, adopted in uncertainty whether it will answer the purpose.

The suggestion of uncertainty invites a more radical interpretation of the word as it ceases to refer to a notion of an original truth which, as we have seen, was one of the potential pitfalls presented by the word 'performance'. Experiment breaks from a conception of a strict teleology, therein differing from performance which can presuppose a stable origin, source or intention.

The third definition expressed 'experiment' as attending to a radical unknown, evoking a sense of openness and reflexivity:

3. An action or operation undertaken in order to discover something unknown, to test a hypothesis, or establish or illustrate some known truth.
    a. in science (*Oxford English Dictionary Online*, 2018)

Once again, the crucial detail the word 'experiment' lacked was the idea of an audience and any sense of artistic entertainment. On the other hand, when we reflect on the category of 'experimental' art, the prefix indicates the possible lack experimentality in more traditional, isolated notions of performance arts, which might be overly prescriptive and organised, rather than open to the uncertainty of the unknown in the manner that the word

'experiment' seems to invite. At the outset, my intention was simply to tailor the description to the audience in question. For instance, in the context of a science festival I would have used 'experiment', whereas if I was commissioned to participate in a conventionally curated exhibition, I would have called it a 'performance'. This approach would have been ultimately reductive but bears thinking about as an illustration of how the relevance of each term is contextual and relative.

b. Personal Observations

i) Implementation of Cybernetics

For its ability to incorporate biological systems, social systems, mechanical and technological systems in its purview, cybernetics was the perfect framework from which to both execute the experiment-performance as it happened and analyse it after the fact. The project design as a whole modelled cybernetic principles: I began with a question, developed a system to investigate it, and then proceeded to reflect on what I had achieved through the framework of cybernetics, applying the knowledge gained back into the design. This approach illustrates certain aspects which designate this project as 'practice based': I decided on an approximate end goal, devised how to reach it, and eventually arrived at outcomes which came close to the envisioned ends. Rather than consciously deciding to employ cybernetic principles in a series of controlled experiments, I operated with a greater degree of openness, allowing me to adapt and respond to unexpected outcomes. This approach is supported by the research methodologies detailed in *The Artistic Turn* (2009), which identifies the

> hitherto unexpected strengths in employing situated, adapted criteria that derive from, and can be applied to, real-life situations—or at least do not detract from the complexity and richness of these situations — as opposed to universal, static criteria (Coessens, Krispin and Douglas, 2009, p. 64).

Aware of the pitfalls of the modern scientific paradigm which separates fields of knowledge rather than recognising the feedback loops which exist between them, Coessens, Krispin and Douglas observe that 'artistic research could experience the same problem of fragmentation as conventional science'. In view of this, they wonder if

> perhaps there is a way in which the artist-as-researcher may succeed in articulating the limits of a research project and narrative, clarify the research rules, open up his or her knowledge and expertise towards scientific and philosophical debate, and still not lose the singularity of a specific artistic trajectory (Coessens, Krispin and Douglas, 2009, p. 63).

Something of this sentiment structured my own ethos concerning the methodology, balancing the need to control variables sufficiently as to be able to measure the impact of certain changes but without limiting them to the extent that unexpected outcomes were precluded.

Where the expectation had been that people would simply act as passive observers, instead their involvement grew exponentially throughout the event. People asked to be involved, performing in front of their peers and making enquiries as to how they could better manipulate the system, whilst many others sat and observed the process for much longer than I had anticipated. On reflection, the curators themselves also had an unexpected influence as a result of the way they treated us; as the commission winners, they approached my project in particular quite seriously, and this in turn influenced the audience to do the same, thereby changing the atmosphere of the environment. The commission format lends itself to a cybernetic framework in general. Commissioned projects often require certain specific criteria to be fulfilled, but as an artist or designer you are able to identify the gaps which can be exploited to diverge from the prescribed model and generate points of interest. Cybernetics allows for and encourages this, hence why we elected to consciously frame the process within its principles.

Once the experiment-performance was completed, there was an opportunity for me to finally analyse my own participation—a certain distance was necessary to allow me to sufficiently reflect on my role in the process.

ii) Implementation of Social Practice

This particular commission granted me more artistic autonomy than those which followed as there were fewer restrictions. However, socially engaged practice places less importance on the traditional concept of artistic autonomy. In a certain respect, the ideal social practice is a system which runs itself, growing and evolving with minimal involvement of the artist. This experiment-performance diverged from this model as it became apparent that the artist actually could play a really interesting role—not only as the system designer but also as a participant and conductor. Where a wholly digital cybernetic system has the genetic coding already built into it to allow for its emergent properties to present themselves, here, the artist fulfilled this role as an analogue mechanism for re-inputting the feedback from the audience. In a conventional social practice model everyone is afforded the same opportunities to contribute. By contrast, in this instance the centrality of the artist was consolidated as their role was to reincorporate the participant feedback into the artwork. However, this was precisely in order to allow the

greatest number of people to have as much influence as possible.

In this experiment-performance, what was planned for was the unexpected. It encouraged me to stop thinking of the process as a series of design projects but rather as cybernetic projects which could accommodate a social dimension. Whilst design does have a social aspect, my focus until this stage had principally been the technical details. By bringing together social practice and cybernetics, I was able to think about how each concept might apply to the objects and processes presented by the other disciplines. What transpired was that they are in fact already very closely related frameworks. Indeed, Lutterer is sensitive to this proximity when he writes that 'both the ruling doctrine of causality and the delusion of objective truth prove to be hindering. Social cybernetics is second-order cybernetics, as it includes the observer into the system' (Lutterer, 2005, p. 501). Second order cybernetics is premised on the inclusion of the social context to the act of observation.

I expected the first public experiment-performance simply to be an opportunity to test the system by turning it on and walking away. This wasn't the case; audience members and participants were engaged and inquisitive, seeking far more than just entertainment or spectacle. This relates back to Gordon Pask's dictum that "man seeks novelty in the environment." We seek out that which is different and unfamiliar and reflect on it in conversation. The experiment-performance manifested this expansion outwards to encompass that which might otherwise, in a more traditional paradigm, be thought of as *outside* the forms in which people (the participants, in our case) meaningfully interact with their environment. Ultimately, the experiment-performance did indeed allow me to test the system, and I felt confident that I would be able to implement the knowledge gained from doing so, making adjustments in response to what was learned.

5. Synopsis

a. Reflections on Theory

Once the audience was introduced into the equation, I considered to what extent the experiment-performance could be considered fully second-order cybernetics. The role of the audience as simple observer was of course challenged by the fact that they were invited to participate in the performance by wearing the headsets and having their data visualised and sonified in real time. This naturally introduced an awareness of the effect of observation on the system and, in turn, a reflexive awareness of the presence of the observer within the system itself. As such, I decided it is correct to regard the second experiment-performance as modelling second-order cybernetic principles to the extent

that the observer was not separate or apart from the object of their observation. In this respect, we can think of the experiment, in Von Foerster's terms, as a 'matrix': the audience are integrated into the cycle of the system's 'pattern' whilst also simultaneously situating the system within the dynamic of being observed by them.

b. Testing and development

Following the success of the first public commission, the commissioning body (openculture.org) invited me to take centre stage in the next funding round for their next project. This led me to the next experiment-performance and Liverpool Light Night.

In terms of the research question and objectives, I decided to plug more participants into the system, thereby increasing the opportunity for a greater number of interactions between the roles. More precisely, I also resolved to develop the audio side of the performance as in this experiment-performance it wasn't included in the feedback loop—so the simple goal for the next performance was to include it. In each case, the result would simply be to further integrate the roles of audience and artwork by presenting more potential points of interaction between them.

Three – *Zugzwang* (2017)

> Zugzwang: a situation [in chess] in which the obligation to make a move in one's turn is a serious, often decisive, disadvantage (*Lexico.com*, 2019).

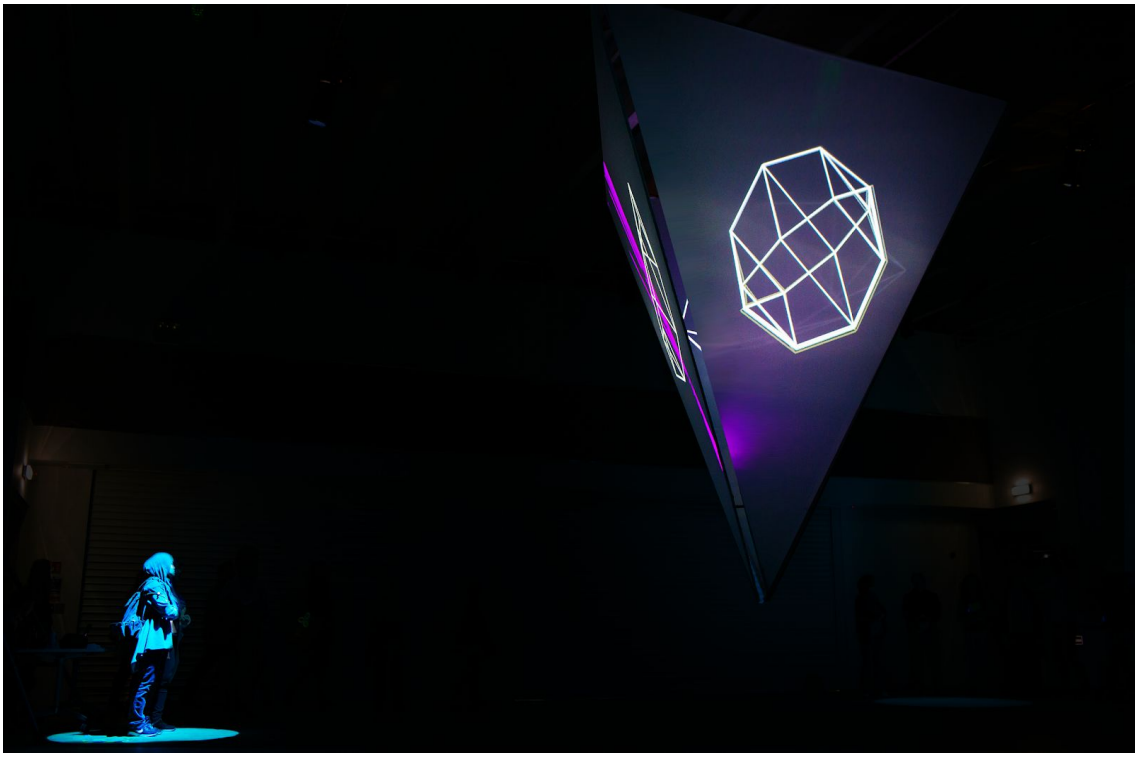


Figure 41: Kaushal, V. (2017). Participant plugged in to *Zugzwang* (2017) at the John Lennon Theater.

1. Summary

Title: Zugzwang

Aim: to provide participants greater control of the biometric devices and to combine their data to form a ‘conversation’, resulting in more interaction between the audience members.

Venue / location: John Lennon Theatre, Liverpool John Moores University

Commissioning Bodies: openculture.org, Arts Council, Liverpool Council, Liverpool John Moores University

Number of Participants: 6

Number of Audience Members: 1,500

Hardware: MacBook Pro, projector screens (x 3), speakers and amplifier, MioLink, NeuroSky Mindwave

Software: Modul8, OSX, MidiOSC, Brainwave OSC, Isadora, Bluetooth

Portfolio: https://www.loganandwilcox.co.uk/copy-of-neu-collective-consciousnes-1

2. Introduction

This experiment / performance took place at the John Lennon Theatre and once again involved projections, light, and sound generated through interactions between participants and their environment. A German word, ‘zugzwang’ loosely translates as ‘the compulsion to move’. It’s often used in chess when a player is forced to move when they would otherwise prefer to pass and are put at a disadvantage because of the decision. This idea of mutual influence grounded my attempt to introduce more points of contact between a greater number of participants, therein enhancing the overall interactivity of the system.

3. Description

a) Overview

The third experiment-performance reintroduced a more traditional role of the artwork as artefact but simultaneously steered the performance towards eroding the divisions between the audience and artist. An inverted pyramid was suspended in the centre of the performance space upon which were projected 3D signatures generated through combining the collective data of participants. By suspending the pyramid in the centre of the space, participants could move freely around and under it, creating a less clearly defined separation between artist, audience and artwork. Distinct from the previous experiment (where the participants and observers were on different sides of a semi-transparent screen), there wasn’t a clear separation or defined space between the roles.

A number of volunteers were recruited from the Manchester School of Art to guide the participants and explain the process. This was particularly important due to the increased number of participants. The volunteers’ duties involved placing the brainwave headset and heart rate monitors onto participants, monitoring the door, and managing the

crowd in order to limit the number of people entering the performance space. Beyond this, the volunteers were given a brief description to relay to the audience as they entered. The experiment also involved collaborating with a musician and sound engineer who created the pre-recorded sounds and then played them live, increasing and decreasing the beats per minute (bpm) in correlation with the heart rate data. There was also a supporting tech-troubleshooter to ensure software ran smoothly during the performance.

The movement from the second experiment-performance to the third involved a shift in the various types of knowledge involved and their position in relation to one other. What had previously existed as more explicit conceptual knowledge in the first public performance this time was internalised as ‘know-how’, both by the artists and the curators. In turn, the testimonies and feedback from the previous experiment-performance shaped the next one, expressed in the changes which were implemented. In this sense, ‘know-what’ from the former experiment manifested itself as part of the new ‘conceptual framework’ of the latter. Indeed, this translation of knowledge-types characterises the modulation of knowledge between each experiment-performance as feedback continued to be integrated.

b) Details

The design of the space and position of the system within it built upon the previous experiment-performance, making some additions. Each side of the pyramid related to one pair of participants. Each participant provided a separate data stream of brainwave activity and heart rate, encouraging them to concentrate and meditate on what was happening. The inverted pyramid was fabricated out of a metal frame with a screen stretched over its three sides. The structure was designed to be demountable for storage and transportation purposes. As in the previous experiment / performance, brainwave data was used to generate and project 3D signatures. Specifically, EEG was recorded to provide data streams of participants’ alpha, gamma and beta waves. By isolating this data we could indicate the participants’ different states of mind (‘meditation’, ‘focus’ or ‘attention’). The participants’ heart rates were combined with those of the others in the room to create an average heart rate which was then sonified. The mean average was then used to speed up and slow down a pre-recorded soundtrack which was pumped back into the room in a sensory feedback loop. Those participants who became aware that their heart rate affected the speed of the soundtrack tried to manipulate them in order to affect the performance. When anyone decided to take off their brainwave headset, the volunteer peer practitioners took receipt of it to hand over to the next participant. Participants were

free to use the headsets for as long as they wanted, but the average amount of time participants chose to wear them was approximately seven minutes. Spatially, the third experiment-performance involved a return to the artefact paradigm. It also introduced the feature of positioning the participants side by side around the artefact in such a way as to elicit a sense of a dispersed hierarchy (Figure 42). In this respect, the experiment-performance could also be seen as modelling the paradigm of the stage in the round, only here the stage encompasses the whole room.

The experience of those involved differed from the previous experiment-performance. During the experiment-performance, certain spectators concentrated on the object rather than the collective whole (i.e., the participants, 3D graphics, and the lighting, etc.). This may have been due to the less conventional arrangement of artist, artwork and audience as there was neither a stage nor clearly defined spaces for the audience and artist / performers. Video interviews were conducted with participants exiting the space. The majority commented that they felt they had influenced the performance but were unaware of how (this lack of awareness was one of the chief ongoing concerns and was addressed most thoroughly in the final experiment-performance). People entering the space were themselves influenced by the people leaving, creating a continuous stream of influence through each other in a feedback loop. Beyond this, the number of participants was limited in order to maintain the atmosphere and ambience of the space which had been specifically chosen for its ample room, allowing free movement. Had the space become crowded, the increased noise level would have disrupted the participants' concentration, influencing the data and therefore producing an undesirable output, hindering the experience.

One surprising outcome was that almost every set of participants held hands and began to work together. As Tiffany Field explains, 'touch is our most social sense. Unlike seeing, hearing, smelling, and tasting, which can generally be done alone, touching typically implies an interaction with another person' (Field, 2001, p. 19). This was unexpected as the pairs did not necessarily comprise people who arrived together but were paired together ad-hoc as spaces became available. The hand holding spread as a 'meme' throughout the space (Blackmore, 1999, p. 4). Holding hands not only assumed a symbolic quality as an instance of interfacing the participants present (Shusterman, 2008, p. 214), but also would have had an affect on the level of oxytocin, the neurotransmitter responsible for producing the sensation of trust and compassion and reducing anxiety (Morhenn, Beavin and Zak, 2012). In this respect, this unexpected outcome was arguably one of the most explicit instances of how the experiment-performances induced a

profound level of interaction and participation:

> The cutaneous senses—especially touch—are crucial yet often-overlooked mediators of social interaction, | contributing not only to sensation but to emotion. […]Major functional roles for social touch include affiliative behavior and communication. Touch- and pain-related representations also provide a basis for intersubjective representations, influencing the understanding of others' sensory, emotional, and mental states (Löken, Morrison and Olausson, 2009, p. 311-2).

Due to the time limitations imposed by the scope of the PhD, this was a dimension of the experiment-performances which I did not explore further but which raised potential avenues for future research as I detail in the conclusion.

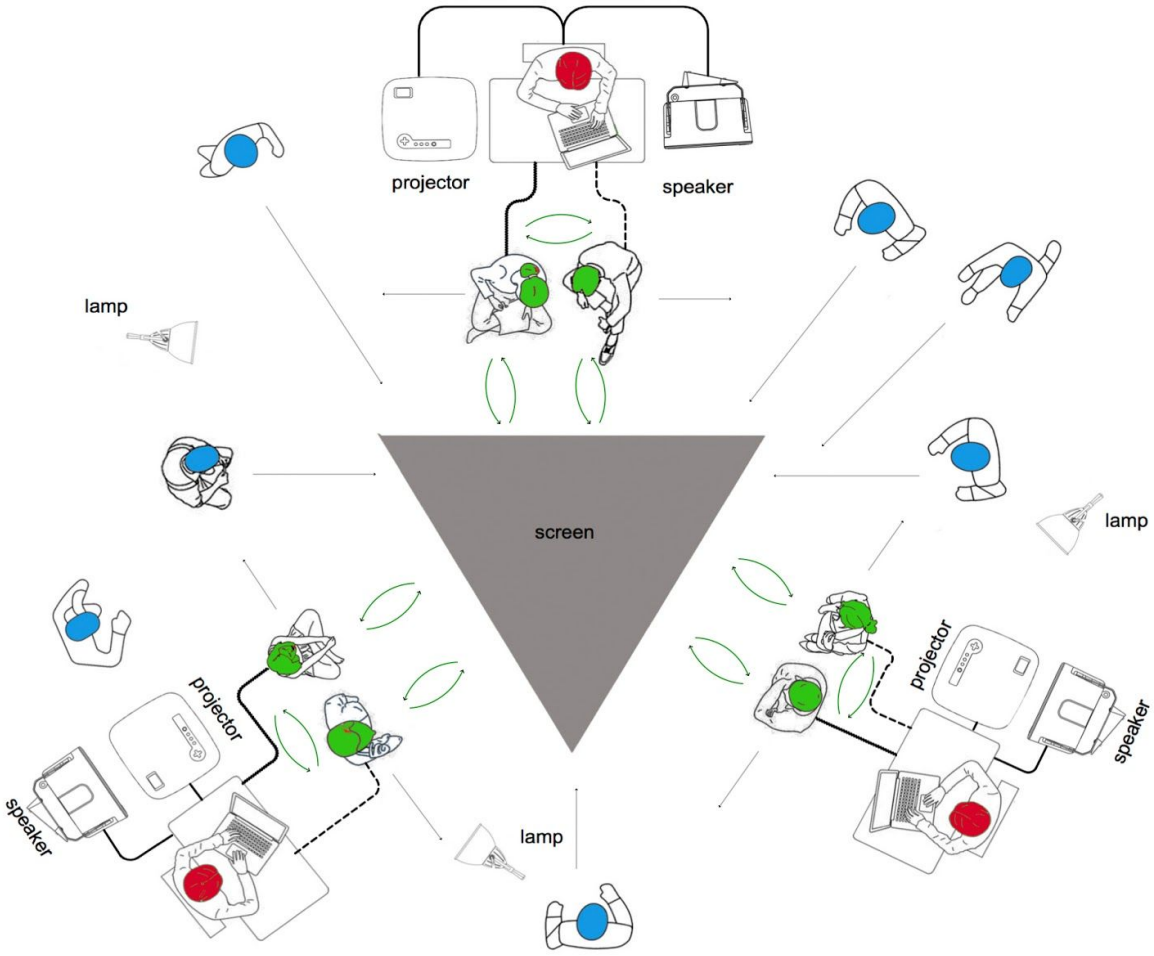


Figure 42: Kaushal, V. (2019). The spatial arrangement of *Zugzwang* (2017) as a variation on paradigm '1. Artefact a)' with participants, spectators and artists.

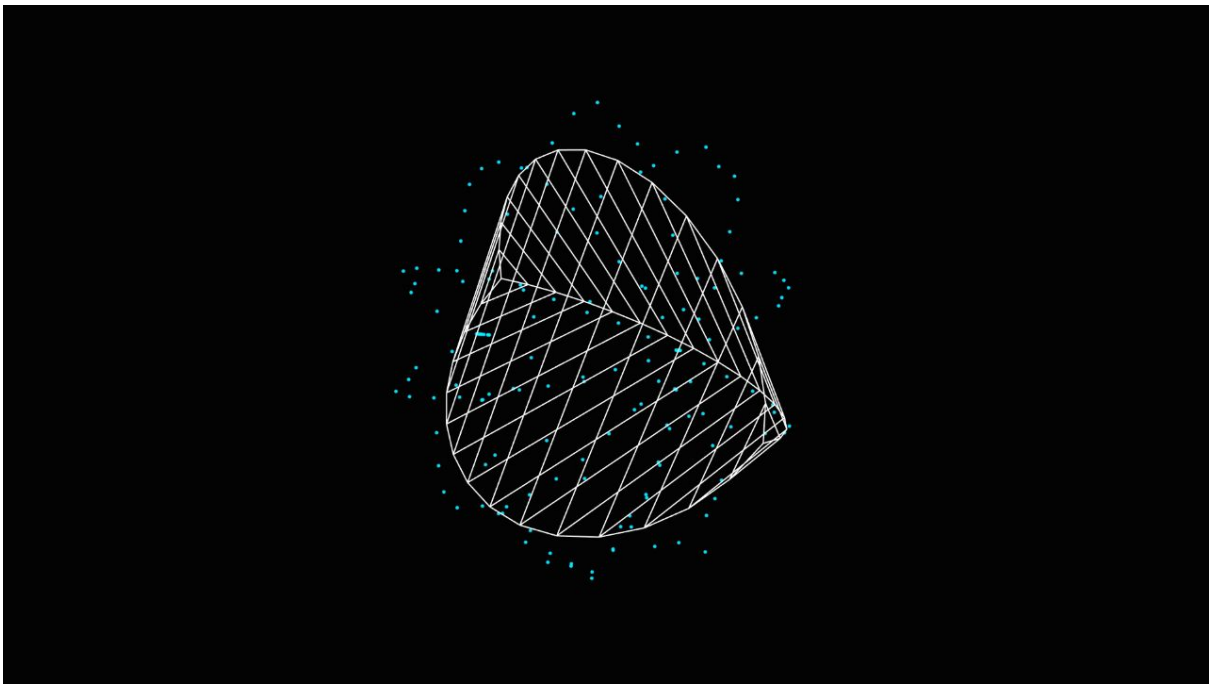


Figure 43: Kaushal, V. (2017). Graphic signature in *Zugzwang* (2017).

4. Analysis

a. Theory and Practice Reflections

i) On Conversation Theory & Interaction of Actors Theory

As discussed in the Literature Review, Gordon Pask's conversation theory (1976) is a way of thinking about learning as the constellation of actions and reactions between human and / or nonhuman agents. A conversation comprises an array of emergent properties such that each participant in the conversation will go away having reconsidered and reconstituted their ideas about the given topic. As Paul Pangaro explains, 'the difference between communication (including the technical, information-theory sense of Shannon) and Pask's conversation is that for conversation to have occurred, something must have changed for one or more of the participants—understandings, concepts, intent, values' (2016, p. 1581). In his article on conversation theory and educational technology, Bernard Scott demonstrates how the theory's more radical features can be lost in the attempt to put them into practice. In Scott's specific example, conversation theory as 'a theory of learning and teaching, in which one participant (the teacher) wishes to expound a body of knowledge to a second participant (the learner) (2001, p. 25). However, in the process of trying to 'apply' conversation theory to an already existing system, especially one involving digital technology and machines, the model of didacticism re-enters the equation. Retaining the properties of continuous change, dynamism, and reciprocal

learning is difficult when dealing with structures that traditionally rest upon normative hierarchies. Efforts to integrate and apply conversation theory as a method seems often to engender a return to the paradigm of the master / slave relationship.

This resistance faced when putting theory into practice relates to another paradox which arises out of the attempt to connect organic and mechanical systems (Pickering, 2014). In an article entitled 'Beyond Design – Cybernetics, Biological Computers and Hylozoism', Andrew Pickering discusses how 'the Modern detour through knowledge and away from the world can also be a *block*,' insofar as certain technologies which mediate natural processes can become 'a trip that forecloses options that Beer and Pask's work demonstrates lie actually already at hand' (2009, p. 486). He goes on to observe:

> nature does not need to make any detours; it does not just exceed our computational abilities, in effect it surpasses them in unimaginable ways (Pangaro, 2016, p. 1581).

As Pask and Beer attempted to integrate biological computing into factories, it became apparent that certain modern technologies diverged from the already existing natural processes which possessed the kinds of regulatory mechanisms they were trying to simulate artificially. Systems which had been otherwise perceived as forms of progress from primitive methods of organising labour actually entailed their own detours. The problem became one of trying to reintroduce what had otherwise been left behind and written off as unsophisticated in order to engineer, ironically, more efficient mechanical systems. The trouble, therein, lay in negotiating an interface between the natural and the artificial.

Conversation theory eventually developed into the interaction of actors theory—a permutation that focuses on the interchangeable roles of the individuals in a given 'conversational' scenario (Pask and de Zeeuw, 1992). Whilst conversation theory stands alone as a macro concept of how learning happens between individuals, interaction of actors theory emphasises the concept of what are called 'p-' and 'm-individuals'. These are different ways of describing mechanical and biological individuals (m-) and psychological individuals (p-). A 'psychological individual' is an attitude or disposition towards a given subject; it is that which determines how one behaves or what ideas a person is likely to bring to a conversation (i.e., these might be different in different contexts). Scott explains, p- and m-individuals 'are not necessarily in one to one correspondence. One m may house several p; one p may be housed by several m's' (Scott, 2001, p. 30). In other words, they are not interconnected in an exclusive and essential way. Were we to have explained the idea of our experiments to, say, an eleven

year old, we would have done so differently than if we were speaking to someone with a PhD. Different p-individuals can describe a particular constellation of ideas in motion, different ways of organising the same ideas, or even just different ways of communicating them.

Thinking about these experiments in the context of interaction of actors theory helps to illuminate the interchangeability of artist, curator, purveyor, participant, and all the various roles housed within the bodies of those involved. Throughout the course of the conversations which took place during the experiment, these roles evolved. People recognised how their actions—or, indeed, their thinking—informed the conditions of the space, feeding back into the other participants and creating an evolving conversation.

ii) On Cybernetic Theatre & Entertainment

Pask deemed theatre a vehicle for exploring his concept of Aesthetically Potent Environments and therefore presenting a suitable site for cybernetic experimentation. However, as Liss Werner describes, Pask felt the conventional 'top-down' approach to theatre was not an efficient method for dramatic presentations. As such, he modified the model to create a cybernetic theatre, which was effectively

> a feedback system that interfaces audience and actors and thus lets both of them act as participants in and control the conversation. In a cybernetic system, audience and actors are equally control systems–identified through the degree of interaction. The system was based on principles akin to the ones used in his teaching machines and the task to include control from the audience over the players, whose reaction again fed back into the audience and so forth (Werner, 2018, p. 2).

For all its radical aspirations, the theatre nevertheless remained a closed system; there were no other inputs besides the tools Pask used to control it. In this respect, whilst it was not technically a conversation, it exemplified some of the principles Pask was attempting to express.

Central to these ideas is the principle of pleasure. Werner offers a sensitive description of such systems in their article on the cybernetic theatre:

> *Paskian Artefacts*, as I observe them, are cognitive *thinking machines*, artificial organisms for interaction, play, and education. In his theatre design, Gordon Pask extended the typology of theatre, traditionally, a place for entertainment and consumption of joy, to a participative performance setup, a 'theatre 2.0', an experimental living architecture (p. 4).

Entertainment and pleasure were essential as without people's attention the whole experiment would have been impossible. People already interested in AI, wellbeing and mindfulness might have attended, but it was important that it attracted a diversity of people

so as to ensure that a diversity of forms of knowledge were contributed to the system in keeping with Ashby's principle of requisite variety. As such, the focus was on retaining people's engagement such that they were present and contributing. By the same logic, as Werner explains, Pask was invested in cultivating a similar atmosphere:

> In a *Cybernetic Theatre* as a behavioural meta-system, a typology of togetherness, an actor becomes an extension of a participant in the social system and vice versa. The second notable point is that a *Cybernetic Theatre* presents a truly collective "Entailment Mesh". In contemporary terms, it represents an organization where crowd behaviour plays the major role in the plot and acts as its main driver (p. 4).

As someone who designs experiential artefacts, I was most interested in drawing upon what makes social experiences uniquely powerful as distinct from individual experiences. Whilst individual reflective appreciation of artworks is undeniably valuable, it was the shared aspect of the experience which I tried most to support. Indeed, two of the operative keywords during the planning stages were 'shared' and 'entertainment', and it was between these poles that the experiment followed in a tradition of attempts to unite conversation theory into art and performance, linking back to the original Paskian artefacts prior to *Musicolour* (1956). Whilst I was confident that the theories behind the experiments were more than suitable starting points, they are only as effective as the ability for the experiment-performances to be evocative and intuitive for the people involved.

b. Personal observations

i) Implementation of Cybernetics

Different from the second experiment, participants were now able to see the object and each other by standing underneath the inverted pyramid. This allowed the participants to respond to each other in real time. I moved away from focussing on using the data for individual experiences towards creating something more collective. As a result, the participants were more conscious of their being connected and their influence on one another. In this respect, while the second experiment was situated somewhere on the spectrum just beyond first order cybernetics, the third experiment came just short of being fully second order. Participants were able to see, interact with, and adapt to the system more dynamically.

Despite the fact that the second experiment was called *Neu-collective Consciousness*, it was only by the third experiment that I explicitly used the data to generate a shared experience by intermingling the participants' readings. The word zugzwang evokes a sense of a dynamic wherein the individual is aware of their position in

a system whose nature is changed irreversibly by whatever action they take. The third experiment attempted to make this explicit by introducing this idea in the name. Like playing a game, participants could observe one another's actions and adapt their own accordingly, the result being something much more 'conversational'.

At this juncture, it is helpful to reflect back on Roy Ascott's study of Telematics (1990), the contemporary branch of cybernetics which makes artworks using the data transfer capabilities of telecommunications. In his article 'Is There Love in the Telematic Embrace?', Roy Ascott writes against artistic models which see 'the artist as sender and therefore originator of meaning', in favour of those in which 'the viewer actively negotiates for meaning', i.e. wherein 'meaning' is

> the product of interaction between observed and the system, the content of which is in a state of flux, of endless change and transformation (Ascott, 1990, p. 241).

This description elucidates the cybernetic principles of this experiment insofar as it involved the participants in the system in a way that even more explicitly positioned them as meaning 'creators' rather than just its 'readers'. Ascott's idea of 'a state of flux, of endless change and transformation' neatly locates the way in which, by introducing more simultaneous active participants, I had invited greater 'uncertainty and instability'. The outcome was something much more resembling a conversation than what previously had in the second experiment been more of a monologue. I had expanded the field of play, approaching my goal to implement a truly reflexive cybernetic system.

ii) Implementation of Social Practice

A further site of variation and complexity within the experiment arose out of its social aspects, specifically the way the different actors were organised in the space. When I designed the experiment, I conducted site visits to establish my options and any obstacles I might face. Straightaway, having seen that the space was essentially a lecture hall, the first and most obvious intervention I decided to make was to subvert the traditional audience / lecturer dynamic. The second experiment was the first step in creating a socially shared experience which could liberate people from their conventional roles as artist or audience. The third experiment took this further by eroding the stability of the stage, organising the participants into a circle around the pyramid and letting the audience walk freely underneath and around it. One of my principal motives for doing so was to test hierarchy, and in doing so, my sense of the word ended up changing from being something vertically organised to a more cyclic, structural process.

Claire Bishop's concept of the art gallery can be used to expound a theory of how the space of exhibition and / or performance affects the content of what is being performed and the roles of those involved. She details how relational art is 'entirely beholden to the contingencies of its environment and audience', and that,

> moreover, this audience is envisaged as a community: rather than a one-to-one relationship between work of art and viewer, relational art sets up situations in which viewers are not just addressed as a collective, social entity, but are actually given the wherewithal to create a community, however temporary or utopian this may be (2004, p. 54).

Bishop goes on to compare what she sees as the overly-cozy relational aesthetics of Liam Gillick and Rirkrit Tiravanija to the more politically reflexive relational aesthetics of Thomas Hirschhorn and Santiago Sierra. The latter, she explains, produce better art as they rely not on the 'fictitious whole subject of harmonious community, but a divided subject of partial identifications open to constant flux'. She explains how,

> if relational aesthetics requires a unified subject as a prerequisite for community-as-togetherness, then Hirschhorn and Sierra provide a mode of artistic experience more adequate to the divided and incomplete subject of today. This relational antagonism would be predicated not on social harmony, but on exposing that which is repressed in sustaining the semblance of this harmony. It would thereby provide a more concrete and polemical grounds for rethinking our relationship to the world and to one other (2004, p. 79).

Whilst my experiment-performances did not foreground their social dimension in the manner of Hirschhorn and Sierra, they did nevertheless formally enact the idea of 'the divided and incomplete subject of today'. As an attempt at grounding cybernetics in social practice, the experiments aimed to be an extension of the kinds of issues dealt with more explicitly in traditional social work, but operated on the level of form, illustrating how the human or mechanical subject is a contingent entity, subject to flux, fractured and dispersed across biological and technological networks and therefore mutually accountable.

5. Synopsis

a. Reflections on Theory

The third experiment-performance introduced a larger number of participants, thereby affecting the number of possible interactions that could take place. By introducing more participants, by definition there were more of what Pask calls 'm-individuals', as discussed above (Pask and de Zeeuw, 1992). There was also an increased chance of more

p-individuals (as distinct psychologies rather than mechanical bodies) because, by averaging the data taken from the participants as a whole, this meant that each m-individual was required to produce more extraordinary data readings in order for their influence on the graphic signature to be perceivable. However, paradoxically, this meant there was simultaneously a lower correlation between participation and influence.

The introduction of the pyramid explicitly encouraged the principles of cybernetic theatre and the importance of entertainment. As a non-traditional method of presenting visual media, more than just a vehicle for the visual data, the pyramid served as a theatrical prop around which the performance was oriented. Moreover, its placement just above eye level meant that the audience and participants could make eye contact whilst still facing the central performance piece. This allowed for ‘conversation’ between the audience and participants to continue uninterrupted by the presence of the spectacle in the centre—but nevertheless oriented around an artefact.

b. Testing and development

Moving into the final public performance I felt I needed to gain a better understanding of what the data correlated to in the brain. As such, I brought in a group of doctors and scientists who could help me to connect the dots between the abstract categories of ‘meditation’ and ‘focus’ and the actual brain activity which produced readings in these categories. This was the point at which I attempted to establish with greater precision what constitutes social and meaningful experiences from a neurological and psychological perspective.

What I learnt in *Neu-Collective Consciousness* was the importance and consequence of how the event was managed. Because there was no obvious ‘stage’, when people arrived at the space and during the experiment-performance, they chatted amongst themselves. Whilst this wasn’t a problem as such, it produced a different outcome in terms of atmosphere than what I had intended to create, and this was taken into account in the next iteration of the system.

Four – *Verrfast* (2017)

1. Summary

Aim: to host workshops with peer educators to provide participants with a deeper understanding of biofeedback, thereby increasing their level of authorship, and to make participants work in pairs to explore the different kinds of interactions produced.

Title: Verrfast

Venue / location: Talbot Mill

Commissioning Bodies: Cornbrook Collective, Capital & Centric, and Manchester Science Festival

Number of Participants: 8

Number of Audience Members: >500

Hardware: MacBook Pro, projector screens (x 4), speakers and amplifier, MioLink, NeuroSky Mindwave

Software: Modul8, OSX, MidiOSC, Brainwave OSC, Isadora, Bluetooth

Portfolio: https://www.loganandwilcox.co.uk/copy-of-zugwang

Figure 44: Kaushal, V. (2017). Participant in *Verrfast* (2017).

2. Introduction

This work was commissioned by the Cornbrook Collective in conjunction with Capital & Centric and the Manchester Science Festival. It brought together all the other components conceived in the previous performances. It was also an audio-visual installation which made use of brainwave headsets and heart rate monitors to collect biometric data (EEG and ECG) from the participants, the collected data then acting as triggers for sonic and visual information projected into the performance space.

3. Description

a) Overview

Workshops were carried out on three days over the course of three weeks in which peer practitioners were trained to help facilitate the running of the event, particularly in how to assist the audience participants attending on the day. Participants were recruited one month in advance of the performance days in order to account for the fact that there had been too large of a knowledge gap in previous experiment-performances. An extensive framework of training and workshops was deemed necessary in order for participants to

have a command of their unconscious behaviour. The workshops explored how the collaborative performance techniques could be used to practice mindfulness. I ran the workshops with the help of experts in neuroscience and psychology. Participants were provided with a basic theoretical knowledge for understanding biofeedback loops and the opportunity to gain hands on experience with the hardware and software. The work workshops all took place at Talbot Mill during an open studio session.

The first workshop provided an introduction to mindfulness, EEG brainwave activity and the ideas surrounding the biofeedback loop. The second workshop used the mindfulness techniques and EEG training from the first workshop to help refine the biofeedback system. This allowed the participants to get hands on with the EEG equipment, learn more in-depth about the brainwave activity and how they could harness it in a performance context. The final workshop involved the participants taking their new skills into a live installation where they were given the chance to train new performers who wanted to take part in the experiment. These workshops were open to all ages regardless of physical or mental abilities. People interested in meditation, mindfulness and improving their wellbeing using non-pharmacologic treatments were encouraged. We aimed for our workshops to be a collaborative process between workshop leaders and participants to learn more about the techniques of mindfulness. In this way, the aim was to bring together the explicit conceptual and academic ‘know-that’ of the peer educators with the critical reflections from the previous experiment-performances.

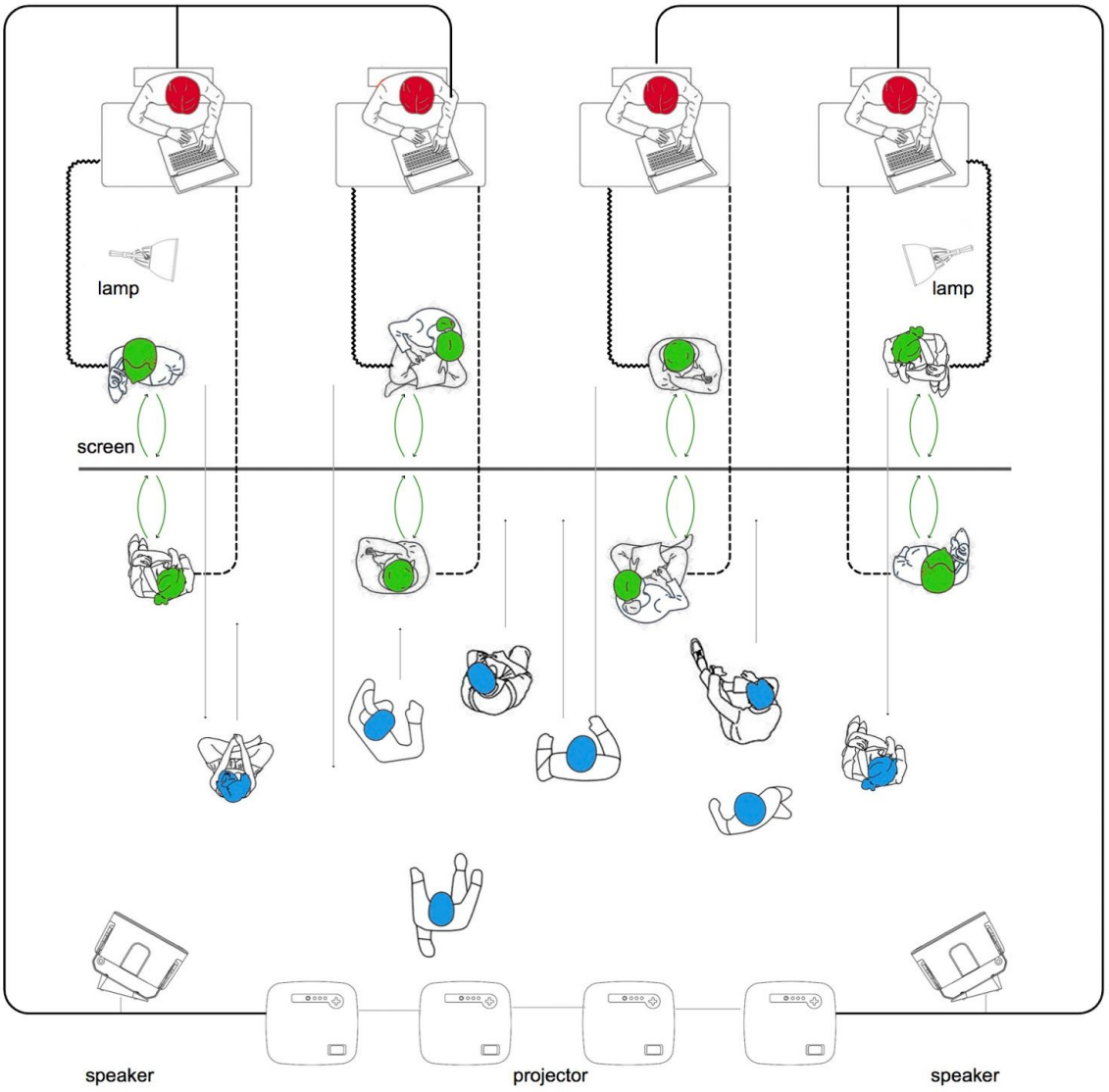


Figure 45: Kaushal, V. (2019). The spatial arrangement of *Verrfast* (2017) as a variation on paradigm ‘4. Hybrid’ with participants, spectators and artists.

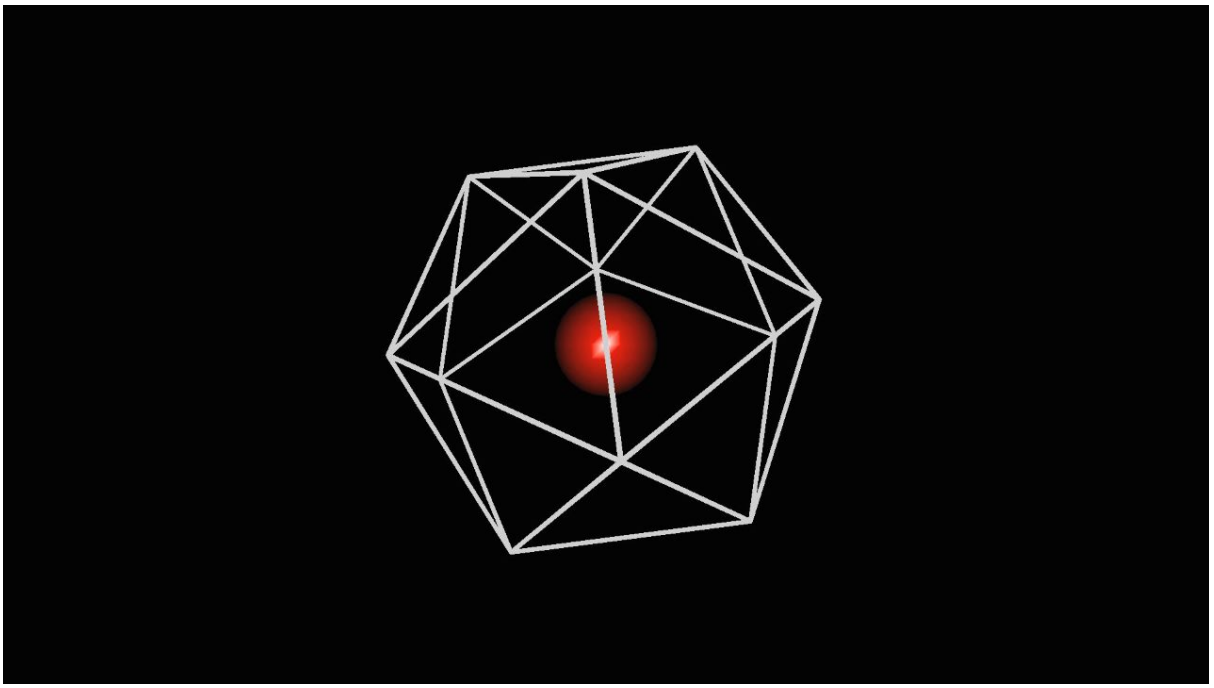


Figure 46: Kaushal, V. (2017). Graphic signature for *Verrfast* (2017).

b) Details

Peer practitioners were recruited from a network of volunteers and experts on the Manchester Museum of Science and Industry (MOSI) emailing list. The call for volunteers was targeted at participants who had already indicated an interest in these areas, particularly from the field of neuroscience. We were able to recruit neuroscientist Dr. Jason Taylor from Manchester University and Dr. Aspasia Paltoglou from the psychology department of Manchester Metropolitan University. It was intended that these two doctors would steer and guide the use and interpretation of the data. Their assistance also allowed me to focus on engaging with the participants, encouraging a dynamic atmosphere of collaboration. The inclusion of people from a variety of backgrounds accorded with the principles of cybernetics as a field which attempts to bring together different disciplines in the interest of increasing variety and, therein, opportunities for identifying previously imperceptible interfaces between what might otherwise be deemed disparate forms of knowledge.

There were a number of practical differences in this experiment-performance. First, it lasted for longer than those previous as the event took place over the course of three weeks. During this time, it was visited by 1,000 people which was in fact the smallest number of people to have attended any of the three public experiments-performances. The trickling footfall allowed myself and the peer participants to engage more deeply with visitors. It also allowed for further experimentation by the visitors as they were afforded

more time plugged in to the system. In turn, participants independently began to find other ways of affecting the performance other than through their brain activity and heart rate. There was a greater number of trained volunteers facilitating and managing participants than in previous experiments. Interestingly, they also partook in the performance as well when brainwave headsets and heart rate monitors became available, therein steering and shaping it themselves.

The academics and peer practitioners provided a number of innovations to the system and performance. Dr. Jason Taylor produced a crib sheet with a clear set of actions and outputs which participants could use to help focus their minds—e.g. ‘count back from ten to help you focus, and the graphic on the screen in front of you will rotate slower.’ As in previous experiments, we found that participants were most fulfilled by the experience when they felt in command / control of the sonic and visual channels. Participants wanted to know that they were actually controlling the 3D graphic signature. One of the peer educators suggested the idea of using blinking as a way for people to see that they were actually controlling the objects in front of them. Blinking causes the muscles in the face and the forehead to contract, generating a noticeable data spike and therein clearly demonstrating the participants’ effect on the performance. Dr. Jason also introduced participants to mindfulness techniques such as controlling the breath in order to take command over one's heart rate.

The aesthetic and spatial arrangement followed the precedent of the second experiment-performance whereby a semi-translucent screen was used (Figure 45). However, this time the instruments were configured slightly differently as each two-person ‘bay’ had an independent system in which one participant wore the neuro brainwave headset and one wore the heart rate monitor. There was no averaging or combining of data from individuals as in experiment 3. Participants worked in tandem, with one person standing on each side of the screen. With four respective screens, heart rate monitors and brainwave headsets in use, there was more interaction between participants and spectators as there were more nodes in the network. Participants’ heart rates were represented by a glowing orb, pulsating and increasing and decreasing in scale. Each participant’s heart rate was also amplified through its own speaker and sonified. Rotation and size were mapped to attention / focus and meditation, respectively. Scale was mapped to meditation. At different points throughout the three days, we switched these around in order to find out what effect this would have on the participants and the performance as a whole.

Figure 48: Kaushal, V. (2017). Workshops at Talbot Mill, Manchester.

Figure 49: Kaushal, V. (2017). Workshops at Talbot Mill, Manchester.

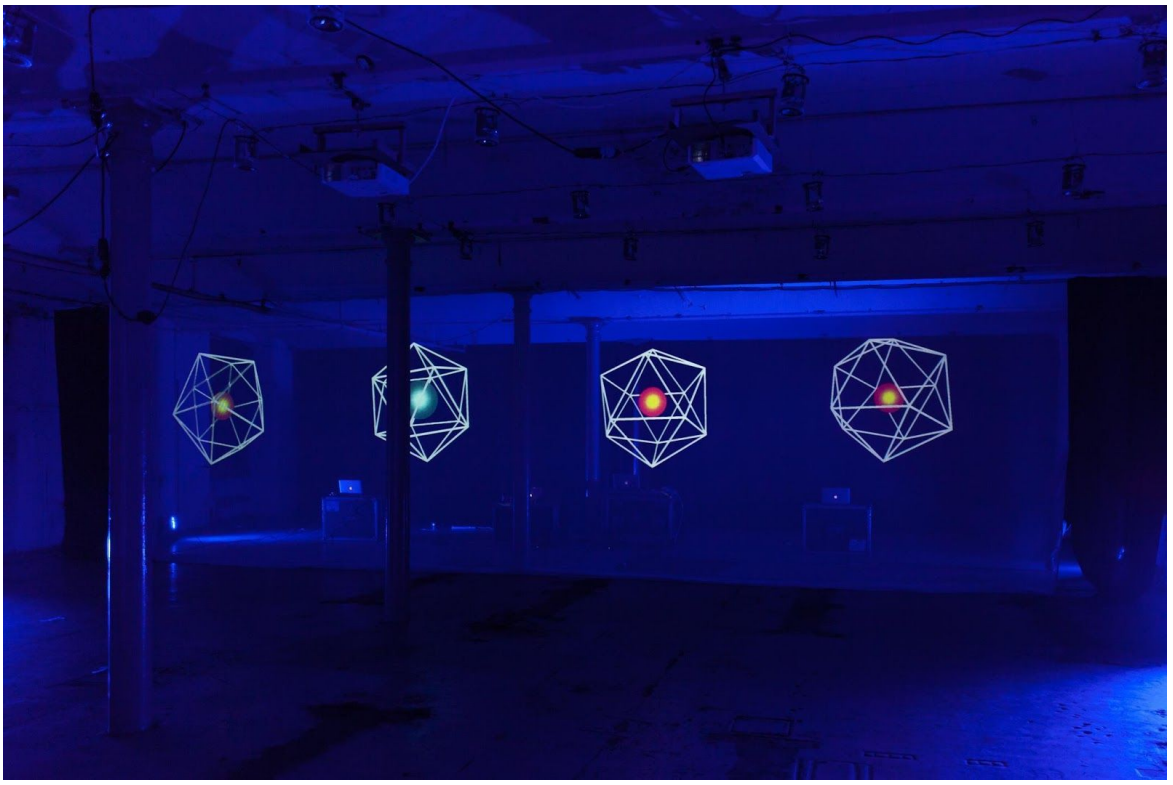


Figure 50: Kaushal, V. (2017). Final setup of *Verrfast* (2017).

4. Analysis

a. Theory and Practice Reflections

i) On Pedagogy

Theories of pedagogy both shaped and retroactively illuminated my practice. To elucidate this, I will detail the pedagogic role of the artist within socially engaged practice and, in turn, the example of cybernetic pedagogy offered by Roy Ascott's work.

Within social practice there are a number of approaches to pedagogy. Whilst always oriented around principles of collectivity, social practice can exhibit varying degrees of reflexive awareness of its position in, and impact on, wider society. In a review of Claire Bishop's *The Politics of Participatory Art* (2015), D. M. Bell observes that, for Bishop, this question of 'critical pedagogy' is

> built on increasing the agency of the student in relation to the educator, in order that the curriculum be opened up to explore the diverse experiences present in the classroom, and the intersecting oppressions that produce them (Bell, 2015, p. 8).

Herein, we encounter an emphasis on the 'bottom up' paradigm, an approach generally considered to be preferable in the world of socially engaged practice. However, during the experiment-performances I discovered that, by contrast, having someone to organise the

project from the ‘top down’ was useful. It allowed me to better coordinate and cohere what was afterall a complex and multifaceted network of interrelated processes. I was able to free my attention to push boundaries artistically and technologically. Of course, here the question of the roles of the artist and audience are central, as Bishop acknowledges. What I discovered was that the benefit of their mutability was in fact limited. Preserving the original, didactic paradigm was useful when ensuring the experiment-performance was carried out to the full extent of its ambitions and, indeed, that it could exceed them.

This was achieved by introducing the peer educators. During the earlier experiments, the participants didn’t understand the technologies so they had to narrate their own versions of what was forming the abstract 3D signatures. At this later stage, participants began to understand the import and consequence of the headsets and brainwave software. By explaining the system, the participants’ intentional agency, or what Kujawski might simply call ‘thinking’ as a process of ‘individuation’, was enhanced (Kujawski, 2018, p. 3). Rather than being a receptacle through which the atmosphere is channelled, the participants were invested with sovereignty, becoming active agents rather than simply passive nodes in the network. In this way, the ‘concepts’ formed in the minds of the participants refer less to static objects than to processes of understanding:

> *concept* here refers to a cognitive process that maintains itself through “agreements” between pure ideations without privileging linguistic significations and semantic contents (Kujawski 2018, 3).[…] [T]he notion of concept we are dealing with is distant from the philosophical common sense (e.g., Hegel’s Begriff) (Kujawski, 2018, p. 3).

Concepts are produced by and as extensions of situations. As such, it made sense that the brain wave data changed as the participants’ understanding of the system changed. The network of processes was never static, but continuously evolved, dissipated and reemerged through agreement, disagreement, discussion and conversation.

By merging the roles of audience and artist whilst nevertheless preserving certain aspects of the traditional artist’s role, a particular breed of pedagogy emerged. Bell offers the following description of what this looks like within social practice:

> The educator's role, then, is not to introduce dissensus, but to facilitate a participatory (or 'collaborative') space, which leads to the emergence of dissensual experiences that already exist within the social fabric (Bell, 2015, p. 8).

The emphasis on pedagogy steadily increased throughout the experiments as I gradually allowed myself and the peer educators to have more and more input. This was partially due to me learning more about the system as I went along and, respectively, implementing feedback from the previous experiment-performances. In brief, I realised

there needed to be some kind of organisational agency. Though I recognised the value of the hands-off, bottom-up approach, I realised that stabilisers are nevertheless important to ensure a project's direction and momentum are maintained.

Roy Ascott's teaching career offers some interesting points of contact and contrast when thinking these ideas through. He understood from as early as the 1970s how emerging digital technologies could be used by artists and how they would change how we conceive of art. In a review of *Telematic Embrace* by Roy Ascott, Char Davies details how (2018, p. 1), 'as head of Foundation Studies at the Ealing College of Art in London (1961-64),' Ascott 'created what might be called a cybernetic art pedagogy.' There, Davies explains,

> the classroom became a cybernetic studio, in which the artist could experiment with behavioral interactions among his students, and in which his students could learn some of the most advanced aesthetic theories firsthand, by participating in them (2018, p. 1).

Ascott's interest in developing new systems of learning was radical in the art world at that time, especially within art school pedagogy. What Ascott developed and then proceeded to question in the roles of the artist and audience was eventually played out for producers and consumers by the logic of prosumption (Toffler, 1980) and the mass amateurization of online content production (Kjaffe, 2009). Whilst the other cyberneticians we have discussed were scientists with artistic leanings, Ascott is an artist with scientific leanings. Claire Bishop critiques pedagogy within social practice, whereas Ascott does so from the perspective of cybernetics. As such, despite surface-level differences, these two strands of thought actually have much in common.

ii) On Scaffolding

A further term which offers an alternative mode of analysing this experiment-performance is the principle of 'scaffolding'. Similar to the concept of pedagogy, scaffolding describes how a system is assembled in such a way as to maximise participants' understanding of their role and impact. It is a term often used in linguistics to describe the notion that, in order to have a conversation, you have to possess a certain level of prior contextual knowledge—whether, for example, in the form of frames of reference, or even just the base conventions of discourse. Whilst popularised as a linguistic concept (Davis, 2004), the term 'scaffolding' is also found in cybernetics. Memory, scaffolding, embodiment, and situatedness build on one another. Pedagogy is directed at understanding the processes which take place within each individual's interaction with a system. In general, some

people learn better by way of certain metaphoric or analogistic mnemonic narratives. As such, pedagogical techniques must always be adapted to the particulars of a given scenario. These specific frameworks are called ‘scaffolding’.

To get the most out of the project, the participants needed to understand the internal processes. Scaffolding is the means by which knowledge of the contextualising processes and apparatuses is transferred to the individuals involved. Previously, even though the experiments were aesthetically successful, fulfilled the commission criteria, and interested audiences, participants still wanted to know more about how they could more precisely control the system. Having command over it is what makes it an interesting and engaging process. For instance, when we blink, a sizable electrical impulse is generated to move the necessary muscles, noticeably changing the graphic signature. Due to the fact that blinking is readily perceptible, people immediately realise that they are actually having an effect. However, even more powerful is to feel oneself controlling the signatures by cognition processes invisible to the naked eye, such as concentrating or meditating. The participants’ brainwave data corresponds to a number of different cognitive processes and sensory perceptions. As such, a rigorous scaffolding was introduced to nurture the participants’ awareness of how their less apparent cognitive processes influenced the graphic signatures.

When participants learn about how the system responds to certain inputs, this knowledge is internalised and stored as memory. In earlier cybernetic research and in later studies of AI, the computer was used as a metaphor to understand cognition and memory. However, recent studies and research have contributed to undermining the credibility of this metaphor, exposing it as over-simplifying and reductive. Instead, cognition is coming to be understood as ‘embodied’ and memory is increasingly regarded as a ‘process’ (Ziemke 2005). The conventional and traditional concept of memory is characterised as a site in the mind in which 'objects' are stored and from which they can be retrieved. However, in an article by Tom Ziemke concerning ‘the relevance of Heinz von Foerster’s work to modern embodied cognitive science and artificial intelligence research’ (2005, p. 118), what Ziemke refers to as the ‘traditional “fridge-theory of memory”’ is replaced by the concept of memory as a set of dynamic processes (p. 122). Giving the example of a robot, the term memory designates a system wherein certain reflexes are recalled to respond to particular actions and events. Scaffolding, the term we have been reflecting on, supports memory as a function of learning:

> what the memory does instead is to adjust the robot’s modus operandi to the situations it is about to encounter. […] [T]hey typically succeed by exploiting the environment as a “scaffold” guiding their behavior and by suitably adjusting their own *modus operandi* to deal

> with future situations. That means, instead of remembering the past in the traditional sense, they are “remembering how to behave” (2005, p. 124).

Ziemke argues memory is not a storage space but a set of processes. This description also takes us away from the aesthetic to re-align us with the concept of behaviour. We adjust our behaviour to the environment, and the environment is constituted by other agents doing exactly the same thing.

b. Personal observations

i) Implementation of Cybernetics

When I began developing these experiments, my approach was experimental and 'trial-and-error' based. By the end of the experiments, I returned to a more streamlined, top-down approach. I established that the system needed to be explained to people as soon as they came through the door. For example, participants in the previous experiments were very interested in the heart rate monitors and the brainwave data, so this time I explained those in advance to avoid having to repeat ourselves as we had done previously. In sum, it was a much more conventional mode of carrying out the process.

As early as the 1960s, cybernetic practitioners were engaged in a holistic array of practices, ranging from traditional scientific pursuits to quasi-spiritual experiments, carrying out seances and discussing the possibility of a collective consciousness, all while researching machine learning. However, this union receded. Whilst they had understood that the study of consciousness, AI, conversation theory, and the body were all relatable under the mantle of cybernetics, such endeavours are now regarded as clearly distinct from one another. If cybernetics had secured itself as a credible mainstream mode of enquiry, we would be teaching young people that mindfulness was part of science. We would be teaching the theory of the sensorium, how knowledge is produced, and a more holistic framework of how the body functions in specific situations. These would have remained scientific concerns rather than being relegated to philosophy. Instead, these disciplines went through a process of atomisation. My project attempts to extend what past cyberticians had endeavoured to promote along these lines. Rather than ridiculing the practitioners for conducting seances, doing yoga and meditating, I see these as part of a holistic, situated practice. These principles align with Ziemke’s analysis of an alternative model of conceiving of memory. Respectively, against the atomic paradigm, Ziemke argues that modern cognitive science must continue to

> emphasize, in line with radical constructivist views such as Heinz von Foerster's, the importance of embodiment and situatedness, […]as central to the emergence of cognitive processes (2015, p. 125).

Cybernetics has greatly shaped my own theory and practice. Whilst I am educated in the arts, my knowledge and understanding of neuroscience is much more limited. However, I recognise the importance of placing them in dialogue with one another. During my time in formal art education, digital technologies were emerging as tools, techniques, and mediums and research which sought to bring studies of consciousness together with aesthetic concerns was limited. My experiment-performances reintroduced these disciplines to one another.

ii) Implementation of Social Practice

This section provides personal observations on the experiment's implementation of social practice. Claire Bishop argues that social practice can often lack critical reflexivity. In this context, reflexivity means being able to recognise that one's participation is always situated within a further context of wider feedback loops. Social practice is complicated insofar as it involves conversation and, as Pask and Pangaro explain, conversation isn't merely linguistic; it's also behavioural. That is what their experiments are concerned with and yet we are only beginning, fifty years later, to arrive at a place technologically where a machine can be involved in conversation in the way people like Ascott and Pask would have wished. Even so, human-machine conversations are still significantly behind the complexity and sophistication of human-human conversations.

What Bishop critiques of social practice in the field of 'relational aesthetics', Ascott recognises in a different forum. However, his work falls short of illustrating a fully-formed reflexive stance insofar as it defaults to developing rudimentary machines with minimal inputs and outputs. Due to technological limitations, he has never been able to create a sufficiently sophisticated example of the principle of reflexivity. Whilst he is indeed aware of the complexity of the feedback loops between humans and machines, his work is either reduced of this dynamism or remains hypothetical.

What Bishop perhaps fails to identify is that there are ways in which artworks which might seem unreflexive can nevertheless exhibit reflexivity on the level of form. Ascott argues that we have simply not yet developed sufficiently sophisticated AI to facilitate a truly dynamic UI. It is worth recalling that the work that people like Ascott and Pask did was outside the traditional route for research and funding meaning progress has inevitably been slow. However, the obstacles are being identified and recorded. Taking

stock of what technological advances have been made, Ascott believes the requisite inventions are simply on their way down the information superhighway.

5. Synopsis

a. Reflections on Theory

In the final experiment-performance it was the introduction of the peer educators which developed the project furthest from its earlier iterations. From one angle, their presence reintroduced the model of the artist at the top of the hierarchy of roles as they steered the experience and interactions of the audience with the artwork. They brought their own pedagogical style (an example of one p-individual in operation) which differed from my own. Whilst I was interested in discovering what was going on in more depth as far as brain activity, the peer educators instead directed their attention to producing the greatest level of influence by the participants on the system, introducing crib sheets which gave suggestions to the participants on certain actions and thought processes which would be likely to produce the most noticeable results. In this sense, the traditional role of artist was subverted insofar as it became distributed between myself and the peer educators, and respectively between each of the different peer educators among themselves.

The concept of scaffolding is close to pedagogy but instead describes the tools and infrastructure needed for learning to take place. Pedagogy, on the other hand, describes the system and decisions which determine the kind of scaffolding employed, depending on the context and end goal. In a sense, my pedagogy led me to introduce the peer educators as a form of scaffolding to enable greater learning about the system by the participants. The peer educators had their own pedagogy which led them to introduce crib sheets as another more discrete form of scaffolding. Whilst my background in social work was such that I introduced various tropes from the discipline (sitting in circles, workshopping the process, encouraging a relaxed, social atmosphere, for example), their scientific backgrounds provided the experience that counting down from ten would produce have certain effects, hence why these kinds of instructions were included on the crib sheets.

b. Testing and development

The involvement of the doctors and scientists was a convenient way of beginning to think about the project within a more explicitly academic framework. Following their introduction to the process, it became clearer how to structure the ideas around various themes to do

with not only participation and interactivity but also problems of consciousness and mind-body dualism. Following a supervisory meeting to agree on the structure of this write-up, I went on to read more about these areas in order to better understand the current state of the discourse on AI, machine learning, and to gain a more philosophical understanding of these issues.

A principal outcome was that I was able to see the project as a whole. More specifically to this experiment-performance, the artist resurfaced as a central role, and so I concluded that in fact this is not necessarily antithetical to challenging the divisions between the roles or artist, audience and artwork as it was only by taking more of an active part in the process that the audience participation was increased. In turn, this was offset by the fact that control was relinquished to the peer educators; their being able to introduce their own objectives inevitably dispersed responsibility and authorship, steering me away from my original intentions.

VI. Conclusion

1. Introduction

Having detailed the content of the experiment-performances in how they challenged the divisions between the roles of artist, audience and artwork, this section will return to the discourses of biofeedback, cybernetics, and social practice. It will show how my own project contributes to their respective questions and wider concerns. To do so, I will recap the stages of the project across each experiment-performance before critically reflecting on the key findings, shortcomings and obstacles faced during its course. I will then propose potential solutions which could be implemented and other conceptual frameworks which could be explored in future research. Before going into depth, a summary of the experiment-performances and their key findings are outlined in tables below which introduce their central issues in relation to the concepts and the work of practitioners they build upon.

2. Summary and Key Findings Tables

The following tables outline how each experiment-performance contributed to the objectives and their respective variables, equipment and outputs. It also overviews the key findings in relation to existing knowledge detailed in the Literature Review.

Experiment-Performances	**Contribution to objectives in addressing research question**	**Variables**	**Equipment**	**Outputs**
1. *System*	Undertook technical research – tests of equipment, processes and methods which facilitated the production of a system that could collect and represent biometric data sonically and visually	Heart rate, brainwaves, breathing, movement	MacBook Pro, projector screen (x 1), speakers and amplifier, Modul8, OSX, Health Tracker, MidiOSC, Modul8, Microsoft Kinect V2, Arduino Microprocessor, Processing, MioLink, Fitbit, iHealth, NeuroSky Mindwave, Brainwave OSC, Isadora, Bluetooth	Biometric data was used to create a feedback loop between the participant and the audiovisual outputs

2. *Neu-Collective Consciousness*	Increased the number of participants and therefore the number of inputs to the audiovisual outputs of the system. Also introduced the system into a live performance context, thereby introducing an 'audience' into the work	Heart rate, brainwaves, number of participants, number of audiovisual outputs, performance environment, presence of a commissioning body	MacBook Pro, transparent gauze, speakers and amplifier, Modul8, OSX, MidiOSC, Modul8, MioLink, NeuroSky Mindwave, Brainwave OSC, Isadora, Bluetooth	A performance involving multiple participants wearing biometric devices whose data readings were visualised and sonified to form a biofeedback loop. As well as this, the work produced the outcome of a further commission in the shape of the third experiment-performance.
3. *Zugzwang*	Granted participants greater control of the biometric devices and combined their data to form a 'conversation', resulting in more interaction between the audience members.	Heart rate, brainwaves, number of participants, number of audiovisual outputs, performance environment, different commissioning body	MacBook Pro, projector screens (x 3), speakers and amplifier, Modul8, OSX, MidiOSC, MioLink, NeuroSky Mindwave, Brainwave OSC, Isadora, Bluetooth	Another performance with multiple participants wearing biometric devices but this time combining their data to form a collective biofeedback loop. This also resulted in a further commission.
4. *Verrfast*	Hosted workshops with peer educators to provide the participants with a deeper understanding of the biometric devices, increasing their level of authorship. I also made participants work in pairs to explore the different kinds of interactions produced between the audience members.	Heart rate, brainwaves, number of participants, number of audiovisual outputs, performance environment, different commissioning body, peer education, preparatory workshops	MacBook Pro, projector screens (x 4), speakers and amplifier, Modul8, OSX, MidiOSC, MioLink, NeuroSky Mindwave, Brainwave OSC, Isadora, Bluetooth	Another performance with multiple participants wearing biometric devices but this time combining their data in pairs to form a collective biofeedback loop. A greater understanding of the relation between the neurological and phenomenological nature of perception and consciousness.

Table 1: Experiment-Performance Summary Table

Contribution to Knowledge		**Existing Knowledge**
Summary	**Details**	
The implementation of biofeedback in audio-visual performances can challenge the traditional divisions between roles of artist, audience and artwork.	This is achieved by bringing together the technologies of biofeedback with the cybernetic principles of interactivity and the social practices principles of participation.	Builds upon Pask, Glynn and Matarasso, extending their work by combining the cybernetic principle of interactivity, the social practice principle of participation and the implementation of biofeedback
	When successful, the work modelled something akin to Pask's concept of 'Aesthetically Potent Environments'.	Builds upon Pask and Ascott, developing their models by implementing biofeedback
The frameworks of social practice and cybernetics strengthened the challenge to the divisions between the roles of artist, audience and artwork.	The social practice principle of participation produces the opportunity for interdisciplinary conversation.	Builds upon Bey, Moten and Harney by producing an artwork which models their theories
	Cybernetics (interaction) combined with biofeedback produces the experience of integration, embodiment and situatedness.	Builds upon Heidegger and Merleau-Ponty by producing an artwork which models their theories of phenomenology
	Combining interdisciplinary conversation with the experience of embodiment, situatedness and integration challenges the even more fundamental divisions between the categories of human, technology, environment, and between the mind and body, and the individual and the collective (see figures 51 and 52).	Builds upon phenomenology, posthumanism, social practice and cybernetics in general by producing an artwork which models their theories
However, there is a limit to the degree to which cybernetics and social practice support challenging the divisions between the roles.	Participation for its own sake distracts from the experience of integration, embodiment and situatedness.	Builds upon Matarasso and Bishop by exposing the limits of participation when producing artworks
	Interaction and biofeedback for their own sake devolve into technofetishism.	Builds upon Glynn and Pask by exposing the limits of interaction when producing artworks

Table 2: Key Findings Table

3. What I Did:

Before detailing the discoveries made, I will first outline what took place across the course of the experiment-performances.

The first step was to develop a system which allowed for the implementation of biofeedback in audio-visual performances. This was achieved using a combination of software and hardware which were tested for suitability. Having done so, I implemented the biofeedback system in a live performance context, inviting participants from the audience to take part in the system, forming a biofeedback loop with their biometric data and responding to the representations of this data in realtime. I aimed at producing a system which enabled interaction between the roles of artist, audience and artwork so as to challenge the traditional divisions between them. This was principally achieved through the use of biofeedback and was supported in the particular ways in which the system and the space were set up.

By implementing biofeedback into an audiovisual performance, my impression from the feedback from participants and audience members in general was that this had been successful. The participants expressed that they felt they had been able to influence the performance and, alongside this, in many cases they described it as having provided them with a ‘meaningful experience’. In response to this feedback, I scaled the system and performance, allowing more participants to take part by introducing more headsets.

By the final experiment-performance, I was inspired to introduce more scaffolding in the form of workshops to aid their understanding of how the system worked. Whilst many participants had said they felt able to influence the performance, this was accompanied by other feedback from some of the participants who described having nevertheless felt that it was sometimes unclear to what extent their participation had indeed had an effect on the performance, therefore suggesting that there was still greater room for further challenging the divisions between the roles of the artist and audience. Moreover, by introducing experts in psychology and neuroscience, I also had hoped to gain a greater understanding of what the participants were referring to when they described having a 'meaningful experience', or what was taking place psychologically and / or neurologically that induced them to do so. Contrary to what I had expected, this introduction of workshops and peer practitioners to the process did not support the use of the system technologies to aid the performance but rather focussed attention away from it and onto the technologies themselves.

4. What I Found:

a) The success of biofeedback

The implementation of biofeedback in audio-visual performances can challenge the traditional divisions between roles of artist, audience and artwork. This is achieved by bringing together the technologies of biofeedback with the cybernetic principles of interactivity and the social practices principles of participation. When successful, the experiment-performances modelled something akin to Pask's concept of Aesthetically Potent Environments.

i) Interactivity and participation

This is achieved by bringing together the technologies of biofeedback with the cybernetic principles of interactivity and the social practice principles of participation. By using biometric devices to create biofeedback loops and implementing these in a participatory performance, I was able to create new systems for interaction between the roles of artist, audience and artwork. The cybernetic principle of interaction and the social practice principle of participation supported this project. The two words have slightly different connotations, and by bringing them together I was able to address the different aspects of the research question to which they pertain.

Rather than simply being involved in its production, Francois Matarsso (2018) contends that 'participatory art' involves the participants' intentions steering the direction of the work in a dynamic relationship, whereby influence is reciprocally made and felt by all those involved. By contrast, interactive art allows for audience members to influence the work with which they are engaged. True interactivity, as opposed to mere reactivity, means 'interaction as a conversational activity between participants' (Glynn 2016, p. 1), wherein the system adapts and changes to the inputs from the audience, whose own inputs are in turn affected by the response from the system with which they are engaged. Where interaction describes a more tangible, immediate relationship to an object or technology, participation examines the individual themselves and their relationship to the system as a whole—both in terms of its internal properties and its contexts of reception and production. Interaction insists upon scrutinizing the nature of the role of the artwork, whereas participation looks at the context and makeup of the audience. Bringing them together in the performance, I was able to challenge division between the roles involved. This can also be thought of in relation to the distinction made by Christy Mag Uidhir between collective production and collective authorship. The greater the level of

interaction and participation, the more the audience were able to author their environment as artists in their own right.

ii) Aesthetically Potent Environments

Ultimately, what was discovered was that the kinds of artworks which seem to challenge the traditional divisions between the roles of artist, audience and artwork are those which model the principles of 'Aesthetically Potent Environments'. As outlined by Pask in 1971, these are:

> I – It must offer sufficient *variety* to provide the potentially *controllable* variety [in Ashby's terms] required by a man (however, it must not swamp him with variety—if it did, the environment would be merely *unintelligible*).
>
> II – It must contain forms that a man can learn to interpret at various levels of *abstraction*.
>
> III – It must provide *cues* or tacitly stated *instructions* to guide the *learning* process.
>
> IV – It may, in addition, *respond* to a man, engage him in *conversation* and adapt its characteristics to the *prevailing mode of discourse* [my italics] (Pask 1971, p. 76).

Aesthetically potent environments are directed at producing the opportunity for 'conversation' via participation and interactivity. Across each experiment-performance, their principles were addressed in the following ways. Throughout, 'variety' was pursued by first of all testing out different types of data: from heart rate to temperature and facial expression. These were then whittled down in order for the system to be sufficiently 'controllable'. From the second to the fourth experiment, the number of participants was also increased and decreased in view of balancing, respectively, variety and controllability. Avoiding unintelligibility was supported by the 'instructions' and 'cues' during the fourth experiment-performance in the shape of the crib sheets and the conversations I had with the participants throughout the entire process. These allowed the participants to 'respond' to the system in the manner of a 'conversation' as they sufficiently understood how it worked such that they could interact with it. Also in the fourth experiment-performance, the participants respective interests in meditation, mindfulness, consciousness and neuroscience, alongside the newness of the technologies used (such as the brainwave headsets), provided the points of contact with 'prevailing mode[s] of discourse', whilst also no doubt contributing to the degree to which the work invited engagement.

In turn, this aligns with the behavioural model of art envisioned by Ascott, who compares the traditional modalities of 'painting and sculpture' for which 'the channel of communication remains largely visual' with a new kind of art whose modalities are 'tactile, postural, aural[…] so that a more inclusive term than "visual" art must be found' which he

proposes as '"behavioral"' (Ascott R., 2008, p. 110). By employing biofeedback, I attempted to respond to the theories of Pask and Ascott, creating artworks which extended their ideas to become truly interactive and participatory systems, composed of images, sounds and behaviour.

b) Social practice and cybernetics

i) Interdisciplinary conversation

The frameworks of social practice and cybernetics strengthened the challenge to the divisions between the roles of artist, audience and artwork. Social practice (participation) produces the opportunity for interdisciplinary conversation. In turn, cybernetics (interaction) combined with biofeedback produces the experience of integration, embodiment and situatedness. Combining these together challenges the even more fundamental divisions between the categories of human, technology, environment, and between the mind and body, and the individual and the collective.

The social practice principle of participation produces the opportunity for interdisciplinary conversation. The participatory aspects of the project, such as the inclusion of different practitioners from different fields and inclusion of audience members, and the fact that those involved could have an influence on the work at all, produced an interdisciplinary conversation. In this respect, the experiment-performances produced the possibility for what Fred Moten and Stefano Harney call 'study'. Moten and Harney subvert the traditional notion that 'study' is a solitary activity, repurposing it to describe what they believe it actually to be, which is a social event:

> When I think about the way we use the term 'study,' I think we are committed to the idea that study is what you do with other people. It's talking and walking around with other people, working, dancing, suffering, some irreducible convergence of all three, held under the name of speculative practice. The notion of a rehearsal – being in a kind of workshop, playing in a band, in a jam session, or old men sitting on a porch, or people working together in a factory – there are these various modes of activity. The point of calling it 'study' is to mark that the incessant and irreversible intellectuality of these activities is already present. These activities aren't ennobled by the fact that we now say, "oh, if you did these things in a certain way, you could be said to be have been studying." To do these things is to be involved in a kind of common intellectual practice. What's important is to recognize that that has been the case – because that recognition allows you to access a whole, varied, alternative history of thought (Harney and Moten 2013, p. 110).

Ultimately what the experiment-performances showed was that these social experiences produce the greatest possibility for conversation in every sense. Hakim Bey identifies other types of events, such as 'the party', as sites at which this becomes possible:

> The essence of the party: face-to-face, a group of humans synergize their efforts to realize [sic] mutual desires, whether for good food and cheer, dance, conversation, the arts of life; perhaps even for erotic pleasure, or to create a communal artwork, or to attain the very transport of bliss—in short, a "union of egoists" (as Stirner put it) in its simplest form—or else, in Kropotkin's terms, a basic biological drive to "mutual aid" (Bey 1994, p. 104).

By modelling this kind of experience, the experiment-performances provided a framework to encourage interdisciplinary conversations. This project is situated somewhere between happenings and parties with which it shares the purpose of people coming together for a common goal. This was especially so by the final experiment-performance which brought together a number of collaborators in informal workshops to share ideas and collaborate. Much like the sites Moten, Harney and Bey identify, the experiment-performances brought together a wider variety of different people with their own diverse forms of knowledge into non-hierarchical organisational structures. In this way, the party presents a different way of organising an otherwise disparate set of people around a common pursuit of enjoyment and pleasure. There is a levelling effect produced by this equality of purpose, wherein each participant's usual role outside the space is suspended in favour of a new, common role. In this respect, the social dimensions of the experiment-performances inadvertently produce the possibility for interdisciplinary conversations.

Social practice describes a mode of artistic production which foregrounds process, participation and an emphasis on contextual considerations (ranging from audience to site), but it also rests upon an often unstated presupposition of what the 'social' aspect of its practice is. Harney and Moten (2013) outline a vision of social practice by repurposing the terms 'planning' and 'study'. To 'plan', by their proposed redefinition,

> is to invent the means in a common experiment launched from any kitchen, any back porch, any basement, any hall, any park bench, any improvised party, every night. This ongoing experiment with the informal, carried out by and on the means of social reproduction, as the to come of the forms of life, is what we mean by planning; planning in the undercommons is not an activity, not fishing or dancing or teaching or loving, but the ceaseless experiment with the futurial presence of the forms of life that make such activities possible. It is these means that were eventually stolen by, in having been willingly given up to, state socialism whose perversion of planning was a crime second only to the deployment of policy in today's command economy (2013, pp. 74-5).

The often overlooked question of what is distinctly 'social' about a given form of art production applies as readily to the 'social basis' of cybernetics which we outlined earlier. 'Study', as Moten puts it, locates such activity in already existing social life: 'study is what you do with other people' (2013, p. 110). By introducing the system I developed into a live

performance environment and inviting the audience to participate in it, the work immediately became invested with the dynamism and serendipity which becomes possible as unplanned interactions are able to take place.

ii) Integration, embodiment and situatedness

The cybernetic principle of interaction combined with biofeedback produces the experience of integration, embodiment and situatedness. My experiment-performances drew upon this heterogeneity of knowledge forms to explore how the roles involved in the performance of art could interact. The interactive aspects of the project were the feedback loop itself and how it captured and represented the data in such a way as to reintroduce the responses by the participants back into the system. Other interactive aspects include the scaffolding of the workshops, the explanations offered to the participants during each performance of how to use the technology, and the conversations between the audience and the artist. Participation describes the inclusion of other actors who have a role in its production and whose intentions are imprinted on the work. Interaction is the quality of the relationship between them such that this influence is rendered and then felt, thereby causing a feedback loop between the participant, the artefact, and the system itself. In the process, what was made felt and understood was the embodiment of the mind and, in turn, the situatedness of the mind and body in the social.

This discovery hails back to the philosophy of Maurice Merleau-Ponty. In a chapter of *Phenomenology of Perception* (1945) entitled ‘The Synthesis of One’s Own Body’, he discusses the ways in which embodiment and spatiality exist as forms of experience beyond being empirical facts (2002, pp. 171-8). ‘To be a body, is to be tied to a certain world, as we have seen; our body is not primarily in space: it is of it’ writes Merleau-Ponty (p. 171), before going on to suggest that ‘the body is to be compared, not to a physical object, but rather to a work of art’ (p. 174) for ‘it is a nexus of living meanings’ (p. 175). The significance of this to the final experiment is two-fold: foremost, the system is invested in bringing awareness to this situatedness of the body as it is integrated with others in, and of, its environment. Following which, by making the participants aware of how the relationship between their embodied place in the performance system and the effect of this on their unconscious activity, they were brought into contact with the ‘meaning’ of this fact: that their individual role was in fact situated and integrated in a wider social whole. Consciousness of this then has a reciprocal impact on how the participants think about and perceive the technology itself. As Merleau-Ponty has it, ‘once the stick has become a familiar instrument, the world of feelable things recedes and now begins, not at the outer

skin of the hand, but at the end of the stick (175-6). Phenomenology addresses the body as a site of meaning, and my experiment-performances attempted to produce the kinds of experiences which make this felt. The reason and basis for this is that being made aware of one's embodiment in turn produces consciousness of the situatedness and integration of one's experience. The system coalesced a set of technologies which made it possible to comprehend how our bodies are situated in wider social networks, which are in turn simply an extended set of neural networks: complex systems nested in complex systems.

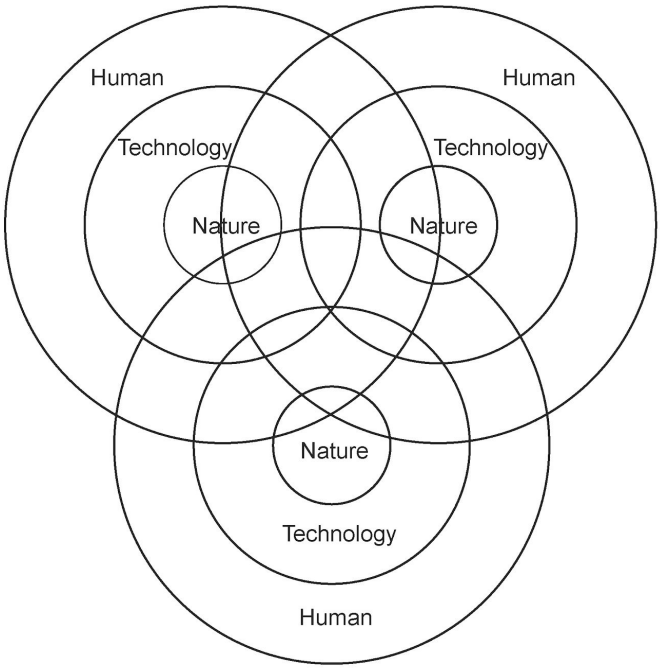


Figure 51: A diagram illustrating the simultaneously integrated and situated relationships between humans, technologies and nature.

By combining interdisciplinary conversation with the experience of embodiment, situatedness and integration, the experiment-performances provided the experience of challenging the divisions between the categories of human, technology, environment, and between the mind and body, and the individual and the collective. As the divisions between the roles of artist, audience and artwork rest upon these even more fundamental divisions, by unsettling the latter, it naturally became easier to challenge the former.

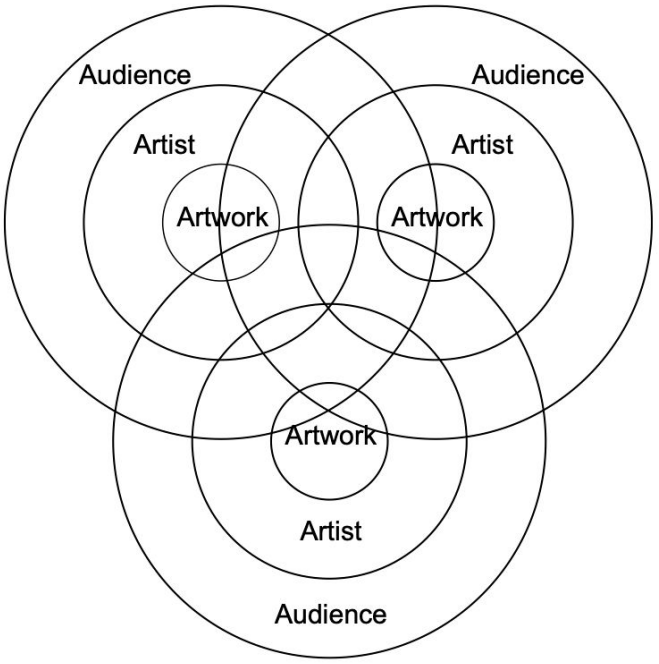


Figure 52: A diagram illustrating the simultaneously integrated and situated relationships between artists, audiences and artworks.

Evolving from the original schema of the integrated and situated relationships between the roles, the process of carrying out the experiment performances revealed how both paradigms operate simultaneously. The extent to which they do rests upon the level of interaction and participation involved.

c) The limits of cybernetics and social practice

i) The pitfalls of participation

However, there is a limit to the degree to which cybernetics and social practice support challenging the divisions between the roles. Participation for its own sake distracts from the experience of integration, embodiment and situatedness. In the first experiment, there was no performance, so no audience. In the first experiment-performance (and second experiment), the audience described having the experience of what I describe as integration, embodiment and situatedness. In the second experiment-performance, though there was an increased amount of technology which theoretically should have scaled up this experience, it in fact was lessened. By the final experiment-performance, in which there was the greatest degree of scaffolding to further increase participation, contrary to what I had hoped, the experience of integration, embodiment and situatedness was even

further undermined.

What this seemed to demonstrate was that participation on its own is not sufficient to produce what Bishop refers to as an ‘aesthetic’ experience. Further still, measurement of a work only in relation to its degree of participation—where the more participatory it is, the better it is considered—can actually hinder the work from achieving this (Bishop, 2012, pp. 11-40). If ‘the quality of the relationships’ produced by social practice artworks ‘are never examined or called into question’, then ‘all relations that permit “dialogue” are automatically assumed to be democratic and therefore good’ (Bishop, 2004, p. 65). This was shown not to be the case as on many occasions in the third and fourth experiment-performances, the quality of audience participation lacked interactivity; rather than engaging in the performance as a dynamic and reciprocal process (in keeping with Pask’s theory of conversation), the audience simply 'reacted' and became infatuated with the technology for its own sake. Even providing a deeper understanding of how the technology worked in the final experiment-performance was not sufficient to induce the experience of embodiment, integration and situatedness. For instance, in an effort to explain the system, the goal of the peer-educators was reduced to simply demonstrating to participants a clear correlation between their brainwaves and the audiovisual signatures (by blinking, for example). Despite securing their active engagement with the devices, the opportunities for the serendipitous, emergent properties of the performance as an aesthetic experience were inadvertently diverted.

ii) Technofetishism

This brings us to the final point which is that interaction and biofeedback for their own sake devolve into technofetishism. Among the main problems encountered across the entirety of the project, perhaps the most consistent was that participants were susceptible to being seduced by the technology. Instead of it being deployed as a means to providing a deeper understanding of the experiences I facilitated, participants often became preoccupied by the tools themselves. This applied both to the participants from the audience and the peer educators who helped with the final experiment performance. To a certain extent, this was due to the fact that the technologies were new to me and my understanding of them was limited to being able to use them, not how their internal mechanisms actually worked. As such, many of the participants were enthralled by the technologies themselves rather than being interested in putting them into use. With that said, the doctors who did understand the internal processes taking place still became distracted by their rudimentary uses. Therefore, it seemed that perhaps if I had allowed

participants, including the doctors, more time to become familiar with using them, we might have arrived eventually at thinking more deeply about what was taking place between the technologies, the brain, and the more profound experiences described to me by the participants. Participants took less of a serious interest in the implications behind the system, becoming enthralled by the technology rather than engaging deeply with the questions it raised about consciousness and the role of the audience in the production of art. To refer back to Merleau-Ponty, the point at which the stick stops being novel or alien is the point it becomes an extension of the arm. Indeed, in this respect, it was the second experiment-performance which came closest to galvanising this kind of response. As the performances became more regulated and controlled, the actual aspects of the work as a performance were stifled, misdirecting focus to the technology itself.

5. Shortcomings and Future Research

The shortcomings and proposals for future research is divided into two sections: theoretical observations and practical suggestions. In the former, I detail how by the end of the experiment-performances I arrived at a fundamental question concerning the categorisation of the project as an artwork, followed by a discussion of a field of philosophy known as somaesthetics which might supplement future research on this topic. In the latter, I propose possible changes that could be implemented in similar projects and practical obstacles I faced which might be considered going forward.

a) Theoretical

i) The category of art

The emergence of the ‘meaningful experience’ which certain audience members described called into question the very categorisation of the project as art. By introducing this concept of a ‘meaningful experience’ as a criterion at all, it brought to my attention the fact that the work could be argued simply to consist of a designer, audience, and system—as opposed to an artist, audience and artwork. Without producing this experience of integration, embodiment and situatedness, there is no definitive reason to regard the system and its performance as an artwork. It could more simply be described as: a system, users, and observers. What actually transfigured the work into being something more akin to art was the more profound, evocative experience the participants described as ‘meaningful’—an experience I am attributing to the more precise experience

of integration with the other participants and the environment, the embodiment of the mind in a network of biological and technological apparatuses, and the situatedness of the individuals involved in a wider collective network. This experience could be understood in Bishop's sense of the 'aesthetic' as the unique capacity of art to harness feelings to produce such cognisance of the contingencies underlying the divisions between these manmade categories. Overly focussing on the technology or emphasising the participation for its own sake distracted from this experience, which arguably was the difference between the work being a system and the system being transformed into the status of an artwork.

This oversight can be attributed on one level to the absence of any criteria for defining art against any system which harnesses formal and stylistic qualities to produce entertainment or pleasure. Whilst no doubt a feature of many artworks, the experience of entertainment or pleasure alone seem insufficient to define artworks in the presence of this other experience which the participants seemed to have, and one which seemed to bear upon much deeper and more profound questions underlying the research question itself. To recall, my objectives to address the research question were as follows:

a. Design a system capable of connecting audience biometric data with the audiovisual material
b. Implement a feedback loop between the data and the performance software
c. Iterate the design across multiple experiment-performances
d. Implement changes based on knowledge gained in each experiment-performance

Whilst the internal differences and multiple statuses of the roles of artist, audience and artwork were addressed (for instance, in the distinction between the performance and the experiment or between authorship and producership) in the Experiment-Performance section, at no point did I attempt to rigorously define what defines art in the first place. In a certain sense, this does not conflict with much of the knowledge produced in terms of how, taking the definition as given, the roles of the artist, audience and artwork intersect with each other when implementing biofeedback in live audiovisual performances. The relationships and their blurring remain. However, no doubt some further knowledge would be gained were I to have attempted to define art more precisely during this process as it would have been more able to be compared to and distinguished against the roles of, for example, a designer, user and system.

ii) Somaesthetics

As to developing the project further, somaesthetics is a field I did not explore in detail but which concerns many of the same issues as those discussed above. At its base, somaesthetics unites the study of aesthetics with the study of embodied experience. Originally introduced to me by way of George Khut's work, somaesthetics is concerned with the study of the perception of the body. Named by philosopher Richard Shusterman and derived from the Greek words *soma*, meaning body, and *aesthesis*, meaning sensory perception, somaesthetics attempts to redress the ways in which the body has historically been perceived as subordinate to the mind and separate from it. This is approached from both theoretical and practical angles, bringing together different disciplines, from the arts to medicine, to reformat how we think about the embodied nature of consciousness and perception. Within somaesthetics, art is studied and proposed as a valuable way of producing experiences which expose the fallacy of this mind-body dualism. In an article entitled, 'Body and the Arts: The Need for Somaesthetics' (2012), Shusterman begins by stating the underlying premise of somaesthetics in general:

> the body is not only an essential dimension of our humanity (expressing all the ambiguities that humanity entails); it is also the basic medium through which we live and the fundamental instrument for all performance, our tool of tools, a necessity for all our perception, action, and even thought. My project of somaesthetics – aimed at improving the understanding and cultivation of the body as a central site of perception, performance, and creative self-expression – is based on that premise (p. 7).

Shusterman proposes art can be a site at which such understanding is cultivated. Indeed, our experiment-performances united mind and body through the system of biofeedback, exposing the mind's embodiment and, respectively, the situatedness of the body within wider networks of social relations. For Shusterman,

> the arts can help us escape the wrongheaded limitations of the sharp dualism between means and ends. The means or instrumentalities used to achieve something are not necessarily outside the ends they serve; they can be an essential part of them (p. 18).

By literally placing the participants in a biofeedback loop where their unconscious activity was rendered as physical, visible information, the dualism was dissolved. Its fallacy is simply obscured by our limited faculties of perception, and this was overcome through the use of biometric devices and audiovisual renderings of the data.

In his book *Body Consciousness* (2008), Shusterman elaborates upon the ways in which these perceived bifurcations are normalised. Quoting the work of the philosopher John Dewey in *John Dewey: The Later Works: 1925–1953*, he explores the ways in which we uncritically arbitrate perceptual boundaries along what are in fact permeable borders:

> Our bodies (like our thoughts) are thus paradoxically always more and less than our own. As Dewey pithily puts it, we “live...as much in processes across and ‘through’ skins as in processes ‘within’ skins”[…]. The semipermeable boundary of our skin is a natural somatic symbol for the merely semi-autonomous status of our selfhood. Being constituted by its environmental relations, the self is ultimately defined by Dewey as “transactional.” He preferred this term to “interactional,” which he thought implied greater separation and independence[…]. Though such terms as “transactional self” and “transactional body” suffer from unseemly mercantile associations[…], they do convey the sense of a dynamic, symbiotic individual that is essentially engaging with and relating to others and is in turn essentially reliant on and constituted by such relations (p. 214)

What my project discovered was something akin to this concept of the transactional self, but might be duly supplemented by way of double description: at the centre of this project was a concept of the trans-interactional self, whereby the body was a site of exchange both ‘across’ and ‘among’ other selves and, simultaneously, an even broader network of encompassing social systems.

b) Practical

i) The relationship between raw data and the software categories

One definite gap in the process of building and iterating the system was the fact that I was unable to establish what precise brainwave data corresponded to the categories provided by the OSC software (i.e. ‘Concentration’, ‘Meditation’ and ‘Focus’) developed by George Khut. The algorithm linking them together remained a black box. Knowing this data would have potentially allowed for me to better understand the relationship between the participants’ neurological and psychological states and the likelihood of them experiencing the sense of integration, embodiment and situatedness they described having felt. Going forward, developing a bespoke copy of the OSC software would be one path to develop the system further. However, whilst there would not be consensus on how to map the data to usable categories for the audiovisual parameters (for instance, undoubtedly the neuroscientists would focus on different data sets than the psychologists, as likely would I), it would nevertheless present the option of having more control over the system design.

ii) Consistent participants as an experimental control

One further opportunity for increased understanding of the effects of each iteration would have been to have invited certain participants to take part in all of the experiment-performances as an experimental control. Their feedback could have offered an understanding of the experience of someone who’d experienced each successive

experiment-performance without compromising or preventing gathering feedback from all the remaining participants unaffected by the previous experiment-performances.

iii) Developing a universal language

Finally, notable throughout the entire process was the practical difficulties presented by the fact that different terminology was used by different actors in the commissions depending on their background and field. For instance, to the scientists, doctors and coders, it was relevant to use the word ‘user’. However, when speaking with the galleries and other artists the word ‘participant’ was more appropriate. The very novelty of the system and the diversity of tools involved, as well as the fact I brought together a number of different disciplines, resulted in a varied and oftentimes divergent vocabulary to describe the processes. This often meant communication was inefficient and energy intensive as extra explanation had to be offered on multiple occasions in order to reduce the risk of misunderstanding. When writing up the project here, the use of double-description presented one interesting solution to this issue, but it was insufficient to address the practical issues which appeared throughout. Different people had different understandings of the terms, often which existed but denoted different things within each field, and moreover often had implicit biases associated with them which occasionally went unacknowledged.

6. Summing Up

The paradox at the core of this project was that the more I set up limits and parameters to control each experiment-performance, the more unlikely it became that they would provide the experience of embodiment, integration and situatedness. In other words, the more the work adopted the modern paradigm of striving towards certainty and knowability, the less the results were actually worth knowing. A certain level of uncertainty was required for the works to accommodate the serendipity required to produce the experience of embodiment, integration and situatedness. However, it’s difficult to measure chaos, and yet, without a certain amount of it, what made the work valuable was sapped out of it.

A too clear a definition of roles and the limits on the participants’ activity precluded particular unexpected outcomes and results. For instance, when the participants spontaneously started holding hands, this was unplanned for. Its significance was only understood in hindsight once I had researched its physiological and psychological effects. Certain of these effects and behaviours, such as when the participants would become

overly infatuated with the technology for its own sake, could nonetheless be frustrating insofar as attention was diverted from the project's goals of challenging the divisions between the roles. For example, by overemphasizing the participatory and cerebral aspects of the work (by introducing crib sheets and workshops) in the final experiment-performance, the participants' experience was steered away from the more profound effects of feeling situated and integrated with one another and the technology, positioning them 'in' the space rather than 'of' it, in Merleau-Ponty's terms (1962, p. 171).

However, relinquishing control was eventually proven necessary for the project to reach any meaningful level of success. This harks back to the principles outlined in *The Artistic Turn* (2009, p. 64) of 'employing situated, adapted criteria', as opposed to 'universal, static criteria' when attempting to stake out the limits and bounds of a given praxis or practice-as-research project in order to retain the 'singularity of a specific artistic trajectory' (p. 63). Biofeedback is a phenomenon which is capable of challenging the divisions between the roles of artist, audience and artwork during live audiovisual performances. The use of biometric devices facilitates this, but their technical nature can also distract from the aesthetic experience of embodiment, integration and situatedness. Cybernetics and social practice are both fields which support this process, and certain levels of interaction and participation produce varying degrees and intensities of this experience. What was discovered in the course of the project was that one of the principal effects of challenging the roles involved in the production of art was the foregrounding of neglected forms of knowledge production and, more importantly, ways of imagining the otherwise unseen and unheard points of communion within and between living systems.

Appendices

Appendix I – Initial Planning

a) Experiments Outline

Originally, the experiments were designed to different specifications and, though the fundamental aspects remained the same, the nature of working to commissions meant certain details changed. Below are the details of how I originally expected to pursue the different themes and technological concerns of the project step-by-step.

1. Feedback systems

Venue / location: Digital innovation shed, John Dalton West, Manchester Metropolitan University (MMU)
Number of Participants: one
Hardware: Jawbone 24 activity tracker, MacBook Pro, smartphone, projector screen and projector, speakers and amp.
Software: OSC, Modul8, OSX, Biosync, Quartz Composer, Processing

This experiment was designed to create a system in which the biometric information of one participant is collected, visualized and sonified. The design replicated George Khut's *Distillery: Wave Forming* (2012) in which the heart rate of a participant is incorporated into a feedback loop to produce audio-visual outputs. In his experiment, Khut explored how participants take control of their own heart rate. Following similar principles, I designed the system such that heart rate data would be recorded using a Jawbone UP24 activity tracker and subsequently mapped to real-time responsive audiovisual channels using the software Modul8.[4] The audio and video was then projected back into the environment to establish a feedback loop between the participant and their own biometric data (see diagram 1).

In order to evaluate the system's performance and how it could be developed, the biometric data was to be analysed through screen captures and sound recordings of the audiovisual output. In addition to this, a practitioner's journal would be used to provide thorough notes detailing all the amendments and adaptations undertaken throughout the experiment as well as the activity of the participant.

[4] UP24 health tracker has the ability to sync wirelessly via Bluetooth to the updated companion app with collected biometric data. Modul8 is a software for live visual performance developed by GarageCube, a company established in 2005 by Yves Schmid and Boris Edelstein, based in Geneva, Switzerland.

2. Multiple data sources

Venue / location: Digital innovation shed, MMU
Number of Participants: Two
Hardware: Jawbone health tracker, MacBook Pro, a smartphone and BioSync
Software: OSC, Modul8, OSX and our bespoke multimodal biometric software

Building on the first experiment, the original design for the second experiment explored the implications of having multiple data sources by introducing the heart rate of a second participant. The purpose of this experiment was twofold: first, both participants would independently experience the audiovisual representations of their heart rates (see diagram 2a); second, the datasets generated from each individual's heart rate would be coupled and integrated into the system in order to gauge the effect of this on the level of interaction between them as coauthors of the work. This experiment was informed by Mariko Mori's *Wave UFO* (1999) and David Rosenboom's *Ecology of the Skin* (1978). In both of these installations, the output is generated by varying degrees of audience-artist interaction. Observations were to be made and recorded in the same manner as in 'System'.

3. 'Hierarchy'

Venue / location: Digital innovation shed (MMU)
Number of Participants: 3
Hardware: Jawbone, MacBook Pro, and a smartphone
Software: Open OSC, modul8, OSX and the multimodal biometric software

The third experiment was originally designed simply to introduce a third participant who would have the ability to act as a 'conductor', manipulating the biometric data generated by the other participants in the system. From there, the level of authority would be adjusted between the artist (conductor) and the audience (observer / listener) by varying their respective control over the audiovisual output generated by both the individual and combined biometric data of the group.

4. 'Performance'

Venue / location: The Roadhouse (Manchester, UK)
Number of Participants: 3+
Hardware: Jawbone, MacBook Pro, smartphone,
Software: Open OSC, Modul8, OSX and the Multimodal biometric software, Microsoft Kinect V2.

The fourth and final experiment was designed to combine all the previous experiments, introducing further participants and increasing the variables in the system by adding motion capture and temperature monitoring. Six audience members would participate in the co-creation of the performance. It was also intended that this experiment would be conducted in a live performance environment.

Participants' movement was to be captured by a Microsoft Kinect V2, creating another data stream to be combined with the heart rate previously established in experiments one and two. Temperature data was also to be generated using the Jawbone UP24 activity tracker which would already have been used to monitor heart rate. In addition to curating a live performance, my aim was to publish the software so other practitioners would be able to utilise it to enhance their own performances, including artists, architects, medical practitioners and game designers.

b) Summary Table

In summary, the following table overviews how I had originally intended to structure and carry out the experiments.

Table 3: Summary of original experiment-performance designs

Experiments	Focus and contribution to objectives	Variables	Equipment	Recordings and data collected
1. *System*	To undertake technical research – tests of equipment, processes and methods which will facilitate the production of a system that will collect and represent biometric data sonically and visually	Heart rate	Jawbone UP24	● Participant activity to be recorded by camera ● Biometric data ● Audio and visuals generated by the participant to be recorded ● The recorded information is intended to be read as a combined data set
2. *Multiple Inputs*	Increasing the number of participants and number of inputs from the body and audio / visual outputs from the system	Heart rate	Jawbone UP24	● Participant activity to be recorded by camera ● Biometric data ● Audio and visuals generated by the participant to be recorded ● The recorded information is intended to be read as a combined data set
3. *Hierarchy*	To devise a method of allowing participants to have all / equal / or partial control and, by doing so, examine the digital technologies aiding communication and collaboration between participants	Heart rate; brain waves	Jawbone UP24; NeuroSky headset	● Participant activity to be recorded by camera ● Biometric data ● Audio and visuals generated by the participant to be recorded ● The recorded information is intended to be read as a combined data set
4. *Performance*	Exhibition of installation: part of a peer-review evaluation, the analytical criteria for which relates to the degree of synthesis between the technologies explored and applied	Heart rate; brain waves; movement	Jawbone UP24; NeuroSky headset; Kinect V2	● Participant activity to be recorded by camera ● Biometric data ● Audio and visuals generated to be recorded ● The recorded information is intended to be read as a combined data set

Bibliography

Ascott, R. (1990). ‘Is There Love in the Telematic Embrace?’, in *Art Journal*, 49 (3), <https://www.jstor.org/stable/777114> (Accessed: 6 August 2017), pp. 241-247.

Ascott, R. (2002). ‘Behaviourist art and the cybernetic vision (1966-7)’, in Randall Packer and Ken Jordan (ed.), *Multimedia: from Wagner to virtual reality*. New York: W. W. Norton & Company Ltd., pp. 95-103.

Ashby, W. R. (1956). *An introduction to cybernetics*. Reprint, Eastford, CT: Martino Fine Books, 2015.

Ashby, W. R. (1960). *Design for a brain: the origin of adaptive behavior*. Reprint, Eastford, CT: Martino Fine Books, 2014.

Ashby, W. R. (1958). ‘Requisite variety and its implications for the control of complex systems’, in *Cybernetica*, 1 (2). Available at: http://pcp.vub.ac.be/Books/AshbyReqVar.pdf (Accessed: 9 August 2018), pp. 83-99.

Beer, S. (1972). *Brain of the firm*. Reprint, Hoboken, NJ: Wiley, 1995.

Bell, D. M. (2015). ‘Review of “The politics of participatory art” by Claire Bishop', in *Political Studies Review*. Available at: https://doi.org/10.1111/1478-9302.12089 (Accessed: 10 August 2018), pp. 1-12.

Benjamin, W. (1934). ‘The author as producer’, in *New Left Review*, 1 (62) (1970). Available at: https://newleftreview.org/issues/I62/articles/walter-benjamin-the-author-as-producer (Accessed: 25 May 2019).

Beuys, J. (1974). *Joseph Beuys Talks about his Art: Everybody is an Artist*. Available at: https://www.youtube.com/watch?v=X7gNR8WH6BM&t=619s (Accessed: 20 February 2019).

Beuys, J. and Glozer, L. (1990). ‘On Blinky Palermo: A Conversation with Joseph Beuys’, in ed. Lynne Cooke and Karen Kelly with Barbara Schröder (ed.), Joachim Neugroschel (trans.), *Arts Magazine*, 64. Reprint. New York: Dia Art Foundation, pp. 21-30.

Beuys, J. and Schwarze, D. (1972). ‘Report on a Day’s Proceedings at the Bureau for Direct Democracy’, in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 120-4.

Beuys, J. (1973). ‘I Am Searching for Field Character’, in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 125-6.

Beuys, J. (1969). Interview with Willoughby Sharp for *Artforum*, November.

Bey, H. (2003). *T.A.Z.: The Temporary Autonomous Zone, Ontological Anarchy, Poetic Terrorism.* Brooklyn, NY: Autonomedia.

Bishop, C. (2012). *Artificial hells – participatory art and the politics of spectatorship*. London: Verso.

Bishop, C. (2004). 'Antagonism and relational aesthetics', *OCTOBER*, 110, pp. 51–79.

Bishop, C. (2015). *Creative times lecture*. Available at: https://www.youtube.com/watch?v=MdKniMT46tg (Accessed: 7 May 2019).

Bishop, C. (2010). *Is Everyone an Artist?*. Available at: https://vimeo.com/83682427 (Accessed: 7 May 2019).

Bishop, C. (2006). 'Introduction', in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 10-17.

Birchall, M. G. (2015). 'Socially engaged art in the 1990s and beyond', *On Curating*, 25, pp. 13-19.

Blackmore, S. (1999). *The meme machine*. London: Oxford University Press.

Bourriaud, N. (1998). in Simon Pleasance (trans.) *Relational Aesthetics*. Dijon: Les Presses Du Réel.

Boyd, G. M. (2003). 'Conversation Theory'. Available at: https://pdfs.semanticscholar.org/8209/bfd5343882a3796b2de8f44a310a56e47a30.pdf (Accessed: 13 June 2018), pp. 179-197.

Bunt, B. (2009). 'Bourriaud and the aesthetics of electronic interaction', in *Faculty of creative arts*. Available at: https://ro.uow.edu.au/cgi/viewcontent.cgi?referer=https://www.google.co.uk/&httpsredir=1&article=1261&context=creartspapers (Accessed: 10 September 2018), pp. 1-10.

Castellanos, C. (2016). 'Coevolution, neo-cybernetic emergence and phenomenologies of ambiguity: towards a framework for understanding interactive arts experiences', in *Technoetic Arts: A Journal of Speculative Research*, 14 (3), pp. 159–168.

Castro, E.. '49 best heartbeat sensor circuit diagram', in *dreamdiving*. Available at: http://www.dreamdiving-resort.com/heartbeat-sensor-circuit-diagram/ (Accessed: 30 October 2018).

Coessens, K., Krispin, D. and Douglas, A. (2009). *The artistic turn.* Leuven: Leuven University Press.

Morhenn, V., Beavin, L. E. and Zak, P. J. (2012). 'Massage increases oxytocin and reduces adrenocorticotropin hormone in humans', in *Alternative Therapies Health Med*, 18.6, pp. 11-18.

Cookbook. (2019) Available at: https://www.devdungeon.com/cookbook. (Accessed: 10 August 2019).

Correia, A. (2006). 'Interpreting Jeremy Deller's *The Battle of Orgreave*', in *Visual culture in Britain*, 7 (2), pp. 93-112.

Critchley, S. (2009). ‘Being and Time’, *The Guardian* Available at: https://www.theguardian.com/profile/simon-critchley (Accessed: 24 November 2018).

Davis, E. A. (2004). *The journal of the learning sciences, scaffolding: volume 13.* London: Routledge.

Debord, G. (1957). ‘Towards a Situationist International’, in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 96-101.

De Landa, M. (1997). *A thousand years of nonlinear history.* Brooklyn, New York: Zone Books.

Deller, J. (2001) *The Battle of Orgreave*. Available at: https://www.youtube.com/watch?v=3ncrWxnxLjg (Accessed: 3 June 2019).

Deller, J. (2002). ‘The Battle of Orgreave’, in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 146-7.

Deller, J. (2019). *The Battle of Orgreave*. Available at: http://www.jeremydeller.org/TheBattleOfOrgreave/TheBattleOfOrgreave_Video.php (Accessed: 10 June 2019).

Dennett, D. and Papineau, D. (2017). ‘Papineau vs. Dennett: a philosophical dispute’, *TLS Online*, Introduced by Tim Crane. Available at: https://www.the-tls.co.uk/articles/public/dennett-papineau-debate/ (Accessed: 25 November 2018).

Descartes, R. (1641). *Descartes: meditations on first philosophy: with selections from the objections and replies*. Translated and edited by Cottingham, J.. Cambridge: Cambridge University Press, 2016.

Dougherty, D. (2012) The maker movement, in *innovations*, 7.3 Available at: https://www.mitpressjournals.org/doi/pdf/10.1162/INOV_a_00135 (Accessed: 10 August 2019).

Duchamp, M. (1975). *The essential writings of Marcel Duchamp*. London: Thames and Hudson Ltd.

Dupuy, J. P. (2011). ‘Cybernetics is an antihumanism: advanced technologies and the rebellion against the human condition’, in *Metanexus*. Available at: https://www.metanexus.net/h-cybernetics-antihumanism-advanced-technologies-and-rebellion-against-human-condition/ (Accessed: 25 November 2018).

Fernández, M. (2008). ‘“Aesthetically Potent Environments,” or how Gordon Pask detourned instrumental cybernetics’, in *White Heat Cold Logic – British Computer Art 1960-1980.* London: MIT Press, pp. 53-70.

Ferneding, K. (2005). 'Embracing the telematic: a techno-utopian vision of art and pedagogy for the post-human age of control’, in *Journal of the American Association for the Advancement of Curriculum Studies*, 1. Available at:

http://www.uwstout.edu/soe/jaaacs/vol1/ferneding.html (Accessed: 10 August 2018), pp. 1-17.

Field, T. (2001). *Touch*. Cambridge, MA: The MIT Press.

Finkelpearl, T. (2014). 'Participatory Art', in Kelly, M. (ed.) *Encyclopaedia of aesthetics*. Oxford: Oxford University Press.

Foerster, H. V. (2003). *Understanding Understanding*. New York: Springer.

Foucault, M. (2008). *The birth of biopolitics: lectures at the Collège de France, 1978-79*. Translated by G. Burchell. Basingstoke: Palgrave Macmillan.

Gaensheimer, S. and Schafhausen, N. (ed.) (2000). *Liam Gillick*. Cologne: Oktagon.

Gavin, F. and Deller, J. (2019). 'Lust for life: an interview with Jeremy Deller', *Cork Street Galleries* (Accessed: 10 June 2019).

Gatt Specifications. (2019) Available: https://www.bluetooth.com/specifications/gatt. (Accessed 15 February 2019).

Gerard, R. (2016). *The Macy Conferences 1946-1953.* Chicago: The University of Chicago Press.

Gillick, L. (2019). 'Biography'. Available at: http://www.liamgillick.info/home/biography (accessed: 20 June 2019).

Gillick, L. and Cotter, L. (2017). 'Knowledge as production: a dialogue with Liam Gillick', in *MaHKUscript: Journal of Fine Art Research*, 2 (1). Available at: https://doi.org/10.5334/mjfar.23 (Accessed: 10 August 2018), pp. 1-10.

Gillick, L. (2006). 'Contingent factors – a response to Claire Bishop's 'antagonism and relational aesthetics'', in *October*, 115. Available at: http://www.jstor.org/stable/40368419 (Accessed: 10 June 2019), pp. 95-107.

Gillick, L. and Meredith, M. (2010). 'Critical Conditions – A Conversation Between Michael Meredith and Liam Gillick', in *Architecture at the edge of everything else*. London: The MIT Press.

Glanville, R. (2008) *Second order cybernetics.* Available at: http://www.pangaro.com/glanville/Glanville-SECOND_ORDER_CYBERNETICS.pdf (Accessed: 21 January 2019), pp. 1-28.

Glynn, R. (2016). 'Conversational environments revisited'. Available at: http://www.ruairiglynn.co.uk/wp-content/uploads/2016/10/0802_PUB_CON_Conversational-Environments-Revisted-Cybernetic-Conference-Paper.pdf (Accessed: 21 January 2019), pp. 1-6.

Glynn, R. (2010). *Performative Ecologies* installation (2010). Available at: https://www.researchgate.net/figure/Ruairi-Glynn-Performative-Ecologies-2008_fig4_281365606 (Accessed 13th October 2019).

Gould, C. (2018). 'Open interactivity – a model for audience agency', *IAFOR Journal of Cultural Studies*, 3 (1), pp. 1-16.

Grammatikopoulou, C. (2016). 'Breathing art – art as an encompassing and participatory experience', *Museums in a digital culture: how art and heritage became meaningful*.

Hall, S. (2012). 'Jeremy Deller's political imaginary', in *Joy in People*. London: Hayward Gallery Publishing, pp. 80-89.

Harney, S. and Moten F. (2013). *The Undercommons: Fugitive Planning and Black Study*. New York: Minor Compositions.

Haslam, D. and Gillick, L. (2017). *New Order + Liam Gillick: So it goes.. ∑(No,12k,Lg,17Mif) - Times Change (Snippet)*. Available at: https://www.youtube.com/watch?v=qtOkQRMG51E (Accessed: 19 June 2019).

Heidegger, M. (1962) *Being and Time*. John Macquarrie and Edward Robinson (trans.). Reprint, Oxford: Blackwell Publishing, 2001.

Hirschhorn, T. (2004). '24h Foucault', in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 154-7.

Hoffmeyer, J. (ed.) (2008). *A Legacy for Living Systems: Gregory Bateson as Precursor to Biosemiotics*. New York, New York: Springer.

Husserl, E. (1970). *Logical Investigations Vol. 1*. Dermot Moran (ed.) and J. N. Findlay (trans.). Reprint, London: Routledge, 2001.

Husserl, E. (1970). *Logical Investigations Vol. 2*. Dermot Moran (ed.) and J. N. Findlay (trans.). Reprint, London: Routledge, 2001.

Hutchinson, M. (2002). 'Four stages of public art', in *Third Text*, 16 (4).

ICA London (1968). *The Colloquy of Mobiles* by Gordon Pask (1968). Available at: http://www.medienkunstnetz.de/works/colloquy-of-mobiles/images/8/#reiter (Accessed 13th October 2019)

Introduction to OSC (2019). Available at: http://opensoundcontrol.org/introduction-osc (Accessed: 6 November 2018).

Kaprow, A. (1966). 'Notes on the Elimination of the Audience', in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 102-4.

Kaprow, A. (1993). *Essays on the Blurring of Art and Life*. London: University of California Press.

Katerina Bantinaki, 'Commissioning the (Art)Work: From Singular Authorship to Collective Creatorship', in *The Journal of Aesthetic Education*, 50.1 (2016) <https://muse.jhu.edu/article/614900> [accessed 5th November 2018], pp. 16-33.

Kauffman, L. and Umpleby, S. A. (2017). ‘A Brief History of (Second-Order) Cybernetics’, in Müller, K. H., Riegler, A., and Umpleby, S. A. (eds.) *New horizons for second-order cybernetics*. London: World Scientific, pp. 3-6.

Kelly, K. (1994). *Out of control: the new biology of machines, social systems, and the economic world.* Reprint, New York: Basic Books, 1995.

Kerr, H. (1953) Gordon Pask with the *Musicolour Machine* (1953). Available at: https://we-make-money-not-art.com/molly_wright_steenson_is_a/ (Accessed 13 October 2019).

Kester, G. (2005). 'Conversation pieces', in Zoya Kocur and Simon Leung (ed.) *Theory in contemporary art since 1985*. Oxford: Blackwell Publishing, pp. 76-88.

Khut, G. P. (2013). *Can Art Help Medicine?: George Khut at TedX Sydney*. Available at: https://www.youtube.com/watch?v=qFyKqLVOhqE (Accessed: 31 October 2018).

Khut, G. P. (2012). Video portrait from *Distillery: Waveforming* (2012). Available at: https://vimeo.com/62140271 (Accessed: 13th October 2019).

Khut, G. P., Morrow, A. and Watanabe, M. Y. (2011). ‘The BrightHearts Project: A new approach to the management of procedure-related paediatric anxiety’, *Proceeding of OzCHI : The Body InDesign*. *Design, Culture & Interaction, The Australasian Computer Human Interaction conference*, Canberra, Australia, November 2011, pp. 17-21.

Khut, G. P. and Muller, L., (2005). ‘Evolving creative practice: a reflection on working with audience experience in cardiomorphologies’, in P. Anastasious, R. Smithies, K. Trist and L. Jones (eds.), *Vital Signs: creative practice and new media now*. Melbourne, Australia: RMIT Publishing, pp. 21-31.

Kirby, M. (1965). *Happenings - an illustrated anthology*. New York: E. P. Dutton and Co., Inc..

Kjaffe (2009). ‘The Mass Amateurization of Social Communication’, *Introduction to Digital Media*. Available at: https://idm09.wordpress.com/2009/11/10/the-mass-amateurization-of-social-communication/(Accessed: 11 October 2018).

Knapik, J. J., Cosio-Lima, L. M., and Reynolds, K. L. (2015). ‘Efficacy of functional movement screening for predicting injuries in coast guard cadets’, *The Journal of Strength and Conditioning Research*, 29 (5), pp. 1157-1162.

Krstich, V. (2012). 'Review of Jeremy Deller's *Joy in people*', in *International Contemporary Art*, 115. Available at: https://cmagazine.com/issues/115/pdf (Accessed: 10 June 2019), pp. 55-8.

Kujawski, G. (2018). ‘Neocybernetic art: affect and conversation in the animal and the machine’, in *Leonardo Electronic Almanac*, 22 (2). Available at: https://contemporaryarts.mit.edu/pub/neocybernetic-art (Accessed: 10 August 2018), pp. 1-12.

Latour, B. (1993). *We have never been modern*. Cambridge, MA: Harvard University Press.

Leger, M. J. (2013). *The neoliberal undead – essays on contemporary art and politics*. Alresford: Zero Books.

'Zugzwang' (2019). Lexico.com. Available at: https://www.lexico.com/en/definition/zugzwang (Accessed: 1 October 2019).

Lippman, A. (2017). 'Art, science and the media lab', in *Medium*. Available: https://medium.com/mit-media-lab/art-science-and-the-media-lab-9871bda622b9 (Accessed: 13 February 2019).

Löken, L. S., Morrison, I. and Olausson, H. (2009). 'The skin as a social organ', in *Experimental Brain Research*, 204. Available from: https://www.researchgate.net/publication/26828777 (Accessed: 10 August 2019), pp. 305-14.

Lucier, A. (1965). Alvin Lucier's performing *Music for A Solo Performer* (1965). Available at: https://www.theguardian.com/music/musicblog/2014/jun/25/sitting-in-a-room-with-alvin-lucier Accessed: 13th October 2019).

Lutterer, W. (2005). 'Systemics: the social aspects of cybernetics', in *Kybernetes*, 34 (3-4), pp. 497-507.

Matarasso, F. (2018). *Francois Matarasso Lecture 13.2.2018*. Available at: https://www.youtube.com/watch?v=DJKGxrRzNw8 (Accessed: 22 June 2019).

Matarasso, F. (1997). *Use or Ornament*. Gloucestershire: Comedia.

Mckay, G. A. (2019). 'Community arts and music, community media: cultural politics and policy in Britain since the 1960s'. Available at: http://usir.salford.ac.uk/2813/ (Accessed: 21 January 2019), pp. 1-22.

Medina, E. (2011). *Cybernetic revolutionaries: technology and politics in Allende's Chile*. Cambridge, MA: The MIT Press.

Merleau-Ponty, M. (1962). *Phenomenology of Perception*. Colin Smith (trans.). Reprint, London: Routledge, 2002.

Mindell, D. (2002). *Between human and machine: feedback, control, and computing before cybernetics*. Baltimore, Maryland: Johns Hopkins University Press.

Moore, P. (1970). The performance of *Ecology of the Skin* by David Rosenboom at Automation House, New York (1970). Available at: http://4columns.org/dayal-geeta/david-rosenboom (Accessed 14th October 2019).

Mori, M. (2001). Participants inside the *Wave UFO* installation. Available at: http://www.digiart21.org/art/wave-ufo (Accessed: 14th October 2019).

Napoleon Bonaparte (1769-1821). (2015) Available at: http://www.bbc.co.uk/history/historic_figures/bonaparte_napoleon.shtml. (Accessed: 18 July 2015).

Nelson, R. (2013). *Practice as research in the arts: principles, protocols, pedagogies, resistances*. London: Palgrave Macmillan.

Niedermeyer, E. and da Silva, F. L. (eds.) (2005). *Electroencephalography: basic principles, clinical applications, and related fields*. London: Lippincott Williams & Wilkins.

Pagliarino, A. (2015). 'Life Beyond Legacy: George Poonhkin Khut's *Distillery: Waveforming*', in *AICCM Bulletin*, 36 (1), pp. 67-75.

Pangaro, P. (2016). 'Questions for conversation theory or conversation theory in one hour', in *Kybernetes*, 46 (9). Available at: https://doi.org/10.1108/K-10-2016-0304 (Accessed: 21 July 2019), pp. 1578-87.

Pask, G. (1961). *An approach to cybernetics*. London: Hutchinson Press.

Pask, G. (1976). *Conversation theory*. Oxford: Elsevier.

Pask, G. and de Zeeuw, G. (1992). 'Interactions Of Actors Theory And Some Applications', in *A Series Of Volumes By Gordon Pask And Gerard De Zeeuw*. Available at: https://www.emerald.com/insight/content/doi/10.1108/03684920410523535/full/html (Accessed: 13 April 2019).

Patient safety: using pulse oximeters (2011). Available at: http://www.who.int/patientsafety/safesurgery/pulse_oximetry/who_ps_pulse_oxymetry_tutorial1_the_basics_en.pdf (Accessed: 6 November 2018).

Penny, S. (2013). 'Art and robotics: sixty years of situated machines', in *AI and Society*, 28, pp. 147-56.

Performative Ecologies. (2012) Available at: https://vida.fundaciontelefonica.com/en/project/performative-ecologies/. (Accessed: 18 July 2017)

Pertigkiozoglou, E. (2017). '1973: Nicholas Negroponte and Architecture Machine Group MIT', in *Medium*. Available at: https://medium.com/designscience/1973-a1b835e87d1c (Accessed: 25 April 2019).

Pethick, E. (2006). 'Degree zero', in *Frieze*. Available at: https://frieze.com/article/degree-zero (Accessed: 10 August 2018), pp. 1-3.

Pickering, A. (2010). *The cybernetic brain.* London: The University of Chicago Press.

Pickering, A. (2009). 'Beyond design – cybernetics, biological computers and hylozoism', in *Synthese*, 168, pp. 469–491.

Pickering, A. (2004). ‘The science of the unknowable: Stafford Beer's cybernetic informatics’, in *Kybernetes*, 33 (3-4), pp. 499-521.

Pickering, A. (2014). *Sketches of another future an interview with Andrew Pickering*. Available at: https://www.youtube.com/watch?v=juGIXi6Lyek (Accessed: 14 July 2018).

Plato (2001). Nicholas Denyer (ed.), *Alcibiades* (Cambridge: Cambridge University Press).

Ragan, S. M. (2013). Infrared pulse sensor. Available at: https://makezine.com/projects/ir-pulse-sensor/ (Accessed: 10 August 2019).

Rancière, J. (2004). ‘Problems and Transformations in Critical Art’, in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 83-4.

Ranciere, J. (2004). *The politics of aesthetics – the distribution of the sensible*, Gabriel Rockhill (trans.). London: Continuum International Publishing Group.

Ritchie D. (2001) *Oldham independent review report*. Available at: http://www.oldhamir.org.uk (Accessed: 20 January 2019).

Rosenboom, D. (ed.) (1976). *Biofeedback and the arts: results of early experiments*. Montreal: Aesthetic Research Centre of Canada.

Rosenboom, D. (1990). ‘The Performing Brain’, in *Computer Music Journal*, 14 (1). Available at: https://www.jstor.org/stable/3680116 (Accessed: 4 September 2019), pp. 48-66.

Rozemond, M. (1998). *Descartes’s dualism*. Cambridge, MA: Harvard University Press.

Sandford, M. R. (ed.) (1995). *Happenings and other acts*. London: Routledge.

Science Gallery (2010). Rafael Lozano-Hemmer’s *Pulse Index* (2010). Available at: https://opencall.sciencegallery.com/pulse-index (Accessed: 13th October 2019).

Scott, B. (2001). 'Conversation theory – a constructivist, dialogical approach to educational technology', in *Cybernetics and Human Knowing*, 8 (4), pp. 25-46.

Scott, B. (2000). ‘The cybernetics of systems of belief’, in *Kybernetes*, 29 (7-8), pp. 995-8.

Shusterman, R. (2012). ‘Body and the arts: the need for somaesthetics’, in *Diogenes*, 59. Available at: https://doi.org/10.1177/0392192112469159 (Accessed: 21 January 2019), pp. 7-20.

Shusterman, R. (2008). *Body Consciousness – A Philosophy of Mindfulness and Somaesthetics*. Cambridge: Cambridge University Press.

Skyscape Medical Resource (2012). Version 1.8.33. Available at: https://play.google.com/store (Accessed: 18 June 2013).

Spyropoulos, T. (2008). ‘The dirty act of architecture’, in Abruzzo, E., Ellingsen, E., and Solomon, J. D. (ed.) *Models: 306090 books, vol. 11*. New York: Princeton Architectural Press, pp. 144-9.

Steenson, M. W. (2019). ‘Nicholas Negroponte, Leon Groisser, Jerome Wiesner – The Architecture Machine Group and The Media Lab at the Massachusetts Institute of Technology MIT’, in *Radical Pedagogies*. Available at: http://radical-pedagogies.com/search-cases/a13-architecture-machine-group-media-lab-massachusetts-institute-technology-mit/ (Accessed: 13 February 2019).

Teitelbaum, R. (1976). Diagram of *In-Tune* (1976), in in *Biofeedback and the Arts: Results of Early Experiments*. Vancouver: Aesthetic Research Centre of Canada.

Teitelbaum, R. (1976). ‘In Tune: some early experiments in biofeedback music’, in *Biofeedback and the Arts: Results of Early Experiments*. Vancouver: Aesthetic Research Centre of Canada, pp. 34-57.

Thompson, N. (2012). *Living as form - socially engaged art from 1911-2011*. Cambridge, MA: MIT Press.

Tiravanija, R. (2015). *Biennale Arte 2015 - Rirkrit Tiravanija*. Available at: https://www.youtube.com/watch?v=R80DvTebclU (Accessed: 20 May 2019).

Tiravanija, R. (2004). ‘No Ghosts in the Wall’, in Bishop, C. (ed.) *Participation*. London: Whitechapel Ventures Limited, pp. 149-53.

Tripp, D. (2005). ‘Action research: a methodological introduction’, in *Educ. Pesqui.*, 31.3. Available at: http://dx.doi.org/10.1590/S1517-97022005000300009 (Accessed: 25 August 2019), pp. 1-21.

Troikatronix (2019). Available at: https://troikatronix.com/ (Accessed: 24 September 2019).

Uidhir, C. M. (2011). ‘Minimal authorship (of sorts)’, in *Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition*, 154 (3). Available at: https://www.jstor.org/stable/41487674 (Accessed: 7 November 2018), pp. 373-387.

Werner, L. C. (2018). 'Gordon Pask's 'Cybernetic Theatre' – Beyond Tinkering with Architecture'

Wiener, N. (2013). *Cybernetics: or the control and communication in the animal and the machine*. Eastford, CT: Martino Fine Books.

Wiener, N. (1964). *God and golem, inc.: a comment on certain points where cybernetics impinges on religion.* Cambridge, MA: The MIT Press.

Wiener, N. (1950). *The human use of human beings: cybernetics and society*. London: Eyre & Spottiswoode.

Wollheim, R. (2015). ‘Criticism as retrieval’, in *Art and its objects*. Cambridge: Cambridge University Press, pp. 124–136.

Ziemke, T. (2005). ‘Cybernetics and embodied cognition / on the construction of realities in organisms and robots’, in *Kybernetes*, 34 (1-2), pp. 118-28.