Brain-Controlled Cinematic Interactions

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I hereby declare that this dissertation is all my own work, except as indicated in the text:

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Abstract

Interactive films have been around for almost a century, yet they have suffered repeatedly from critical, commercial and interactional failings. We propose that brain-computer interfaces can offer interactions with narratives and encourage cinematic engagement by minimising active control. We ask what are the problems inherent to interactive cinema? Can real-time interactions via a brain-computer interface (BCI) construct cinematic content? And how do groups of individuals experience brain controlled cinema designed for individual, shared or distributed control? Our review of related work motivates the interactional choice of using Passive BCI with real-time cinematic construction to synchronise rhythms of the viewers blinking, Attention and Meditation to the rhythms of cinema. We use the *Performance Led Research in-the-Wild* methodology to probe public deployments of our films, and we describe user interactions *in-the-Wild* during screenings of multiple designs of two interactive films: three single user, three multi-user, and a live score performance. Our descriptions of BCI mappings to cinematic techniques and production strategies to produce interactive content efficiently, contributes to the understanding of practical interactive cinema production. In our results we define 1) different stages of control; discovery, conscious and unconscious, 2) awareness of the affective loop, 3) a shifting prominence of engagement between the narrative, the visual qualities and the agency of users' interactions. We offer a dynamic view of control; people's experiences are shifting from awareness of their self, the film, and their control. Our hyper-scanning multi-user study introduces the concept of effects moving across groups, working together to produce engaging experiences, and instances of group members disrupting other's experience by deciding to unilaterally take control of the film. Our discussion contributes to our understanding of passive interactions with narrative systems. Our research contributions include our insights into seven designs of two brain-controlled films. We define two taxonomies, of control and group control, and produce insights into value to audiences of brain-controlled films. We show the development of affective loops of physiological response and cinematic content, and provide new design directions and practical implications for interactive filmmakers.

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This thesis is the result of a seven year journey which started with the intention of using thought to create art. The work presented here has taken me across the world, highlights include invitations to exhibit in New York and Hong Kong and presenting to audiences in Montreal and Barcelona.

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This thesis is dedicated to the memory of Sandy Livingstone.

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Chapter 1

Introduction

The idea of interactive cinema in which the audience can steer the story has long been a dream of many- but has been notoriously difficult to achieve. This thesis explores a promising new approach, brain-controlled cinema, in which passive interactions via a brain computer interface offer interactions with a cinematic narrative and encourages cinematic engagement by minimising active control.

1.1 Motivation

Brain-controlled cinema falls into the broader classification of interactive cinema, which has a chequered past. There have been several moments where the concept has emerged into the mainstream, and for various reasons sunk again below the watermark of relevance. Reasons such as incompatibility between cinematic engagement and active, conscious control, costs involved of interactive content and infrastructure and critical failures. The concept itself has been denounced as *"doomed"* [Lunenfeld, 2004]. There have been laudable designs of interactive films which have reacted against branching narratives, and active methods of control, although many of these have been based in research, or one off public experiments.

The trajectory of interactive cinema has followed developments of non linear video playback; film reels, Laserdisc, DVD, and the capabilities of consumer computing; CD Rom, Mac, Intel, Smart TVs, online, Steam. However, as a new generation return to the subject, the technical, consumer, and distribution landscape has changed; there is a recent boom of interactive films from filmmakers, studios, and researchers in the form of streaming services, apps, online content and live events.

Yet the critiques and problems defined in the 1990s-early 2000s do not seem to be addressed. Namely, that the paradigm of active control and branching narrative is at odds with cinematic engagement.

We argue for brain-controlled cinema as a vehicle to address these problems.

1.2 Research context

In this thesis we explore brain-controlled cinema which is encompassed by the fields of human computer interaction, neurocinematics, brain computer interfaces, film and new media studies. We will introduce each in turn to frame our body of work.

Human Computer Interaction (HCI) is the study of the design and interaction of people with computer systems. It has its origins in cognitive science and human factors, as the user is studied in the computer system. The second wave of HCI brought contextual perspectives to, mainly, work settings. While this thesis is firmly planted in the third wave of HCI, which challenges efficiency, rather exploring experience and meaning making, [Bødker, 2015] it is aware of HCIs roots in cognitive science.

The 'brain' part of brain-controlled cinema has to do with brain computer interfaces (BCI), a field that combines computer science, signal processing, and neuroscience, [Vidal, 1973a]. BCI raises several challenges for HCI. One of these concerns the nature of control. It has been a central tenet of usability that the locus of control shall remain with the user in the form of Direct Manipulation, which has become a core approach to the design of many user interfaces [Shneiderman, 1997]. However, the emergence of ubiquitous [Weiser and Brown, 1996] and affective [Picard, 2000] computing has given rise to indirect forms of control in which computers try to sense and respond to behaviours and even emotions in different contexts without humans consciously exerting or even being aware of their control. This distinction is mirrored in discussions of modes of interaction with BCIs active, reactive and passive. The active BCI responds to direct control, the user entrains themselves to modulate their brain waves to perform a task, reactive BCI utilises the users brain activity which is reacting automatically to a stimulus in order to control an application, and finally passive BCI, in which arbitrary brain activity is collected related to the users mental state and is used as a secondary unconscious control to enrich a primary task [Zander and Kothe, 2011]. Similar to passive BCI, HCI researchers are also often concerned with monitoring or modelling the behaviour of users such that they do not have to exert direct control over something. Even in 1992, researchers like Rubine [1992] were considering mixing direct manipulation with reactive indirect gesture control. Recent work with physiological sensing has revealed various forms of partial control that lie somewhere between direct and indirect. Marshall et al's breath-controlled bucking bronco directly exploited this limited amount of control to create a thrilling ride experience; riders had battle with both the bronco and their own autonomic breathing response in order to try and time the ride, sometimes reaching a peak moment where they were holding their breath to try and stop it moving while becoming acutely aware of the need to breath soon at which point the ride would begin to move vigorously [Marshall et al., 2011].

Given the centrality of BCI to this thesis, it is worth briefly commenting on where our research fits within the overall approach. Khalid et al. [2009] identify five key stages of BCI research: collection, processing, extraction, classification and control (the resulting action/effect). Our focus in this thesis is entirely on the 5th stage, working with consumer-grade brain sensors that encapsulate research and industrial developments from the preceding four stages. Our work, then, is concerned with how we design interactions for brain-controlled films, given preprocessed brain signals from a commercial input device, rather than being about the underlying processing.

Commercial BCI products have been emerging into the mainstream as a new form of control; moving from research into affordable commercial products for the home. BCI is increasingly being adopted by the entertainment industry [Bos et al., 2010] both as a tool to understand people's emotional experience [Gürkök et al., 2011] but now also as a way of controlling emotionally engaging experiences [Folgieri and Zampolini, 2015, Molina et al., 2009].

This thesis is interdisciplinary, combining film and audience studies with HCI. Fortunately, there is some overlap, and HCI has been influenced by cognitive film theory. When defining experience in HCI McCarthy and Wright [2004, pp.80-94] frame it as having sensual, emotional, compositional and spatio-temporal properties and compare it to how viewers make meaning from film. Specifically, how the framework from film producer and theorist Boorstin [1991] describes the simultaneous mechanisms of the film logic (voyeuristic), the emotional hold (vicarious), and thrill (visceral) as creating three parallel threads of experience. The study of what was called 'new media' by the likes of Manovich [2001], Murray [2016], Ryan et al. [2015] at the beginning of this brave, new millennium brought together online media, new interactions and devices to develop the theories that would influence VR, interactive art and video games. Now, twenty years later and the analogue signals have been turned off, the theories developed during digital media's emergence are still relevant. However, as media theory continues to develop new ways of looking at traditional media emerge.

The affect that film has on the viewer is also explored by cognitive and neuroscientific methods in the relatively new field of neurocinematics. This field is concerned with how the brain responds to various cinematic forms by connecting theory from cognitive film studies and neuroscience. Gathering data from quantified dissections of cinematic techniques and neural data from viewers watching movies measured by brain sensing technologies researchers such as Cutting et al. [2011], Hasson et al. [2008] and Smith [2012] are beginning to illuminate why *"films have the potency to "control" viewers' neural responses."*[ibid] and so, theory developed from neurocinematic research can inform design of brain-controlled cinema.

The work presented in this thesis draws on neurocinematic, BCI, film and new media theory to inform designs of interactive cinema, and studies interactions with said films through an HCI lens.

1.3 Approach

In order to explore practical lessons and real-life implementations of design we employ a *Performance Led Research in-the-Wild* methodology [Benford et al., 2013a]. Our film-making practice, *in-the-Wild* studies, and developed theory is carried out iteratively, each process informs and guides the other. This thesis unravels these knotty processes and presents it as linear trajectory. The making of the films reported here were a concern spanning multiple research questions.

1.4 Research questions

By the end of this thesis we will have answered the following research questions:

RQ1: What are the problems inherent to interactive cinema?

RQ2: How can real-time interactions via a Brain Computer Interface (BCI) construct cinematic content?

RQ3: How do interacting individuals respond to various brain-controlled cinematic designs?

RQ4: How do groups of individuals experience brain-controlled cinema designed for shared or distributed control?

RQ5: How can brain-controlled cinema add value to audience experience?

1.5 Author's voice

If it seems that the author's voice switches between first and third person throughout this thesis, you would not be wrong. Throughout the research journey I wore two distinct hats, as director/artist and as researcher. As the creator of the brain-controlled films presented here I am reporting my own experience of making, based on my intuitions as a filmmaker and artist. In all other chapters of the thesis I speak as the researcher of these works, in the third person. So while the roles of artist and researcher are interdependent; lessons learned from research informs artistic practice which is, in turn the basis for further research. It is also important to note these processes were intentionally self contained to preserve both artistic and scientific integrity. I found this switch of working as an artist and as a researcher to be necessary, as I found the two activities to be mutually exclusive, that is, the act of researching artistic practice while that process is ongoing would produce inauthentic work. And so I report the artistic processes in my own voice.

1.6 Description of the work

We summarise the chapters of the thesis below:

Chapter 2. Related work

We explore how cinema acts on the audience and how audiences interact with different types of cinema. We synthesise problems related to interaction, engagement and production reported within interactive cinema which sets up **RQ1**. We consider alternative narrative filmic constructions to the branching narrative paradigm and alternative interactional methods based the sensing of physiological data. Our review motivates the interactional choice of using Passive BCI with real-time cinematic construction production to synchronise rhythms of the viewers blinking, Attention and Meditation to the rhythms of the film.

Chapter 3. Methodology

We describe how we use the *Performance Led Research in-the-Wild* methodology to iteratively develop our brain-controlled films, studies and theory. We further explore how HCI research and artistic practice can offer complementary processes and findings. We detail our methods of study and analysis and motivate our choices of technology and development.

Chapter 4. The making of *The Disadvantages of Time Travel*

In this chapter we begin to address the problems raised in Chapter 2. As the writer/director I narrate this chapter in the first person. I map the journey from prototype platform *#SCANNERS* to making our first brain-controlled film *The Disadvantages of Time Travel*. It details the interactive design of the single user and hyper-scanning versions of the film. The chapter explores the processes of each filmmaking department, paying close attention to how the production is informed by the projects' interactivity. Our descriptions of five BCI mappings to cinematic techniques, and production strategies to produce interactive content efficiently contributes to the understanding to practical interactive cinema production.

Chapter 5. Results 1: People's experience of *The Disadvantages of Time Travel* from Studies 1 and 2

From our real world deployments of *The Disadvantages of Time Travel* at FACT Liverpool and a small UK tour. We combine our results from our first two *Performance Led Research in-the-Wild* studies to report on how controllers experienced their individual control and physiological feedback, both in the single controller and hyper-scanning versions. This chapter offers a dynamic view of control, people's experiences are shifting from awareness of their self, the film, and their control.

Chapter 6. Results 2: Social aspects of *The Disadvantages of Time Travel* from Study 1

On a small UK tour of screenings with participant groups of three we investigate multi-user BCI interactions through a thematic analysis of group interviews. We find how controllers in the hyper-scanning iteration of *The Disadvantages of Time Travel* worked together together as groups to create engaging films, and how various interaction strategies affected the groups' experience. This chapter introduces the concept of affects moving across groups, when working together they produce engaging experiences whereas group members disrupt the others experience if they decide to unilaterally take control of the film.

Chapter 7. The making of *The MOMENT*

Our updated design is informed by theory we arrived at from the results of chapters 5 and 6; focusing on frequencies of peak Attention. The design attempts to create a more lean-back experience for the controlling viewer and be engaging to non-interactors as well. Cinematic processes are built upon based on our experience of making our previous film. Again, as the director I narrate this section in the first person. This chapter further contributes to the synchronising of physiological data to cinematic rhythm as well as offering practical insights into interactive production processes.

Chapter 8. Results 3: Single users, audience and repeat viewing of *The MOMENT*

During the premiere of *The MOMENT* interviews and questionnaires were carried out. This results section reports on users and non interacting viewers experiences of the film. We find that an increased passive interaction with Attention produces less instances of cinematic disruption.

Chapter 9. Study 4: *The MOMENT* Live Score

A scaling up of *The MOMENT* to screen in full auditoriums as a live score, we describe the performance and report on the co-design of, and initial responses to the live score of *The MOMENT*, in which four individuals work together to create a live cinematic event.

Chapter 10. Discussion

We discuss practical iterations our designs and project possible further developments to filmmaking processes. We describe a framework of control we developed from the single user version of *The Disadvantages of Time Travel* and apply it to interactions of *The*

MOMENT, we develop a further framework by analysing our hyper-scanning control results. We conclude with future directions for practice and research. Our discussion contributes to our understanding of passive and semi passive interactions with narrative systems.

Chapter 11. Conclusion

In our final section we summarise our work, detailing how we answered our research questions and brings together our contributions to research; namely practical guidance for passively controlled cinematic works, synchronising physiological data and cinematic technique through affective loops and interactive design frameworks.

1.7 List of publications arisen from this research

The following publications relate to the research described in this thesis.

1. Matthew Pike, Richard Ramchurn, and Max L. Wilson. #Scanners. In *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition - C&C '15*, pages 151–152, New York, New York, USA, 2015b. ACM Press. ISBN 9781450335980. doi: 10.1145/2757226.2764546

   Our first paper documents the design and initial deployment of our prototype, *#SCANNERS* which is detailed at the beginning of Chapter 4

2. Matthew Pike, Richard Ramchurn, and Max L Wilson. Two-way Affect Loops in Multimedia Experiences. *Proceedings of the 2015 British HCI Conference*, pages 117–118, 2015c. doi: 10.1145/2783446.2783595

   Also based on our prototype, *#SCANNERS*, this position paper defines the 2 Way Affect Loop (2WAL), where philological data influences the flow of multimedia content which in turn affects the viewer. This initial concept is built upon throughout the thesis

3. *The Disadvantages of Time Travel* (Richard Ramchurn, 2015, UK)

   Our first brain-controlled film follows the waking and dream life of boy approaching adolescence. The making of this film can be found in Chapter 4.

   (a) 2014, FACT, Liverpool

   (b) 2016, Hayword Library, Nottingham

   (c) 2016, Whitburn Academy, West Lothian

   (d) 2016, Dundee College

   (e) 2016, Digital Catapult, London

4. Matthew Pike, Max L. Wilson, Steve Benford, and Richard Ramchurn. #Scanners. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '16*, volume 07-12-May-, pages 293–296, New York, New York, USA, 2016b. ACM Press. ISBN 9781450340823. doi: 10.1145/2851581.2889468

   An extended abstract from the demonstration of *The Disadvantages of Time Travel*, (named as *#SCANNERS*) at CHI 2016.

5. Matthew Pike, Richard Ramchurn, Steve Benford, and Max L. Wilson. #Scanners. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '16*, pages 5385–5396, New York, New York, USA, 2016a. ACM Press. ISBN 9781450333627. doi: 10.1145/2858036.2858276

   Winner, Best Art Paper at CHI 2016. Describes the design and deployment of *The Disadvantages of Time Travel*, (named as *#SCANNERS*) at FACT, Liverpool. The results make up some of Chapter 5 and were developed into our single user taxonomy in Section 10.2 of our discussion in Chapter 10.

6. Richard. Ramchurn. Brain controlled cinema. In *Proceedings of the 30th International BCS Human Computer Interaction Conference, HCI 2016*, volume 2016-July, 2016. doi: 10.14236/ewic/HCI2016.6

   PhD research proposal.

7. *The MOMENT* (Richard Ramchurn, 2018, UK)

   Our second brain-controlled film. A science fiction thriller set in a dystopic future where minds are monitored. The making of this film can be found in Chapter 7.

   (a) 2018, Lakeside Arts, Nottingham
   (b) 2018, FACT, Liverpool
   (c) 2018, Geneva International Film Festival
   (d) 2018, Sheffield Doc/Fest
   (e) 2018, Ars Electronica, Linz
   (f) 2018, Arts by the Sea, Bournemouth
   (g) 2018, Mayhem Film Festival, Nottingham
   (h) 2018, Leeds International Film Festival
   (i) 2018, Aesthetica Film Festival,York
   (j) 2018, Geneva International Film Festival
   (k) 2018, Sheffield Doc/Fest
   (l) 2018, BlueDot Festival, Cheshire
   (m) 2018, Kendal Calling, Kendal
   (n) 2018, Continue Conference, York
   (o) 2018, Reykjavik International Film Festival, Iceland
   (p) 2019, SPARK British Council event in Hong Kong
   (q) 2019, Brain Film Festival, Barcelona and Madrid
   (r) 2019, Riverside Film Festival in Padua, Italy
   (s) 2019, FACT, Liverpool
   (t) 2020, Festival of Science and Curiosity, Nottingham
   (u) 2020, Spirit Studios, Manchester

8. Richard Ramchurn, Alan Chamberlian, Steve Benford, Richard Ramchurn, Alan Chamberlain, and Steve Benford. Designing Musical Soundtracks for Brain Controlled Interface (BCI) Systems. 2018a

   A focus on the adaptive audio production and design of *The Disadvantages of Time Travel* and *The MOMENT*. Discussions from this paper can be found in the making of chapters, 4 and 7.

9. Richard Ramchurn, Max L. Wilson, Sarah Martindale, and Steve Benford. #scanners 2 - the moment: A new brain-controlled movie. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI EA âĂŹ18, New York, NY, USA, 2018b. Association for Computing Machinery. doi: 10.1145/3170427.3186481

   An extended abstract from the demonstration of *The MOMENT*, at CHI 2019.

10. Richard Ramchurn, Sarah Martindale, Max L Wilson, Steve Benford, and Alan Chamberlain. Brain-controlled cinema. In *Brain Art*, pages 377–408. Springer, 2019b

    A chapter which further explores the process of designing and directing our two brain controlled films. Discussions from this paper can be found in the making of chapters, 4 and 7.

11. Richard Ramchurn, Sarah Martindale, Max L. Wilson, and Steve Benford. From Director's Cut to User's Cut. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19*, pages 1–14, New York, New York, USA, 2019a. ACM Press. ISBN 9781450359702. doi: 10.1145/3290605.3300378

    Honorable Mention, CHI 2019. Reports on our *in-the-Wild* study of *The MOMENT* at its premiere at Sheffield Doc/Fest. The paper shows that our film encouraged lean back control and users created their own personal edits. This paper is expanded on in Chapters 7, 8 and 10.

12. Richard Ramchurn, Juan Martinez-avila, Sarah Martindale, Alan Chamberlain,

Max L Wilson, and Steve Benford. Improvising a Live Score to an Interactive Brain-Controlled Film. In *NIME*, 2019c

We describe the co-design and performances of *The MOMENT* live score. We describe the difficulties of playing to a film that is different each screening and what performance systems and tactics were employed to combat this. The study that this paper is based is described in Chapter 9.

1.8 Physiological mappings

The prototype and two films that are described in this thesis, *#SCANNERS*, *The Disadvantages of Time Travel* and *The MOMENT* have been designed with different control types. For reference we include Table 1.8 which brings together all of the versions of the films and their control mappings.

Table 1.1: Control modes of all versions of *The Disadvantages of Time Travel* and *The MOMENT*

Film	Attention	Meditation	Blink
Prototype	High Attention arms Cut	Mixes music	Cut
The Disadvantages of Time Travel (Original)	Blends layers, mixes music	Blends layers, mixes music	Cut and switch between Attention and Meditation
The Disadvantages of Time Travel (Performance)	Blends layers	Mixes music	Cuts
The Disadvantages of Time Travel (Multi, Competing)	Highest Attention has control. Blends layers	Mixes music	Cuts
The Disadvantages of Time Travel (Multi, Collaboration)	Average. Blends Layers	Mixes music	Cuts
The Disadvantages of Time Travel (Multi, Cooperation) 1	Blends layers	None	None
The Disadvantages of Time Travel (Multi, Cooperation) 2	None	Mixes music	None
The Disadvantages of Time Travel (Multi, Cooperation) 3	None	None	Cuts
The MOMENT (Original)	Peak detected, Cuts	None	None
The MOMENT (Live score)	Peak detected, Cuts	None	None

Chapter 2

Related work

2.1 Introduction

The following review aims to give an understanding of the various research areas and problems relating to brain-controlled cinema. This is broken down to the component parts which construct interactive narrative film utilising BCI technology. We will explore together the following areas which will contextualise the problems, illuminate opportunities, and motivate design for brain-controlled cinema.

How audiences experience meaning making in linear cinema and the interactivity of reception and how atypical film forms engage audiences in divergent meanings. Then we explore the chequered past of interactive cinema, its critiques and how novel examples of interactive cinema engage with these problems. We then look to HCI concepts of implicit interaction for wider context and then focus on the passive mode of brain computer interfaces (BCI). We look at a synthesis of existing artistic BCI experiences for common themes and interactional designs We then turn to the disciplines of neuroscience, psychology and cognitive film studies combined into the field of neurocinematics to offer knowledge and act as inspiration for brain-controlled film design.

2.2 Cinematic interactions

In order to backbone the upcoming sections on interactive cinema and practical chapters let us first explore what the practice of film is. This will be a concise rundown of the various techniques, for a more in-depth exploration see Bordwell and Thompson [2001]. Filmmaking is an activity which engages many professionals and can take years to develop a script, produce, shoot and edit. Here we will look at the component parts of what makes up a film and then the core roles and responsibilities of those filmmaking professionals.

In order to explore new ways of creating interactive cinema we can do well to examine the constituent parts of cinema, how they have been understood and how they each affect the audience. In order to do this we focus on several disciplines. We will draw from the practitioners who have developed and evolve the techniques that we now call cinema and from cognitive research and neurocinematics, we can begin to understand how these various techniques affect the audience.

2.2.1 Cinematic technique

So, to design systems and algorithms to produce an interactive edit in real time what can we learn from the history of cinema and cinematic affect?

Cinema has been the discovery of putting images and later sound together in a temporal form to communicate ideas, stories and emotion. The artists making these movies were the pioneers of the moving image. Moving from the techniques of theatre they discovered the effects of montage.

Some of these early directors were also theorists, devising new knowledge from their practice which is still studied in film schools today [Eisenstein, 2014]. The evolution of cinema has led to a great variety of form and like the theatre in which cinema once drew its inspiration from, subsequent forms of media, research and culture draw their inspiration form cinema. In pace with innovation on screen the lexicon of cinematic techniques continues to be expanded and formalised. The library of film has been and continues to be analysed to describe cinematic techniques which elicit a specific response in the audience.

Film form is the pattern of the film the interplay with the various parts. Narrative and stylistic elements, the what is happening and the how is it being told. Narrative can have different shapes, which can confirm or frustrate expectations.

Mise-en-scene, which translates as ‘putting into the scene’, accounts for how everything onscreen looks, from costume and makeup to the lighting quality, colour palettes and staging. All of these elements come from creative decisions made by the director, cinematographer, writer or production designer, et al.

At its most base element movies are made up of shots. What is in the shot, how it is composed, how the elements are lit, shot duration, how the camera is stabilised are all decisions which effect the film’s style. These shots are sorted and selected by an editor who builds iteratively refined edits creating the rhythm and flow of the film. Composers, musicians, sound designers and vocal mixers will create and record music, build the audio world and mix clear audible dialogue.

The director holds in her or his mind the interconnected layers of meanings of the endeavour and should attempt to pull good performances from the actors, and is helped by assistant directors (1st and 2nd AD) and script supervisor to keep to the schedule, script and storyboards. They consult with the cinematographer on lenses, shot sizes, and compositions.

The photographic process is one the main activities and is led by the cinematographer (also referred to as the director of photography or DP) with the help of camera operators, assistants, riggers and sparks who set up the lights, grips who operate dollies and tripods. The cinematographer’s choices, both creative and practical set the mood of the story, pick out detail and reinforce themes, and work with the director to best capture the actors’ performances.

Continuity editing, also called the Hollywood style is a very common style of constructing film. It is has developed over many years and can be traced back to Eisenstein and Russian Montage [Eisenstein, 2014]. As viewers of movies, we have come to take the techniques of: establishing shots, crosscutting, match on action, shot/reverse shot, the 180 degree rule for granted. These are the grammar of visual language, how viewers make meaning. By matching screen position, direction, and the temporal flow between shots continuity editing maintains continuous narrative action. Directors have been known to skilfully break these rules to create specific effects, for example the limited use of establishing and wide shots in *Kids* (Larry Clark, 1995, US), goes towards creating feelings of intimacy and claustrophobia.

Sound and music can be used in both diegetic (within the film world) and non-diegetic (outside the film world) perspectives to create mood, rhythms, preserve continuity, or introduce concepts from another time or place.

All of this taken together creates a pattern which "engages our senses, feelings, and the mind in a process. That process sharpens our interest, focuses our attention and urges us forward." [Bordwell and Thompson, 2001, p.51]. Bordwell and Thompson here describe an active form of viewing which we will explore more in the next section.

2.2.2 Interactivity within cinema

There are many different ideas of interactivity when we speak about cinema. There is the idea of the active viewer who decodes the film text, which has been designed to capture and direct their attention. The Bazinian realism of the French New Wave, promoted reality and allowed the viewer to discover and mind wander during long takes and ambiguous compositions. Then there are puzzle films of the mid 90s on, such as *Dark City* (Alex Proyas, 1998) or *Memento* (Christopher Nolan, 2000, US) where the structure of the film keeps the audience guessing, re-structuring their expectations of the film world.

Since the early days of cinematic theorising its was acknowledged that the act of viewing contained some kind of active construction, of the narrative and the beings which inhabit it. In 1916 the German psychologist and one of the first film theorists Munsterberg said:

> The photo-play obeys the laws of the mind rather than those of the outer world... The screen may produce not only what we remember or imagine but what the persons in the play see in their own minds. [Münsterberg, 1916, p.97]

Not only does the movie become an externalisation of perception, mirroring rules that govern our cognitive processes, but the inner states of the characters' minds as well.

This concept has endured; cognitivist film theorist Tan [1995] writes of a *"willingness on the part of the viewers to cooperate"*, to *"sit back, watch, and let their imaginations be controlled"* while simultaneously and actively imagining the feelings of the protagonists and anticipating actions.

Thus the process of comprehending a cinematic narrative is seen as an active activity. Bordwell, a film students' staple, assigns four types of cognitive construction to the act of viewing a narrative film. One, the construction of the world in which the narrative takes place, the *"referential meaning"*. Two, the conceptual, *"explicit meaning"*. Three, the *"implicit meanings"*, or themes of the narrative. And four, the involuntary divulged meaning of the film; the *"symptomatic meaning"* [Bordwell, 1989, pp.8-9]. When put together the viewer is in a flurry of constructing, conceptualising, formulating and cross referencing all the time in order to make the meaning of the film.

This creative act has been called by Murray: "the active creation of belief" [Murray, 2016, p.107], energising Coleridge's more passive concept of the willing suspension of disbelief [J. Ferri, 2007]. This creation of meaning seems to happen at a subconscious levels too.

When we watch action something else happens automatically,

> Watching someone grasping a beer mug, biting an apple, or kicking a football activates the same cortical regions normally activated

> when actually executing the same actions. [Gallese and Guerra, 2012]

The discovery of mirror neurons Ramachandran and Hubbard [2001] describe the phenomenon of broadcasting action and emotion from one person to another. As the viewer observes an actors actions or expressions of emotion the viewers' brain both mimics and considers what is felt [Goleman, 2006]. That this happens automatically, unconsciously and outside our control sheds new light on why my wife will cover her eyes during scary parts of movies.

2.2.3 Proto-interactivity

Before we get to interactive cinema proper let us look at some other types of interactions that can occur. Above we described the ways viewers make meaning from linear narrative cinema. But when the screen is split up, when there are multiple simultaneous frames to view how does the audience make and comprehend narrative then? This format has been called Multilinear by Dixon [2007], while Manovich calls it Spatial Montage [Manovich, 2001].

Manovich is a proponent of Spatial Montage as a presentation style. He saw it both as an extrapolation of the windows based GUI and also as a cultural refrain to historical multi-image frescoes and the micro narratives of Hieronymus Bosch.

The first example of a multi-screen film is Able Gance's epic, *Napoleon* (1927, Fr). A triptych film made in 1927 projected on three simultaneous reels of film [Cuff, 2017, August 3].

Further examples of this technique can be found in Mike Figgis' *TimeCode* (2000, US) and Hans Casona's *Conversations with Other Women* (2005, US), these films are wholly composed of multi-screen compositions. In *Conversations with Other Women* the screen is vertically bisected into two frames, each independently cut, and are composed to compositionally work as one image. In *TimeCode*, four single takes are presented in real time in a two by two grid. Each audience member moves their attention from quadrant to quadrant constructing their own linear sequence. “Interactivity is, in these cases, reduced to the itinerary of the viewer’s attention, which must jump from one space to another.” [Verdugo et al., 2011]

Figgis was however able to steer that attention, by using the sound mix to highlight certain moments in particular frames: “Although there are no visual cuts in the film, the sound editing serves to influence the viewer’s focus of attention by alternately raising or lowering the volume in one of the four quadrants at particular moments of the film.” [Denson and Leyda, 2016, p.75].

Dixon [2007] talks about *Timecode* as being multilinear, the multiple lines through the narrative are *“linearly sequenced and finite in plot and length.”* While the audience is able to explore the four simultaneous happenings it is still the responsibility of the scriptwriter devise the effective plot developments.

Another movie which employs the technique of using multiple frames within the cinema screen is *The Tracy Fragments* (McDonald, 2007). In this film by Bruce McDonald the frames are used creatively, changing in location and context, *“emotionally like an echo or like embroidery.”* [Gruben, 2012] calls this proto-interactivity; she observes of her students’ reactions watching the film:*“. . . after an initial period of confusion they allowed the film to carry them, maintaining one track of their minds for cognitive reconstruction.”* [Gruben, 2012] There is the hint here that the full image containing the multiple screens is to be taken as a whole and as a way to experience the world as the main character Tracy does.

Spatial montage in the form of a multi-screen combination of shots has crossed into mainstream commercial film, albeit mostly as small vignettes within the body the movies themselves. *Indiscreet* (Stanley Donen, 1958, US), *The Thomas Crown Affair* (Norman Jewison, 1968, US), *Sisters* (Brian De Palma, 1972, US), *Jackie Brown* (Quentin

Tarantino, 1997, US), *Lola rennt* ([Run Lola, Run] Tom Tykwer, 1998, De), *Requiem for a Dream* (Darren Aronofsky, 2000, US), *The Rules of Attraction* (Roger Avary, 2002, US/De), to name a few, all include scenes where the action breaks into two or more screens. Thus, the language of spatial montage is assumed to be understood by general audiences.

I have presented Multilinear or Spatial Montage, as interactivity which can occur within the cinema as an additional layer of the meaning making process. We will see that audiences desire more from even the most classic of films in the form of Live Cinema.

2.2.4 Live cinema

Live cinema is a term given to public screenings which include some form of performance, be it dressing up to see *The Rocky Horror Picture Show* (Jim Sharman, 1975, US), attending a Secret Cinema[1] event where audience inhabit a recreation of the cyberpunk streets of 2019 LA while watching *Blade Runner* (Ridley Scott, 1982, US/UK/HK), to attending a film concert performance of John Williams' score of *Indiana Jones and the Raiders of the Lost Ark* (Steven Spielberg, 1981, US).

Live cinema is a growing industry, almost half of independent exhibitors in the UK host live cinema events and organisations such as Live Cinema UK[2] and websites dedicated to live score performances exist to promote these events[3].

Atkinson and Kennedy [2016] categorised live cinema into three distinct types. First, *Enhanced*, such as outdoor and site specific screenings such as the events held by Secret Cinema. Second, *Augmented* screenings, the most common instance being live score performances alongside film presentations, such as Jason Singh's vocal performance of John Grierson's silent film *Drifters* from 1929[4]. and theatrical interventions, like Nathan

[1] www.secretcinema.org/
[2] www.livecinema.org.uk
[3] www.moviesinconcert.nl
[4] www.jasonsinghthing.com/gallery

Penlington's *Choose Your Own Documentary*[5] . Finally *Participatory* events which invite the audience to interact with the screenings by dressing up, singing along or, in the case of *The Room* (Tommy Wiseau, 2003, US) throwing plastic spoons at the screen[6].

Interactive films can also be screened live: Morten Schjødt performing a director's cut by controlling his interactive film *Switching* (2003, Dk) or Mike Figgis remixing live the soundtracks of his 4-screen feature *Timecode* [Lew, 2004]. As of 2016 interactive cinema only accounted for 1% of Live Cinema instances [Brook et al., 2016] whereas live scores and re-scores account for over half of live cinema productions.

Live scores, similar to historical silent film performances in which music would be played live, commonly improvised, come in two distinct modes; the original score played alongside the movie which has the original vocal and sound effect track, and the re-score, where musicians will compose a new score usually for a cult or well known film. Atkinson and Kennedy note that the re-scored films such as *THX1138* (George Lucas, 1971, US) have sparse dialogue allowing space for the new composition as well as allowing the audience to hear the dialogue [Atkinson and Kennedy, 2016].

Live cinema can also be used as a probe to generate Human Computer Interaction (HCI) research questions. *The Experiment Live* (Brendon Walker, 2011, UK)[7] was a live cinema horror broadcast to explore the use of a team of armature paranormal investigators' physiological data as a tool to enhance drama [Tennent et al., 2012].

2.2.5 An overview of interactive cinema

Interactive cinema can be defined as a movie that is experienced live, that will be different on each viewing based on input from participating viewer(s).

There are several published histories collecting interactive cinema, the most extensive

[5] www.cyod.co.uk
[6] www.screenrant.com/room-viewer-participation-guide
[7] www.thrilllaboratory.com/the-experiment

being those of Dixon [2007] and Hales [2015]. Below this is briefly summarised and added are some examples which both predate and bring up to date the journey of interactive cinema.

The first recorded instance of the interactive movie is from 1926. Directing duo Leventhal and Crespinel were commissioned to create six 3D stereoscopic films. The last of these, *As You Like It* (US) instead of using the anaglyphic technique to produce a 3D effect they created two final scenes, one projected red and one in green. The audience could individually choose an ending, or switch between the two endings by closing one eye or the other [King, 2008]. Little is known about this intriguing early example, it is not cited in any of the interactive cinematic literature and it is unlikely the film has survived the passage of time. It has some of the qualities of proto-interactivity akin to *Timecode* et al., objectively, the film itself does not change, but each audience member would have to make a decision of which eye to close, thus experiencing a different version of the film. One wonders how this concept could have developed theoretically and practically had it not been lost to time.

The interactive film system *Kinoautomat's* only film *One Man and his House* (Radúz Činčera, 1967, Czechoslovakia) is consistently cited as the first interactive film. Shown at the World Fair in Montreàl in 1967 the audience was able to vote via a red or green button at nine interactive moments. The film was compared by two individuals on stage who would explain the dilemma to be voted on and then a projectionist changed the appropriate reel. Hales [2005] gives an extensive look at the film, and its restoration.

Dixon [2007] gives an in depth history of interactive cinema in the Performing Interactivity chapter of his book Digital Performance. He differentiates between artistic and commercial tracks of developments looking at the experimental and exploratory work made on CD ROM, laserdisc, web, and mainstream theatrical and DVD releases of the 1990s. Dixon suggests four categories of interaction specific to digital artworks and performances; Navigation, Participation, Conversation and Collaboration, each with more interactive openness and depth than the last. With the exception of the installation by

Toni Dove [Dove, 1994], Dixon puts Interactive Cinema into the category of Navigation. Dixon's examples ask the user to make plot driven choices for characters and actively explore narrative spaces either alone or with a collocated audience. Dixon concludes his delve into interactive cinema by discussing what he sees as its inherent problems which are collated with others in the next section.

Hook [2018] presents a contemporary and comprehensive corpus of current online, interactive video which specifically engages with personal data. They discuss that adaptive narratives, defined as, "*Selection and order of video content changed based on data.*" Were both the most under-explored and most promising technique of engagement.

Now at the beginning of the 2020s there has been another influx of interactive cinematic content. Apps like Ctrl Movie[8], Steven Soderberg's *Mosiac* (2018, US), and streaming service Netflix are able to reach massive audiences because of technologies increasing capacity and ubiquity. Unlike the interactive cinema of the 1990s there is no need to install remote controls into cinemas, just download the app for CTRL Movie. Audiences don't even need to go to the cinema, they can use Netflix's own app installed on their smart TV, PlayStation or XBOX to watch and interact with titles such as 'Bandersnatch' ([*Black Mirror*] David Slade, 2018). Traditional broadcasters such as the BBC are also exploring reconfigurable programming [Smith et al., 2017]. BBC's Research and Development Department has begun to pilot their Object Based Media platform (OBM) which can present media in non-linear and context specific ways[9].

There has been a long history of experiments in interactive cinema. The development of non-linear technologies, computing power, high bandwidth, highly compressed video files and accessible distribution methods are now allowing a much greater audience to participate.

However there is also a history of criticism of interactive cinema. In the next section various conceptual and practical failures and dead-ends are collated.

[8] www.ctrlmovie.com
[9] www.storyplayer.pilots.bbcconnectedstudio.co.uk/experience/click1000

2.2.6 Critiques of interactive cinema

The 2000s was a dark time for interactive cinema. Prominent commercial examples of the 90s such as *I'm Your Man* (Bob Bejan, 1992, US), *Mr. Payback: An Interactive Movie* (Bob Gale and Charles Croughwell, 1995), and *Tender Loving Care* (David Wheeler, 1998, US) were denounced as critical and commercial failures while more interesting experiments did not receive attention outside academic circles. The MIT Interactive Cinema group ceased its activity after 17 years[10]. Collected here are reasons why interactive cinema has been considered a failed endeavour, and there are many. Hopefully by identifying and collating these common problems, a design brief for creating alternative interactions and structures can be arrived at. The first boom of interactive cinema which plateaued, or fizzled out in the late 1990s is characterised by branching narratives, character or plot choices chosen via remote and many broken fourth walls. More recently there has been a second push for the interactive film, however as we will see barely any of the criticism levelled at the work of the 1990s has been addressed.

Interaction

Manovich [2001] argues that all media and art is inherently interactive in that one must actively and cognitively create meaning from what is presented. Following this logic Manovich asserts that if this is the case it renders the term interactive cinema redundant, instead opting for the term Database Cinema. While others refer to algorithmic cinema [Enns, 2019] or verbose terms such as hyper-narrative interactive cinema [Ben-Shaul, 2008].

The concept of interactive cinema is described as a “doomed genre” by Lunenfeld [2004]. He describes the interactional aspect as seeded from users' introduction to personal computers and their non-linear experience of navigating the internet. He cites Manovich when saying that all media is interactive as one actively creates meaning through recep-

[10]media.mit.edu/groups/interactive-cinema/overview

tion and argues that even though there are many examples of interactive cinema, they had (at least in 2004), not succeeded creatively, technologically or financially. Lunenfield points to artistic cinematic installations such as that of Toni Dove, which uses the viewers movements and position to interact, as a possible space for hope [Dove, 1994].

In Siskel and Ebert's review for the movie *Mr Payback* they attack the very nature if interactivity within the cinema, "*we don't wanna interact with a movie, we want it to act on us. Its why we go, so we can lose ourselves in the experience.*"[11] However, Ebert in particular has been criticised for his stance on the video game which he says "*can never be art.*" [Ebert, April 16, 2010]

Dixon echoes this sentiment when he says audiences "are uninterested in navigating through or creatively experimenting with a maze or road map, but prefer the best and most direct route to cinematic satisfaction" [Dixon, 2007]

Immersion

When Lopes [2001] excitedly describes the emergence of interactive art he defines the concept of 'strong interactivity' where the participant is able to modify the structure of the work such as a story's narrative content.

Murray [2016] has said that agency adds to the feeling of immersion, in contrast Ben-Shaul [2008] argues that in interactive cinema immersion and interactivity are mutually exclusive, he offers some potential solutions for what he calls *"Hyper-Narrative Interactive Cinema."* Ben-Shaul draws on dual coding, cognitive load, and constructionist film theory to assert why the viewer of an interactive movie cannot both attend to the ongoing narrative and their own interaction at the same time.

However he does not think this problem is insurmountable and suggests if the narrative and interaction are designed to complement each other this could counter the cognitive split. This concept of a reciprocal interface is exampled by Udi Ben Arie and Noam

[11] Two-Minutes Hate: Siskel & Ebert on Interactive Movies (1995) - YouTube

Knoller's interactive narrative film *One Measure of Happiness* (2003, Il) in which cuts, cross fades and wipes between related video clips are actioned by swiping one's finger across the screen [Dekel et al., 2003].

Story and interactive design

Dixon [2006] points out that for the scriptwriter to author a successful single narrative is an achievement. To author fifty or one hundred interweaving plots, all of which are successful, engaging, and narratively complete is nigh on impossible. This presents a problem for the interactive cinema screenwriter. How has this challenge been met? The simplest method by far can be found in William Castle's film *Mr. Sardonicus* (1961, US), billed as an interactive movie where the audience will choose the ending by holding up a thumbs up or thumbs down card (or flashing their headlights in the drive-through version). Castle, infamous for flying skeletons through the audience or giving them electric shocks was able to get around the problem by only filming one ending. There was no alternative ending. A comedic example, but Castle's intuition was that the concept of an interactive story would draw more audiences [Hales, 2015]. Perhaps it would be best then to explore one of the most recent and most seen interactive films.

Bandersnatch, a Netflix produced interactive episode of Black Mirror, has once again brought the medium to public attention. A WIRED article states that its reach is a potential "27 languages to 137 million Netflix subscribers" [Reynolds, 2018, 28 December]. The narrative is that of a 1980's video game designer who becomes trapped in the process of making a choose-your-own-adventure inspired game. As the story decisions progress he becomes aware that he is being controlled. This results in a post-modern, meta narrative which breaks the fourth wall.

The film was produced from seven drafts of a 170 page script and consists of 250 video segments, totalling 150 minutes of footage. The structure of the film was designed in Twine incorporating If and Then logic statements before transferring to Netflix's own interactive authoring tool, Branch Manager [Reynolds, 2018, 28 December].

There are three core segments. The viewer is asked to make a choice around every 5 minutes. Each decision path is logged and certain decisions will unlock sections later in the film. Dead ends in the story structure are dealt with by playing one of the 41 recaps, pre-made sequences that highlights the decisions made so far, before offering the choice to go back into the story or to the end credits [Reynolds, 2018, 28 December].

The system designers Russell McLean and John Weeks regards *Bandersnatch* as a game whereas writers and exec producers Charlie Brooker and Annabel Jones refer to it as an interactive film. It is telling that this ambiguity is present even within the production team, Roth and Koenitz [2019] suggest that this miss-categorisation is responsible for the mixed reactions they found with subjects interacting with the film in their study.

The creators of *Bandersnatch* do appear to be confused as to what they created, Brooker is quoted as saying "*I couldn't tell you how to get to* [some scenes]." And Exec Producer, Annabel Jones comments, "*We've tried to think about every way that people can play it, but there are so many different ways that it's hard to totally understand the emotional reaction that they are going to have,*" from Reynolds [2018, 28 December].

One of the design challenges for interactive stories as pointed out by Marie-Laurie Ryan, is how the transitions between narrative junctures are handled. In the DVD release of *I'm Your Man* characters break the fourth wall imploring the audience to make decisions, (a technique that appears again and again throughout interactive cinema), directly asking the audience what to do, sometimes accompanied by a timed countdown. Ryan suggests that this approach will quickly become cliched.

> If self-consciousness becomes the standard way to compensate for the anti-immersive effect of interactivity, it will take a lot of ingenuity to prevent the device from becoming a metacliché [Ryan, 2001, p.278]

Bandersnatch uses a neutral holding shot with binary narrative options and a time limit to interact. Like *"I'm You Man"* the fourth wall is broken in *Bandersnatch*, but it is a gradual process which eventually becomes the central conflict of the narrative. CTRL Movie's first film *LATE/SHIFT* (Tobias Weber, 2016, Ch/UK), like *Bandersnatch* has timed options but apart from the intermittent text on the screen the interaction is not directly referred to.

Steven Soderbergh's *Mosaic* (2018, US), released via the US Apple App Store, is a thriller told from multiple perspectives. *Mosiac* was marketed as an exploration of a story which can be re-watched many times. The project was released to mixed reviews, which has been suggested is due to interruption of viewer identification within a multi-point-of-view story [Kapila, 2019]. However the concept of identification is contentious, as Barker outlines in a historical review of the surrounding literature and demonstrates in his audience research of identification [Barker, 2005]. To summarise the subject; it is a term that does not have strong theoretical backing and is often used as simply meaning 'feeling engaged'. As Noel Carroll says: "*In order to understand a situation internally, it is not necessary to identify with the protagonist.*" [Carroll, 2003, p.95].

Tan [1995] discusses how it is the physical inaction which is self evident in film watching that brings the viewer into the fictional world and while not specifically referring to interactive cinema we can see how it might relate: "*Invisible witnesses are unable to act. Both invisibility and the lack of control over their gaze preclude any cause for action.*" The viewers are disembodied and directed to where to look, "*The viewers' feat as witnesses coincides with their inactivity in the cinema, though they are not identical: lack of command in the fictional world is part of the guided fantasy that the film imposes on the viewers; sitting in a chair in the dark is not.*" Attention to their physical presence, of sitting and watching is not compatible with their immersion,

> The viewers, both as spectators of what happens on the screen, and as witnesses in the fictional world, are limited in what they are allowed to see. This tends to enhance the diegetic effect. More

> importantly, no one in the fictional world appeals to the viewers for action, either in terms of help or advice, and indeed that would clearly be pointless.[Tan, 1995, p.17]

We can thus see how breaking the fourth wall, *"appealing"* to the audience to interact can be incompatible with engagement with the *"fantasy"* world on screen. As noted, Tan is not specifically speaking about interactive cinema, so when the viewers are called to *"action"* how does that change their relationship to the fiction? To explore this question we become entangled with concepts of agency and authorship.

Agency and Authorship

The viewer performing actions and referring to the interactive viewer as the interactor is telling, does the participant of an interactive movie have the status of author? And how does agency manifest itself?

> We could perhaps say that the interactor is the author of a particular performance within an electronic story system, ... but we must distinguish this derivative authorship from the originating authorship of the system itself. [Murray, 2016, p.143]

Murray has more to say on the subject of authorship, specifically procedural, rule based authorship and how it relates to agency.

> The interactor is not the author of the digital narrative, although the interactor can experience one of the most exciting aspects of artistic creation—the thrill of exerting power over enticing and plastic materials. This is not authorship but agency. Murray [2016, p.143]

So, perhaps it is better to talk about agency rather than authorship. Prioritising experience rather than the resultant object, after all, who *is* telling the story? Of course that depends on the originating author, did they approach creating the experience as a game where there is a desired end goal? Or have they designed the narrative so that each variant viewing has its own equal value?

Murray's definition of agency is highly cited. Within narratives, Murray observes interactivity can reinforce immersion if the user feels they have agency:

> When we are immersed in a consistent environment we are motivated to initiate actions that lead to the feeling of agency, which in turn deepens our sense of immersion. This phenomenon can be thought of as the Active Creation of Belief. [Murray, 2016, p.91]

When framed this way it is possible to further dissect the concept of agency into global and local agency, local agency is the immediate effect that happens from the users choices, whereas global agency happens at the end of the experience. A study by Knoller and Ben Arie [2009] of *Turbulence* (Nitzan Ben Shaul and Daphna Ben Shaul Cohen, 2009, Il) aimed to reduce both global and local agency. Their results state that some audience welcomed the loss of global agency but found the loss of local agency detrimental to their engagement.

The terms of local and global agency can be viewed from a different perspective, that of high and low frequency of interaction, in branching narratives where a user or viewer may only have a handful of choices, Knollers' example suggests that this local agency is preferred to global agency, to only being able to change how the story turns out. This could suggest that by increasing the frequency of interactions would move towards a *"consistent"* interactional environment.

When applying this concept to branching stories, as seen in hypertext fiction and early instances of interactive cinema such as *Mr Payback* and *Tender Loving Care* which are characterised by a few branching paths, and can have multiple endings, "*frustrates our desire for narrative agency*" [Murray, 2016, p.128]. If we are to increase the frequency of interaction, how do we do so while not getting lost in possibilities? Or as Murray puts it:

"*How can a writer tell a connected story in so fluid an environment?*" [ibid, p. 149].

As we will see increasing the frequency of interaction in turn raises other, more practical challenges for interactive filmmaking, which we will focus on next.

Practicalities

Filmmaking is already an expensive business. Dixon [2007] points out that to make a branching interactive movie the amount of scenes double with each decision point. So a director making a movie with six decision points has to shoot 127 scenes. However, in any one performance the audience only gets to see six of these scenes. In the study conducted by Roth and Koenitz [2019], 32 participants' experienced the interactive film *Bandersnatch*, which has 150 minutes of footage, the average view time was of 83.5 minutes (SD 19.3). The time watched of unique scenes is likely to be lower as the film is structured so there is some repetition of scenes.

In many cases the screenwriter, director and interactive designer are the same person or roles are shared among a small design team and often bespoke software must be developed and learned. However the production scale of *Bandersnatch* is untypically high for an interactive film, supported by one of the larger content producers, Netflix.

Shooting multiple versions of the same scene should in theory be as simple as setting up a shot and shooting each of the versions before moving to the next setup. However with *Bandersnatch* the actors and director became overly confused about which 'reality' they were in, and resorted to shoot a full narrative path in order, one at a time, replicating setups and ultimately sacrificing efficiency. In the end production took 8 months, around four times as much work as a linear *Black Mirror* episode [Reynolds, 2018, 28 December].

When preparing interactive movies, specifically when their main reason to exist is to be studied, can also be problematic. Low budgets and inexperienced cast and crew can end up producing amateur results. When studying narrative engagement this will reflect in the data. [Kirke et al., 2018] describes such issues in the process of making *many worlds* (Kirke, 2013, UK). He explains that he had to use his students as actors combined with the complexity of script writing caused one of the endings to be “narratively weaker” than others. Communicating the complexity of the production with the editor was also problematic. Issues with the acting and the filming were also reported by participants to be weak, and one of the branches of his narrative was never seen.

In this section we have collated critiques, challenges and problems related to the design, interaction and practical making of interactive cinema. In the next section we will look in detail at the potentials of passive interaction and alternate narrative systems. We will illustrate with examples from artists and researchers, and explore physiological cinematic affect, HCI concepts and the potential of brain computer interfaces..

As we can see, within the realm of actively controlled interactive cinema there are problems with the narrative, interaction and practical. We summarise these below to motivate our strategy to answer them:

Narrative

1. Successful narratives are hard to make, branching narratives are harder.
2. With scale comes confusion.
3. Navigating a narrative is not the quickest route to cinematic satisfaction.
4. An overuse of breaking the fourth wall causes clichéd narratives.

We respond to these problems by taking lessons from database cinema, algorithmic cinema, and alternate narrative designs of interactive cinema.

Interaction

1. Fine grain agency is more agreeable than global agency.

2. Split cogitation over film reception and participatory control disrupts immersion with the narrative.

3. Narrative agency can be disrupted by complicated plot interactions.

We will explore how a high frequency of input can produce passive interaction, an ideal candidate for this is to use physiological data as an input. This can be eye tracking, EEG, comparison of neural data, tactile and group physiological interactions.

Practical

Our practical findings from the previous chapter are summarised below. They sensitise our search for narrative and interactive alternatives to established interactive cinema techniques.

1. There is a history of limited creative, critical and financial success, although there has been a new wave of interactive films.

2. Productions can take longer to make and be more expensive than linear film.

3. It is rare that all of the footage shot will be seen by the audience.

4. Tools may have to be developed to realise creatives vision.

2.3 Beyond Interactive Cinema

We will now look at ways in which artists and researchers have approached alternative interaction and narrative designs for interactive cinema.

2.3.1 Alternatives to active control and branching narrative

Many of the following works are made by artists and researchers reacting to the problems collated in the previous section.

We first look at interactive movies that employ more passive interactions, then we identify various systems that have been designed to create and re-combine narratives, finally we identify three works that use physiological data within a tight feedback loop.

Towards passive interaction

Let us first look at a range of interactive films that use alternative inputs that can effect narrative combination.

Asking the user to press a button, click a mouse or other such active physical movement is shown to be detrimental to the primary task of enjoying a narrated story. This has been the most used interactive paradigm, one that continues to be used within interactive cinema. Now contrast this with a passive input, which does not ask the user/viewer to make a choice, and that interprets a persons' data as an internal state. Passive inputs can be from eye tracking sensors, GSR, EKG, EMG, or EEG headsets and can interpret states of arousal, valence, meditation, attention, excitement and more. Knoller [2010] sees this as an opportunity to enable the artistic potentials of the interactive storytelling medium:

> Current sensing and affective computing technologies are able to react to implicit aspects of user behaviour and performance. Being implicit - and therefore unintentional - these aspects of interactivity can't be understood in terms of local control-agency, which is necessarily intentional, and yet they may produce meaning retrospectively, as the player's implicit causation of events becomes apparent. [Knoller, 2010]

This can be thought of as a co-production or renegotiation of the roles of artist, system and the interacting participant, "*As the role of the artists can be moved more and more behind the curtain to direct audience peer-production of the content*"[Rostami et al., 2017]

Rostami et al. ran workshops to create design ideas exploring relationships between audience technology and narration. Two of the devised scenarios were examples of interactive cinema using physiological data as an interaction device. From analysing the ideas generated the authors foresaw three topics "*Temporality of Input*", "*Autonomy of Control*" and "*Visibility of Input*". We discuss each of these in turn.

Temporality of input

Within interactive cinema, footage can be either generated in real-time such as via a render engine as with *PINTER* [Gilroy et al., 2012a], filmed live as with Blast Theory's *Bloodyminded* (2019, UK) or, as in most cases it will use pre-filmed or rendered footage. Therefore it is the edit, the choice of shots and sequences, which the interactive film mostly acts upon. For branching narratives these edit decisions may only happen twice as with *Many Worlds*, or every five minutes as with *Bandersnatch*.

When writing about the process of editing film Walter Murch [1992] refers to it as the act of making 24 decisions a second, to cut or not to cut.

Correspondingly, the temporality and the continual nature of physiological sensor data brings the possibility of a much finer temporal granularity to the interactive edit.

"*The passive nature of the input relied upon in bio-sensed and bodily tracking systems gives rise to the possibility of providing input on different temporal scales.*" [Rostami et al., 2017] Physiological sensors provide a steady stream of data. This data can be analysed simultaneously in different ways to assess fine or course grain affect and as such be mapped to different modalities of the interactive media.

Autonomy of Control

> Action in a traditional interactive performance goes hand in hand with agency and control; the audience member chooses when to interact and how that interaction is directed [...] Even with data

> collection that is temporally bound to the audience member's interaction with the performance, as we move towards more passive and bodily sensing the control that participants have over their input drops. Inversely, the control that the artist has over the audience's input increases. [Rostami et al., 2017]

This addresses previous criticisms that audiences want to have a story told to them and that the interactive film disrupts that. The artist is able to curate the ongoing interaction and narrative in a more controlled way in what fellow artist-researcher Tikka calls, second-order authorship. Tikka [2010] differentiates this "*derivative authorship*" Murray [2016, p.143] of the interactor as second-order spectatorship and of the artist as second-order authorship. The second-order author is the creator of the experience, of the story, its possibilities and interaction design. The second-order spectator is the interactor, the driver of that one story path and, as the term implies, does not have complete control over the interaction.

Visibility of Input

"*The individual actions involved in providing input to bio-sensing and bodily tracking systems can have different communicative abilities with respect to the system and others around the user.*" [Rostami et al., 2017] The action of providing such bio-data, apart from the action of putting on and wearing the relevant sensor, is invisible; however the output of the data, the effect it has on the media, if understood by the interactor and/or the audience is not. How participants negotiate and audiences react to that is an open question.

2.3.2 Alternative narrative systems

The defacto mode of building an interactive movie system has been using the branching narrative concept which, for reasons presented at the beginning of this section come with some unique narrative, interactional and practical problems. The following examples acknowledge the limitations of branching narrative and suggest alternatives. These examples do not attempt to break the fourth wall, but provide contained narratives.

Detour narrative [Verdugo et al., 2011]
This research film explores the concept of co-construction, re-envisaging the Kuleshov effect without directly referencing it. Kuleshov, an early Russian filmmaker and theorist observed the contextual effect that adjacent shots had on the viewers sense of a characters' emotion, his famous example was of a man looking, cut to his POV of some bread- he is hungry. And the same shot of the man looking, now cut to an alluring lady- he is in a state of desire. Verdugo et als. goal was to include the viewer in this process to create "*participative artistic reception (co-creation)*".

The term 'detour narrative' is derived form the structure of shots and detour or alternative shots. A backbone of scenes are always seen, but between each 'vertebrate' one of two detours can be chosen. Dragging onscreen objects onto an action space (the video window) chooses one of the two detour scenes. These detours have been explicitly designed to provide alternative contexts to the backbone scenes. The study showed that these slight changes of detour shot change the perception of the character's motives and scene as a whole.

Metadata based edit [Davenport et al., 1991]
MIT's interactive cinema lab led by Glorianna Davenport was active for 17 years until 2004 and aimed to create "*personalisable and conversational*" narratives that dynamically reacted and adapted to the audience.

When Davenport says *"Interactive Multimedia proposed that the participant viewer can affect selection and sequencing of cinematic story elements"* [ibid] she describes a scheme for applying (meta) data to shots in order to create associative sequences in pre-production. Much focus was put on to the environment of the recorded media and data associated with video and audio at the time of capture. This research was undertaken at a time when the only data explicitly associated with video was the SMPTE time code[12]. A main aim of this work was to create linear sequences from user preferences.

It is Davenport's position that actively engaging with narratives especially documentaries would increase engagement and learning [Davenport and Murtaugh, 1997].

Davenport's Automatist storytelling system has roots in Surrealist and DADAist automatism, which both aimed to incorporate stream of consciousness writing and remove conscious authorship. Davenport's Automatist system "*consistently integrates the viewer's interaction... the viewer exerts influence over the emergent functionality of the system in the same way that any other component of the system does, by altering an aspect of the environment or influencing the operation of other components.*"[Davenport and Murtaugh, 1997]

User preference based edit [Smith et al., 2017]
BBC Research and Development have been exploring the concept of re-combinable content for some years. Initial work was to dynamically adjust colour grade and and story paths based on a user profile[13]. Recent work such as their Object Based Media platform which, in the same style, takes user preferences and adjusts the video content to suit, curating content which has a tiered relationship from simple additional content such as subtitles, onto alternative camera angles/music levels, to logic defined media which can change the duration of the programme, to finally a 'game style interactivity'. This was prototyped by defining 'story chunks' that have thematic dependencies and relationships to other chunks. This network of narrative parts is used to build a narrative map to define possible routes through the programme. This has been developed to a public release stage and the 1000th episode of *BBC Click* (BBC, April 2000-) was broadcast in this format[14].

Database Narrative. [Anderson, 2006] Manovich and Andreas Kratky explored Spatial Montage in the form of database narrative in their *Soft Cinema* project. These were a

[12]Abbreviation of Society of Motion Picture and Television Engineers, and is an embedded electronic position signal for video and audio.
[13]bbc.co.uk/rd/projects/visual-perceptive-media
[14]bbc.co.uk/taster/pilots/click1000

series of short algorithmically composed narratives. They employed spatial montage to combine text, voice over, stills and video to create unique narratives combinations on each view [Anderson, 2006]. In *Soft Cinema*, Kratky and Manovich "modelled a compositional mode in which the work of the 'artist' is shifted from encoding desired meanings into a montage structure to establishing the rules and metadata by which the *Soft Cinema* engine will create its own combinations of media elements (video, text, sound, composition), the meaning of which will ultimately be produced through reception and interpretation by a viewer." [Anderson, 2006] While the *Soft Cinema* films are not interactive in the sense of user interaction, they are different on each viewing as the algorithms powering the narratives produce new combinations on each run.

2.3.3 Physiological data as input

Now we have explored alternative narrative systems of interactive cinema let us look at alternate interactive systems. A number of research projects employ sensors that detect physiological data for interaction with media. Galvanic Skin Response (GSR) or Electrical Dermal Activity (EDA) can measure the emotional arousal of a participant either on a positive or negative axis. Electrocardiograph (EKG) detects the mean heart rate. Consumer grade Electroencephalogram (EEG) devices can be used to measure levels of attention, meditation, calmness.

The following list of works by practitioners and researchers employ various physical measures that change the output of cinematic content.

Group physiological [Kirke et al., 2018]
The film *many worlds* was made specifically for research. The aim of the director was to increase arousal, a more emotionally powerful scene is chosen if the previous scene's arousal data was below the set threshold. To measure the arousal of the audience, four participants were used as a proxy. EKG, EMG, EEG and GSR were measured. A moving average of arousal was calculated while the viewers watch the first clip, if this value is

above a threshold at the first decision point then choice a is chosen, if below choice b, and so on.

Tactile [Mazalek et al., 2002]
Another of Davenport's works out of the Interactive Cinema Lab at MIT. This work used small movable 'pawns' on a smart, projected table. The user(s) can move these objects to explore three different characters viewpoints on a single narrative which is then shown on a LCD screen. Actions such as moving and touching the pawns together, cause story segment selections and queries. The narrative progresses by using a weighted narrative database which uses the context of what has been seen to hide unimportant story elements and join characters stories together.

Neural data comparison [Zioga et al., 2015, 2016]
Cinema Performance involving a singer against a video backdrop. Wireless headsets sense EEG data from two audience members and one performer on stage. The system compares the mental load of the performer to the audience members. Feature extraction is performed on the EEG data which is then used to modify the RGB colour values of VJed video clips. Although there is no change to narrative, this project is notable for the continuous lean back nature of the interaction.

Eye gaze [ang]
The Angry River (Armen Perian, 2016, US) is a short drama that follows three characters. This online film is cinematically shot, and uses the computers webcam to track eye gaze. Perian uses eye gaze to effect which character's narrative is to be further explored. The story structure changes depending which characters are watched most. "The result feels less like a game and more like an exploration of narrative structure."[Perian]

Eye tracking and EEG [Cohendet et al., 2014]
HAL is a branching narrative based on eye tracking and Emotiv's five pre-processed emotion classes derived from EEG data. In this experiment there are twelve possible combinations of the film. A first study was done to classify the footage. Sequences

were categorised by what emotions they elicited. Eye tracking data was used to identify when in the film emotional data would be an active trigger mechanism. Shots with the greatest variability in eye tracking data were chosen to be most likely to not trigger the same emotion. When viewers emotion data matched during the active shots a specific corresponding sequence was played.

Passive interaction and novel interactive narrative design

When a passive physiological input paradigm is used then the design of the interactive movie can also re-mediated. The following two works utilise interaction via physiological data and re-imagine the cinematic delivery system.

Emotional affective [Gilroy et al., 2012a,b]
Affecting cinematographic techniques and methods of representation the *PINTER* system uses EMG and GSR data as an indicator of the users preference of actions and emotional state respectively. The film is a real time computer generated hospital drama. The CG generated virtual set makes it possible to change cinematographic techniques such as camera angles and lighting in real time. Narrative actions can be staged in various ways dependent on the arousal of the viewer. An example of passive, affective interaction, it uses physiological sensor data as proxies for emotional states to passively interact with a cinematic story. By assessing the viewer's affective state, in this case emotional arousal and valence, the PINTER system modifies non-diegetic qualities of the narrative to achieve an affective response. The authors submit that this passive approach can be used to adapt and evolve a narrative to a user. The continuous data stream that physiological sensors output is seen as a beneficial mode of interaction compared the paradigm of physically interacting at set moments in the story.

Physiological data within a tight feedback loop [Tikka, 2010]
Pia Tikka created a cinematic installation that used physiological data from an audience member to influence the ongoing montage of a film. This sees the embodied participant

as part of an enactive self-organising system. Enactive media [Tikka, 2010] has its philosophical foundations in the concepts of Merleau Ponty, and theoretical foundations in enactive and embodied cognitive science [Varela et al., 1991].

Second-order authorship produces "*systematic environments for the spectators to explore*" [Tikka, 2008]. The spectator's physiological data changes the montage from a database of elements to create a real-time cinematic narrative.

It is the view of Pia Tikka, an artist and researcher who has championed the theory of enactive cinema/media, that an enactive cinematic creation sees the Second-order author put their self into the emotional construct of the situations being written in order to feel the emotions of the characters. Thus, the film makers embodied experience of making is mirrored in the audience at the time of viewing. [Tikka, 2010]. This pre cognitive affect is predicated on the neurophysiological mirror neuron system (MNS) [Rizzolatti and Sinigaglia, 2007] in which the same neurons will fire in the brain of the observer of an action as the one doing the action. This is central to the interrelationship of mind, body and world promoted within enactive cognitive sciences by Varela et al. [Varela et al., 1991, Thompson and Varela, 2001]

2.3.4 HCI concepts

Human Computer Interaction has worked over the years to simplify interactions in order to allow users to concentrate on their primary task. As the field of HCI has continued to focus on user experience, the context of engagement has become more important. Dourish and Bellotti [1992] explored extracting context and information from background feedback of shared work spaces. Nielsen [1993] envisaged the next generation of user interfaces to be implicitly interactive, for interfaces to interpret users actions, become embedded in the environment and more autonomous. For some a more human centric approach was needed, Buxton [1995] presented a framework which described background processes for computer mediated human-human and human-computer interactions. The indicated problem was the distance felt by people communicating or working via computer; integrating ways for people to be peripherally aware of others, or systems to be aware of users' indirect interactions would allow researchers to think about the usage of systems rather than just the technology.

Over the next two decades sub-fields of HCI came to exist with concepts which take for granted the embodied status of the user in the world [Dourish and Bellotti, 2004] and Natural Interfaces (NI) bring together "*computer sensing and information presentation*" [Valli, 2008] technology together as experiential design. However there has been a lack of agreement on what is exactly meant by implicit interaction. A recent review of implicit interactive designs catalogue five definitions [Serim and Jacucci, 2019]. These are implicit interaction as:

Unintentional, the background assumptions that users take for granted in their embodied experience are designed into interactive systems [Ju et al., 2008].

Attentional Background, designs which preserve the finite capacity of user attention by encoding information into ambient or peripheral systems [Ishii and Ullmer, 1997].

Unawareness, refers to the sliding scale of awareness a user has to their input into a system, [Dix, 2002, Waern, 2016].

Unconscious, a measure of how aware the user is of their own mental processes when interacting [Miyata and Norman, 1986].

and **Implicature**, interaction is intentional and directed but implied by other actions. [Serim and Jacucci, 2019].

Additionally there are interactions which aim to alter the users' affective state by sensing and affecting it via an interactive system such as affect loops [Höök, 2008], affective computing [Picard, 2000], and mood enhancing technology [Wadley, 2016].

2.3.5 Passive BCI

The first experiments which used the term Brain Computer Interface were conducted in California by Vidal [1973b]. The assumption was that, with training, live filtered EEG measurements can be used to sense mental reactions and decisions. The technology has since been developed in the medical field to help patients who are unable to move to communicate, and for military applications [Wolpaw et al., 2000, Wolpaw, 2002, Schalk et al., 2004, Macintosh, 2008, Miranda et al., 2014]. It has been predicted that BCI technology will be able to augment the lives of the general public with applications of mental state detection, brain process modification, communications between computers and other humans and direct and indirect control of robots, media and environment [Lance et al., 2012].

BCI systems can be categorised into three user interactions. Active, reactive and passive BCIs. Active and reactive BCIs both have the aim of voluntary control [Zander and Kothe, 2011]. Passive BCI is defined by Zander as "one that derives its outputs from arbitrary brain activity arising without the purpose of voluntary control, for enriching a human–machine interaction with implicit information on the actual user state" [ibid]. In other words it combines cognitive monitoring and a Brain Computer Interface (BCI). It can be used to provide an input to a system without any cognitive cost to the user and used in parallel with another task to complement that users' abilities. Passive BCI can also detect multiple indicators of cognitive activity at the same time without causing the user confusion, as can be the case with self-monitoring techniques and perform actions based on predetermined neurologically sensed events [Zander and Kothe, 2011]. Passive BCIs can be seen as a way to open up BCI systems usefully to healthy populations and HCI researchers [Cutrell and Tan, 2008].

2.3.6 Artistic BCI

The idea of artworks interacted with via a brain-computer interface sounds like something from the pages of a pulp science fiction novel, and thematically this is not lost on the creatives [Mori, 2003]. However, artists have been making work and experimenting with BCI for the past sixty years, even predating Vidal's coining of the term BCI [Straebel and Thoben, 2014]. Artistic BCI overlaps the disciplines of neurophysiology, computing, Human Computer Interaction (HCI) and the arts [Andujar et al., 2015].

Prpa and Pasquier [2019] lists a comprehensive state of the art detailing over sixty instances of BCI used in artistic works, from Alvin Lucier's *Music for Solo Performer* in 1965 to *The MOMENT* in 2018. Well over half of the artworks listed were made in the past decade. It is well known that artists are early adopters of new technology, add to that their historical interest in the mind, and the development of low cost computing and accessible mobile EEG devices all go towards explaining the current boom in BCI artworks.

Of the 61 artworks analysed by Prpa, 41 were defined as employing passive BCI interaction. Passive BCI can be seen as an additional modality that can be used to add context about the users' affective state to ongoing interactions [Nijholt and Nam, 2015].

With such a corpus of artistic BCIs we can start to see trends in interaction and themes, identify challenges and envision opportunities for the future.

Control and Agency

The original use of BCI was as an assistive technology, for communication, movement and object manipulation, allowing people with disabilities new liberties. Users would have to learn or *entrain* themselves to actively modify their neural patterns in intentional interactions. This active mode of interaction takes time and can be tiring and holds little benefit to able bodied people over a direct interaction such as pressing a button [Zander et al., 2010].

A number of researchers have classified modes of interaction with artistic BCIs. Wadeson et al. [2015] defined four distinct modes of control: passive, selective, direct and collaborative control. Prpa and Pasquier [2019] borrows form Zander et al. [2010]'s modes of control and re-categorises as modes of agency: active, reactive, and passive. Within the modality of passive control Pike et al. [2016a] defines a two-axis taxonomy consisting the extent of voluntary control on one axis and extent of self-awareness on the other.

Several factors lead to these classifications, the artists' intention, the system design and finally the audiences' approach to the artwork. Artists may direct participants to feel a certain way. The system design may explore the uncontrollability or ambiguity of agency or control [Marshall et al., 2011]. But ultimately it is the participant who defines in their embodied interaction with the work how they interact. Prpa and Pasquier [2019] notes that in a passive system if the user tries to modify their brain signals then the system moves from being passive to being active. This movement of intention by the user is developed into the taxonomy seen in [Pike et al., 2016a] where it was suggested that the participants' prior knowledge, discovery and awareness of the workings of the system, and of their self, affected how they traversed through voluntary and involuntary control.

Mapping

The design of how EEG data effects changes in the interactive work- the mapping is defined in [Prpa and Pasquier, 2019]'s review as falling into three distinct categories. Direct, Indirect and Adaptive. In direct mapping, an attribute of the work is effected in a predictable way by a measure of brain activity. Indirect mapping is described as where the EEG data effects one parameter which, in turn goes on to effect another. Finally, with adaptive mapping, logic can be built in into the design system so that the output is ever-changing or adapts to the participant.

Audiences

Often the audience are the participants offering their brain data up for artists to perform upon. In a few occasions the artists will join the audience [Lancel et al., 2019] or in other cases be the subjects themselves [Pearlman, 2017].

Of course audiences can be a rich source of data and some call for the participants of artistic BCI experiences to be studied. In a review of Brain Art by Nijholt [2019] a collection of artistic related BCI articles, born from the first artistic BCI workshop at CHI 2019, Albu [2019] hopes future publications focus on audience views, and how they create meaning from the neural patterns they see.

In several cases when artists are working with scientists the artworks can act as data collection sessions. Some scientists also are able to complement the artists investigation with their own research questions allowing for academic outputs as well as artistic. The added engagement of these public facing events can allow for a much wider participant count than is usually found in neuroscientific studies.[15]

Challenges and opportunities

Prpa and Pasquier [2019] notices a lack of documentation from artists about the design of their work. This causes problems for researchers who want to understand the field of BCI art in detail. It also makes reproducibility of experiments almost impossible. However this last point is common to digital art in general.

2.3.7 Deconstructing cinematic affect

Before we explored how audiences actively make meaning and construct narratives while watching films, let us now look at how films "*act on us*" (Siskel & Ebert on Interactive

[15] myvirtualdream.net

Movies 1995). This should give some insight of how passive interaction is a good fit for cinematic interaction. We synthesise research which explored how our "*arbitrary brain signals*" [Zander and Kothe, 2011] can be affected by cinematic content and specific cinematic techniques. These researchers explore at fine granularity, the affect on viewers by editing construction and how specific filmic techniques act on us from a cognitive and neuroscientific point of view. As we look at editing and rhythm we combine theory from film theorists and film practitioners, and cognitive and neuroscientists.

2.3.8 Neurocinematics

Neurocinematics is a fairly new discipline which combines the fields of cognitive film theory and neuroscience to understand why movies have such an intimate power to elicit emotion and meaning. To be more specific these cognitive and neuroscientists are exploring why film, which is made up of thousands of discontinuous shots is perceived by the viewer as a continuous flow [see: Aznar et al. [2019] for review]. Insights into how viewers internally perceive highly curated and discontinuous images and sounds can be useful to the interactive film director.

Areas of investigation include event boundaries and event segmentation, film rhythms, the presence of and affect on attention, and the similarity of responses to different genres of film.

Hasson et al. [2008] set out to find the "*effectiveness of a movie in controlling viewers' emotions and thoughts*". Using fMRI and eye-tracking Hasson et al. looked at the inter subject correlation (ISC) of subjects' neural and eye gaze data watching segments of several different genres of film. Their findings were that certain types of movie are able to "control" viewers' neural responses and thus their mental states in a reliable and predictable way. They found more ISC with heavily structured movies and a low ISC in unstructured clips of everyday life. Hasson et al. discuss that ISC increases when filmmakers are using the Hollywood style of film making, also known as continuity editing, exemplified by the work of Hitchcock. Based on this Hasson suggests a single continuum going from reality- to documentary- to art house- to Hollywood- to propaganda on the far extreme, where the further to the right the higher the ISC.

Cinematic continuity

Smith [2012] presents the Attentional Theory of Cinematic Continuity (AToCC), which approaches the continuity editing rules or the *Hollywood Style* from the perspective of visual cognition. In Smiths words the theory "acknowledges that the viewer is active, even when sat stationary in a cinema auditorium, and through their gaze they seek out information on the screen, formulate expectations about future events, attend to objects across cuts, and represent minimal details of a scene that are relevant to the narrative. The continuity editing rules use natural attentional cues such as off- screen sounds, conversational turns, motion, gaze cues, and pointing gestures to trigger attentional shifts across cuts." In other words the filmmaker directs the audiences' flow of attention by signposting action, sound and camera movements from one shot to the next.

The AToCC is based on three stages: first, attending a shot, second, cueing attention for the next cut and finally matching expectations for the following shot.

Stage one: The viewer attends to the properties of the shot. They do this both covertly, out of the corner of their eye and overtly as fixated areas of attention. Fixated points are attended because of properties of the image or movement, the semantic properties being attended under voluntary control and camera/ lighting manipulation. "*A filmmaker will attempt to align these three factors to ensure coordination between where they want the viewers to look and where the viewers want to look. If this marriage is successful it will result in attentional synchrony.*" The filmmaker is guiding the viewers' attention within the frame, allowing them to observe what is important and setting them up for the next stage.

Stage two and three: Cueing the viewers' attention for the next shot and matching the viewers expectations of that shot. Smith [2012] says: "*In order to minimise viewer awareness of the visual transients associated with a cut and maintain the assumption of ... continuity the filmmaker needs to coincide the cut with an attentional shift.*" When the cut happens, the whole visual field changes; in order for the audience to feel a continuation of the passage of time, action or a reaction the following shot can be designed in various ways.

Smith [2012] defines three of the most common techniques which preserve spatial and temporal continuity. The Match Action Shot uses movement to guide the audiences' attention fixation and anticipate its trajectory. The next shot should be spatio-temporally consistent and the locus of attention should be in the position where the audience is already looking or directed by the previous shot. The Establishing and Shot/Reverse-Shot, commonly used during dialogue action, is shot on one side of a 180 degree line between 2 actors so the actors face each other between cuts. Point-of-View and Point Shot, when a character looks off screen creating an inquisitive glance by the viewer to the following shot, present what the character is looking at [Smith, 2012].

The cut as a blink

A practitioner/theorist Walter Murch puts forth that the experiencing of cuts in a film is similar to that of blinking [Murch, 1992]; where he likens the cut to a blink, a shot to a thought and film to dream.

The analogy of the shot being like a blink for Murch is predicated on two things. First, the observation that it is common to blink as one moves one's head to look from one point to another. We rarely keep our eyes open while moving our view, like the of the change of shot when the view changes over 30° within a scene. Second, Murch noticed that he would place the cut in a film at the same point where an actor would blink. He saw these blinks as the actors completing a thought, that they would blink when moving from one thought to the next.

There is some neuroscientific backing to Murch's claims. Nakano [2015b] finds evidence that while actively engaged with watching video content spontaneous eye blinks occur at attention break points, this is called the attentional blink. Further, there is evidence that the time between blinks increases when watching movies and increases even more during memorable scenes [Shin et al., 2015].

Murch also likened film to dream, as in his opinion it is only in film that we experience unquestioning discontinuity of vision outside our dreams. He posits that the nature of film feels so natural because we all have similar experiences every night. Comparing film to dream however has been disputed. Carroll, summarised by Currie [1995] reacting to the now out of favour psychoanalytic forms of film criticism, Carrol disagrees with the notion of film watching being analogous to being in a dream by pointing out that one does not believe that they are physically in a film, quite the contrary, immersion in film narrative encourages the suppression of conscious self.

Event segmentation

It is not only the editor/therorist's that are curious as to why the cuts in films "*obeys the laws of mind*" Münsterberg [1916]. Neurocinematic researchers are exploring other theories such as event segmentation and event boundaries to explain the ease of understanding and feeling of flow inherent in cinema. Event boundaries are neurological signals that can be detected at the perceived separation of actions. Just as people perceive objects in space rather than just a field of colour and shades, in time people segment action into discrete events. The edges of these events can be detected at event boundaries when a feature of the perceived environment unpredictably changes. This segmentation is automatic and generally agreed upon across subjects. They are also hierarchical and can be divided into fine and course boundaries. The fine boundaries, made up of the smallest meaningful events are grouped together into large, meaningful events, course boundaries [Zacks and Swallow, 2007]. You can begin to see how this lines up with movie shots and scenes.

Understanding just how visual features are processed is important to understand how viewers segment ongoing events. It is suggested that both perceptual and conceptual processing come into play. Lighting, sound, and the movement of objects are perceived while actor's intentions and social conventions are conceived. When a viewer is able to correctly segment ongoing action they are more likely to correctly retain the memory of the events. This is somewhat corroborated by Ben-Yakov and Henson who found that perceived event boundaries correlated with hippocampal activity responsible for memory and that these boundaries may be more likely caused by conceptual not perceptual shifts [Ben-Yakov and Henson, 2018].

To relate these concepts directly to film and more specifically continuity editing rules we can apply them to the nature of filmic techniques, particularly the cuts and editing of film.

> human perceptual systems are already segmenting ongoing activity into discrete events all the time. If a cut is paced where a viewer would naturally segment the activity, then the cut will be perceived as natural even if it is readily detectable. [Zacks and Swallow, 2007, p. 139].

Fine grain event boundaries produced by the completion of smaller actions can be directedly compared to the continuity edits that appear within scenes and the course grain event boundaries to scene breaks.

Cutting [2014] defines seven types of event segmentation that can occur within a scene involving changes of location, character and time and all combinations of these three dimensions. Some scenes in movies are better defined by Cutting as sequences. These are scenes which include changes in location, character or time but still preserve a flow of continuity. Usually a scene changes when one of these three variables change. When this happens viewers report an 'event boundary'. It is the end of one event and the beginning of another. However when music is present and the shots are more uniform in length, changes in location, character and time are less likely to be perceived as event boundaries by viewers [Cutting, 2019].

To clarify the definition of sequences according to Cutting, their meaning and presence in film, where scenes themselves have a beginning middle and end, sequences often cross cut between ‘middles’ of narrative threads. The sequence is made up of sub-scenes or sub-segments shorter than the mean duration of scenes in the movie. The addition of music improves the perceived continuity of sequences as it defuses the viewers’ attention [Cutting, 2019]. A practical example would be where two interrelated actions are happening such as a fight on a helicopter and someone on the ground trying to defuse a bomb. This sequences’ cuts between the two locations and characters are not defined as scene changes.

Results reported by Zacks and Magliano [2013] identified fine and coarse grain event boundaries from fMRI data while participants watched *The Red Balloon* (Lamorisse, 1956, Fr). It was found that course grain event boundaries occurred during scene breaks, fine grain event boundaries were observed when continuity of action was preserved even with temporal and spatial discontinuities. These event boundaries are identified in regions of the brain that overlap with what has been observed in attentional control tasks, possibly because bridging the gaps in continuity require the same mental effort. Another cited study [D’Ydewalle and Vanderbeeken, 1990] reports that cuts are more readily detected if shots are rearranged and played out of sequence from the original, suggesting that the design of incoming and outgoing shots prime the viewer to correctly segment the action. This somewhat goes against French realist Bazin when said the cinematic success of The Red Balloon doesn’t “*owe anything to montage*” [Bazin, 1967, p. 45].

Attention and rhythm

Other Neurocinematic research focuses on viewers’ attention, and how it is related to the edits of film.

Carroll and Seeley [2013] define the experiential power of movies as a consequence of the always shifting point of view of the camera. Continuity editing conventions are used to filter information and control the audience's attention. "Movies are *attentional engines* fine tuned to a range of natural cognitive and perceptual capacities" [italics in original], that is, each shot is a recognitional prompt which pragmatically mimics normal perception.

The temporal fractal pattern 1/f (present in white and pink noise) is found in nature, art and across the sciences. This fractal pattern seems to be a constant in complex systems including neural systems [Gilden, 2001]. This pattern was also found by Cutting et al. [2010] in the sequence and patterns of shot lengths of 150 popular films released between 1935 and 2005. Between 1960 and 2005 an increasing trend in temporal fractal like patterns was determined. Cutting et al. suggest that this pattern has developed naturally and unintentionally as filmmakers have worked to make their narratives flow with the viewer's natural patterns of neural activity, specifically attention.

These findings were expanded in subsequent research, doubling the amount of films studied and increasing the physical measures [Cutting and Pearlman, 2019]. The main film making roles of writer, director, cinematographer and editor are shown to be responsible for the rhythm or pulse of a film. This pulse is likened to physiological pulses, in the heart, in gait and breathing, which are variable, not metronomic. Cutting et al. doubles down on the claim that the viewers' attention and the properties of the film are fractally linked [Cutting et al., 2018].

> ...the goal of the filmmaker is to create sensory, perceptual, and emotional rhythms in a movie and to synchronise the viewers' rhythms to them... when we as movie viewers track shots, scenes, and their content in a contemporary film (and we must), we are paying attention to fractal-like patterns. [Cutting et al., 2018].

Could this synchronisation of filmic and attentional pulse go towards engrossing the movie goer? The human mind does seem to have a preference for fractal patterns [Yu et al., 2005].

And if so could the reverse also be true? If we reverse the above statement from Cutting et al. [2018] to say: the goal of the filmmaker is to synchronise *the viewers rhythms to create sensory, perceptual, and emotional rhythms in a movie.* In other words the viewers own physiological properties are used to drive the rhythms of an interactive film, here is the basis of brain-controlled film.

Poulaki [2014] comes to a similar conclusion when she suggests the instances of Hasson's low ISC could be encouraged and harnessed:

> ...instead of bracketing out noise it seeks to classify it and model its different realizations within a system of alternative film/clip versions. Far from abandoning control, this approach seeks to control for what in Hasson et al's methodology would be a low ISC, in other words, for how minds can wonder [sic] in different trajectories not directly triggered by the film stimulus.[Poulaki, 2014]

Poulaka is describing a possible interactive film system where the viewers brain data is not controlled by attentional continuity editing rules but whose mind is allowed to wander and in response the system offers alternate shots and sequences.

2.4 Conclusion

To conclude we have seen that interaction happens in many ways within cinema viewing, which changes with the characteristics of cinema performance. Immersion comes as a process of making meaning as the mechanisms of mind are mirrored in the mechanisms of film. There seems to be a dichotomy where the audience must submit to the film first in order to actively engage with it. With films that offer multi-linear narratives across multiple screens filmmakers take on an additional curatorial role as audiences create divergent meaning. While these films offer more open interpretations, viewers' attention can still be steered. Other forms of cinema such as live cinema which can include musical and directorial performances, offers further value to audiences.

We showed a new trend of large streaming organisations experimenting with interactive, non-linear narrative content. However to date, the problems associated with the most common characteristics of interactive cinema, branching narrative and active control are still relevant. We identified these as three main problem areas, that of production, interaction and audience reception.

The problems in production stem from the excess of footage that needs to be shot. Bespoke systems need to be built in order to play it back, and even then the audience will probably not see everything. The writer has to contend with all this as well as create multiple compelling narratives.

The problems with interaction come when viewers are asked to halt their 'active creation of belief', reframe the experience as one that they must physically act upon before being allowed to submit again to the process of making the meaning of the narrative. However there was some evidence that smaller more frequent interactions may be preferable.

The problems with audience reception are evident from the lack of creative and critical success. Critics have bemoaned the breaking of the 4th wall cliché which has emerged as a tool to call the audience to action, the inefficiency and sometimes the over complexity of storytelling.

In order to provide examples of alternatives to active control we introduced a number of interactive films and research projects which used physiological data as user input. By looking specifically at examples that used a passive interaction it was seen that a remediation of the artist, the media system, and interacting participant can occur, increasing control over the narrative by the artist. This implicit interaction is invisible, requires no effort and may reduce dual attention problems. Systems can be designed to dynamically react to the user's affective state and not disrupt the cinematic aesthetic. The natural responses produced in the act of viewing can be used as a context to direct the ongoing film in real time or at different time frequencies along a local to global axis. Members of the interacting audience can be seen as a proxy for the audience as a whole and can participate simultaneously with on stage performers. Further, multimodal data can be combined to produce a fuller picture of audience affect. However just how an audience negotiates meaning making and interaction in these cases is an open question.

We also explored a number of interactive films and research projects which diverge from the branching narrative concept. By looking specifically at examples of alternative systems to create dynamic narrative we see high level systemic design methods and finer grain cinematic techniques of recombination. We saw that authoring tools are being made to create interactive systems. These can be used to enter preferences to personalise the viewing experience, media elements can be databased and given meta data to aid in filmic recombination and algorithms can be embedded into systems to produce rule like interaction and intentionality which has the potential of framing the viewer as an integrated component of the system. On a finer grain or more local design we saw how cinematic techniques can be appropriated as building blocks of what participants act on. Conventions from continuity editing can be employed as inspiration for re-combinatory systems to create alternative narrative meanings.

We were able to show some examples which both used passive interactions and employ novel narrative systems. These cinematic systems can be thought of as producing an emergent narrative; the interactor gives up full control of the system in an enactive realisation of the artist's second-order authorship. Cinematographic techniques such as montage, lighting, and camera angles can be manipulated in real time and in response to affective states of the viewing participant.

Within the field of Human Computer Interaction there are many disparate and competing concepts which encourage implicit interactions. Design which brings sensing and display technologies together as one system can encourage natural interactions. One such concept is that of Passive Brain Computer Interfaces which can add context to a situated interaction without disturbing primary task focus. Further, new commercial headsets have the advantage of portability, ease of use and price over medical grade BCI sensors, allowing for their use in artistic BCI applications.

We have seen that artists are using various strategies to create different levels of interaction with BCI. Of these designs the most fruitful is the Passive BCI method. However, how participating audiences react, their intention to control, self-awareness and agency and how that can influence the locus of control suggests potential research questions. Further, as artists rarely publish the intricacies of their systems, or how audiences interact with them, this offers more opportunities for investigation.

We saw how researchers are exploring, via neural responses the cognitive effect of continuity editing on viewers' cortical activity. Flow of attention is directed by filmic techniques. When filmmakers' attentional cues and the viewers' attention align, attentional synchronicity occurs. Timing filmic cuts with the viewers' attentional shift and following with an expected composition preserves continuity of action and time. Tightly orchestrated continuity editing will produce a similar responses across viewers' neural activity as opposed to art films or movies that have ambiguous meanings, which have a lower neural correlation. We also saw that the moment of and periods between viewers' blinks may have connections with attention and memory retention, respectively. These lessons from Neurocinematics can act as framing for the design of passive BCI movie experiences.

From our review of interactive cinema we have seen the potential of upping the frequency of interaction, and integrating the structure of shots according to continuity editing rules, and incorporating attention as a guiding principal to construct new interactive cinema approaches. By matching the viewers' EEG, and blinking rhythms to cinematic construction we can explore non branching storytelling methods of cinematic construction and passive interaction. By involving the viewer as co-constructor of the film at the point of meaning making we hope to uncover new knowledge of interaction, design and audience experience.

2.5 Revisiting research questions

RQ1: What are the problems inherent to interactive cinema?

We define the problems related to interactive cinema in section 2.2.6. We also see how other researchers and artists have approached designs which deviate from active control of branching narrative in section 2.3.1. when considering these problems we set out traditional cinematic technique which may prove useful for the reader in upcoming chapters reflecting on practice.

RQ2: How can real-time interactions via a Brain Computer Interface (BCI) construct cinematic content? We see in section 2.3.5 that passive BCI could be a good fit to create real-time interactions with cinematic content. Section 2.3.8 lays out findings of cinematic affect on viewers which, if reverse engineered could be used as design directions for interactions. We also note in section 2.3.6 that there is limited documentation of how artists approach Artistic BCI design.

RQ3: How do interacting individuals respond to various brain-controlled cinematic designs? And ***RQ4: How do groups of individuals experience brain-controlled cinema designed for shared or distributed control?*** How people interact with linear film is well researched and set out in section 2.2. However, as we see in section 2.3.6 there is limited research of how audiences interact with artistic BCI, as individuals or in groups.

RQ5: How can brain-controlled cinema add value to audience experience? In sections 2.2.3 and 2.2.4 we see how different and unique approaches to filmmaking can add both personalised meaning and added value to the cinematic experience.

Now that we have provided context to our research questions we will define our methods of discovering the answers. The next chapter describes how we approach our practical filmmaking, and how *in-the-Wild* studies will go towards developing theory.

Chapter 3

Methodology

3.1 *Performance Led Research in-the-Wild*

In order to find out how brain-controlled cinema can be made and how it is interacted with this thesis takes an empirical approach to analysis. This allows us to observe the actual processes involved in the practical design and making of the films and collect empirical data from direct experiences of audience engagement. The resultant analysis provides authentic and unexpected insights based on rich and dynamic data.

This thesis follows the approach of *Performance Led Research in-the-Wild* as introduced by Benford et al. [2013a]. This methodology has its roots in cultural cognition *in-the-Wild* [Hutchins, 1995] and falls under the broad umbrella of Research Through Design [Zimmerman et al., 2007]. One development of HCI has seen a convergence of the interactive arts [Sengers and Csikszentmihályi, 2003] and HCI research *in-the-Wild* [Rogers, 2011] allowing novel designs to be studied outside the lab in real world settings.

Following the now widely accepted theories of embodied interaction, increasingly over the past two decades *in-the-Wild* HCI studies are set in participants' real lives, not the lab. This can also be attributed to new, affordable mobile technology components that can make quick prototypes allowing researchers to probe real world, ordinary, everyday situations [Rogers, 2011]. While artistic work aims to present experiences out of the ordinary, the act of going to an art gallery specifically to seek these experiences are part of everyday cultural engagement. Therefore, *in-the-Wild* studies of artistic experiences requires data to be captured during participants engagement with artistic experiences.

Being a practice-led methodology means that research findings emerge from reflection on the making of specific interactive artefacts. Being performance-led means the practice is led by an artist who is also a co-researcher, who follows an artistic process and delivers a professional artistic artefact, in our case various brain-controlled cinematic works. Being *in-the-Wild* means this artistic product is experienced by public audiences under realistic conditions, in our case private and public screenings in auditoriums and bespoke spaces at artistic venues and major festivals. The approach involves documenting both the artist's rationale for the work and audiences' experience of it, before reflecting on both perspectives to draw out wider lessons for the field. *Performance Led Research in-the-Wild* is an artist- and practice- led approach to research with and for the cultural and creative industries, and HCI community.

Figure 3.1 shows an overview of Benford et al.'s *Performance Led Research in-the-Wild* methodology; each numbered connection in the diagram is a process. When taken together they represent a viable workflow for artistic and research collaboration. Below are the numbered processes:

1. Practice provides data for studies.
2. Studies iteratively refine practice.
3. Studies ground the theory.
4. Theory sensitises studies.
5. Theory guides practice.
6. Critical reflection on practice generates new concepts and frameworks.
7. Inspiration comes from practice.

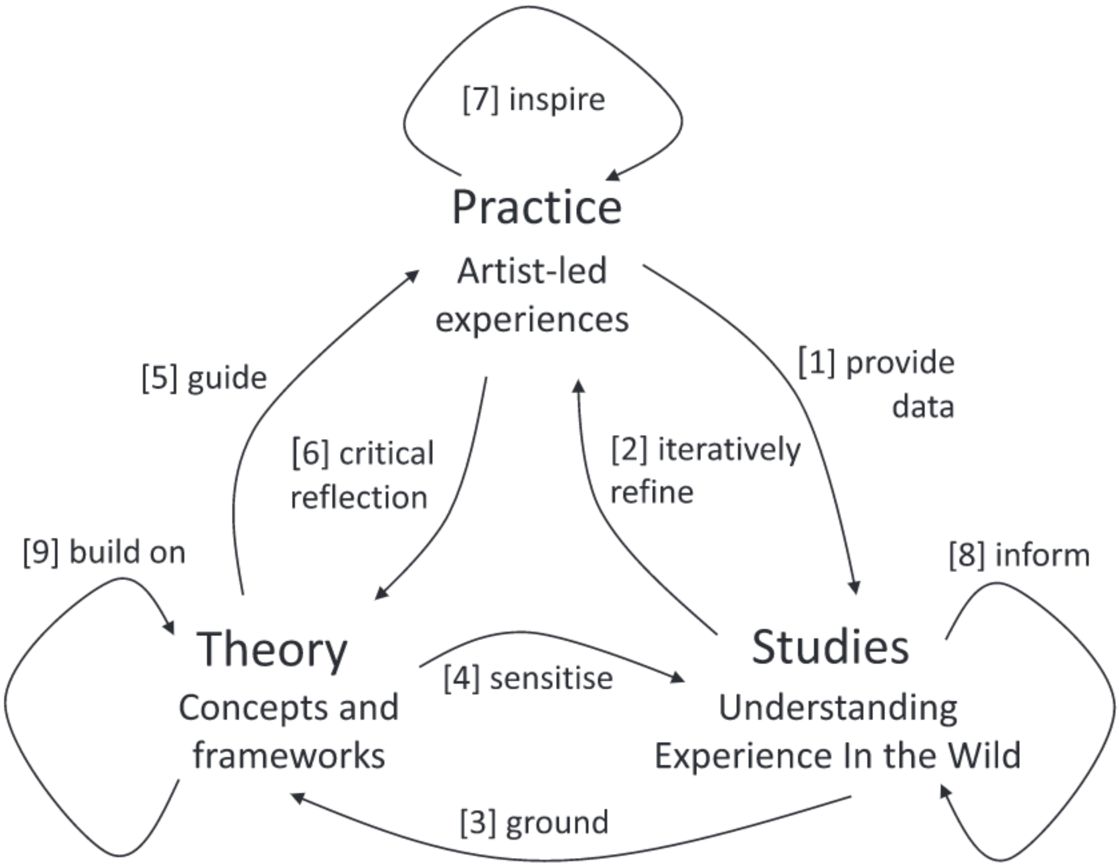

Figure 3.1: Overview of *Performance Led Research in-the-Wild* from [Benford et al., 2013a]

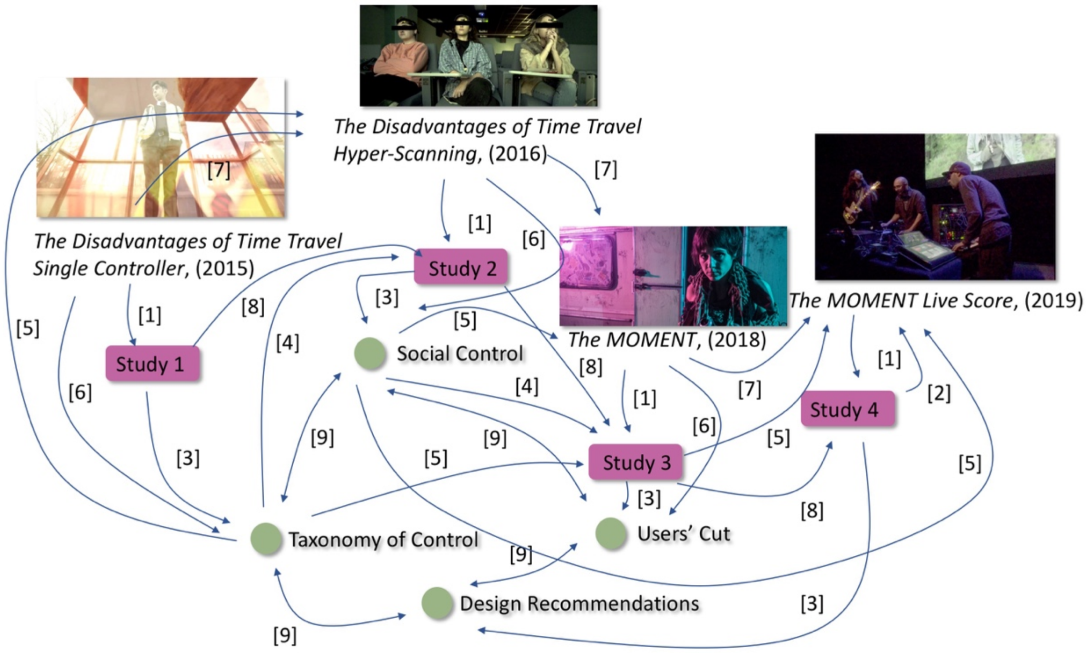

Figure 3.2: How *Performance Led Research in-the-Wild* processes manifest in this thesis.

8. Studies inform further studies.
9. Theories are built upon.

In the following section we will explore how these processes can be directly mapped into the making, study and theorising of the practice and research in the thesis.

3.1.1 Adapting Performance Led Research in-the-Wild for brain-controlled cinema

Performance Led Research in-the-Wild is at its core iterative, and mapping the processes involved can get complicated quickly, see Figure 3.2. The thesis structure unravels this iterative development and real world deployment of seven instances of two brain-controlled films: The making of the original single user version of *The Disadvantages of Time Travel* is detailed in chapter (Chapter 4) and four updated multi-user versions in chapter (Chapter 4, section 4.4), the development of *The MOMENT* is found in chapter (Chapter 7) and its Live Score performance version in chapter (Chapter 9). These chapters relate to design considerations, from script to exhibition. We focus on the interactive reper-

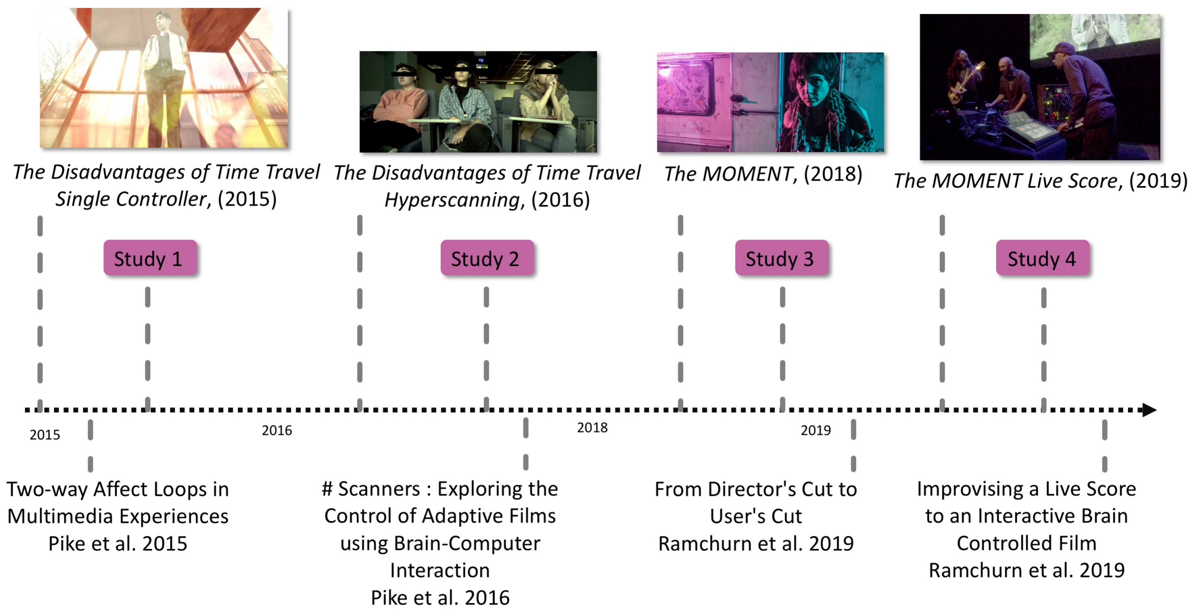

Figure 3.3: Timeline of practice, studies and theory.

cussions on filmmaking practice based on interviews with attached creatives, production notes, documents, sketches, storyboards. The results chapters, 5, 6, 8 and 9 contain findings that iteratively guided development laid out in the practical chapters. These design developments are outlined in the discussion in Section 10.1.

To further help unravel the complexity of Figure 3.2 we can re-envisage the practice, studies, and theory in chronological order. Figure 3.3 shows a timeline of the work presented in this thesis, along with key publications, [Pike et al., 2015c] and [Pike et al., 2016a] are introduced in Chapter 4, [Ramchurn et al., 2019a] is introduced in Chapter 7 and [Ramchurn et al., 2019c] in Chapter 9.

The four studies are summarised as follows:

Study 1: Single user study of *The Disadvantages of Time Travel*. Interviews with 35 participants. Exploring awareness and application of control. Screenings took place in a cinema caravan at FACT, Liverpool in 2015.

Study 2: Multi-user study of *The Disadvantages of Time Travel*. Interviews with 45 participants. Exploring group control and shared understanding. Screenings took place in auditoriums in London, Nottingham, and Dundee in 2016.

Study 3: Single user and audience study *The MOMENT*. Interviews with 78 participants. Exploring unconscious control and cinematic effectiveness. Screenings took place in a cinema caravan at Sheffield DOC/FEST in 2018.

Study 4: Performance and audience exploratory study *The MOMENT* live score. Interviews with 7 participants and 4 musicians/artists. Screenings took place in auditoriums in Iceland and Nottingham 2019.

Benford et al.'s methodological processes shown in Figure 3.1 provides a iterative underpinning to this thesis. As such we will step through each of the three main activities, practice, studies and theory and nine key relationships (referred to as the numbers in square brackets in Figures 3.1 and 3.2), which will go towards revealing the interlinked processes.

Practice

The practice [7] in our case is both the process of designing interactive brain-controlled film systems and the many processes contained in filmmaking. It involves learning from the design [7] and deployment [2] of professionally made artistic works that as far as possible are experienced by audiences in realistic conditions, i.e., as genuine cultural products in recognised venues such as theatres, galleries and festivals [1]. Further, theory developed from studies folds back into ongoing practice [5] allowing for grounded iterative development of the artistic work.

Studies

Under the approach, the artist's – in this case a filmmaker's – creative decisions ultimately shape the design and staging of the experience over and above experimental considerations [1]. The advantages are ecological validity and an unpacking of artistic rationale alongside audience experience. However, these do come at the cost of a lack of experimental control both in the design of the experience and the selection and management of participants.

The studies reported in this thesis have iteratively developed [8] ways to collect data around the core artistic experience, by planning post screening interviews and questionnaires and also collecting log data and recordings of the interactions and movie versions. Studies have developed as much as possible to be non-invasive to participants' experience. For example, by incorporating question and answer sessions as data collection exercises we add some value to the experience for the audience as well as collecting data [2].

Theory

The theory created in this cross discipline methodology can be seen as boundary objects [Star and Griesemer, 1989], made to be relevant to both the HCI and artistic HCI communities and, in this case interactive film practitioners.

The studies *in-the-Wild* act as continual grounding [Bowen, 2006] for theory to develop [3]. These "wild theories" [Rogers, 2011] can consist of taxonomies which sensitise further studies [4].

The theory developed can also be instructive for future design, as craft knowledge is distilled to design guidelines for works into this thesis and also for interactive filmmakers [5]. Further theoretical insights arise from the critical reflection on both the film practice of the author presented in this thesis, and on the work of other interactive filmmakers [6].

Each iteration of design draws on the theory from previous studies and in turn builds upon the existing theory [9].

3.1.2 The artist as researcher

Benford et al.'s methodology talks about collaborations between artist and researcher, in the case of this thesis the artist *is* the researcher. However, this is Practice *led* research as opposed to practice based, the knowledge of the thesis is not generated from the themes and content of the two films, but rather from the practical techniques of construction sensitised by an iterative reflection on theory and audience experience. Another researcher who has one foot in HCI and one in the arts puts it "*the role of evaluation extends beyond focusing on the attributes of the artwork or artefact itself to the context of use and all the multiple layers of participative experience this implies.*" [Candy and Ferguson, 2014, p. 2] Thus, theories developed in this thesis become '*boundary objects*'[Star and Griesemer, 1989] in that they have multi-disciplinary relevance, in this case to interactive filmmakers as well as HCI researchers.

It is Edmonds' position that that artistic practice will push forward HCI research and that artists will include in their practice formal studies [Edmonds, 2014]. His concept is simple, if digital artists are more informed by research they will be in a better position to produce affective art, and likewise, artistic work that pushes the boundaries of research can inspire interaction designers in HCI. In fact this position was echoed in a keynote speech by Benford himself at the ACM conference *Halfway to the Future* in 2019. Reflecting on 20 years of *Performance Led Research in-the-Wild*, and looking to the future of HCI research, he said that artists and researchers have a lot to learn from each other.

As artists and researchers have different priorities this raises an interesting question related to the scientific rigour of the research. How does it affect participants' responses to questions from a researcher when that researcher is also the artist? We respond to this question by identifying skills learnt via artistic practice that can benefit to research methods.

It is in the post show discussions and questionnaires that the audience can reflect on what happened while they watched. Although this thesis is not asking the question 'Did the works succeed artistically?' when negative feedback from participants was given it has not been omitted, especially when it impacts interactions.

It must be acknowledged that most audiences would be aware that the person asking questions, conducting interviews is also the filmmaker and designer. It could be assumed that social norms will prohibit some from displaying negative attitudes so as not to appear rude. We anticipated this and at no point in the interview was the question "was it a good film?" asked. Participants that were concerned about reporting a bad experience were able to feed that back in their questionnaires.

Interviews were concerned with how the participants approached control in the movies, what they physically and mentally did while watching. In our social study we asked how the participant groups interacted with each other, and how they negotiated control, and for repeat viewers we were interested in how their film experiences compared.

Eliciting critical feedback is useful to develop an artistic practice, as engaging with the public is part of the profession, and with that artists have to grow thick skins. It is common knowledge that artists are known to embrace failure, and so eliciting frank responses is a valued skill. Additionally filmmakers experienced in documentary filmmaking have to develop sharp interview skills. As you will read in the results of this thesis some of the negative responses provide the most interesting findings.

3.2 Filmmaking practice

In the case of the iterative design approach of *Performance Led Research in-the-Wild*, creating the artistic object partly for the purpose of answering specific research questions becomes a method in itself. Hence, processes and techniques specific to the interactive design of these brain-controlled films is reported both to give context to the results and also as an insight into design. However, there are many more processes of film production which have been described with the broadest strokes. Activities such as fundraising, casting, and location scouting while essential to the production, hold less value in answering our research questions. The other practical method of creation is the computational implementation of the interactive media.

3.2.1 Visual programming practice

One way to create systems which can process live data from EEG headsets, manipulate and play video, and mix and play audio, all in real-time, is to use a visual programming environment. Packages such as Quartz Composer[1], MAX/MSP[2], Pure Data[3], vvvv[4], Isadora[5] amongst others, use graphical elements representing code functions which can be linked together to create complicated processes, meta rules and algorithms [Edmonds et al., 2004]. Many of these programming environments have been specifically created with artists in mind. With care these systems can be optimised to present high quality aesthetic outputs. Visual programming languages have a number of benefits over writing and compiling languages such as Python, C or Open Frameworks, which we will list below.

Rapid prototyping. Unlike object-orientated programming (OOP), many VPLs continually compile, where changes in the code produce effects live. This speeds up the ability to produce prototypes.

Visual/spatial syntax. Many artists do not have basic training in programming. Not to say that all artists are dyslexic but there is at least a folk understanding and some hypothesising that dyslexia and artist capabilities are in some way intertwined [Chakravarty, 2009]. It stands to reason that abilities associates with artists (and dyslexics alike) such as visualisation, lateral thinking, and spatial awareness will have a lower barrier to entry and ease of use of VPLs rather than OOP languages [Powell et al., 2004].

Video and audio integration. Many VPLs have integrated video and audio modules

[1] developer.apple.com
[2] cycling74.com
[3] puredata.info
[4] vvvv.org
[5] troikatronix.com

able to interface with hardware processing. MAX/MSP has a full graphic suite called Jitter.

Performance based. Many of these VPLs have been designed for performance be it music with Pure Data and MAX/MSP or interactive dance with Isadora. Reliability is a core concern for these languages in development where a patch is created for a single work of art [Puckette, 2016].

Forums and community support. Like most OOP languages, VPLs such as MAX/MSP and vvvv, have rich and active communities.

The work detailed in this thesis used, at various points, the OOPs: objectiveC, Open Frameworks, and Python and the VPLs Quartz Composer and MAX/MSP.

3.3 Studying the audience

To find out how audiences (as users) go about navigating their interactions with our brain-controlled films a number of practical steps needed to be taken. First and foremost, there needed to *be* an audience to study. Second, the audience had to be in a position where their primary activity is interacting with the artwork, making the built environment an important consideration. Finally, the methods of just how data would be gathered needed to be defined.

3.3.1 Finding the audience

Usually coming near the end of the artistic process, finding an audience (participants) becomes one of the first steps for the researcher to be able to collect data. For the research to be truly *in-the-Wild*, the audience should be present by their own volition, not incentivised by a fiscal compensation, but there to experience the artwork. Several activities were taken in order to find the audience whose data is presented in this thesis.

Relationship development; by talking and pitching to arts organisations and venues, (FACT, Dundee College, Sheffield Doc/Fest, Lakeside Arts) we were able to access their core audiences who trust that venues programming.

Marketing; a number of marketing tools were called upon such as creating a website[6], designing posters (Figures 3.5 and 3.4), and working with University of Nottingham press department to write and distribute press releases.

Raising tour funding; there were several funding pushes which allowed the work to travel to festivals, and covered the expenses of running a mobile installation.

The mobile installation we speak of are caravans converted into cinemas which screened the works studied here. The original caravan we used was on loan from AND Festival[7] for the single user presentation of *The Disadvantages of Time Travel*. The second we made to specification with prize funding from the EPSRC's Telling Tales of Engagement fund. Having a self-contained, controlled environment served several proposes. First, it allowed audience a space to feel immersed and focus on the experience. Likewise, the space acts to remove as many external forces as possible which could influence data being produced and collected. Finally, it is an externally attractive object which generates curiosity and attracts potential audiences and bookings, (it was also used as a filming location for *The MOMENT*).

Other spaces were used to present versions of the interactive films. When screening the multi-user versions of *The Disadvantages of Time Travel* we toured to auditoriums in various locations in Nottingham, London and Dundee. The multi-user versions were presented with three participants in the form of a scratch performance using a not-for-production prototype system. This was before we had converted our own caravan cinema, and informed the decision to pursue funding to make our own. The live score of *The MOMENT* was presented to auditorium audiences in Reykjavík and Nottingham to explore the implications of scaling up the audience.

[6]braincontrolledmovie.co.uk
[7]andfestival.org.uk

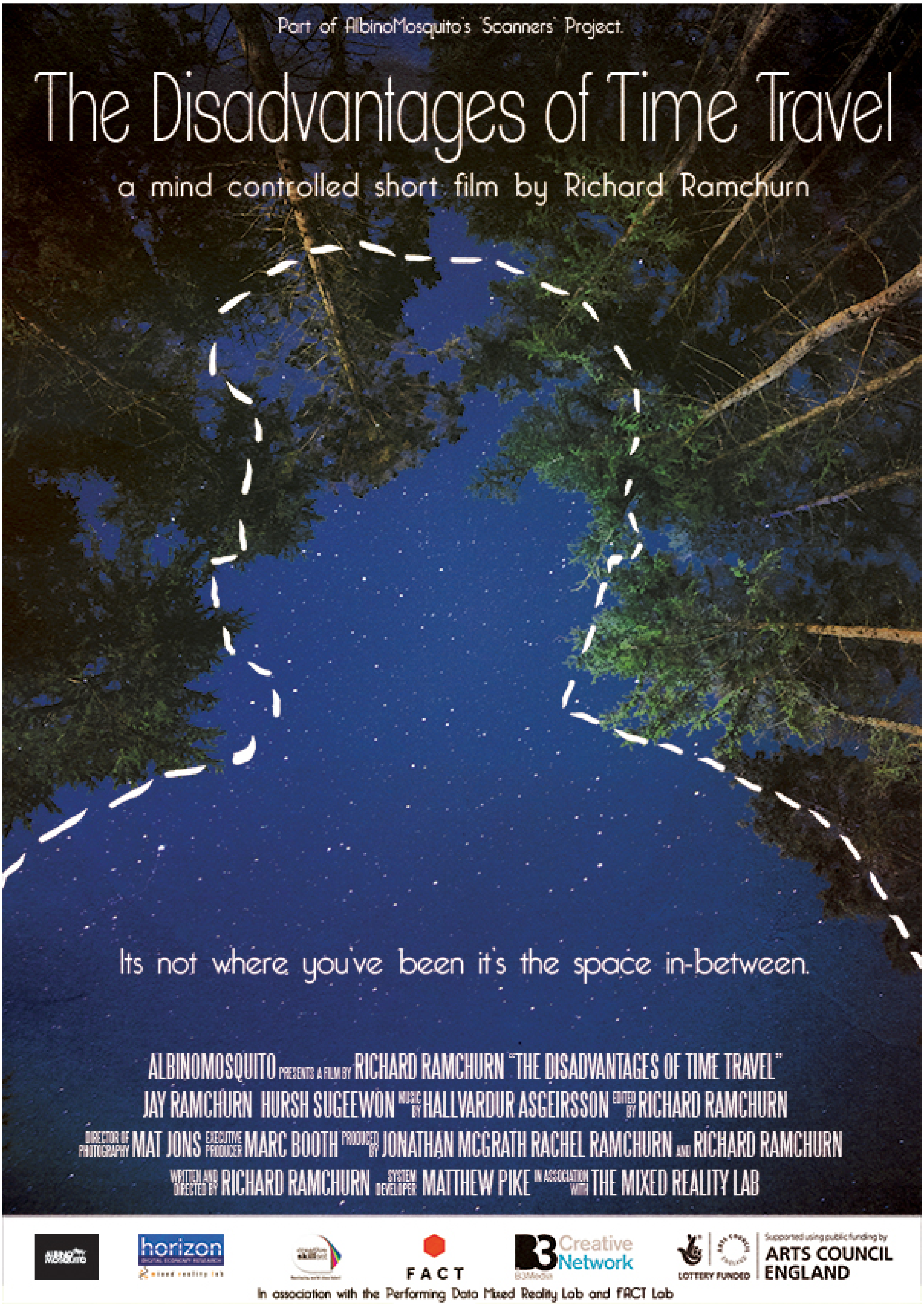

Figure 3.4: Poster for *The Disadvantages of Time Travel*

MOMENT Poster a0finalsmall.jpg

Figure 3.5: Poster for *The MOMENT*

Now to look at our methods used to collect data.

3.3.2 Audience study methods

The primary method of generating data was from semi-structured single and group interviews in a number of different configurations: one on one interviews with controllers (Study 1), with groups of controllers (Study 2), with controllers and audiences (Study 3), and with performers and audience members (Study 4). As per the *Performance Led Research in-the-Wild* methodology and grounded theory [Corbin and Strauss, 1990] the focus of interviews developed iteratively as studies progressed, analyses conducted and theory produced. Interviews were either recorded on video and/or audio, and then transcribed for an inductive thematic analysis [Bowen, 2006]. Transcriptions were coded by line and paragraph and grouped, and regrouped until a set of themes was arrived at which both saturated, and represented the corpus as a whole.

Some of the data from the production analysis reported in the practical making Chapters 4 and 7 were derived from interviews and conversations with the professionals involved. These were undertaken to illustrate specific implications to practice, rather than to be thematically analysed.

Interviews and questionnaires

Participant interviews were semi-structured to allow for the emergence of unexpected themes. These were undertaken by researchers once questionnaires where completed, directly after their experience watching/interacting with our brain-controlled films, either inside the caravan cinema spaces or outside in a sheltered spot. In the case of auditorium screenings interviews took place in the auditoriums themselves.

In order to collect answers to specific questions *across* an entire audience we designed descriptive surveys [Oppenheim, 2000]. We deployed post screening questionnaires for

Study 3 (see appendix A). The content of these questionnaires were sensitised by our previous findings, and designed to be as convenient as possible for the public to complete. Our design aim was to be able to describe the range of audience make up and broad experience, to complement the in-depth qualitative analysis of interviews.

Quantitative research

Python scripts and later MAX patches were written to record and save log data to CSV files at the end of each screening. These described both the physiological data (NeuroSky Attention, Meditation and blink) and data generated by the configuration of the created films. Data from these logs allowed us to classify participants by their interactions and physiological responses and to interrogate and represent the uniqueness of each screening.

Recorded Films

As each time our films were watched a new version was created, we opted to record and collect each one. These films could be used to verify our CSV log data.

3.4 Analysis methods

3.4.1 Thematic analysis

Our qualitative data gathered from interviews was understood through a thematic analysis in the mode of [Braun and Clarke, 2006, 2012]. This thematic analysis was coded with interests relevant to HCI, film and audience studies. The themes were identified at the semantic level, we were investigating what happened during the participants experience of interacting, and not necessarily the wider social issues related to BCI. In the analysis we progress from the description of what was said to interpreting the data and theorise from trends to pull out meanings and implications.

In practical terms this took a number clear steps guided by the methods set out by Braun and Clarke [2006, 2012]. First we became familiar with the data, by transcribing the interviews or, in the cases when transcription services were used, by reading them. Then we brought all interviews together, and coded each sentence and paragraph. These codes were grouped and rearranged until a set of themes was arrived at. These last two steps were done iteratively; codes and themes changed until it was felt the themes were fully developed. We concluded the process when the themes became saturated; that is, the remaining data ceased to shed new insights. We then refined the themes and grouped them into broader themes. The data from studies 1 and 2 were coded by hand; studies 3 and 4 was coded using Nvivo[8] software.

3.4.2 Real-time quantitative analysis

In order to drive the interactive film experiences we wrote real time algorithms that took in NeuroSky, Attention, Meditation and blink data. This data was compared, manipulated and used as triggers to change the movies in real time.

3.5 Choice of technology

3.5.1 EEG patterns and rhythms

Electroencephalogram (EEG) signals were discovered by Canton in 1875 but it wasn't until in 1924 that Hans Berger was able to record EEG from the exposed cortex of a trepanned teenager becoming the first to record EEG from a human. He reported in 1929 the existence of alpha waves (8-13 Hz) and beta waves (>13 Hz) [Desmedt and Tomberg, 1994]. Beta waves are predominant with open eyed wakefulness; the alpha rhythm can be an indicator of cognitive engagement and relaxation; other rhythms theta (4-8 Hz) and

[8] qsrinternational.com

delta (0.5-4 Hz) are associated with REM and deep sleep respectively [Teplan, 2002].

3.5.2 BCI devices

There are many sensors that can collect data from the human mind. fNIRS and fMRI detect areas of blood usage by infrared light and electromagatism respectively. EEG sensors detect the electrical potential changes in the scalp created by the firing of neurons in the cerebral cortex [Vidal, 1977]. Until fairly recently the cost and availability of brain sensing equipment meant they were used in medical and research domains. Rarely were they used for artworks but for a few remarkable occasions which we explored in the previous Chapter. In the past decade a number of companies have released commercial consumer Brain Computer Interface (BCI) EEG headsets. Emotive, MUSE, and NeuroSky have made some of the most affordable headsets and each has its own library of apps (for a full review of headsets see [Ramadan and Vasilakos, 2016]). Commercial headsets have the advantage of portability, ease of use and price over medical grade BCI sensors. Thus, these headsets have been used by artists and in research to varying degrees [Prpa and Pasquier, 2019]. This thesis uses the NeuroSky MindWave headset, a single dry sensor EEG Bluetooth device.

3.5.3 NeuroSky associated research

The NeuroSky Mindwave has one dry electrode that sits on the forehead at location prefrontal 1 (Fp1) [Jasper, 1958] and a reference sensor which clips on the right earlobe. The sensor is placed on the forehead on top of the pre-frontal cortex, once considered the centre for attention [Bianchi, 1895, p. 503] and more currently as the 'seat of cognition' [Otero and Barker, 2014]. The MindWave houses a ThinkGear microchip which uses propriety algorithms to detect raw EEG and uses Fast Fourier Transform to filter out 8 frequencies. These are low-alpha (7.5 – 9.25Hz), high-alpha (10 – 11.75Hz), low-beta (13 – 16.75Hz), high-beta (18 – 29.75Hz), delta (0.5 -2.75Hz), theta (3.5 – 6.75 Hz), low-gamma (31 –

39Hz), and mid gamma (41 – 49.75Hz). The MindWave also has two more algorithms which output Attention, and Meditation levels (1-100) calculated from the alpha and beta rhythms [Teplan, 2002]. The ThinkGear chip also records when the user blinks as this produces a large, readily detectable muscular signal in the dermal tissue.

The NeuroSky data does come with a caveat; as previously mentioned, the defined Attention and Meditation (henceforth capitalised) output from the ThinkGear chip are calculated by a propriety algorithm. My understanding of data from the NeuroSky algorithms is based on personal experience of using the headset while programming, and observing my own inner state and comparing that to the Attention and Meditation data. I have found that with practice I can, to some extent increase the Attention metric, (a number between 0 and 100, representing low and high attention) by singularly focusing on a single point. When my mind wanders or I shift my focus the Attention metric will drop. Meditation, on the other hand is much more tricky to control, NeuroSky say that this relates to the level of *"calmness or relaxation"*[9].

Attention and Meditation readings have been specifically used in several published studies [Yamauchi et al., 2015, Liu et al., 2013], but as the algorithm is not available to us there is some ambiguity in what exactly it is measuring. However, in an exploratory observational study of motorway driving while wearing the NeuroSky, Pike [2017] observed that between Attention 98 and 100 the driver was exclusively overtaking and at Attention under 10 the driver was on a clear road, sometimes talking to the passenger.

Furthermore, an independent study published in Clinical EEG and Neuroscience Journal found strong correlations between data from the ThinkGear chip and their research grade Neuroscan EEG. The authors concluded that it had utility in EEG recording where portability and ease of use are a priority [Johnstone et al., 2012].

The ThinkGear chip is found in various NeuroSky headsets and has been used in a wide range of studies from involving children with fetal alcohol spectrum disorder [Hemington

[9]neuroSky.com/biosensors/eeg-sensor/algorithms

and Reynolds, 2014], to self-paced learning tasks [Yamauchi et al., 2015], attention training [Lim et al., 2012], event related potential detection [Grierson and Kiefer, 2011], mental task awareness [Shirazi et al., 2014], and recognising attention [Liu et al., 2013].

We have established the foundation of our investigation into brain-controlled cinema, we can now identify the practical building blocks which constitute the interactive film we are going to study. In Part 1 we will reflect on the construction of our first interactive film and what differed from traditional processes of making. We focus on how data from the NeuroSky was used in five different designs to allow audiences to interact with our brain-controlled film *The Disadvantages of Time Travel*.

Part I

The Disadvantages of Time Travel

Chapter 4

The making of *The Disadvantages of Time Travel*

This chapter will explore in depth the making of our first brain-controlled film. I am describing my own practice at a time before I came to research and so I will speak in the first person from my experience as the director. This chapter will describe the inception, design, funding, pre-production, direction, post production and development of this film and how it became a research project. I will endeavour to uncover how this process differed from traditional filmmaking practices while being sensitive to the fact that there is no singular way to make a film. I start by describing the prototype system called *#SCANNERS* and how, through a short tour, we collected audience feedback to facilitate discovery of design considerations. I then describe the algorithm for the film *The Disadvantages of Time Travel*, which gives us the interaction data for our first study. We then step through the various practical making activities reflecting on challenges and impacts on practice which occurred due to the interactive nature of the film. We end by describing four alternative interactive designs which are the basis of our second study.

4.1 The *#SCANNERS* prototype

Before unpacking my approaches to each discrete process of making *The Disadvantages of Time Travel* I would like to address the questions: Why and how? Why make a film that the audience interacts with via their mind? And how did it come about?

Beginnings can often be set into motion by coincidences, in this case it was a convergence of possibilities. I was running a creative agency AlbinoMosquito[1] in Manchester in 2012, we were in a lean period of work which was when we as a company would explore our own creative practices. In the same week three items came to my attention, some ideas from a book about why the cuts in films work, a Neurocinematic study and the NeuroSky Mindwave device.

4.1.1 Inception

I was reading, Walter Murch's *In the Blink of the Eye*, a reflection on his film editing practice. In it he sets the hypothesis that blinking is an indicator of internal thoughts, when a thought completes one blinks [Murch, 1992]. He likens this to the editing of film. He describes how when editing footage, he would find that the actors would blink just at the moment he would place a cut in the film. Murch also relates this to the experience of dream, likening dream to film, as psychoanalytic film theorists have in the past [Eberwein, 2014]. Although Murch takes a phenomenological approach, comparing the perception within dreams of being in one place, then another, to why we accept the cut from one place to another in a film. This was the first time reading the book and his insights resonated with my own practice of film editing. I had found in my own experience when editing, I would be in a flow state [Csikszentmihalyi et al., 2005], that choosing the points in which a shot would cut happened without consciously thinking about it.

The second inspiration was a paper by Shinji Nishimoto et al. [2011] titled Reconstructing

[1] albinomosquito.com

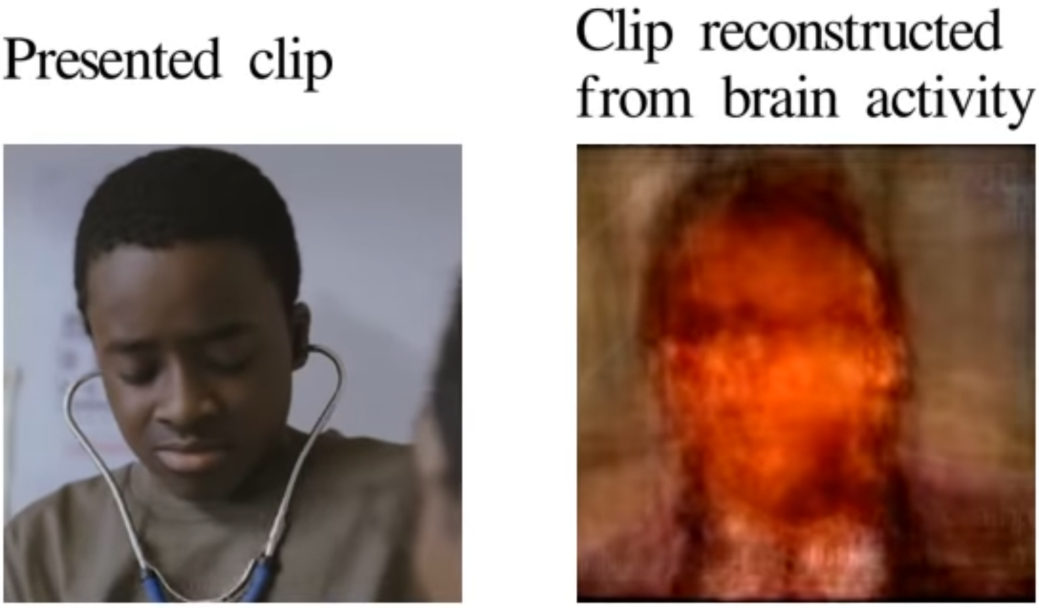

Figure 4.1: Still from video figure from Movie reconstruction from human brain activity Nishimoto et al. [2011].

Visual Experiences from Brain Activity Evoked by Natural Movies (Figure 4.1). Nishimoto recreates the perception of visual stimulus using fMRI data captured whilst participants were watching film footage. What struck me on an emotional level was, they reminded me of abstract expressionist paintings, and the idea of artistic expression created directly from the mind became a real possibility[2].

The third was when a college, Greg Foster showed me a device which the Copenhagen Games Collective was using in one of their social games [Foster, 2017, p. 27]. The device was the NeuroSky Mindwave, a commercial EEG device which connected via Bluetooth and also detected blinking. This was the first time I had seen an affordable BCI, and the possibilities of creating artistic work with one compelled me to explore what could be done.

Taking these three ideas together, the blink as a cut, creating video content from the mind and using a commercial EEG headset. I saw the possibility to make an experience that synced to the viewer. From this the initial design concept for our prototype technical

[2]Since then an entire field of generative art through machine learning using Generative Adversarial Networks has emerged [Luo and Huang, 2019]

platform *#SCANNERS* began to form.

4.1.2 Prototype design

#SCANNERS is the initial name for our prototype platform, one person wore a NeuroSky Mindwave headset, and watched video footage, as they blinked, the footage cut, the sound mixed with Meditation data. The prototype was built with Open Frameworks by artist and programmer Maria Alverez-Martiez under my direction. The hardware used was an iPad to control the settings, and display information to the operator and a MacBook Pro to play the video footage with a single NeuroSky headset providing the data for the system.

The initial concept design for the prototype was:

- The system would use a XML file exported from Final Cut Pro to choose which order and parts of video files to play. An XML file is a plain text file that can be generated from an non linear editor and imported into another it describes the structure and location of a video edit.

- If Attention was high and a blink was detected the film would cut to the next shot. This initial concept of when to cut based on physiological data will become a central design consideration.

- Meditation levels would mix between several layers of sound.

We used footage we had shot from a recent trip to Hong Kong, the footage was not shot specifically for the system, it was edited on a single video track in Final Cut Pro 7 and a XML file was exported. An XML file is like an Edit Decision List, it defines which videos to play with a start and end point from each.

4.1.3 Tour of prototype

We presented *#SCANNERS* at four events: Hope Mill Manchester, w00t festival[3] Copenhagen, IIeX[4] in Amsterdam and Manchester University Life Science open day. Our event at Hope Mill consisted of an invited audience of mainly artists and performers, to gather feedback on the experience, and interaction. w00t festival explores new types of games and innovative uses of technology, the audience were mostly young professionals interested in gaming. IIeX is a market research conference where we demoed and presented a talk to industry, the audience was made up of market researchers looking for innovation insights into their industry. Finally, Manchester University Life Science open day is a community targeted event allowing hands on interactions with scientific research and artists inspired by science. At all these events we collected video interviews to further understand the interactions.

4.1.4 Prototype presentation

When we came to present the experience, (at the time we did not think of it as a film) we built a room from a gazebo frame and weighted black fabric, inside was a screen, projector and speakers with a single chair. An internal partition contained the playback computer and operator. We conducted interviews with as many people as we could after their time in the tent where we asked them about their experience. We had no clear method of research and did not do any real analysis on the interviews. We used some quotes in a promotional tour video[5]. This whole process was a proof of concept; and from the interviews it was plain there was something to be further explored.

[3]copenhagengamecollective.org/2013/02/09/w00t-copenhagen-play-festival
[4]iiex-eu.insightinnovation.org
[5]albinomosquito.com/2013/06/scanners-teaser/

4.1.5 Observations of *#SCANNERS*

From our feedback whilst touring *#SCANNERS* and our experience working with the system we noted the following observations

- The mapping of Meditation data to audio was effective.
- Blinking producing cuts when Attention was high was effective but was assumed not to work consistently as no cut was produced when Attention was low.

We came to the following points to improve in future work:

- Using XML as a framework was unreliable, it didn't always work.
- The interaction was limited.
- The ways the media adapted to the viewer had potential to be improved.
- Media had to be made specifically for the system with an understanding of viewer interaction.
- During our experience of screening outside in Copenhagen the gazebo was not wind or rain proof, as such it was unsuitable for outside exhibition.

These observations pointed a number of design directions that we took forward into the next stage of the project. The platform needed to be redesigned, both how the platform dealt with video footage and the NeuroSky data mapping. Having a mobile performance space was a real bonus, we wanted to keep that but we had to think of another way to do it. It also seemed like the prefect opportunity to create content specifically for this new system. We will explore each of these in more detail in the next section and how they formed the design my first film *The Disadvantages of Time Travel*.

4.2 The making of *The Disadvantages of Time Travel*

In 2014 changes in my company's structure meant I was able to prioritise the creation of new specially made film and platform. Over the course of ten months the film was funded, shot and exhibited. It gained attention from international press[6] and I was asked to give a TED[7] talk about the work. During the search for support I made contact with researchers at The University of Nottingham, and began a PhD research program, which has culminated in the thesis you are now reading. Now we have established how and why the film was made I'd like to dissect the process in relation to making the film interactive, and brain-controlled.

4.2.1 Initial design

At the beginning of this as yet unnamed film a lot was unclear; I had no software developer or indeed software design, no partners, and no budget. I did have a working proof of concept, *#SCANNERS*, a producer, a (very) small studio, and the following artistic and interaction goals:

- **Each frame is unique.** The film is to have a painterly quality, an always changing aesthetic to direct and provide a method of feedback to the viewer. The prototype mapped meditation to the audio mix of the soundtrack as this feedback was found previously to be direct and effective. This new film would expand on that finding by expanding the feedback into the visual space, by constantly modulating visual blending between film layers, to create spatial montage of overlaid images.
- **The interface is not a remote control.** The film responds to the viewer's physiology rather than their conscious control. The aim is to create a subtle hypnagogic experience within the viewer, to put the viewer in the same space as the main character, between wakefullness and dreams.

[6] www.stuff.co.nz/technology/gadgets/71290740/scanners-becomes-a-mind-controlled-movie
[7] www.youtube.com/watch?v=EQeEz7S-cWI

- **A blink is a shot is a thought.** Blinking is used within the interactive design with Murch's assumption that it denotes a thought has been completed. Any blink detected by the headset is to produce a cut in the film [Murch, 1992].

- **Mappings are opaque.** Attention and Meditation data from the NeuroSky is opaquely mapped to visual and audio feedback/through. There is no on screen display of Attention and Meditation for the viewer/interactor.

- **The film is to mix between dream and reality.** The film is based on childhood memories of day to day life, dreams and day dreams, mixing between these in a way the blends these together.

- **Reproduce the main character's psychological state.** Both on screen and with the viewer. This is the central guiding principle that the tools of storytelling, direction, cinematography, and interactive design will be guided by.

- **Not just a single person experience.** The film that is created can be watched by an audience as well as the interactor.

4.2.2 Algorithm

tdottalgo From the artistic goals the following algorithm/design was conceptualised, this is summarised in Table 4.2.2 which shows how NeuroSky data was mapped to the visual and audio media. A more detailed account of the algorithms workings can be found below.

- The film has 4 video layers, 2 layers in the dream group and 2 in the reality group. These layers are all the same duration. All layers are played at one time. Only one group is visible at any one time.

- Attention data from the NeuroSky between 0 and 100 is mapped to the alpha channel of the top layer in the reality group and likewise meditation is mapped to the top layer of the dream group.

Table 4.1: Mapping of Attention, Meditation and blink data to cinematic language for the single controller version of *The Disadvantages of Time Travel*

Mapping	Visual	Audio
Attention 0-100	Blend between two reality layers	Mix sound from reality stems, vox and soundFX
Meditation 0-100	Blend between two dream layers	Mix sound from dream stems, VOX and soundFX
Blink	Cut between reality and dream threads	Cut sound between reality and dream threads

- A blink will cut between groups.

- The soundtrack, sound effects and voice tracks are distributed between these four layers. Attention data from the NeuroSky (between 0 and 50) is mapped to the volume (scaled to 0-100) of the bottom layer in the reality group and (Attention 51-100) to the top layer (also scaled 0-100). Likewise Meditation is mapped in the same way in the dream group. In this way, visual fading and audio fading follow each other.

4.2.3 Script

Although at the time I had directed several large commercial projects this was to be the first film for which I had been writer and director. The story was personal to me, one that I had been incubating for years. It addresses the discovery and malleability of memory, I did not feel that a linear film would be sufficient to express the narrative. In the previous twelve months it became apparent that a brain-controlled film would be an appropriate vehicle to support the narrative.

The writing of what would be *The Disadvantages of Time Travel* was organised as a retreat. I would return to my home town and spend a week there. In the mornings I would take walks into the countryside where I spent a lot of my time as a child and then I would write. I visited locations to assess their accessibility and appropriateness for locations to film. It was a quiet, reflective time. I had also planned to record video to

Figure 4.2: Still from the teaser trailer. Filmed in West Lothian, Scotland, June 2014.

act as creative catalysts later in the process, and so filmed scenes which had atmospheres that captured the tone of what I was trying to write.

It was a cathartic process. The places had changed, they only now existed in my distant past. I found myself letting go of painful memories and creating new connections. The film itself does the same, on each viewing it recreates itself, it creates new narrative connections and it does not tread the same path twice.

From the writing retreat I came back with around twenty-five vignettes; short, self contained pieces of prose. Some of these pieces were memories, some were memories of dreams and some were a mix of both. Also, a selection of footage (Figure 4.2) and recorded sound from nearby locations, which would be used in a number of ways in the making process.

The next step was to re arrange these vignettes not into chronological order but an order that would work narratively. To do this I had to change my relationship to the text. This was no longer about me and my version of events but about a story that I was telling, with its own internal logic. The writing process described above was intense and emotionally demanding, and so consciously shifting my relationship to it allowed me to have a more objective perspective to the material.

The script was written in Celtx[8], at the time an open source script writing software. It went through three drafts and was about 10 pages. The script was sparse in dialogue, and very descriptive. Perhaps more like instructions for devising scenes than a traditional screenplay. As writer and director and the only creative working on the film at this point a lot of the information only existed in my head, which became a problem that I had to actively address.

The synopsis is as follows: The narrative follows a boy as he grows from childhood into adolescence. As he goes from loner to making friends, he is antagonised by bullies that take exception to his race. All the time he lives within a duality of dream and reality.

4.2.4 Pre-production

The project had two producers, Jonathon McGrath, who took the project up to the funded stage and Rachel Ramchurn who took over as production manager to organise the physical making and budget management of the film. To give the reader an idea of the scale, context and effort involved in the project I will give an account of the organisations, support and funding that our team was able to secure in order to complete this endeavour.

In order to acquire the skills and resources to make the film we fostered relationships with the following organisations: FACT Liverpool, (Foundation for Arts and Creative Technology), B3 Media, an organisation that aims to support Black and Minority Ethnic (BAME) artists and filmmakers, Abandon Normal Devices (AND) Festival, London Film School (LFS) and The University of Nottingham. We raised funding from The Arts Council England and a Kickstarter campaign.

B3 Media:
I applied and was accepted for B3 Media's TalentLab program. B3 Media is a talent

[8] www.celtx.com

development agency for artists, writers, filmmakers, and directors from Black, Asian and Minority Ethnic (BAME) backgrounds.

The engagement with B3 Media consisted of a week long series of workshops with directors, sound editors and industry creative. I was also keen to engage with their partner The University of Nottingham's Mixed Reality Lab (MRL) as I was aware of their work with Blast Theory. There was an opportunity to meet with and pitch to MRL researchers, from those pitching sessions a partnership with the MRL was made.

Abandon Normal Devices: (AND)
A few years previously Abandon Normal Devices ran a festival where various artworks and artistic experiences were built inside old caravans. AND employed the Liverpool based gallery design and installation company Arciform[9] to re-purpose twelve caravans to be used for various artistic installations, one of which was a cinema. These Caravans were being stored, unused at an old barn; AND agreed to lend the cinema equipped caravan to the project for the opening exhibition of the work.

London Film School (LFS):
As the filming dates approached I felt that I needed a little more confidence and experience working with actors. The LFS was running a two day workshop titled The Director/Actor Collaboration. I was eligible to access Creative Skillset's Diversity Fund which allowed me to offset the cost for the course.

The Mixed Reality Lab (MRL) at The University of Nottingham:
The collaboration with the MRL consisted of my company taking on an intern, Matthew Pike while he completed his PhD thesis [Pike, 2017]. He developed the Open Sound Control (OSC) software that made the NeuroSky headset data available to other programs. This software was used for the next four years until I started using BrainWaveOSC. This signalled the beginning of my practice led research.

Foundation for Arts and Creative Technology, (FACT), Liverpool:

[9]www.arciform.co.uk

Our original producer McGrath and I fostered a relationship with FACT; we pitched our film to them and secured a place in their public exhibition programme, see Figure 4.3.

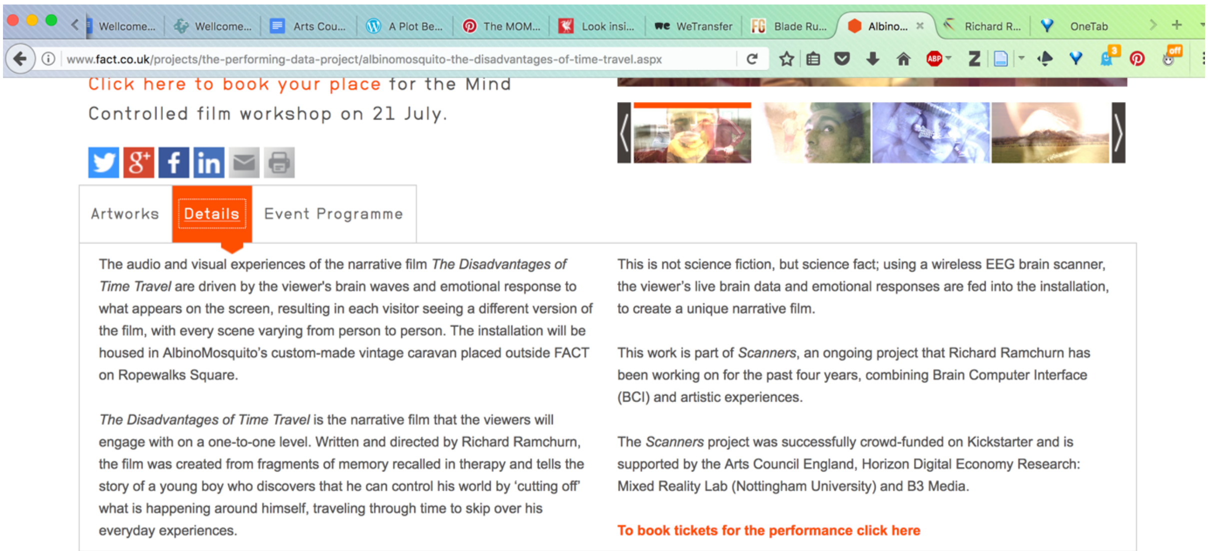

Figure 4.3: *The Disadvantages of Time Travel* at FACT, Liverpool shown alongside the Performing Data Project, an Mixed Reality Lab practice led Research project.

Arts Council England (ACE):

The Arts Council England is England's national funding body for the arts. The Arts Council does not usually fund film projects; this can be problematic for artists who work in moving image, making unconventional or experimental films. Our application we highlighted the uniqueness of the project and artistic development for the main artist and were awarded a £14k Grant For the Arts (G4A).

Kickstarter:

For about 3 months of the development of the project the producer McGrath and I ran a Kickstarter campaign called *#SCANNERS* - after the prototype, the title *The Disadvantages of Time Travel* was not yet coined. We had 48 backers and raised £3,531. This campaign had the added impact of gaining national and international press attention for the project.

Alongside fundraising and partner building the traditional pre-production tasks of location reconnoitres, the casting of young non-actors, costume design, prop sourcing, and crew recruitment were undertaken, overseen by new producer Rachel Ramchurn.

4.2.5 Storyboards

This is an abridged account of the storyboard process. The aim is to find specific instances where the interactivity can be evidenced in the process and special considerations were made. The production storyboards were made nightly before the following days shoot, and used on the day of the shoot. This is a long time ago to remember a very brief and intense period of production. In order to help recall the storyboarding process, I spoke with the DoP while we both had access to the storyboards. I photographed each page of the storyboard sketchbook and sent it to the DoP and we discussed the process via video chat. The conversation was recorded, transcribed, and coded in Nvivo.

There are two sets of storyboards for the film. The first was made before the script was finalised and the second was made during the shoot. The original storyboard is traditional in form; it describes a linear progression through the story, see Figure 4.4. The key emotional moments are laid out and form the backbone of the story. It does not describe what is happening in all four layers; but the storyboard moves between dream and reality sometimes within the same scene, see Figure 4.5. It wasn't till later, during production that the more detailed storyboards were drawn which expand the different layers of Dream Passive and Active, and Reality Passive and Active.

The second set of storyboards were made during the shoot itself. The originals did not have the level of detail required to be useful on location. So, each evening before the next day's shoot I would draw up the storyboards, taking into account scheduling, locations and layers sometimes with the DoP sometimes alone, an example can be found in Figure 4.6. These storyboards acted in place of a detailed shot list, and were even ticked off as we went. The following exchange between the DoP and myself shows how we used the production storyboards.

Dir

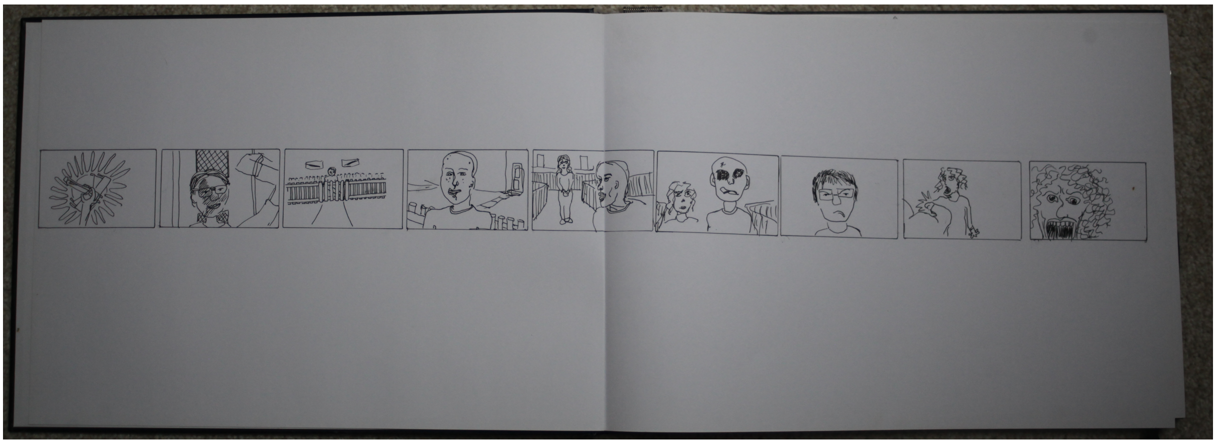

Figure 4.4: Page 1, Scene 1 of the original storyboards from *The Disadvantages of Time Travel*.

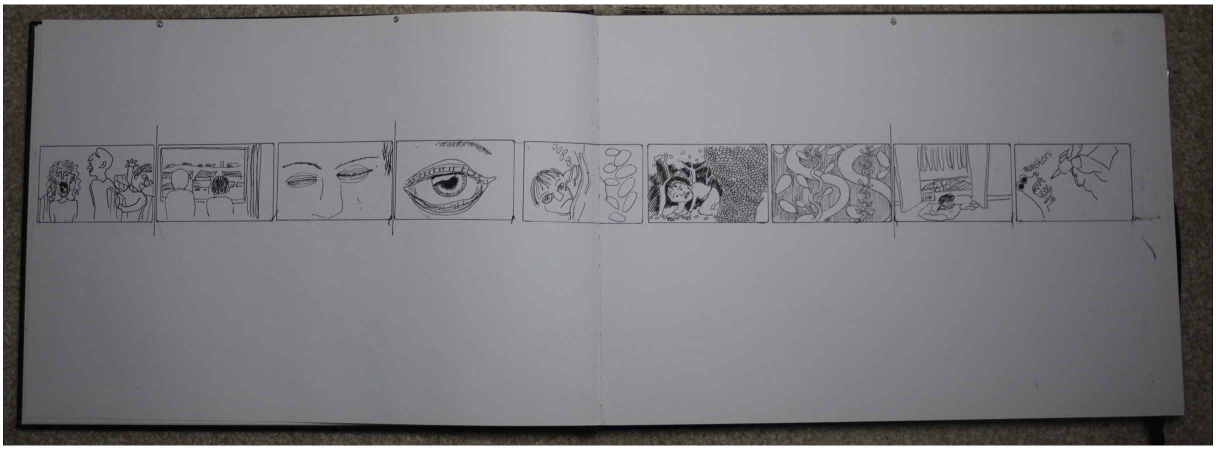

Figure 4.5: Page 2 of the original storyboards from *The Disadvantages of Time Travel*. showings scenes 1 to 4. Scenes 2 and 3 are storyboarded between Dream and Reality layers.

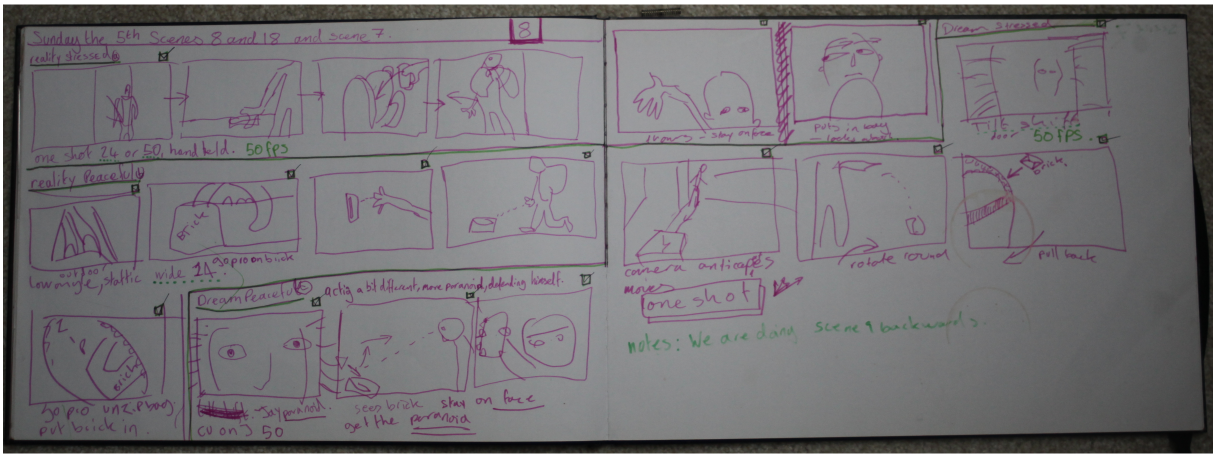

Figure 4.6: Production storyboard for *The Disadvantages of Time Travel*. Scene 8, Shot on the 5th April 2015.

What I'm confused about is how we actually used these storyboards on the day. Did we just, literally... Because we'd done... Because we drew them the day before, did we just know what we were going to do? So, it was like: Oh, yes, that's...

DoP

I think we did for some of the days. And then there were other days where you would have stayed up late doing the boards, and then we would have run through them in the morning.

Dir

Yes.

DoP

And I remember... I seem to remember and, again, I can't be too specific here. But, I seem to remember us making time to do that in the morning, to just be able to see... I can't say we did every day, but I seem to recall that happening.

In Figure 4.6 you can see underlined labels for the four layers, Reality Stressed (Active), Reality peaceful (Passive), Dream Stressed and Dream Peaceful. There are also directing notes for the actors and cinematography notes regarding which lenses, and frames per second.

Figure 4.7: Production storyboard for *The Disadvantages of Time Travel*. Scenes 2 (left), 4 (middle) and 1 (right) Shot on the 7th April 2015.

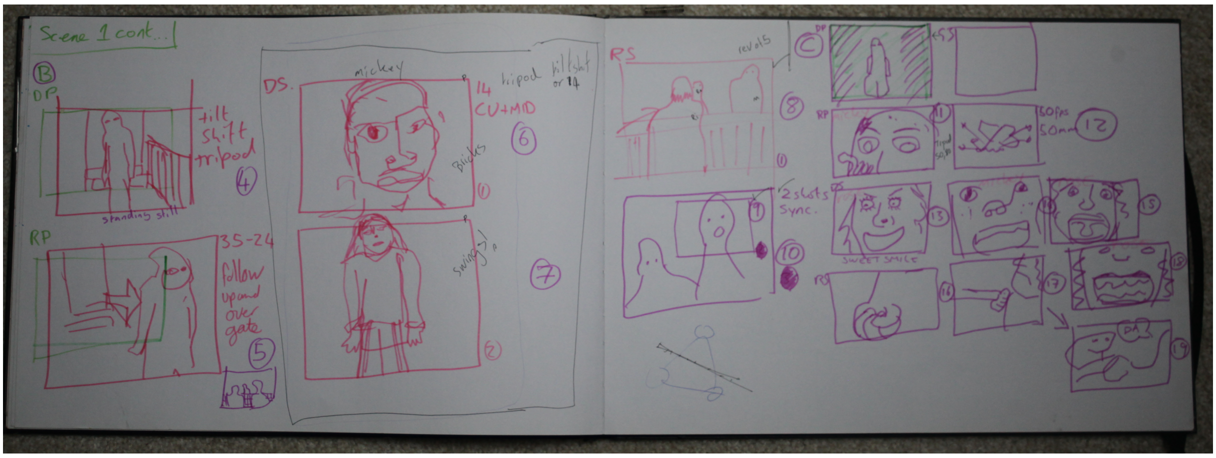

Figure 4.8: Production storyboard for *The Disadvantages of Time Travel*. Scene 1 continued, shot on the 7th April 2015.

An example of how a scene is broken down by both the scene layers, and the considerations for the practical shooting of a scene can be seen in the three panels on the right of Figure 4.7 and all of Figure 4.8. The labels A, B and C denote introductory setup shots (A), coverage of action (B), and insert close ups (C). The labels DP and RP are abbreviations for Dream Peaceful and Reality Peaceful can be seen throughout this scene. In the cinematography section it is explained the relevance of these labels and how these labels were used.

4.2.6 Shoot

The shoot took place in April of 2015 over 8 days. The relatively small crew of six comprised of the director (myself) the producer, the director of photography (DoP)-Mat Johns, a second camera operator, a sound recordist, and production assistant. Everyone had additional and sometime interchangeable roles, for example producer Rachel Ramchurn was also the costumire and caterer, the DoP was also the Digital Imaging Technician- managing and labelling the digital media. This sharing of responsibilities is common to low budget filmmaking. A small crew can also be agile; they are able to move locations quickly, and have the added advantage of being less conspicuous. Scenes were shot out of order, and synchronised sound was recorded independently. Filming took place during the day, in the evening the footage was copied onto hard drives, labelled and backed up.

The cast was made up of young, non-professional actors from the local area all under the age of eighteen, our relatively small crew had the added advantage of being less intimidating and allowed myself and the actors to work closely. There was a legal obligation to limit the number of hours we could work with them per day due to their age. This meant that our shooting days were kept relatively short; we were not on location for more than 8 hours. All of these variables helped us to keep to schedule.

Figure 4.9: Examples of lighting used to denote psychological and temporal space in *The Disadvantages of Time Travel*. Heightened emotion in a Dream layer (left), simulated night time (right)

4.2.7 Cinematography

The film was shot on new digital single lens reflex (DSLR) cameras. We choose the Sony a7s bodies which can record full frame video at HD 1080p S-log. This footage has the benefit of a high dynamic range and low light capabilities and footage is relatively robust and versatile in post production. This was important as we knew we would make alternative colour grades for a lot of the footage, the high dynamic range allows for heavy grading without image degradation. We had a variety of lenses; we shot on 14mm, 24mm, 50mm, 85mm prime lenses, and a tilt shift lens. Another benefit of the a7s camera is that it can record "crop sensor" mode which effectively zooms the image by about 20 percent effectively doubling the amount of lenses available to us.

Lighting setups were for the most part minimal; we had a lot of external day time shooting which did not require additional lighting. Exceptions were creating specific lighting effects for the Dream layers of the film where we would add coloured lights to highlight surreal and emotive moments. Another specific case is interiors lit to look like night time, where we would black out windows and use small LED lights to simulate moonlight, both examples are shown in Figure 4.9

The cameras and lights needed to be held in position by stands or by hand, the choice of which also came down to which layer the shot fell into; the Active layers were generally hand held, and the Passive layers on a tripod.

The DoP explains the challenges of this interactive film and how it is actually not so far removed from the traditional film-making process.

> Getting a grasp on the multi-narrative angle. And trying to [...] turn that information into a plan, I guess, of how we shot scenes effectively and efficiently.[...] Just making sure that, right, in this lighting state, we'll get everything we need for this, and then we'll do this, [...] ultimately, those are issues you face on any shoot. You shoot out of continuity, you shoot out of order, you have to just use the space and time effectively as possible. But, yes, it's just a little bit more intensified with this one. So, it was finding the rhythm with [the director], understanding how [the director was] going to lay this story out, yes.-Mat Johns, DoP.

As I worked with the DoP we developed our own shared language of how to approach each shot, a "meeting in the middle" of practical filmmaking language and the specific world building language of the film. This was a process that was developed over the shoot. The DoP needed to know which lenses to use, what grip to attach, what lighting states and angles to shoot from. As we developed a visual language for each layer we were able to use that shorthand and the DoP would know exactly which the lenses, additional lighting, and grip was to be used. In the DoP's own words:

> there were times where you were trying to explain stuff to me, in your way of explaining things, and couldn't quite get my head around it. And then, over time, I started to understand that, and you started to tweak the way you talked about it too, you know what I mean. I think we met... Basically, we met in the middle.

To get the pictures I had in my head onto screen, meant effective communication with the DoP. Translating the "images in my head" to instructions for the DoP is not as simple as saying "point the camera there". The DoP has his own craft. To over-direct takes

Figure 4.10: Graded still from the intermediate edit showing four visual aesthetics. From scene 8 of *The Disadvantages of Time Travel*.

me away from my main responsibility to the actors and undermines the DoP's position. Learning how to communicate my ideas without micromanaging meant building a shared understanding of how the film's layers related to each other and how each one was different. In a way it was like directing four films simultaneously, so it was important that the DoP knew which layer we were shooting, and how to work creatively within the constraints of that layer (see Table 4.2). These communicative discoveries happened as we shot the film. It became advantageous to draw up storyboards for the day to come the night before. As well as the visual plans being fresh in our mind we co-constructed a shared language relating to the layers, to the point the the DoP could work to his own initiative.

To illustrate an example of a scene where we approached from four different visual aesthetics. in Figure 4.10 the top screens are Dream and the bottom are Reality, Passive on the right and Active on the left.

Practically this meant that that we could have one camera for the Dream group and one for the Reality group. Each camera would have the relevant lenses and grip equipment set up as a time saving measure. This also allowed us on occasion to film the same action

Table 4.2: Defined cinematic toolbox for each of the four layers of /tdott

Dream Passive / Peaceful	**Dream Active / Stressed**
Tilt shift lens Slow motion Camera on tripod Subjective	Tilt shift lens Slow motion Handheld camera Subjective
Reality Peaceful / Passive	**Reality Active / Stressed**
Long lenses Camera on tripod Objective	Wide angle lens Handheld camera Objective

with the two camera setups, enabling us to capture two layers at once.

4.2.8 Direction

As the director on this film my three main responsibilities were: one, working with actors, two, working with the DoP (discussed in the previous section), and three overseeing the interactive repercussions on the process.

Actors

My foremost responsibility was to the actors; as previously mentioned they were non-professional young actors from the local area. It was important that they understood as much as possible about the story but also about the interactive nature of the film. I workshopped them before scenes, going through the emotions of the upcoming scene, going through how the different layers would be filmed. A lot of this was explaining what it was like growing up in the 1980s, finding a common ground and working from there. The fact that the film did not have a branching storyline with conflicts of continuity made it easier for the actors to understand when we filmed a scene more than once.

An example of shooting a scene from multiple perspectives was scene 6. The main character is experiencing his first day at a new school. The scene was shot objectively and then subjectively. The objectively shot scenes for the Reality layers and the subjective

Figure 4.11: Ungraded intermediate edit still from *The Disadvantages of Time Travel*.

scenes for the Dream layers. Here I directed the scenes differently, asking the actors to be heightened and more intense for the Dream layers, changing the emotional centre of the scene. Figure 4.11 shows a still from the intermediate edit of this scene, in the top two screens, Dream, you can see the actors leaning in closely, the bottom two screens, Reality, the actors have calmer expressions.

Interactivity

I also had the ultimate responsibility to make this film readable in its final interactive form and so it was up to me to make sure enough footage was shot, that what was shot would be versatile enough to be made to work. My questions to myself were: what are the relationship between Dream and Reality layers at any point in the film? And secondly what are the Active/Passive relationships within those. This meant being aware of the different emotions that each layer is expressing, what has been shot and how remaining layers needed to be created.

As writer/director, I related to the text in a very personal way. This manifested in the images of the film being "in my head" to the point that new ways of communicating needed to be found. Nonetheless there was an element of releasing control which was due to the interactive quality of the story. As a result of this there was an added element of freedom in directing as I wasn't setting up for the rhythm of the film. There is a style of filming called *shooting to edit*, where each shot is used from beginning to end with how the film will be edited in mind. It is interesting to compare this method to that of *The Disadvantages of Time Travel*. In both instances the process maximises what is shot to what is used. But where shooting to edit allows for a minimum of options of how it will finally be seen *The Disadvantages of Time Travel* maximises the variations in which the film's final form will be.

4.2.9 Editing

A typical editing process

I will describe what occurs in a traditional editing process before I explore how this film was made and the differences in process. In a typical, traditional editing process the footage is first prepared for an *offline edit* (Nothing to do with the internet, an offline edit uses smaller resolution proxy files for speed), the logs produced during production are consulted and the files are renamed with scene, shot and take number. Then the footage is put onto timelines and is synced with audio, if recorded separately, and organised into scenes. The best takes are chosen and a rough assembly can be made of each scene. Then a roughly assembled cut can be made bringing all the scenes together. From there a tighter cut can be made by the editor, with guidance from the director, which creates the rhythm of the narrative [Pearlman, 2012], and encodes meaning by juxtaposing images in temporal sequence [Kuleshov, 1974]. Once a picture lock is agreed on the sound mix can be refined. In parallel, the colour grader can work on the visual look of the footage. This grading can enhance certain emotion, feel and tone to the film. From there an *online edit* can be produced; this replaces the proxy files with maximum resolution footage ready to export for broadcast/distribution.

Challenges editing *The Disadvantages of Time Travel*

There were only two people involved in the post production of *The Disadvantages of Time Travel*, the musician and myself. I took on the role of director, editor, grader, and sound designer. The process of editing proved to have its own unique problems; these issues demanded solutions specific to the film's infrastructure. The main challenges that arose were:

- **Resisting the urge to edit with rhythm as would be expected in a linear film edit**

  The film was essentially going to be edited by the user/audience. It was no longer the case that the main responsibility of the editor, was to choose when to cut.

  Early on in the edit process it became apparent that a lot of the decision making that characterises editing was not appropriate. Shots had been filmed as longer takes than one would expect in a traditional film and so the task of editing was more about placing shots to match the duration of the longest scene layer.

- **Editing the four layers to make maximal opportunities for meaning to be made**

  Edits were made based on different criteria than usual. Part of the work was in finding out what those criteria were.

  As there was more than one shot per scene per layer that meant there had to be at least one edit in each scene. Where possible I would co-locate in time the cuts across layers, this was done to minimise the number of cuts not produced by the audience, see Figure 4.12.

- **Reviewing the edited scenes**

  In a normal editing process reviewing scenes is as simple as pressing play on the timeline. Here there are four layers of video of which one or two layers are seen at any time. A new way of reviewing scenes had to be produced.

  A technique of reviewing all of the four layers at once was come upon. This involved

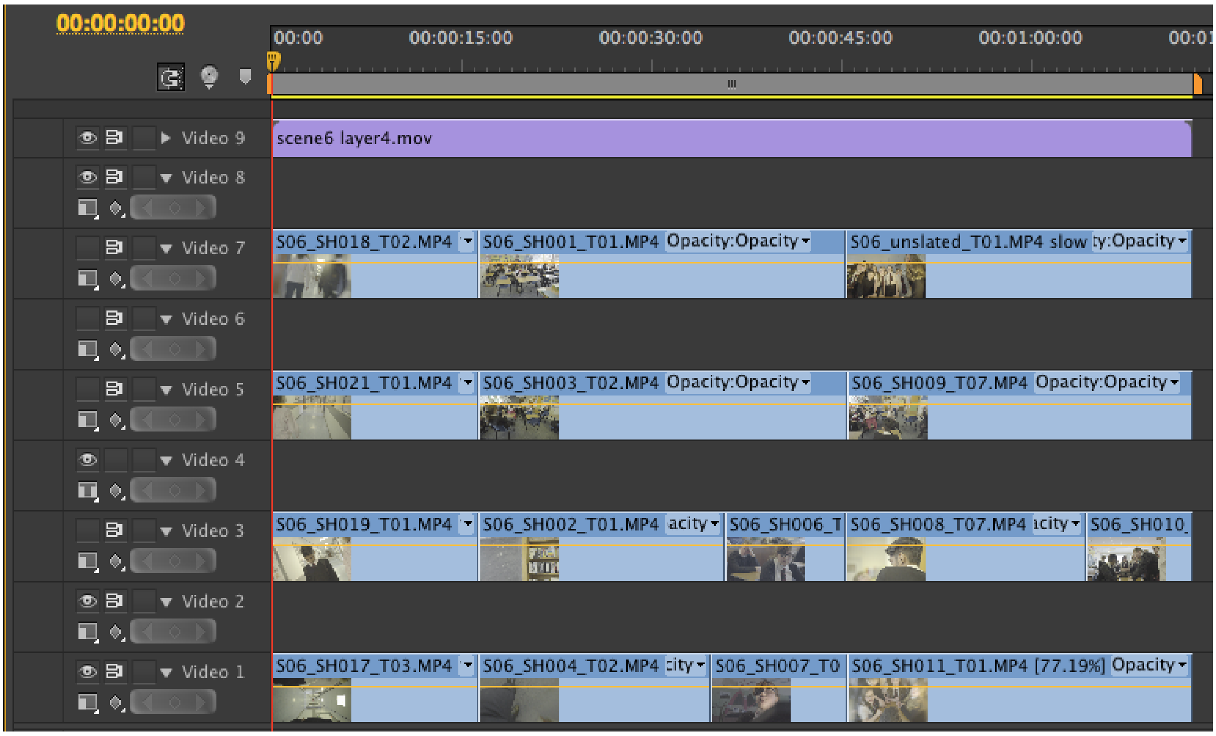

Figure 4.12: Edit timeline from scene 6 of *The Disadvantages of Time Travel* with edit points placed at the same time position across layers.

having the four screens as quadrants. This is visually similar to Mike Figgis's *Timecode* and meant that one could watch the film and flick between layers with one's eyes. In this way I was able to share the film with the musician for reference and see what worked in terms of emotion and visual continuity.

- **Expanding coverage**

  On the shoot it was not possible to get the full coverage of four different takes or versions of each and every shot and so some of these variations had to be made in the edit suite. To allow for this we made sure the footage we did shoot was versatile. What I mean by this is that the footage was shot in a way that it could be manipulated in the edit. We shot a lot of the footage at 50 frames per second with a flat, high dynamic range picture style. A standard frame rate is 25 frames per second, when shooting at 50fps meant that we can use the footage at both normal and half speed. Shooting with a flat picture style allows for the maximum manipulation of the image in the colour grade which can produce diverse emotional pallets. Figure 4.13 shows the same shot with the original flat colour on the right

Figure 4.13: Example of a colour grade next to original shot.

and the final graded version on the left. The intention here was to give a hot, oppressive feel to the shot, reflecting the main characters anger and hopelessness.

- **Syncing different takes together.** When parallel layers comprised of the same action but different takes then sound sync became an issue to be addressed.

  One of the most challenging aspects of the project was the sound mix. Specifically, any scenes where people are talking. As the sound was synced to the corresponding picture, when different takes were used across layers there would be a doubling up of lines. For some scenes I lined the layers up so that for the most part the audio was in sync, other parts I removed audio from one of the layers.

Editing workflow

The raw footage was brought into Premier Pro and put into folders corresponding to the scene number. Footage was worked with *online* (i.e. I worked with the full quality original footage rather than a lower resolution transcoded versions). Figure 4.17 shows the edit workflow, labels are detailed below.

Scene assembly sequences (a.) were made for each scene individually, and synced with the recorded sound. Each narrative layer had two video layers assigned to it. One had the raw footage that could be trimmed, and manipulated, and the other was a space for the colour graded version of the underlying clip. Pre-sets of colour corrections and grades were made to keep visual continuity, (see figure 4.19). An example of a scene timeline can be seen in Figure 4.12. These scene sequences were copied four times, each had one

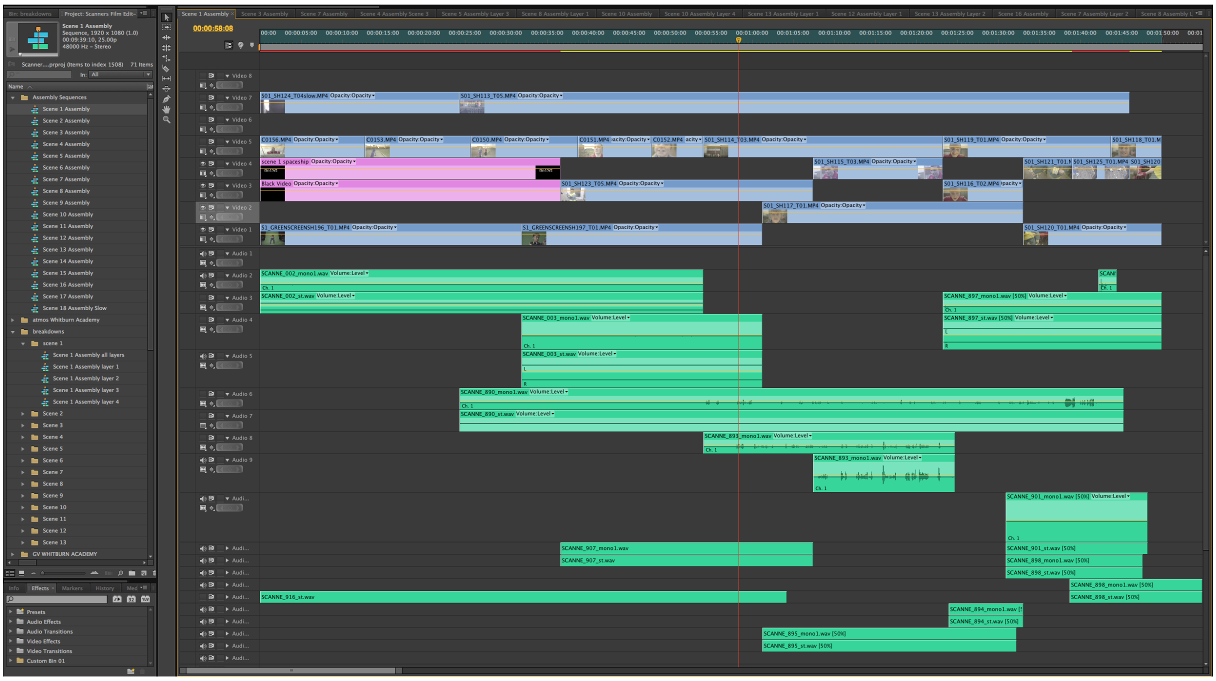

Figure 4.14: The first assembly edit of scene one of *The Disadvantages of Time Travel*.

of the four layers made visible (shown in green). At this level the scenes are dynamically editable, any changed will filter through subsequent levels.

The dynamically nested *Scene assemblies*, (b.) were sequentially ordered from 1 to 18, and sequenced in parallel from layer 1 to 4, in a new *Full assembly* sequence, which can be seen in Figure 4.16. These *Full assembly* sequences were copied four times, each had one of the four layers made visible (shown in green). At this level the length of each scene can be altered and music can be positioned over several scenes.

Once the colour grade had been implemented and the sound design and music finalised a *Final timeline* was made. This *Final timeline* (c.) consists of the four *Full assembly* edits, can be seen in Figure 4.18. This sequence, like the previous timelines are nested; meaning they contain other edits within them. It was used to create the *4 screen breakdown* for reviewing (d.) and the final *4 individual layers* for the playback system (e.).

Figure 4.15: Scene one of *The Disadvantages of Time Travel*. Four layer Breakdown ungraded footage used to review edit.

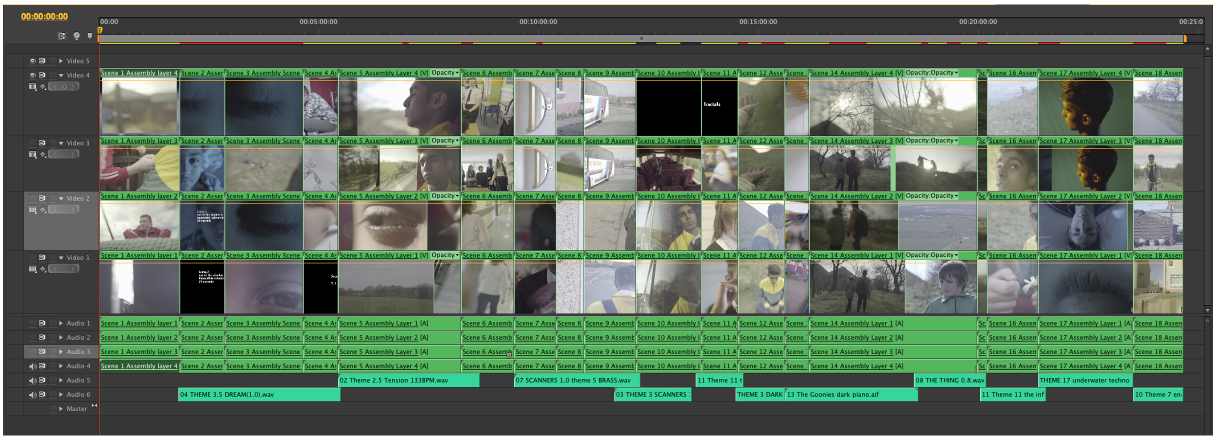

Figure 4.16: First full assembly edit of *The Disadvantages of Time Travel*.

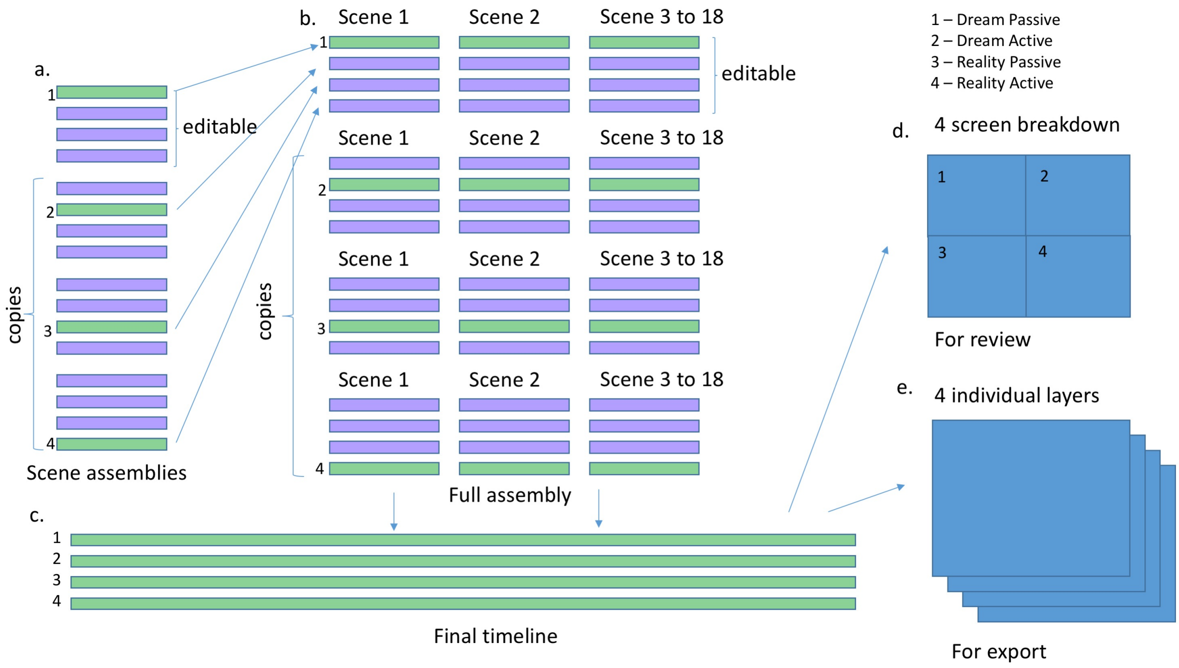

Figure 4.17: Workflow for the edit of *The Disadvantages of Time Travel*.

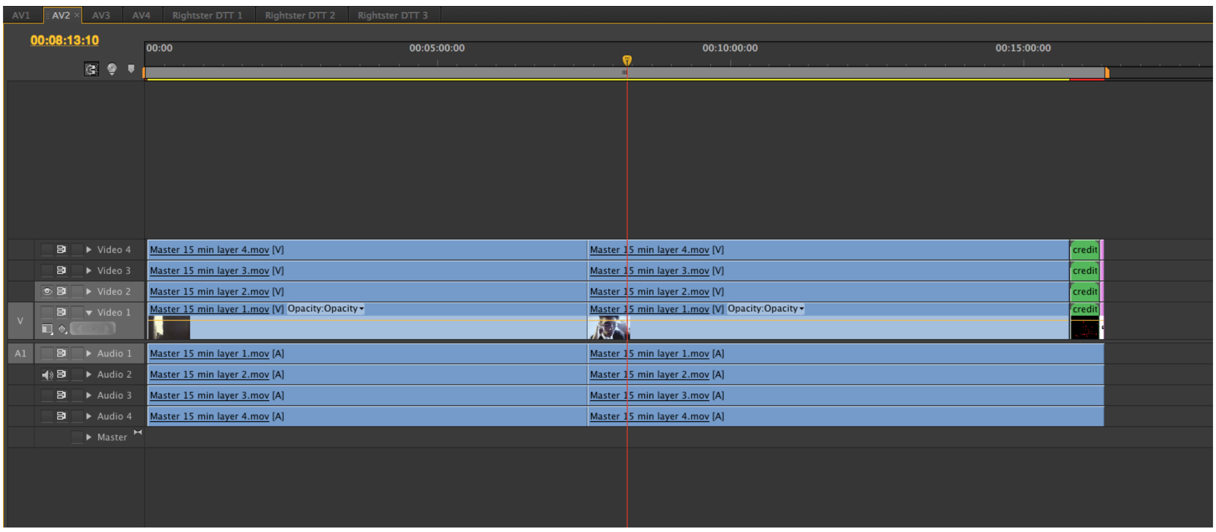

Figure 4.18: The final nested timeline of *The Disadvantages of Time Travel*. Titles, Credits, logos, sound mix, export master AV tracks.

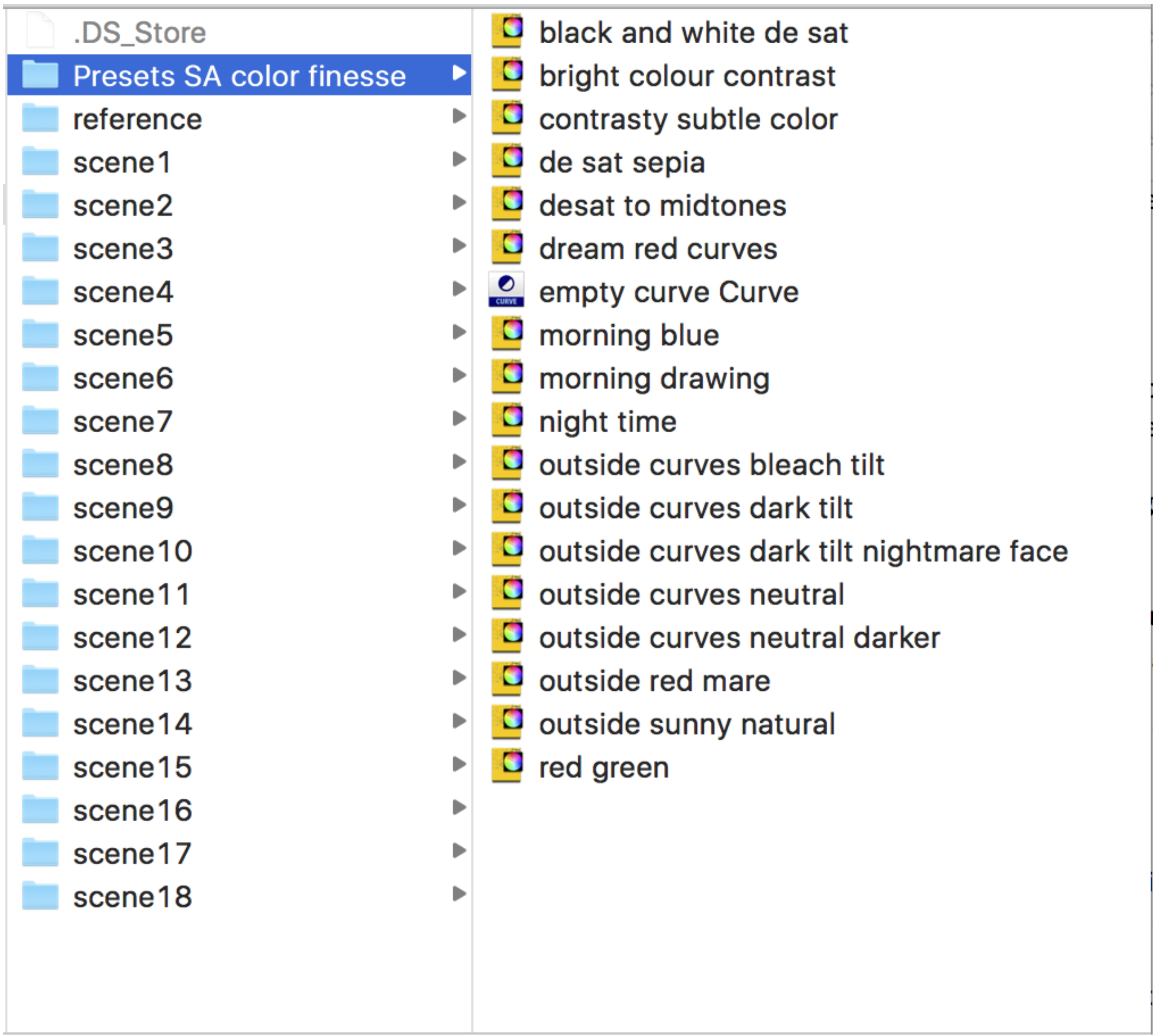

Figure 4.19: 18 different presets made for the grading process of *The Disadvantages of Time Travel*.

4.2.10 Music production

The concept for was to create a shifting re-combining musical score that was constantly changing in relation to the viewers Attention and Meditation data. To do this complex pieces of music would be written which would be broken down into its component parts; drums, bass, melody, and synths. These four layers are split into two groups of two. One group is played within the Reality layers, the other is played within Dream layers.

The music was composed by Hallvarður Ásgeirsson[10] which started soon after the script writing stage. The scene fragments used to create the script, static video shots which I took during the writing retreat and discussions we had about real and imagined music were all used to inspire individual pieces of music. The composer and I worked remotely, in total eleven themes were written.

4.2.11 System development

In order to make the software to run the system the following technical implementations were made:

- **Get data from NeuroSky headset.** My intern, a PhD researcher, Matthew Pike developed Python code which looked for a Bluetooth device matching the MindWave. Once it found the MindWave connected it attempted to read the data. Then using PYOSC it sent individual streams of data in Open Sound Control (OSC) over a port. It also created a .csv file with a log of the data.
- **Implement playback algorithms using NeuroSky data.** The system had to playback at least 2 video files in real time and in sync. The playback of the system was handled in Quartz Composer (QC). QC is a patch based visual programming language that is part the Xcode development environment for MacOS. It is specifically used for graphical processing and rendering. QC was able to read the OSC

[10]hallvardurasgeirsson.com

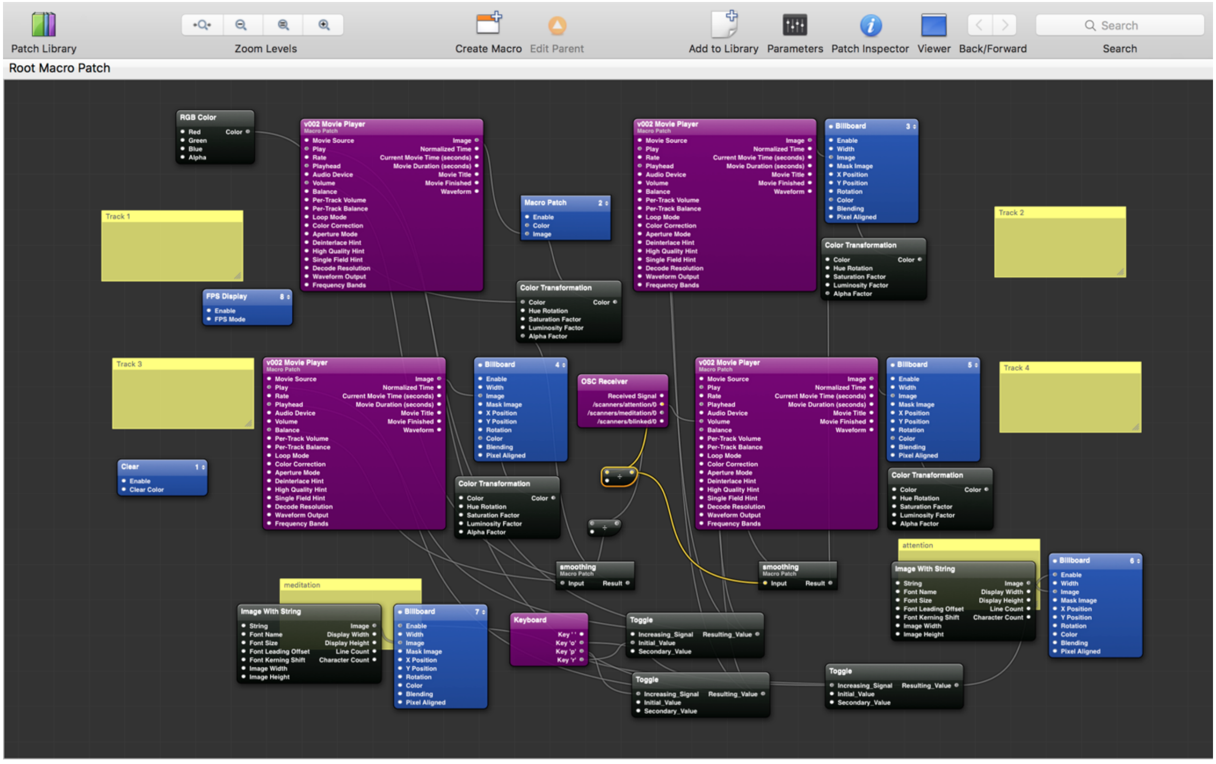

Figure 4.20: An in-progress Quartz Composer patch with smoothing implemented.

data from a port and then use that to control volume and opacity of the video files, see Figure 4.20.

I return now to the artistic and interaction goals that were set out in the beginning of this chapter. These goals were used as a guiding design and translated into interaction and systematic rules for the playback system.

- **Each frame is unique.** The NeuroSky sends Attention and Meditation data at 1Hz. In order to have smooth transitions in opacity which blends the video layers a smoothing operation was implemented. The incoming Attention/Meditation data was split into two instances, the first held for a second then a quadratic interpolation was made between these two numbers (figure 4.21). This resulted in the Attention/Meditation data to constantly move from the one second previous data point to the current data point. This method introduced a one second latency but produced a smooth blend between layers.
- **The interface is not a remote control.** Not designed as conscious control.

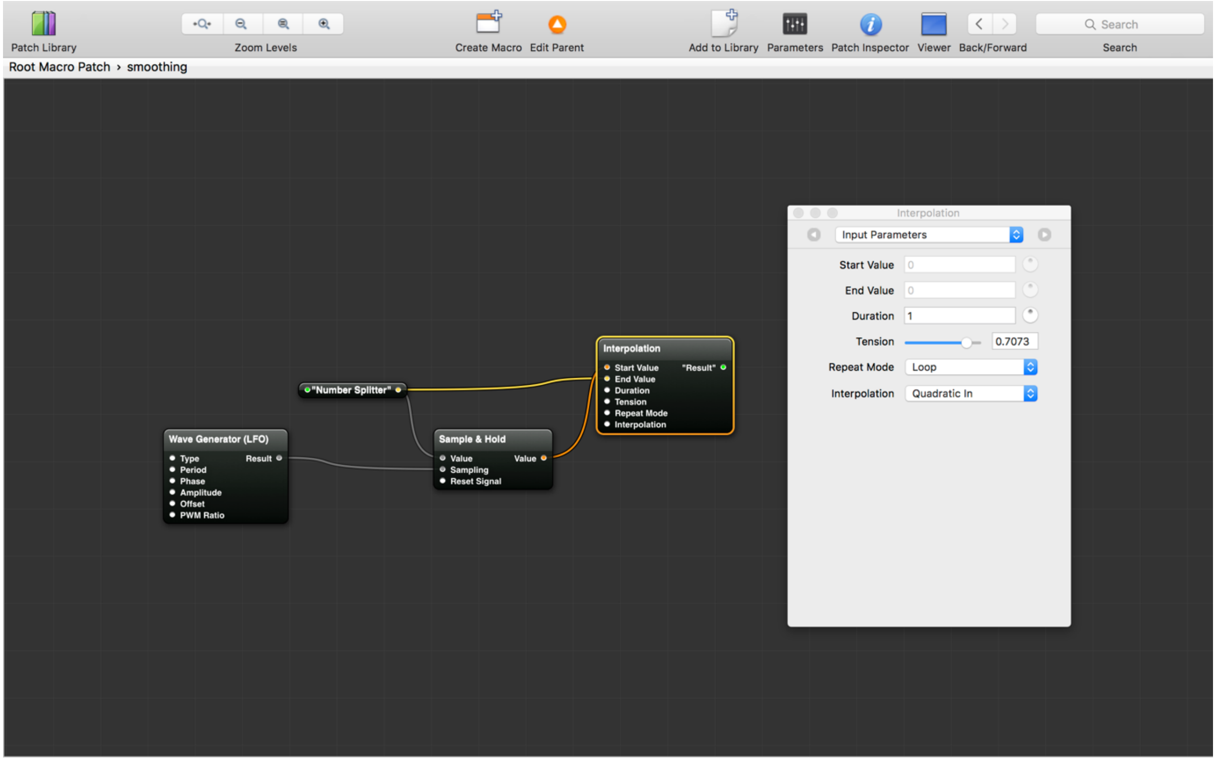

Figure 4.21: The smoothing function.

- **The film is to mix between dream and reality.** The patch is separated into four layers each layer can be at an opacity (Alpha) state of between 0 (off) and 100 (on). The NeuroSky Attention data was mapped directly to the alpha layer of Reality Active and the Meditation data to the Dream Active layer. The music soundtrack was split into their constituent stems and each video file had one stem as the encoded sound. The volume followed the alpha of the second layer, that is got its value from the smoothed Attention or Meditation.

- **A Blink is a shot is a thought.** When the patch received a signal via OSC that a blink had been detected, the alpha state of the currently visible layers were set to 0 and the other invisible layers set to 1. The data mapping moved from Attention to Meditation or vice versa.

- **Reproduce the main character's psychological state.** By creating an ambiguity as to what brain data is controlling what picture and sound we remove the power that a user is used to having, this shift of power is reflected in the narrative of the main character.

- **Not just a single person experience.** By keeping to the traditions of film such as having no on screen display, to project onto a large screen, and have as high frame rate as possible I hoped to encourage cinematic flow.

I have described exactly the initial design of *The Disadvantages of Time Travel*, I now describe its *in-the-Wild* screenings, as the first public study.

4.3 Deployment of single user version (Study 1)

The original single controller version of *The Disadvantages of Time Travel* was deployed in Liverpool, UK at FACT for 6 days in April 2015. Screenings took place in a 6 seater cinema converted from a caravan. The space had no windows, low lighting, plush seating, an eight foot projected image, and stereo speakers. *The Disadvantages of Time Travel* was part of FACT's Performing Data Exhibition, see Figure 4.3. Audience booked their place for free via an online app with FACT staff of with volunteers, no financial incentive was offered to take part in the study. Upon arriving at the caravan they were greeted by the filmmaker, and introduced to the film. The introduction was not set, the filmmaker answered any questions while readying the system, but did not have a set script. Controllers who agreed to participate in our study provided informed consent. Active viewers were fitted with the headset which took on average about 2-3 minutes to set up. Their film experience lasted approximately 16 minutes. Each participant's experience was recorded, both their unique version of the film and the brain data was recorded. From the FACT screenings 75 people engaged with the film, of these 35 controllers (20 male, 15 female, aged between 20 and 75) agreed to take part in a post screening semi-structured interview, of between 7 and 15 minutes. The interview asked about the extent of control they felt, how the experience differed from watching a normal film, and if they forgot about their control. Participants from the single controller study are numbered P1a to P35a.

We group the results from the single controller version with participants who described their singular experience of the hyper-scanning versions, where their experience of control is not related to other people in the group. Within the hyper-scanning study we observed more detailed data regarding interactions with media directly mapped to Attention and Meditation data. The differences in the control and mapping of the single and hyper-scanning version of *The Disadvantages of Time Travel* are described in detail in subsections 4.4.1 and abbreviated in tables 4.4.1 and 4.2.2. These tables also distinguish participants' screening version and controlling role.

The data presented has been through a thematic analysis as described in Subsection 3.4.1 of the Methodology.

Efforts to extend control for multiple viewers resulted in the second iteration of *The Disadvantages of Time Travel*. In the next section we describe three designs of distributed control and an alternate single person control mode.

4.4 Designing the multi-user version of *The Disadvantages of Time Travel*

Having introduced and described the production and design for the single viewer version of *The Disadvantages of Time Travel*, we now turn to address ***RQ4: How do groups of individuals experience brain-controlled cinema designed for shared or distributed control?*** We look at how interactivity was extended for social viewing. Before diving into the details, we clarify our methodology. Again, we follow the approach of *Performance Led Research in-the-Wild*. The adopted approach was to design and artistically experiment with different versions of *The Disadvantages of Time Travel*, each with its own control mode. While the following account should still be read an as example of the *Performance Led Research in-the-Wild* methodology, it does have something of the flavour of an experiment. However, this is still very much an artistic experiment with real audiences rather than a controlled laboratory study. The platform for *The Disadvantages* *of Time Travel* was remade as a social experience, our findings concern both the design process and the ultimate experience of audiences.

This study (Study 2), reported in Chapters 5 and 6 involves the staging of four technical extensions to *The Disadvantages of Time Travel*. We used semi structured interviews to answer the question: what are the experiences of individuals and groups using various distributed modes of interaction with a brain-controlled movie? It adheres to the *in-the-Wild* approach by setting up a series of intimate screenings for small (3-person) audiences as the movie toured through a series of venues as part of artistic professional practice.

4.4.1 Extending *The Disadvantages of Time Travel* for social viewing

Adapting *The Disadvantages of Time Travel* for group interaction raised three important considerations as to how best to share control among multiple viewers: designing mappings between the various outputs of the headset and the different elements of the movie; designing different configurations of shared control among groups of participants; and deciding what feedback to provide.

Based on their experience from the single-user version, the I began by revising the mappings between the outputs reported by the BCI device (Blinking, Attention and Meditation) and the different elements of the movie (temporal montage, spatial montage and music) with a view to making a 'cleaner' separation that would both enhance clarity for viewers while also allowing for greater consistency across different sharing configurations. Blinking continued to control temporal montage [Manovich, 2001], triggering 'hard cuts' between dream and reality layers (i.e. one image is replaced by another). Attention would be the only control for spatial 'montage within a shot' (i.e. images appear on screen at the same time) [ibid]. Meditation, also, was changed to only apply to the musical mix of the soundtrack, so that the soundtrack could be now controlled independently of the visual experience. In order to have more precise control over a new suite of designs, the system was rebuilt in MAX/MSP[11].

I then designed the four different interactive configurations shown in Table 4.4.1 in order to explore the impact of different control dynamics on the experience of the movie. Each of the four control configurations was designed to promote a different style of engagement with regard to the balance of who acted as performers and spectators in the experience [Reeves et al., 2005] and the ways in which control was negotiated between them. The first two configurations were called Collaborative and Cooperative based on the definition proposed by Roschelle and Teasley [1995], where Cooperation involves allocating the different aspects of the work amongst participants, while Collaboration involves all participants contributing to a given aspect of the work.

Hyper-scanning modes for collective control

Hyper-scanning is the term given to the simultaneous detection of data from multiple brains [Montague et al., 2002]. Below are the four designs we implemented.

1. **Collaborative**: In this configuration, the real-time average of each participant's data was used, such that all controllers could Collaborate to effect changes in the experience. For Attention and Meditation, the mean level of all three participants was used. Blinking from all 3 participants were measured together and every third blink would produce a cut. This was designed to try and facilitate group cohesiveness and to democratically share the control. At all times, all participants were simultaneously a performer and a spectator with equal, but partial control of the experience.

2. **Cooperative**: In this configuration, one of each of the three modalities of control (Blinking, Attention, Meditation) was allocated to a different participant. This mode was designed to promote collective responsibility for the final experience, while preserving autonomy. At all times, each person was mapped to control of

[11] cycling74.com

a particular aspect of the movie (spatial montage, temporal montage, and music, respectively), and was a spectator in regards to the other mappings.

3. **Competitive**: In the competing control configuration, the person with the highest Attention level became the sole interactor of all three modes, with Attention data being compared every second. This method was designed to encourage engagement by allowing the person that was most attentive to the movie to affect changes in it. In this mode, only one person at a time was in control, and the other two were spectators of the experience, but the controller could switch at any moment. Exactly who is in control at any point is not explicitly revealed.

4. **Performative**: In this configuration, which was closest to original single user design, only one pre-decided person was the sole performer controlling the experience throughout, while the other two (who were not wearing headsets) were spectators of the experience that the controller created.

Another design consideration was how much feedback to provide to viewers. The inherent nature of control in *The Disadvantages of Time Travel* is that its physical aspects are largely hidden. Attention and Meditation are largely internalised while blinking is a small gesture that is difficult to read when sitting next to someone. Moreover, it was envisioned that, even as a social experience, *The Disadvantages of Time Travel* would remain largely intimate and contemplative, with small groups sitting in a darkened auditorium. In social systems where it is not easy to see the interactions of others, such as this one, the approach of feedthrough [Dix, 1997] in which the system itself provides cues as to what others are doing may be used to reveal aspects of control, such as who is in control of what aspects of the system. However, I felt that this additional information would also be inappropriate to the nature of *The Disadvantages of Time Travel* as it would distract from the on-screen content of the movie and force a situation in which viewers were more highly aware of control issues. Instead, true to the original single-user configuration, the system provided no additional external cues as to the nature of control, shared or otherwise, allowing the viewers themselves to be more or less aware of this as they engaged with the movie.

Table 4.3: Control mode, mapping and participant number for the hyper-scanning version of *The Disadvantages of Time Travel*

Mode	Group member	Role	Attention mapping	Meditation mapping	Blink	Participants
Collaborative (average)	1, 2, 3	(Collaboration)	cross dissolve	Sound Mix	3rd blink = cut	P7, P8, P9, P25, P26, P27, P28, P29, P30, P34, P35, P36
Cooperative (distributed)	1	(Coop/ Blending/ Att)	cross dissolve	none	none	P11, P21, P24, P45
	2	(Coop/ Music/ Med)	none	Sound Mix	none	P12, P19, P22, P43
	3	(Coop/ Cut/ Blink)	none	none	cut	P10, P20, P24, P45
Competitive	1, 2, 3	(Competing)	Highest Attention is sole controller) =cross dissolve	Sound Mix	cut	P4, P5, P6, P16, P17, P18, P31, P32, P33, P37, P38, P39
Performative	1	(Solo Interactor)	cross dissolve	Sound Mix	cut	P2, P13, P40
	2,3	(Spectator)	none	none	none	P1, P3, P14, P15, P41, P42

Now we have discussed five different designs of *The Disadvantages of Time Travel* we ready to report on the setup of the *in-the-Wild* screenings.

4.5 Deployment of multi-user version (Study 2)

The hyper-scanning screenings of *The Disadvantages of Time Travel* took place in London, Dundee and Nottingham between August and November of 2016. At all locations, the movie was screened in auditorium settings: either a raked seating theatre with a 6 meter screen, or smaller 3 meter screen in a screening room. Audiences at these screenings were invited to participate in the study and a total of 45 people (19 male and 26 female, aged between 18 and 60) viewed the film in 15 groups of 3. No financial incentives were provided. Upon arriving, participants were given information about how they could interact with the movie: the interactive configuration for their screening and individual roles were explained to each group. Once informed consent had been gathered, a short preliminary interview was held. The headsets were then set up and tested, before the movie was screened. Immediately after the movie, a longer post-experience interview was conducted that probed key questions including whether: the interaction made the movie more difficult to follow; if they could tell what they were controlling; if they interacted with each other; and if they felt a responsibility to perform.

4.6 Research questions

We reflect on what has been learned about our research questions from the making of this first brain controlled film. ***RQ1: What are the problems inherent to interactive cinema?***

We identified previously that interactive film can be more expensive than traditional productions, we took measures to bring the cost to a realistically raiseable amount. Measures such as working with a very small crew and having minimum pre and post production costs. Raising the funding meant courting multiple funding bodies some, such as the Arts Council outside of the traditional narrative film ecosystem, crowdfunding, and pitching this unusual form of film.

Addressing the complexity inherent in interactive cinema was achieved in several ways. Meticulous pre-production is always recommended, even more so given the complexity of interactive film, however this process intentionally bucked that trend, instead embracing improvisation from both cast and crew. Original storyboards told a liner journey through the film, the second set of storyboards, drawn during production where more practically focused on the individual narrative threads. Problems of writing scripts –

Communication between director and DoP was achieved by developing a shorthand for what equipment and tone for each narrative layer.

The small crew size also meant that production days were agile and adaptive which was important as we still needed to capture four times as much footage.

We set practical constraints for each narrative layer and worked creatively within them. By using slow motion photography that could be manipulated in post, shooting flat footage that can be heavily graded, using two camera set ups with different lenses, all meant that the footage that was shot was versatile.

We adopted a non-branching format of interactive cinema which in turn meant less continuity worries for actors and crew.

The post production process demanded developing a new workflow using a standard non-liner editor (Premier Pro). By using multiple nested sequences edits could be made at various levels of the edit and changes would propagate throughout. Additionally the problem of reviewing all four narrative threads at once was solved by outputting a 2 x 2 grid of the footage.

RQ2: How can real-time interactions via a Brain Computer Interface (BCI) construct cinematic content?

The challenge is to make these audio /video constructions feel like film. This is explored by matching understandings- both from literature and our prototype, of Blinking, Attention and Meditation to filmic components. We map blinks to a hard cuts, visual attention to blending [Murch, 1992]) (spatial montage [Manovich, 2001])between layers, meditation to sound.

The initial algorithm was developed in parallel with and informed by the story structure, and acted as a grounding throughout the production process. By designing the content to allow specific meaning making when interaction occurs makes the moments of interaction essential to the reception of the narrative.

Treating the headset data to be compatible with film by up-scaling from one data point per second to twenty-five, a more cinematic temporality, allowed the images to flow and feel more like cinema.

Viewers do not have conscious control of cinema, as it unfolds in ways the audience may not anticipate, a parallel can be made to an un-entrained individuals relationship to their EEG data. The difference is that the EEG data is derived internally rather than externally. Thus the construction of cinematic content here is derived from non-conscious internal responses.

Subtle changes to the interactive sound design was made when creating the multi-user versions, initially when the film cut between dream and reality the dialogue track would also cut, which caused an unintended jarring effect. By changing the hard cut of sound to a cross fade solved this.

RQ3: How do interacting individuals respond to various brain-controlled cinematic designs?

By separating out the different mappings of Blink Attention and Meditation we are able to study interactions with each independently and look at how an individual experiences each mapping.

RQ4: How do groups of individuals experience brain-controlled cinema designed for shared or distributed control?

Various intentions behind the design of shared control: working with each other in the cooperative and collaborative modes and against each other with competitive mode raises questions of how audience experience will differ with these various control methods.

In the next chapter, our first results chapter, we report on peoples' experiences across Studies 1 and 2. We explore themes related to control, how they related to their own physiology within the affective cinematic loop and how they interacted with various aspects of the narrative. In Chapter 6 we gather interview responses concerning participants controlling together, or with an audience, focusing on social interactions in control and participant affect.

Chapter 5

Results 1: People's experience of *The Disadvantages of Time Travel*

We report the results from peoples' singular experiences of interacting with the single (Study 1) and hyper-scanning (Study 2) screenings of *The Disadvantages of Time Travel*. Our analysis of these interviews is done in the mode of Braun and Clarke [2006, 2012] as detailed in Subsection 3.4.1 of the Methodology Chapter. The study design for Study 1 can be found in Section 4.3, and Study 2 in Section 4.5. For detailed description of control and mapping of the single and hyper-scanning versions of *The Disadvantages of Time Travel* see Subsection 4.4.1 and abbreviated in tables 4.1 and 4.3. These tables also distinguish participants' screening version and controlling role.

5.1 Control

Our investigation is largely based around control, here we bring together how people discovered, or didn't, that they had, an influence over the film. How they went on to exert that control and how it moved between being conscious and unconscious. We observe occasions people choose to not control the film or break the feedback loop they find themselves in.

5.1.1 Discovering control

Many of those that experienced the original version of *The Disadvantages of Time Travel* began without knowing how it could be controlled. What they discovered while watching the film varied; some quickly came to understand aspects of their control, even if they did not interpret its effect correctly. Aside from knowing they were wearing a brain scanner, however, a few participants remained unaware that they could have some control: *"I didn't realise there was anything to control"* P19a and *"I thought it was just how it was"* P16a. Some, during the experience, realised that they had some control: *"it did feel like something else was controlling. There was something more kind of [transient] in the edits, you know. It didn't flow in the same way that it would do if you were watching something else..."* P15a. Whereas p28a immediately discovered, during the title screen, that blinking was having an effect: *"I noticed that when I blinked, it [the text] changed between blue and red, and green and white. And I liked the blue and red so I tried to keep on that as long as I can."*

People didn't necessarily understand how they were controlling the film, nor what impact their control was having. P6a said: *"[I tried to] alter my breathing"* and *"I tried messing about with my hands in front of my eyes"*. P7a believed they were altering the story line, saying *"there were little bits where I could control wither people were being aggressive or not."* Similarly P10a said *"I did [think I could control characters] near the beginning, especially when I thought: pick that brick up and hit them."*. P33a thought perhaps they were controlling the temporal flow of the film, saying *"I thought, if...I really, really focus on what's going on, it will travel quickly and I will get through this section that I don't really like, if that makes sense and it seemed to do that"*.

Some participants did knew at the start how it worked, because this was a second viewing, or had spoken to previous audience members or the filmmaker at the venue. p5a said

"I enjoyed concentrating because I had the control of the concentrating". While some had control over their Attention levels, it wasn't always easy for others to do so: *"my meditation, I tried to play with that but I wasn't sure if I was having much effect"* - P6a. Some participants seemed satisfied, however, with this limited control: *"I was happy with the amount of control, because I didn't know the parameters of how to affect it and trying to manually affect how your brain is reacting is really difficult"* P1a.

In reflection, some said that it would have been better not to know exactly how to control the film. P13a said *"I wish you hadn't told me before, its not as authentic if you know before"* and P14a said *"I would have liked to have done it, not knowing anything"*. When asked if P10a (who did not figure out how to control the system) would have liked to have known in advance, they said *"no cos then I'd be blinking like anything, and its our observation that changes what happens anyway. I'd have liked to be told that I would be told [how it worked] afterwards. Maybe I would have thrown myself into it more"*.

5.1.2 Exerting control

For those that exerted a level of control, some found that this increased their engagement with the film: *"more immersive definitely, I'm used to going along with a story line and having no control over what's happening and feeling not-connected to the film whereas that I felt more involved with it, more connected to the film, and to the characters as well"* P2a. Others, like P2a, used this control to manage their exposure to difficult material; P18a said *"The audio became really, really annoying and very abrasive I was using the opportunity to just switch to a less abrasive... I mean it was... both were still abrasive but I was switching to the less abrasive at that point and checking in, every so often"*. Using control wasn't always easy due to its semi-autonomic nature: *"yeah I tried to play with [blinking] but sometimes I blinked involuntary, so sometimes where I didn't want it to change it would change"* P6a. Similarly P22a said *"I think sometimes like I was stopping myself from blinking and then my eyes will get dry."*

Conversely, thinking about control meant that some participants found it hard to fully enjoy the film: *"a lot of the time I found it difficult to remove myself from the thought of... the fact that I was changing it and I was controlling it, and I kept thinking like why is my mind doing that pace like what's going on in the film?"* P23a. Similarly, P31a said *"sometimes you notice that you have the agency, and that flipped you out of flow. But sometimes you've really added to the dramatic effect."* P28a worried that even more control might reduce the enjoyment of the experience *"I think any more control maybe I think that, maybe more control would have taken away from the immersive elements of the film."*

5.1.3 Unconscious control

For solo, competing, and collaborating controllers there is a mix of both conscious and unconscious control. The Blink/Cut method makes it clear that there is an option of exercising conscious control, however for Attention/Blending and Meditation/Music controllers their method of control is more ambiguous. Reflecting on their experience of control, (P23 Coop/Att/Blend) sees the value of a more unconscious and subtle form of influence,

> I think it would be again interesting to see more in terms of is this supposed to be a reactive experience or is it supposed to be a consciously active interaction and I think in terms of controls that's gonna be one of the big divisions. whether you control it by blinking or waving your hand you are still controlling it, but concentration, meditation that puts some pressure on you to focus in or not focus in[...] if the film is reactive to you it's kind of an interesting experience but if you are supposed to be able to consciously alter the film I think it tends to be a bit of work.

The following three controllers describe different ways they relate to moments where they influenced the film. The comment from (P2 Solo/Controller) illustrates how the mapping of Attention data can affect the film without conscious effort. The temporal attribute of film as a medium encourages continuous readjustment from the controller. *"I don't know, sometimes things would transition into a new scene and I feel like I had nothing to do with it, like I wasn't thinking about that I was just kind of watching and was just spectating and kind of like OK this is happening now"* (P2 Solo/Controller).

Some controllers experience unconscious control and appreciate it, *"I think we got a lot of, with games and stuff it's easier to make something where you can consciously control how the narrative is done so it would be interesting to see a subconscious method instead"* (P44 Coop/Att/Blend). Another member of the same group finds that when control becomes unconscious it also becomes self-reflexive. *"I think it's better when its unconscious because you feel like it's telling something about you as well, you know, you are getting more out of it instead of if you were just directing it."* (P45 Coop/Blink/Cut).

Finally, P23, a Coop/Att/Blend controller describes how specific elements of the film, especially when they were visually coherent – that is when the layers were not blended – would allow them to focus. *"I mean it was easier when there were specific details that I could focus on, the reading of a poem, the clear scene where they were all laughing at him even that shot of VHS tapes, it's like oh I wonder what's on that shelf, when there was something emotionally or visually detailed that you could focus on."* P23 Coop/Att/Blend). What is interesting here is that high and sustained Attention data will produce an unblended visual scene which, by P23's account will sustain their attention.

5.1.4 Affective loop

The affective loop described by Höök [2008] in which a user is affected by a system, which is affected by the user, and so on is framed in terms of film by Pike et al. [2015a] as a 2 Way Affect Loop (2WAL). This is a description of how the film can affect the viewers, and their brain data, which in turn affects the output of the film and so on. The following interview excerpts are analysed in relation to this framework. The 2WAL can be interacted with in many ways, by observing, trying to break it, and get back into it. However, there may be evidence that the loop may have its own agency as controllers describe the feedback *snowballs* out of control.

The first step of becoming aware that a feedback loop exists is becoming aware of their own mind within the loop. This can occur when the cinematic feedback of their own brain data is observed. *"I think it made me notice when I lost concentration,"* (P8 Collaboration).

From their experience P7 describes how observing the loop in action interests them. *"I don't know how you would be looking at the screen and the person but, it would be quite interesting to see how the movie provoked a reaction and the reaction would then provoke the film,"* (P7 Collaboration).

As part of their experimentation to discover their control and agency P23 describes how they attempt to break the loop, to change their own state of mind and see the effects onscreen. *"so yeah I tried to zero in on the screen which is difficult when there's all kinds of things moving around and changing anyway, and then purposely tried to throw it off and see what happens and I sort of got an effect but I'm not exactly sure..."* (P23 Coop/Att/Blend).

For a competing controller that has observed feedback they want to re-join the loop. *"and I'm thinking why did it change? An' can I change it back (laughing),"* (P17 Competing).

For some, the search to find feedback and become actively aware of the loop becomes a core activity. *"yeah well I tried to stay calm throughout the kind of meditation thing and then tried to figure I mean for the music wasn't it, for the music for the meditation if that was making it I don't know louder or change or anything like that"* (P22 Coop/Med/Music). Not feeling that they have found feedback from the music they settle into an engaged state nonetheless. The story trumped the need to search. *"I felt like then when I got into the characters like found their story, I was more neutralised you know what I mean like I* *was actually watching a film like rather than trying to like you know mess with my brain but then when you finally got kinda a felling for the characters you kinda meshed into the film."* (P22 Coop/Med/Music).

Another controller is aware that their state of mind is influencing the film, especially at emotional points of the film, *"I'm not sure if it was all the film or it was internal cos I knew what I was thinking - well not that what I was thinking was being projected - but it was definitely influenced by what I was thinking"* (P7 Collaboration)

In the following exchange we see how more cuts happen during a charged scene, bringing awareness to their own physiology, upsetting the experience. This is an example of the affective loop feeding back on itself.

(P28 Collaboration)

So there are bits where he looks like he is being bullied and I noticed at that point I was actually aware of blinking and it sort of changed so I don't know if that has an affect on, you blink more if you don't want to see something.

(P29 Collaboration)

Yeah, yeah.

(Interviewer)

So that hard cut, that higher frequency of cuts.

(P29 Collaboration)

Yeah which is the also more disruptive.

P10 also found the same. *"When something intense started happening blinks started firing up"* (P10 Coop/Blink/Cut). This was a controller who was considerably affected by the emotional content of the film.

Another Cooperative group discusses how they felt their different channels of feedback all started increasing when they became aware of either their own physiology or of the feedback itself.

(P19 Coop/Med/Music)

I didn't feel like I was in direct control but I could like, after it happened I'd be like oh yeah that's me,

(P21 Coop/Att/Blend)

Yeah like I knew I was doing something but I didn't feel like I had as much control as maybe [Participant 20].

(Interviewer)

I'm interested in what that feedback was that you say you had some control, how did you feel that?

(P21 Coop/Att/Blend)

You just knew you were doing something like maybe depending on what you just saw felt like maybe it influenced the next thing.

(P19 Coop/Med/Music)

Yeah and I think for me like, as soon as the music started ramping up I could tell like it was ramping up cos I was thinking about how its ramping up and it just like...

(P20 Coop/Blink/Cut)

Snowballed.

(All)

(laughing)

(P21 Coop/Att/Blend)

Out of control yeah.

(P20 Coop/Blink/Cut)

Yeah cos I was definitely blinking fast when I thought about blinking which made me more panicky which kind of like you said snowballed out of control and like, yeah.

This 'snowballing' of feedback is described above for controllers with a direct mapping, but the same was found in the Collaboration condition, when a controller latches on to their physiology and feedback response and it produces an affective accumulation which takes over their experience.

> ...obviously the more I thought about it the more I heard it and the more I heard it the more I thought about it just sort of snowballed until it was all I was thinking about was the music I wasn't actually watching it I wasn't seeing the colours I wasn't seeing what was going on I was just hearing this. (P7 Collaboration).

Another controller from a Collaboration mode found the same accumulative effect which they *can't stop*, this time with blinking, and specifically in the first few minutes of the film when they were experimenting with their control.

> And also realising the control and the not knowing the control actually what your controlling in the beginning 'cos I didn't realise the direct control like whether the blink will make changes or not I didn't really realise in the first minute then I just thinking, OK, its changing and something I just don't know what's going on I tried to look at it more clearly then, I realised the blink seems to change

> the things and I try to play it after playing a while it starts getting quicker and I just can't stop it. (P34 Collaboration)

5.1.5 Withholding and releasing control

On a few occasions controllers will choose to not blink, to blink repeatedly without watching the film, or to concentrate on objects or persons outside the film to affect their attention. People give different reasons to withhold control, or to choose to actively not control the film. For P11 and P25 it is because they didn't like what was happening in the narrative or did not trust the film to not show something they consider horrible, or against their sensibilities. However, other controllers such as P8 and P40 engaged in the film may also consciously try and break the loop. This may be an attempt to create a coherence of narrative, to make the film make sense for themselves or others in the room.

An extreme example of a controller being emotionally affected by the content of the film and causing a change in behaviour was from P10. For P10 the film triggered a withdrawal of interaction. This Blink/Cut controller was sensitive to the themes of bullying in the film which in turn caused them to physically withdraw from their interactive assignment, although they stopped short at taking the headset off (in the introductory briefing they were told they could stop at any time). Below they state how they avoid this type of content in everyday life:

> *"but there was just moments where you know like I don't particularly like bullying and I don't like stuff like that so I'd rather not watch it like see if stuff happens like that on TV at home I'd like get up and leave I'm like no thanks,"* (P10 Coop/Blink/Cut)

How this manifest when they are in a theatre, wearing a headset which is monitoring their blinking is further described:

> I'm gonna keep blinking till this film is OVER (laughing) I'm like I

> literally was like this is making me uncomfortable so I'm just gonna blink cos I don't wanna watch it. An I kept looking away as well. I was like I'm not watching this so you guys can just deal (laughing) and then when I looked up again an some guy was wanting to be choked and shit I was like (blows through lips) see ya, nope. No thanks. (P10 Coop/Blink/Cut)

As well as looking away and blinking randomly P10 also blinked very fast at times, *"still I just wanted it to be over by the end of it so. If I blink faster it'll finish"* (P10 Coop/Blink/Cut). What then is the effect of this behaviour on the film and how does this affect the other controllers? The nature of direct mapping blinks to cuts in the film will manifest in more dramatic changes. For P12 they sometimes wanted it to cut and at other times, *"I couldn't work it out cos I didn't know it was a part when it was flicking really all the time,"* (P12 Coop/Med/Music). From the interviews with the other controllers in this group there was discomfort with how the film played out. In another group, this time a Collaboration group (average Attention and Meditation and cut on every third blink) one controller reacted similarly to the content, although not as strongly. P25 also choose to look away at certain points, *"I thought you were going to have the child run over on the bus at the end and roll [credits...] I'm not even gonna look (laughing) [...] I thought its gonna have the bus if we keep blinking or whatever it is we do that bus is is going to run over that child and I'm not playing this game (laughing)"* (P25 Collaboration).

For others who made conscious decisions not to blink for periods of time, it was not because they were apprehensive about the upcoming content but attempting to create a coherent journey through the film narrative. *"When he was on the bus I felt I was in control of the images, I was trying not to blink, I was trying to watch it."* (P8 Collaboration). This was also the case for solo controller P40, they found the blink to cut attribute to disrupt the flow of the narrative and they explain in detail why they choose not to use it.

> Yeah so, because we were all watching it I didn't want to blink too much because blinking would ruin the sequence of events, but

> I wasn't too concerned about the music, and the the, - I got to a point when the different images started mixing up I tried to actively get them out like clean it up... I would try not to blink and as soon as I blink I feel like I lose that scene and I moved into either a different view or a different part of the movie so then I feel like I've lost something so OK fine let's go on with it. (P40 Solo/Controller).

So, like a film editor -who not only chooses when to cut but when not to cut- by choosing not to blink P40 is curating the filmic viewing experience for themselves and the others in their group.

For participants in the original single controller version of *The Disadvantages of Time Travel* understanding and using control was momentary, users did not retain control over the film throughout the screening. Some enjoyed giving up the control, *"So you try not to blink. So that was, I think it did add to it, yeah feels good. I mean I could have let it go as well a little bit, but that was nice. Sometimes I just let go. It's good."* P31a. Some participants even forgot about their control for periods of time, with P1a saying *"I completely forgot, I was concentrating on the film then a couple of minutes the pressure point there started aching and yeah I'm wearing a headset."*

Withholding interaction seems to depend on engagement, intention and the extent of influence a controller has over the film, it is a form of control itself. Engaging with the content may provide a more positive experience to the other audience members or controllers. However, awareness of their control disrupts their ability to engage in the narrative. Control methods such as the Collaborative method, which limit the extent of influence, may mitigate against controllers reacting in unpredictable ways.

5.2 How people's physiology was felt

While filmic effects from Attention and Meditation data were observed predominately in the hyper-scanning version of *The Disadvantages of Time Travel*, effects from blinking were reported from both the original single user and hyper-scanning versions. We report instances where individuals relate to their own Meditation, Attention data and blinking across all versions.

5.2.1 Feeling feedback from Meditation data

Within the group's physiological mappings to cinematic attributes there is a lot going on. To separate out the different channels of physiological data let us look at how participants related to their own Meditation data when it is mapped to music. To recap, in the hyper-canning versions Meditation data, a number between 0 and 100 is assigned to a music channel mixer; the higher the Meditation level the more music layers play. Some controllers still do not understand what is meant by *meditation* or how the music changes based on that even if they have experience of meditating in their own lives. For some there is a feeling of not having control even when someone can feel the music change with their calmness. At some points a participant may feel they can control the music before losing that control.

For many controller's, feedback to their Meditation data was harder to feel than Attention or Blinking. For some this could be down to their relationship with meditative states, an inexperience of meditating, or just an uncertainty of what was meant by Meditation data, *"I'm not sure what meditation is"* (P25 Collaboration). Even when controllers had personal experience of meditating they did not necessarily feel their feedback through the music. Within the collaborative mode of course feedback is averaged and so may be even harder to perceive.

"I wasn't sure how the how the music was effected. . . I wonder whether I skewed that

because I do meditate because I do a lot of yoga and meditation so I might of squeezed that... it just I'm kind of I can switch off." (P28 Collaboration). This '*switching off*' may be similar to P22's relaxed state which they described as allowing them to become more immersed in the film. Indeed, understanding or feeling feedback does not impact the appreciation of the viewing experience, P43 was not aware of any control but still had a positive time; *"and I apparently did the music but I had no idea that I was controlling anything but it was kinda really interesting to me..."* (P43 Coop/Med/Music). Perhaps the method is so novel that even when a controller experiences control they are not able to identify it. P12 a Coop/Med/Music controller could be an illustration of this, they set out to have 'high' Meditation *"to be the best I could be,"* and they describe a moment where they become aware of the mapping of their state of calmness to the music, *"then there was point in the film where like if it was calmer on screen it made me feel calmer but then I noticed the music getting louder the more calm I got."* Yet they go on to say, *"I don't feel I had any control with it"* (P12 Coop/Med/Music). This is interesting as they simultaneously define and refute control.

For P40 they decide not to interact with their perceived meditation because they felt it was complementing their experience, *"when it came to meditation I didn't actively try to control that because the music, at one point the music I didn't know if I was controlling the music or the music was the one affecting my mood so that was all right that was in the background that was a bit ok that was subtle."* (P40 Solo/Controller)

For some however control is momentarily felt, *"and then there was at one point I felt like I was in control of the music"* (P4 Competing). It is especially complex to have control of the music in the competing mode, first they would have high Attention which would make them the sole controller then they would have to modulate their Meditation data.

Another controller who set out to influence the music and felt that they succeeded is (P29 Collaboration). Likewise, their control was brief, but what is interesting is that their mental state became entangled in the qualities of the film as we see in the following conversational extract:

(P29 Collaboration)

I was like I say a few times I was trying to figure out, I tried to do the soundtrack ones in fact I think I did do the soundtrack once I think at one point that was when I was looking around the room heres like staring and letting it all wash over me and then I felt that when I looked around the room it dropped away into the,

(Interviewer)

do you remember what part of the film that was at?

(P29 Collaboration)

it was in the, I think it was in the bit where there's the woman and I don't know what she is doing, the dance bit with the beats yeah, I felt that that was happening there.

The attributes of meditation are made apparent in the film's soundtrack and in the control of it. Even though some controllers feel they have influence, they make the link between their own calmness and the mix of the music, they cannot necessarily control their calmness. Indeed, the noticeable increase in volume, of the realisation that they are influencing the music may break their reverie.

5.2.2 Feeling feedback from Attention data

To put the Attention mapping into the context of the other two mappings, Meditation and Blinking. First compared to being in a meditative state, if a controller strives to be in a perpetual attentive state it is assumed to cause some stress *"I mean if you have the attention one that is a bit I think more stressful a bit because you are always trying to focus focus focus"* (P22 Coop/Med/Music). Second, when compared to blinking, Attention mapped to the blending of images is not as obvious as that of blinking mapped to hard edits in the film, *"yeah like I knew I was doing something but I didn't feel like I had as much control as maybe Participant 20 (P20 Coop/Blink/Cut)."* (P21 Coop/Att/Blend). Another controller thought they would be able to see the link between their ongoing Attention and the state of the film more than they did, *"I thought I would have be able to tell more clearly about what I was controlling."* (P11 Coop/Att/Blend). Another tried to interact with the filmic elements of the scenes, attempting to move from location to location by moving their focus. *"When it was like when I was eh the bike and the bus I was trying to get it to go to the bike and I was really focusing hard on the bike but it wouldn't change I couldn't get it to I didn't know how, I didn't really understand how what I was supposed to do or if I was meant to focus on something or"* (P11 Coop/Att/Blend). Likewise this controller tried to gauge their agency by changing their focus, but this time they were moving their attention from the screen to external points in the auditorium itself. *"I tried to control it I tried to switch attention. I was trying to switch from focused attention on the movie and trying to observe you and I dunno trying to switch my attention in the room I didn't feel any particular thing,"* (P36 Collaboration). Of course, it would be hard to see the film change if they are not observing it. For P8, in a Collaboration group, when they found their focus wondering they were reminded that their attention was being monitored and that brought them back to the screen, *"cos usually I wouldn't focus as well as I did that time, because I kept, I looked away "no wait I have to stay here."* (P8 Collaboration).

Some controllers did feel their own attention feedback, in a Collaboration mode. (P7 Collaboration) was able to say that they could identify their own agency in the film, "*Even after having that film once I felt like that was, OK that was me*". Further, (P11 Collaboration), who above said they weren't sure of their ability to influence the film, describes the process working, *"Or there's like ... two different things sort of happening on screen and I'd focus on one and it would focus in"* (P11 Coop/Att/Blend). As high Attention data will bring one image into clarity, low attention data will bring the other layer in fully there is a 50/50 chance that the image focused on will become prominent.

Hence, the controllers do not know from the film if their Attention is high or low, each extreme will produce a clear image. There is a feeling of movement and change however that the controllers do attempt to interact with, *"attention was fine but I would think that if attention was raised the image would become more sharper instead the other way around, cos if I'm losing attention maybe then other scenes would come in and if I focus on that and it would become clearer but it seemed to be the other way around so I had to space out for it to become clearer."* (P40 Solo/Controller).

The use of Attention data may cause more stress for people than engaging with a Meditative state, and compared to blinking there is less evidence for direct control. The interaction is quite opaque, when controllers know that their attention is affecting the blending between two layers of visual imagery it is not clear which image is mapped to high and which to low Attention.

For some they might try changing their focus, experimenting with their own feeling of attention to see if they could observe changes in the film; for others, the knowledge their attention was being monitored would remind them to keep their attention on the film.

Some controllers (P11 and P20 Coop/Att/Blend) above, noticed a sense that the film reacted to their attention and felt that the film was reacting with or against them.

5.2.3 Feeling feedback from blinking

Being able to now separate out the blink to cut mechanic means we can explore how it affects controllers' journey to control, narrative construction and comprehension. As we will see, the explicitness of the blink and the cut make it the first mapping that is felt, this is especially so with Coop/Blink/Cut and Solo/Controllers in the hyper-scanning version. It is felt first and felt most. The blink to cut mapping makes people hyper aware of when and how often they blink. For controllers who have multiple mappings (Collaboration, Competitive, Solo/Controllers) the straightforwardness and effectiveness of the blink mapping amplifies the ambiguous nature of Attention and Meditation mappings.

Furthermore, the cut that the blink produces is often seen as disruptive to the story, with controllers actively trying to abstain from blinking to allow the narrative to flow.

The blink mapping can give controllers active control, but when they exercise that control there are side effects. It makes them actively aware of their own physiology, which is not a desired state for cinema goers. *"and then there were other times where I probably had bit more an active awareness of the fact that like I had something to do with the scene changing especially with like when I blink and something will change"* (P2 Solo/Controller). This awareness of their own (semi) conscious physiological actions can become overpowering, and make controllers hyper aware: *"[I was] so self-conscious of my blinking (laughing)"* (P45 Coop/Blink/Cut).

It is common for controllers to try to experiment with their interaction, blinking is obstructive of two things: first, to the understanding or feeling the other mappings and second, to the flow of the film. *"First of all I was trying to feel for the few things that you mentioned like what happens when I space out, what happens when I focus, what happens when I blink. So I tried not to blink too much because it will cut the scene. The scenes will cut and the it wouldn't really make sense,"* (P40 Solo/Controller)

Although blinking is directly mapped and available to control at any time, it is also involuntarily. When a controller feels that to blink is undesirable this can causes stress. Thinking about the next time they will blink interrupts moments of immersion in the story.

> I'm not sure actually that you can consciously I mean you can control blinking to such an extent but then but you either close your eyes or have to blink and for me this was something that distracted me that was you know feeling like was it going to change again if I blink? Am I the one who is controlling and sometimes I felt I was and I just didn't want it to change for some time and I couldn't and even although consciously wanted to happen it didn't

> because physiologically you can't not blink for such a long, well I can't. (P24 Coop/Blink/Cut).

For some it was not just their immersion that was compromised, but the structure; the construction of the story became something that the blink-to-cut mechanic also caused controllers to be concerned with. Cinematically, the cut and the blend are felt differently from each other; it must cut to somewhere else, which can be seen as not encouraging flow. For these reasons some then try not to utilise the cut interaction. *"yeah so, because we were all watching it I didn't want to blink too much because blinking would ruin the sequence of events, but I wasn't too concerned about the music, and the, - I got to a point when the different images started mixing up I tried to actively get them out like clean it,"* (P40 Solo/Controller).

In a rare instance of the collaborative mode where a controller feels that blinking is synced to them it becomes too strong an interaction and they refrain from blinking, *"I felt that was like the flashing images I was like its changing every time I blink I don't like it, I was trying not to blink (laughing),"* (P8 Collaboration).

(P40 Solo/Controller) continues to describe the blinking mechanism discouraging cinematic construction, as it becomes a conscious choice to cut the film they feel they *"lose"* something when the cut happens. Similar to making a choice at a juncture point in a branching narrative they are left wondering what is happening in the other path. They feel this to the extent that they would rather blinking wasn't part of the interaction.

> I would want to see the end of the scene so because [of] that I would try not to blink and as soon as I blink I feel like I lose that scene and I moved into either a different view or a different part of the movie so then I feel like I've lost something so OK fine let's go on with it. So, I think blinking might be, I don't know maybe it's because I knew blinking would ... change the scenes that's why I decided not to blink, I guess we are used to movies flowing in a certain

> way so yeah, I would probably leave out the blinking. cos that would actually people might make a conscious effort as opposed to meditation for instance. (P40 Solo/Controller).

We see with the blink mapping a tension between active control and involuntary physiological response. A tension between participants' ability to repress blinking verses their desire to construct a meaningful cinematic narrative.

5.3 Visual and narrative interactions

We explore how participants engaged with the visual language of the film, the narrative, and interaction at different levels and how one technique can have an effect on another.

5.3.1 When interactivity helps the story experience

There is the impression for some that to be the controller increases the readability of the film narrative:

"*I mean because I wasn't in control, there were moments where it was hard to follow the narrative and where it was going and why certain things were happening the way they were*" (P1 Solo/Spectator)

In contrast, as we saw in Subsection 5.1.4 (P22 Coop/Med/Music) describes becoming immersed with the film, by empathising with the characters and their situations. This immersion is described as a state of entanglement with the film which 'neutralises' the impulse to try to actively control.*"I was actually watching a film like, rather than trying to like you know mess with my brain..."* (P22 Coop/Med/Music). Being immersed in the story does not only happen when controllers give up control however, the following two controllers report active interaction adding to their experience of the story: "*[I was] certainly more into the story, the interaction I think because you're when you're actively* *interacting with it or trying to you are trying to get something out of it.*" (P35 Collaboration). "*there was some points that made me immersed more because I knew I was controlling it. Like for instance with when they had the knife on the boy's throat like I was like I was almost willing myself I was like No! get them to not cut the boy, get them to not cut him! (laughing) and I was like trying to use my mental powers to change them and then when they started kicking them I was like well that [is] not really what I wanted either (laughing) but I suppose it's better than nothing.*" (P16 Competing). Both these controllers are striving to steer the story. We saw positive reactions when actively attempting control when there is a perceived possibility of changing the story. Even though they may not get the results they desire, the act of "*actively interacting*" or using "*mental powers*" contributes to getting "*into*" or "*immersed more*" with the narrative.

5.3.2 Moving between narrative and visual immersion

The Disadvantages of Time Travel is a visually rich film, it is designed to deliver a constantly changing stream of images, as well as telling a story. P1 understands that the interaction is via feedback based in filmic language. "*The control is more over the visual rather than the narrative, is what it is at the moment isn't it.*" (P1 Solo/Spectator). They separate and define the control as visual and unconnected to narrative, P40, a solo controller is less sure of how much of the narrative they controlled,

> How do I feel about the movie? see, the thing is I don't know how much I control apart from the visual aspect, I don't know how much of a story line I controlled, so I can tell I was maybe the switching of the scenes, the image meshing the music I couldn't tell too much but then as to whether the film would have ended differently I don't know if it was because of me that it ended how it ended or that's how it's supposed to end I don't know. (P40 Solo/Controller).

By only seeing the film once P40 has open questions as to how it might play out at another time. They feel the extent of their control is not fully explored in a single screening. Their visual blending and temporal montage feedback is understood and felt with a single screening but narrative interaction is not. P22 describes their switching from focusing on the narrative to the visual layers of the film and back again. They are interacting via the headset with the music and so will not be causing effects to the visual blending, however even without that mapping they are still engaged in the visual transformations:

(P22 Coop/Med/Music)

I remember specifically I don't know, well not specifically I guess but if he was in the car or something and he was moving and his head was actually like the landscape in the back? I would focus more on the landscape because I was feeling a bit woozy a bit so I was like o I'm gonna focus on this landscape and things like that but yeah it was his head. you know. that was interesting.

(Interviewer)

and did that detract from, did that add something to the film or detract from the readability of the film.

(P22 Coop/Med/Music)

I think it did I mean for me I think it did cos I had to focus on one layer and then have to then kinda get out of that and then focus more then back to the story of the film,

(Interviewer)

it did sorry?

(P22 Coop/Med/Music)

it did it did distract me a bit yeah, because I was so interested in

> the story but then I was so interested in the different layers of the film as well yeah.

The above excerpt shows that participant who do not have control over what they are seeing can go from immersion in the story to immersion in the visual language of the film. There are relationships between characters, narrative, and visual interactions that impact on the reception of the film. Understanding the characters allows the viewer to let go of control and become part of an entangled narrative system.

5.3.3 Aesthetic interactions

Controllers spoke about the visual interaction, how the blending of the film layers made them act and react. For some it encouraged interaction, to explore the film, but for others it became a barrier, overwhelming the narrative.

The blending of layers offered a choice of what image to attend, the ongoing variation gave them an opportunity to identify their agency. "*I really liked when it mixed different things on screen at the same time so I was trying to work out what made it do that. I was like do I pay attention do I not pay attention? (laughing) yeah,*" (P13 Solo/Controller). The appreciation of the imagery offers the choice of which image to attend and becomes an interactive mechanism as P23 reinforces, "*I thought the textures were really I mean nice to see kinda just what I was talking about the background and then the face and then there's another layer all in the same shot you know, you are trying to kinda focus on one but there is that one there and that one there so which one do you focus on?*" (P23 Coop/Att/Blend). As well as representing part of the narrative (the boundary between reality and fantasy) the blending of visual layers is a technique of interaction. It is constantly there reminding the controller that there is an opportunity to interact and explore the film. P35 also makes this case adding that it not only encourages the direct mapping interaction of Attention/Blending but that of blinking to edit as well.

> Having the layering of the visuals was quite nice because it meant

> that when you could sense there could be another way to look at it so you could blink between these two ways of looking at it or three ways of looking at it so for me having that visual layer helps prompt me that there would be another way to look at this film, (P35 Collaboration).

Some saw this spatial montage as a creative tool that assisted in creating an original film. (P44 Coop/Att/Blend) places their self 'in' the film, hinting at a closeness and immersion, "*I wouldn't say that it was detrimental to the experience though no. Because having that superimposition of one scene on top of another creates something completely new that we don't get to see, almost reminding you that you are in a film. I think that could work to the advantage yeah.*" (P44 Coop/Att/Blend). Blink/Cut controller P45 from the same group described a visual satisfaction to cutting the film by blinking unconsciously and that this encouraged them to interact, "*a bit of both yeah, a lot of it was just we did it without thinking and oh, that looked cool you know and you try and do it again*" (P45 Coop/Blink/Cut). For these controllers who appreciated the visual style of blended imagery there was a feeling that it added to the narrative and encourages interactivity.

However, this is not the whole story, for others these '*crazy transitions*'- (P1 Solo/Spectator) sometimes caused confusion, and overwhelmed audiences and controllers. For some, the visual aspect dominated the narrative. The perceived abstract nature of blended images caused a disconnection with the story. "*Yeah so it's interesting, I think I was more -I experienced it more as an abstract thing and less in terms of the storylines and it just lended itself to that for me.*" (P24 Coop/Blink/Cut). Likewise, P22 found the visual aspect of the film withdrew them from the narrative, "*... the different layers of the cinematography took me out of that for sure took me out of the actual story,*" (P22 Coop/Med/Music). At certain moments the cross dissolving of shots can obscure details within those images as the following two participants point out, "*like the fading between scenes, I didn't expect that but it was interesting, sometimes it was hard to see what was going on but, yeah.*" (P21 Coop/Att/Blend), and "*so, it was confusing for me when there were too many layers* *at the same time and I tried to figure out how we can focus on just one layer (laughing) or maybe two because sometimes it is really cool to see two things at once but if, sometimes it is getting confusing,*" (P26 Collaboration). This constantly changing spatial montage of images, caused even more disruption, "*so for me it was a bit overwhelming all together to like focus on the constant changes in the, in the sort of the cuts but not necessarily just the blinking but altogether there was a different perspective*" (P24 Coop/Blink/Cut). However, this was not a permanent state, and participants could become acclimatised to the visual style, "*yeah, interesting obviously because it is so essentially like there is so much going on its quite overwhelming I think at first but once you get used to it I think its quite interesting,*" (P38 Collaboration).

5.4 How people were affected

As we have seen the interactions happen a lot in the controllers' minds. These can be positive and negative, mindful interactions can cause moments of reflection, both on the film content and on their own thoughts. Although in extremes controllers can become overly critical of what they are thinking. Perhaps one of the most surprising findings is from controllers reporting an altered state of consciousness once finishing the film.

5.4.1 Feeling vulnerable to being judged

There were instances where participants feared that the controller had some vulnerability. That a value judgement could be placed on how they interact with scenes, themes or actions within the film. "*there's a level of exposure as well as an individual so if I'm the one to be wearing the headset and if I get uncomfortable ... kinda putting yourself on the platter you're exposing yourself to the people you are with,*" (P1 Spectator/Solo). How one would come to that judgement over a controller was not made clear but another controller felt that perhaps people would think the controller was responsible for the events that take place in the film. "*I was just like oh my god what's gonna happen next? I really hope he doesn't do something really violent 'cos maybe people will think that I am violent (laughing),*" (P2 Controller/Solo). These opinions show a general anxiety about the technology as much as the cultural experience. As one controller puts it "*you don't need to judge my brain*" (P16 Competing). Others expressed fears regarding the privacy of their mind being infringed especially when in a group of people that they don't know, "*I think I would feel a bit exposed, because I feel that they are reading into my mind.*" (P27 Collaborative). This is echoed by P13 who fears the researcher has insight into the controller's mind. "*I think I was aware of like what you'd be able to tell from the way it was cut or like if you would know if I lost attention (laughing),*" (P13 Spectator/Solo).

5.4.2 Self-discovery

In the process of interacting with the film there is an element of self-discovery, in that controllers become aware of their own thoughts, their body and to the amount of control that they have over themselves.

The film experience is imagined by some as a personalised film made specifically for the controller(s): "*does that mean that like its gonna [be a] little film for our own head?*" (P4 Competing). Even from a spectator's perspective it is felt as more akin to a virtual reality experience, "*it's more the personalised journey so to speak cos, I guess the way the film is pieced together and re interpreted is kind of a journey so I say more towards VR as well I think.*" (P1 Solo/Spectator). Perhaps this feeling of closeness adds to a level of intimacy which the controllers reflect on.

Indeed, as we have seen, the controllers will test for their control and as part of that they exercise their own physiological and neurological states. "*whether its emotions or whether it is just how calm or relaxed you can make your body.*" (P16 Competing). By doing this they may discover things about themselves, "*I think it made me notice when I lost concentration,*" (P8 Competing). Likewise, the process of interacting with the film can encourage a self-reflexivity as the controllers reflect in the moment what their thoughts are doing, "*I felt very aware of what I was thinking so I was constantly thinking about what I was thinking. Like I was trying to make sense of the film but at the same time I was, cos I knew we were concentrating on what our brain was doing I was also concentrating on that*" (P4 Competing). The concept is that *thought* is as a perceived method of interaction, and dwelling on these thoughts may cause anxiety because these thoughts may not be controlled or even controllable. "*... there is definitely that element of I guess fear maybe or concern or like over thinking things.*" (P2 Solo/Controller). This realisation, of what is being thought and how much that is controlled can give the controller insight into themselves, "*I think you are kind of exposing yourself it gives you insights into your own psyche how the makeup of the audience effects the experience/interactor's reactions as well like how comfortable I am reacting to certain things in front of people and then when I'm alone how do I react differently so it's sort of an exploration of yourself at the same time while watching this film, having this experience.*" (P1 Solo/Spectator). So not only is there insight into themselves, there is a perception that with further viewing more can be discovered about their own mind and self.

5.4.3 A psychedelic experience

An interesting result of interacting with the film is that controllers may feel 'altered' after their experience. In fact, as we will see many directly liken the experience of the psychedelic. From a spectator about to watch who foresees the experience to that of taking a psychoactive substance, "*which then may end up being like an LSD trip.*" (P3 Solo/Spectator), to a competing controller having an uncanny moment, "*I've just had a really big deja vu moment yeah, (Participant 17) said that before*" (P16 Competing). P16 was not alone in having a mind altered reaction, in the same post viewing interview, (P17 Competing) said, "*I think it was quite trippy like*" That same competing group go into more detail as to how the visual construction of the film is facilitating a hallucinogenic state.

(P18 Competing)

Yeah cos you don't actually, no see it has kinda two side like you can see a background and your trying to see what the background is then you forget about the actually picture in front of it so that a bit trippy on a way.

(P17 Competing)

I feel cool.

(P16 Competing)

I feel little bit trippy still. A littlest like what did I just watch?

It is worth comment that this mental state persists, for the group, after the film has finished, as the above exchange took place two minutes after the film had finished. It is also worth noting that this group was mistakenly told they were using the Cooperative control method: P16: was told they would be in charge of blending, P17: was told they would control music, P18: was told they were controlling via blinking.

Yet another controller who expressed a continued feeling of being in an altered state is P22, "*I'm a bit confused, I feel like I've just taken a couple tablets of acid or something and watched this film like, it just took me out of reality too much that to be put in this thing to come back and actually speak I'm a bit different now, yeah. Good*" (P22 Coop/Med/Music). Perhaps this is less surprising when we look at the etymology of the word psychedelic, *psykhe* meaning mind and *delos* meaning make clear, or reveal.

In this chapter we explored what arose when participants related to their singular experiences of interacting with various designs of *The Disadvantages of Time Travel*. We were able to define different stages of control; discovery, conscious and unconscious control, and awareness of the affective loop they found themselves in. We further explored the feedback they feel from the three specific physiological measures (Meditation, Attention and Blinking). From focusing on these measures we saw that blinking was a strong and sometimes overpowering interaction, Meditation was rarely felt and less so controlled, and controllers using Attention felt some correlation between the visual presentation of the film and their own assessment of their attention. We saw that people had shifting prominence of engagement between the narrative, the visual qualities and their agency of interaction. We also discovered secondary responses they had in relation to the film, from feeling vulnerable, to feeling mindful to feeling altered. Now that we have a baseline for how individuals experience their own control, the next chapter will look at how groups of individuals interacted together in the hyper-scanning version of *The Disadvantages of Time Travel*.

Chapter 6

Results 2: Social aspects of *The Disadvantages of Time Travel*

The results collected here from Study 2 relate to moments where people interacted with each other via their BCI control. Again our analysis of these interviews is done in the mode of Braun and Clarke [2006, 2012] as detailed in Subsection 3.4.1 of the Methodology Chapter. The study design for Study 2 can be found in Section 4.5. For detailed description of control and mapping of the hyper-scanning version of *The Disadvantages of Time Travel* see subsection 4.4.1, and abbreviated in table 4.3 which also distinguish participants' screening version and controlling role.

6.1 Working together

The theme of working together was quite prominent in the data, especially with groups that reported satisfying cinematic experiences.

6.1.1 Group dynamics

The Participants from all the multi-user screenings were video recorded so we had a record of the interaction. On review of these recordings we see they stare straight ahead and watch the film with little or no physical interaction with other members of the group. However, the presence of others, their reported interactive behaviour and whether they know each other or not, all become factors that influence their behaviour as a group. Consequently, the experience of watching and interacting becomes social.

The following audience/controllers came to realise that they must work together to create a meaningful version of the movie. When interacting in a group with the film, the membership of the group and how they might react becomes important. "*I think it really depends because if I knew the other two who were taking part with me if I knew their personalities I might be able to predict but right now I don't think I'm in a state, it could go either way.*" (P27 Collaboration). If the members of the group don't know each other they report it will be unlikely to predict what will happen, "*yeah or, if I'm using it as a user I think I would rather use it with people I know, it would be more predictive [sic] for me,*" (P27 Collaboration). In addition to how well the participants know each other, just by being part of a group causes this audience member to wonder how they might behave or react differently, "*as well like how comfortable I am reacting to certain things in front of people and then when I'm alone how do I react differently,*" (P1 Spectator). The following participant considers the Cooperative mode and wonders if by dispersing control could create a readable or harmonious film. "*I think the one where we all compare different aspects [the Cooperative mode] would be interesting to see if it fitted together controlled by different people or not,*" (P13 Solo Interactor).

We see there is an initial effect from multiple users interacting at the same time by their very presence. But how do other elements of the interactions create affects across the groups and how do people impact each other within the experience?

6.1.2 On the same wavelength

Here there is evidence that other peoples' thoughts are present throughout the experience, "*yeah you're constantly thinking about what they're doing,*" (P18 Competing). Even in the Competing mode there is evidence of intended collaboration. In the next example a controller is assuming that because they want one layer of the video to become clearer, others are thinking the same. They are assuming there is a correlation with their Attention data. "*When I was watching it, I was trying to... cos I thought I was doing the blending right I want this to be clearer so they must want it to be clearer,*" (P16 Competing). This preference to collaborate is reiterated by a fellow controller who makes a connection between collaborating within choreographed dance practice and the Collaboration mode of *The Disadvantages of Time Travel*.

> ... especially cos we know each other it would be quite cool to have the one where it's the average maybe because especially when your dancing an' stuff like that sometimes you kinda have to try and get yourself on that same kind [of] mental wavelength as weird as that sounds so it would be weird to see it in that mindset with three people that know each other quite well, how, like what would come out of that, (P17 Competing).

This describes controllers imagining mentally collaborating to create an artwork, transferring their collaborative and creative experience as a dancer.

A direct example of mental collaboration is within a Cooperation group, there is a feeling of working together, of group creation. The following controller who is affecting the music from their Meditation data sees the other modalities of control synced to the group's intentions. "*We were all talking about like it felt that it should be cut there, there, it probably influences, especially the blinking decisions (laughing),*" (P43 Med/Music/Coop). This happened without prior discussion, as the group only understood how they interacted together in the post movie discussion. "*I think the strange thing is if you were to take* *that and upload it to YouTube or whatever it would feel like all of that was done for some artistic reason and it still felt cohesive even although we weren't talking to each other,*" (P44 Att/Blending/Coop). It may be relevant to mention that the members of this group knew each other. In this Cooperative mode, the group worked together to make the film enjoyable and interesting for each other. P45 speaks about the group unconsciously manipulating the film. They become aware of what happened because it was cinematically pleasing and so attempted to repeat. "*...A lot of it was just we did it without thinking and oh, that looked cool you know and you try and do it again,*" (P45 Coop/Blink/Cut).

There are triggers from the film, how it appears that brings the controllers thoughts to what other members of the group are thinking. "*As well when there was like, just a kinda passing thought in my head [...] when the picture or like was changing really, really quickly I was like what are they thinking about.*" (P17 Competing) Here, the trigger was produced from the group's blinking. Each third blink is creating a cut, "*changing the picture*" and so the controller moves their attention to the group.

One controller did wonder about how collaboration may happen and worried that the other members of the group may not be in sync. In a pre-screening interview a participant said, "*Yeah. it could be a good collaboration or it could be like numbers all over the place and the average could be dispersed,*" (P27 Collaboration). It was clear that they worried about the other members in the group's performance, continuing, "*What if they're rubbish?*" However, in that particular group, after the screening it was another controller that felt let down.

> Obviously you can't say this but I feel that I did my best to be calm and to slow that film down - I don't know about those two. (laughing) it would be interesting to see like whether I really was being the calmer one or not because I felt that I, yeah, those two messed it up. (laughing) no I don't mean they messed it but it just not being able to control it yourself but I wonder if I really was the calmer one, (P25 Collaboration).

P25 feels the other two controllers responded differently and this was detrimental to their experience. There was an assumption before and after the film was played; if the group was in sync with each other it would produce a more positive experience.

There were moments where participants blinked at the same time as cuts even when their blink was not controlling cuts, as we see in the next two quotes: "*me sometimes, it wasn't like I was doing it purposefully, just by accident*" (P15 Solo/Spectator). "*yeah, a few times we blinked at the same time and I thought it was me,*" (P11 Coop/Att/Blend). While this may be coincidental it still produces a connection between the participants through the film.

The following exchange between members of a collaborative group, where every third blink produces a cut in the film experienced something similar.

(P28 Collaboration)

Do we blink at the same times?

(P29 Collaboration)

yeah, or that going blink blink blink and its changing but then its changing again

(Interviewer)

Yeah, I noticed it would go one two three, then one two three really quick, maybe seeing the cut would make you think of blinking and all three of you would blink at the same time

(P30 Collaboration)

Maybe.

(P29 Collaboration)

Yeah it seemed like a lot - the blinking like maybe more than one person alone blinking would switch it.

Here we have seen that participants reported instances where they felt themselves synchronising together, and compared it to collaborating in other artforms. Some would assume that the other people wanted to see the same things on screen and were doing the same. The effect on the film created a curiosity about the other group members thoughts. For some, they unconsciously and actively worked together as one entity to create an satisfying artwork.

6.2 Considerations and limitations of responsibility

In this theme we will see how controllers together relate to the responsibility of others experience. We will see that controllers fall into two camps, some work together to make an enjoyable experience, and some individuals may try and direct the film when they are sharing control. We reflect on the positive and negative consequences of these actions

6.2.1 Responsibility to others

A group of people, all contributing in different ways to a single shared experience can exhibit a responsibility to each other to create something that is enjoyable to others, "*I want them to enjoy the movie as well and it not to cut so fast or blend so fast,*" (P16 Competing). As we have seen, controllers go between actively and passively interacting. The felt responsibility encourages an unselfish behaviour to interact for the benefit of others in the group. "*And I did at times feel that OK I need to alter the experience for those around me and stay focused at sometimes,*" (P23 Att/Blend/Coop). Here the controller feels an impetus to take initiative. They resist their mind from wondering and actively motivate themselves to be immersed in the film for the sake of the others in the group. P24 from the same group agrees, reporting that they consciously manipulated the film. "*I did the same thing sometimes I tried to blink a lot and sometimes I tried to close my eyes, and then I had opened it and tried to see if that had an effect,*" (P24

Blink/Cut/Coop).

In one group a controller felt a strong responsibility of providing 'good' experience for the rest of the group and made conscious efforts to do so.

> I felt that there were cycles, as I mentioned and because I'm not very good at multi-tasking I'm probably better at focusing at one thing at a time I was switching from more a director view to a giving the experiences to other people and literally having moments to try and maybe give them a different experience so I was taken out of the story for bit and moments where I would be really watching the movie so going back into the viewer or the audience so in a way I guess it influenced my experience the interconnectivity but not in a bad way. There were moments where I felt (P35 laughing) was doing that, so. I wouldn't try to control anything of moments where I was really into the story. (P36 Collaboration)

A lot is happening in this excerpt, which I will unpack for clarity. P36 went through phases of being immersed in the story and passively interacting, and being "*out*" of the story and trying to exert control on the film. To exert control, they would blink until they felt their blinks were producing cuts in the film. However, the collaboration control method produces cuts on every third blink and so the film responded by cutting much faster than usual. P35 laughs ironically as they feel patronised that someone should feel the need to control their experience, as they make it clear later by saying, "*I've learnt something about (laughing) someone's desire to control my experience (laughing).*" The third controller from that group also comments on the particularly fast cutting of this screening: "*it makes my mind and brain and eyes a bit more tired than watching it in a normal way ... I don't know whether it's the video content or [that its] interacted by other people it makes all the scenes are changing very quickly,*" (P34 Collaboration). Upon the realisation that -what they believed an unselfish interaction strategy produced a negative effect on their fellow controllers P36 concludes, "*so that's my end of career,* *director career.*"

We have seen that members of the controlling group feel responsible to their fellow controllers for the creation of the experience. However, acting on that responsibility can come with unintended side effects. Furthermore, if the film's themes make them uncomfortable, these feelings may cause them to override that responsibility and withdraw their interaction. When foreseeing controlling the film with a large audience watching there are mixed attitudes to their imagined responsibility to that audience.

6.2.2 Directing for others

As seen above, the controllers feel a responsibility for others in their group. When a controller feels that they have the power of the director, the power to manipulate the emotions of others, do they use it? Here we further explore the motivations of why one such controller who does, and their explanation why. "*The actor was watching him[self] in the mirror I was trying to take control so I was literally just blinking continuously because I thought I might give them a better experience, I felt a little bit part of being a director in a way. I thought it's nice to change the screen very quickly and go back and forward.*" (P36 Collaboration). They interact to increase an emotional reaction with their fellow controllers, "*It was kind of emotional watching it and sometimes dramatically changing the scene very often would fit would probably increase the pressure in a way at certain moments*" (P36 Collaboration). These moments when P36 consciously chooses to interact with the film on the behalf of the other controllers did however remove their engagement with the story. This controller does have some reservations on how they would perform the film to an audience however, and would like to gain a proficiency of interaction with the film first, "*yeah I would feel maybe weird to give other people the experience so I don't know whether they would like what I would do with it. I would test it a little for myself first. In a way you become a director little bit of a director, you decide which camera to show.*" (P36 Collaboration). Another controller that saw themselves as the director felt that they weren't watching a film but actively editing it, "*it was yeah, an* *interesting film, I thought like with the blinking (blows) I don't know I felt that I was like the director of the film...I was sitting there like oh shall I do a jump cut now or should I do it later... y'know I wasn't watching a film, I was clearly sitting here thinking about when I should blink when I shouldn't blink and doing what I would like to see best.*" (P20 Coop/Blink/Cut).

6.2.3 Controlling for audiences

Controllers imagine how they might feel about controlling the film with a large audience based on their recent experience with *The Disadvantages of Time Travel*. Generally, controllers envisage more pressure; they would not want to get distracted while controlling and would like to please the audience. Some may not care about an audience that they are not going to see again. Some feel that sharing control with the group will split the responsibility, or even doubt they will have space to worry about an audience because the interaction with the movie will take all their resources. "*maybe it would matter in terms of living the experience, cos if you have a room full of people then its somehow the whole embodied experience is totally different, so in that sense I think it would matter, I may feel a little more pressure or a little bit more but the actual experience I think would be different,*" (P24, Blink/Cut/Coop). This shows a limitation of asking participants to imagine how they might feel rather than reflect on an actual event. However, some valid points and strong opinions were raised.

For example, one controller showed an extreme disinclination to the idea of having an audience present, "*I would be horrified and mortified to do that. Much too much,*" (P20 Blink/Cut/Coop).

P27 observes that audiences may prefer different types of films and is anxious that as a controller it may be hard to match the tone of the film to the audiences' preferences.

> That is why I feel like if I control it and a full audience watches it these kind of things would make me feel a bit nervous. I'm like

> what if they don't like the way my brain is thinking about this movie right now, what if I am making it darker for them? Or if it's an audience that likes darker movies what if I'm making it too light for them and they are bored all of a sudden? (P27 Collaboration)

P17 sees a difference between passively watching the film and actively controlling it. With a large audience they would like to curate the film based in their personal preference. "*I think I would have tried cos there was some points where I kinda let myself just watch the film and just... but if I think there was more people I would tried to have like kept [what] I thought were nice for longer,*" (P17 Competing). A fellow controller agrees but feels that controlling the film to an audience they don't know may reduce the pressure felt to produce a 'nice' film. "*If I knew the people in the audience ... I'd be more self-conscious of what I was controlling for them to see,*" (P16 Competing).

Another group is less certain that a larger audience will make a difference. The following conversational exchange of a cooperative group shows a feeling that the responsibility would spread out when interactivity is shared.

(P24 Blink/Cut/Coop)

I don't think it would matter either, if it was only me controlling it maybe, but if its three people who's controlling it think I don't think it would matter much.

(P23 Att/Blend/Coop)

Yeah [...] slightly more pressure but the same concept,

(P22 Med/Music/Coop)

I mean the film is so intense as well it would be difficult to even think about them.

This last comment refers to all cognitive capacity being taken up by engaging with the film, there being no space for considering the audience.

6.3 Competing paradox

The Competing mode needs special attention as it has some differences from the other modes. While it was a popular mode when participants were told about the various control methods, the actual experience of interacting in the Competing mode was perhaps the most confusing to controllers. Active control would flit from person to person as whoever has the highest NeuroSky Attention data became the sole controller. Thus, controllers may feel they are in control while a correlated blink and cut occurs. However, this is fleeting and some participants may feel someone else is in control or not feel any control at all. As we will see this swapping of active controllers is an added layer of interaction and may reduce narrative immersion.

The loss of interaction causes confusion as using control disrupts attention. In the following example P4 realises the moment where control has passed to them when a blink correlates with a on screen cut but is not able to tell when interaction moves to someone else. "*I'd blink and then something else would happen I'm like so am I in control of the music am I blinking?*", (P4 Competing). The interactive design of this mode encourages people to blink to try and feel if they are the lead controller. Correspondingly this testing for control is reported more so in the Competing mode than in others. When a controller feels they have control it appears the disruption to their Attention data will cause them to 'loose the lead' and allow someone else to become lead controller. "*yeah I felt like near to the end where it was that girl and it kept switching and I was doing it I was blinking to see if it was me and then eventually it stopped so after that I just trying [to] do things*" (P5 Competing).

While it may be difficult for the controllers to feel when they are in control it seems they are able to perceive other people's agency. "*I thought that maybe there were points [that I was in control] but then maybe I became conscious of it then I thought I maybe lost it. Cos* *it kept changing and I thought that's definitely not me,*" (P31 Competing). This agency is perceived by the cuts to the film, but it is not just the film cutting evidences interaction "*and then everything went blurry and I was like, who is doing that?*" (P4 Competing). Here they see a cross dissolve in the film but do not feel it was themselves that created it.

For others this interaction mode provided no feeling of control at all "*currently I don't think that I'm controlling anything,* "(P32 Competing). For the controllers, trying to figure out who is in control results in losing control and may disrupt the flow of the narrative. It becomes an extra layer of interaction that is not part of the narrative and thus can get in the way of immersion. "*I suppose the only thing I would say is that you are also intrigued as to who's controlling it that kind of takes away a factor of concentration cos . . . in your head when you blink and it jumps and you think oh I'm controlling it now and it kinda takes away a bit of like concentration from what you're watching,*" (P38 Competing). This attention to the act of striving to interact brings the same controller to be highly aware of their situation, "*I think it makes you more aware of what you are doing. So, say you are watching a normal film, if like you are watching it for the story then you kind get lost in it whereas this is quite disjointed. I was more focused on the fact that we were watching the film rather the fact that there was some sort of narrative that played along of a boy being bullied or whatever.*" (P38 Competing). In short, the constant wondering about who is creating what effect is at odds with the lean-back reception and active meaning making of cinematic content.

6.4 Cross controller affect

We see interactions between three things, their own physiology, the film's cinematic narrative and other's supposed levels of blinking, Attention or Meditation.

The following two exchanges show some participants who are more aware of their own blinking or have their blinking affected even when it is not interactive. In the first group the controllers are speaking about P10 a blink to cut controller who, as we have seen was alternately blinking or not blinking independently of the movie.

(P11 Coop/Att/Blend)

I think cos that blinking was like quite a big factor in it every time I blinked I was thinking I just blinked. were you thinking that?

(P12 Coop/Med/Music)

Yeah.

(P11 Coop/Att/Blend)

Even although you were not getting measured

(P12 Coop/Med/Music)

Yeah.

In the second group the Solo Controller blinked at random times throughout the film. Even although other two members of the group have no feedback mapped to their blinks they become hyper-aware of their own blinking. The semi-autonomous nature of blinking makes a non-controller in the this group feel that they lose control of their own blinking.

(P15 Spectator)

It was like I couldn't stop blinking

(Interviewer)

And you weren't controlling it

(P13 Solo Controller)

I was aware of when I was blinking

(P15 Spectator)

Even though I was I could not stop blinking.

Thus, the blink as an interactive mapping not only causes interruption to the blink-mapped controller but to the audience as well.

Another instance of one controller's behaviour affecting another's is demonstrated through cinematic language. Specifically, the effect that the cut has on the music, where music is mapped to Meditation. The following two controllers speculate on how this may be the case, "*surely the cuts the person that's doing the blinking that would somehow affect the music*" (P19 Coop/Med/Music).

"*But if its constantly cutting then surely you won't be having calm music,*" (P20 Coop/Blink/Cut). Their predictions are that if the film is cutting quickly that this will impact on the controllers Meditation data and thus on the music mix.

The editing of the picture did have an impact on the reception of the music, "*The cutting, definitely the general editing I mean I think it made it difficult to focus [on] the music I honestly just toned out through most of it just became part of, part of the experience,*" (P23 Coop/Att/Blend). We can see an instance of both the cutting and blending of the film making an impression on a Coop/Med/Music controller, "*And then you'd switch and you'd fade out and I was like wooooooah (laughing),*" (P12 Coop/Med/Music). Although this may just be an appreciation of the system at work, the cinematic changes have caused a perceived affect on them.

This Coop/Med/Music controller talks about controller (P10 Coop/Blink/Cut) who was uncomfortable during the screening, "*I feel like I was more trying to interact with him if there was a part where it was a bit weird to watch*", (P12 Coop/Med/Music). His focus is moving from the film to their fellow controller when he found the film to be '*weird*'. This weirdness was not defined and may be the content of the film as well as effects of P10's withdrawal from the interactive process.

Seeing the effect that others blinking has on the film causes other spectators and controllers to focus on their own physical blinking, especially if the cuts created seem unnatural. Likewise Attention and Meditation modalities of control are shown to be affected by or affect other's physiological responses, be it in appreciation or concern.

6.5 Striving for high Attention or Meditation

In the Competing mode it makes sense that people will want to be the one in control, that is be the one with the highest attention: "*cos you want to see like if it's your brain that's given the best results*" (P5 Competing). However, another Competing controller, P37 focused on their own attention to the detriment of their viewing experience "*it was like I was concentrating a lot but at the same time not really following what was going on.*" (P37 Competing). This contradictory circumstance seems to be a side effect of the Competing mode, but it was not just members of the Competing groups that felt they had to have 'high' Attention. A member of a collaboration group P7 describes how they felt their attention or lack of, effected the ends of some scenes, "*I feel that there were definite climaxes and some of them got there and you found out what it was and other one's sort of plateaued or tailed off I can only assume with a lack of concentration or attention or whatever*" (P7 Collaboration). It is interesting that P7 makes sense of their agency in cinematic terms, they assume that it is their '*high*' Attention that causes narrative climaxes. For a Coop/Att/Blend controller just the measuring of their Attention means for them they have to keep that measure high:

(P21 Coop/Att/Blend)

I felt like I had to be paying attention the whole time, because I'm controlling it somehow.

(Interviewer)

Is that because you, it was your attention that was being measured and being fed back?

(P21 Coop/Att/Blend)

Yeah, I think so cos I know that's what its measuring so I was like I've gotta concentrate yeah, (laughing)

Another cooperative group discusses why they try to have high Attention and Meditation.

Interestingly, the Meditation/Music controller feels that by relaxing they were actually more receptive to the story.

(P22 Coop/Med/Music)

I mean if you have the attention one that is a bit I think more stressful a bit because you are always trying to focus, focus, focus. Where for the meditation with me it was a bit more laid back you know breathing deeply things like that you know, I think that that was why I was more involved in the story cos I was just kind of relaxed breathing things like that.

Interviewer

so high Meditation was good?

(P22 Coop/Med/Music)

Yeah that's what I felt yeah,

P22's account of "*more involved in the story cos I was just kind of relaxed*" could be put down to the inherent qualities of being in a calm state, and of not competing with other people. Whereas P23 only felt that they occasionally had to adjust their concentration.

For some controllers they equate being measured with being tested. They want to be the best. Indeed, when presented with a choice of the different modes before experiencing them, the Competing method was the most popular. Even though in the introductory information it was never alluded to that high Attention or Meditation produced a 'better' viewing experience, there is an assumption with some controllers that it does. There is a feeling that they will be rewarded for high Attention, or Meditation. Paradoxically, as we have seen striving for these states can sometimes detract from the reception of the film.

In this chapter we have looked at the social implications of distributed control with a brain-controlled film. There is a feeling of responsibility reported and we have seen that how individuals approach their intent to control can positively and negatively affect others in the group. When members work together they report a positive experience, however a single 'rouge' controller can disrupt cinematic engagement for the rest of the group. Some controllers assume there is a right way to control and strive to have a heightened state of Attention or Meditation. We observed a tension between immersion in the film and thinking too much about how control is working or what the other members of the group are thinking.

In Part 2 we continue our journey through the production of a new film *The MOMENT*, the design of which is in response our findings here in Part 1. We attempt to encourage a more unconscious control and try to eliminate overpowering interactions that interfere with cinematic engagement.

Part II

The MOMENT

Chapter 7

Making *The MOMENT*

7.1 Introduction

In this chapter I narrate, in the first person, an account of practice; of writing, designing and directing a second brain-controlled film. As I am speaking about my own experience of making this film, I have chosen to speak in my own voice, for authenticity, as certain decisions are made through filmmaking intuition others are influenced by theory developed in our previous studies.

The second brain-controlled film that I directed is called *The MOMENT*, a science fiction dystopic thriller, exploring a possible future impacted by ubiquitous high bandwidth BCI and embodied singularity. This production was more ambitious than *The Disadvantages of Time Travel* in both concept and scale.

In the months following the film's premiere Dr Sarah Martindale and I conducted interviews with, director of photography, Mat Johns, and composers Scrubber Fox and Hallvarður Ásgeirsson. I have used excerpts from the transcripts from these conversations to illustrate some practical considerations involved in the later stages of production.

My roles in the making of *The MOMENT* were: story, screenplay, storyboard artist, director, editor, colourist, co-CGI designer, interaction and software design.

7.2 Iterative design

As the primary creator of this film I brought with me both the explicit findings from studies of *The Disadvantages of Time Travel* as seen in Chapters 5 and 6 and the implicit experience of making, reflected on in Chapter 4. I will take below, point by point the design decisions I iteratively developed, in the following sections I will set out how they practically manifested in the process of making.

1. **Unconscious control**

   One aim of *The Disadvantages of Time Travel* was to create a film that responded to unconscious interactions. This was partially successful. From studying interactions with *The Disadvantages of Time Travel* I found that blinking as a method of control overpowered the other modes, Attention and Meditation. Blinking is both conscious and unconscious. It also caused interruptions to narrative engagement as controllers focused on their ability to actively control the film as they were watching. This made exploring unconscious control difficult and so for this new filmic interaction I opted to remove the blink as a control mechanism and focus on one modality only.

2. **Reflect viewers own physiology**

   In order to make a film that reflected the viewers own physiology I wanted to create an unconscious control method that would not interrupt cinematic engagement.

3. **Cinematic vision**

   Overall I set out to create a cinematic experience, in how the film is presented, as a fixed duration, familiar to viewers in form. It had to work for non-controllers too, and so the film form was designed to feel like a film, rejecting other interactive film designs which breaks the fourth wall, offering narrative choices and branches. Narrative flow was prioritised in the in both the narrative and system design.

4. **Repeat screening experiences**

   I decided early on that it was important to design the the film with repeat screenings in mind. I reasoned, the first time audiences saw the film they would not have anything to compare it to, and so a design where each screening would be as narratively satisfying as possible had to be arrived at so that it doesn't have to be watched multiple times. But the knowledge that the film was different on each viewing would extend the life of the film, encouraging audiences to return or want to see it again.

5. **Genre**

   A challenge I set was to ask the question -is it possible to make a traditional genre film that is different on each watch? My intention to make a sci-fi thriller was two-fold. First it presented clear guidelines; it allowed me to talk about current societal anxieties, such as the rise of the far right, and the weaponization of personal data in an appropriate narrative form (the script was developed in early 2017), genre was a metaphorical rock to tether the production to [Chandler, 1997]. Second, the science-fiction genre, defined by some as *"the literature of cognitive estrangement"* Suvin [1972] becomes a 'meta' genre as the experience contains the embodied conceit of a brain-controlled movie for the audience, while watching a narrative about a society of interconnected minds.

6. **Importance of music/ sound design**

   Of course music and sound is important within film, it creates mood and gives context to what is on screen. In *The Disadvantages of Time Travel* the soundtrack was dynamic in that layers of the soundtrack faded in and out, the vocals cut with the image which would lead to a sometimes disjointed narrative. With *The MOMENT* the audio was placed at a much higher importance in the design both in coherence and recombination. As you will see, the audio design became a core element of the interaction design.

7.3 Pre-production

During the pre-production process for *The MOMENT* thousands of documents were produced, from character breakdowns to shooting schedules, storyboards and department notes. In order to gain insights in to the making of process I have revisited these documents. What follows is an abridged account of the processes that went into making *The MOMENT*. I have focused on key stages which are also relevant to the interactive aspect of this production. The algorithmic concept was developed during the screenwriting stage, it informed structure of the story, and choice of cinematic techniques.

7.3.1 Script

The ideation phase was split into three blocks before moving into the process of writing the screenplay. The first block consisted of a free writing exercise where I wrote about nineteen concepts, ideas, images and influences that I wanted to potentially explore. From this I developed possible plot points, and explored possible character archetypes and arcs. The second writing block identified the three main characters and focused on fleshing them out, further developing their motivations, relationships, voices and dialogue. In the third block I further developed the characters motivations and internal psychologies, I conceptualised the plot by drawing from Campbell [1949] and identified and wrote first drafts of some key scenes.

Throughout this process I used a Powerpoint slide to lay out and rearrange scenes, see Figure 7.1. The three thread/character narrative was developed, and so parallel scenes were able to be visually placed next to each other. Alongside this I began designing the interactivity which would inform the interactive narrative structure.

In early narrative designs the film was to be 7 minutes long and to be watched two or three times in succession, with three narrative threads to be shot in two different ways. This concept developed in parallel with the interactivity design to be longer but each

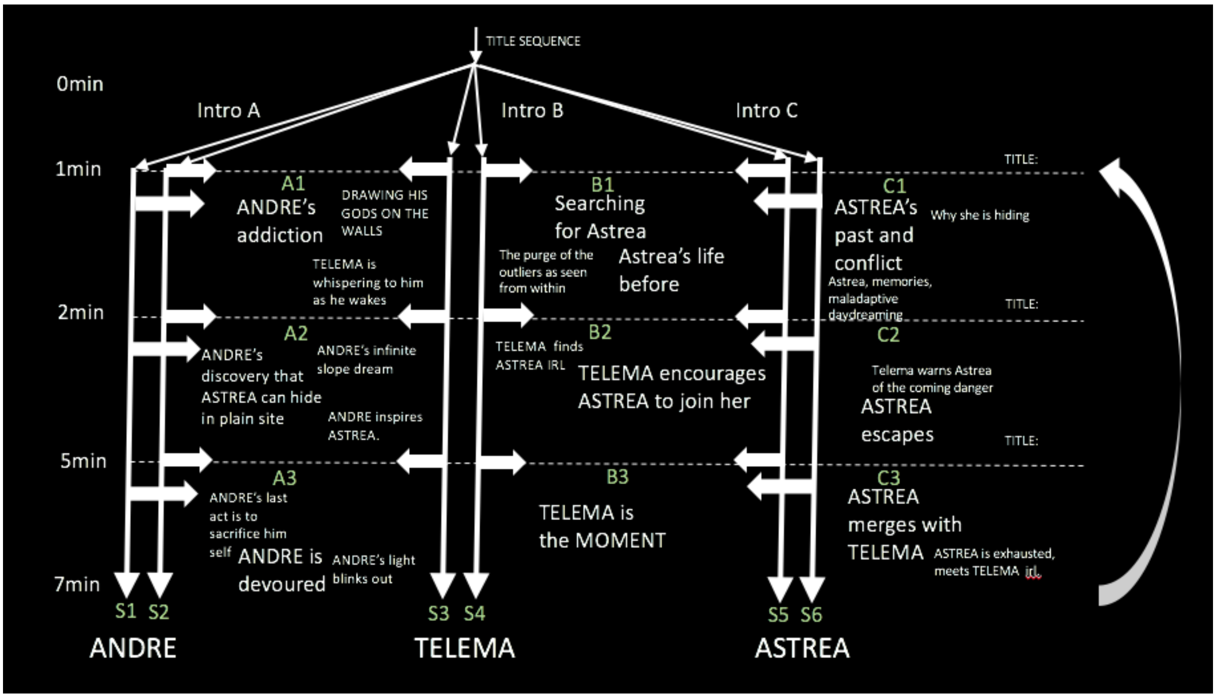

Figure 7.1: Interactive narrative sketch used to plan the narrative structure of *The MOMENT*.

narrative would be shot in one way and have a primary and a secondary soundtrack.

From this a treatment was developed. Usually a treatment is a prose version of the script; in this case it numbered the major narrative points of the story across all narrative character threads. This treatment was then used to populate a scene matrix shown in Figure 7.2, in which scenes from the treatment can be seen as circled numbers. Some scenes were separated across narrative threads, dispersing the story throughout the threads. This matrix was a working document and was many times reedited but it acted as an overview for the development of the story.

The script went through several iterations before finding a structure that supported the interactive production process. As the advice that exists on writing a script is based around the production of linear film, the script should be a moment by moment, blow by blow account of what happens on screen. Of course, here what happens moment by moment is different on each viewing. This presented the challenge of finding a way of writing a screenplay for a film which will never be seen as it is written, but will still act as the blueprint when it comes to producing the storyboards, and ultimately the filmed

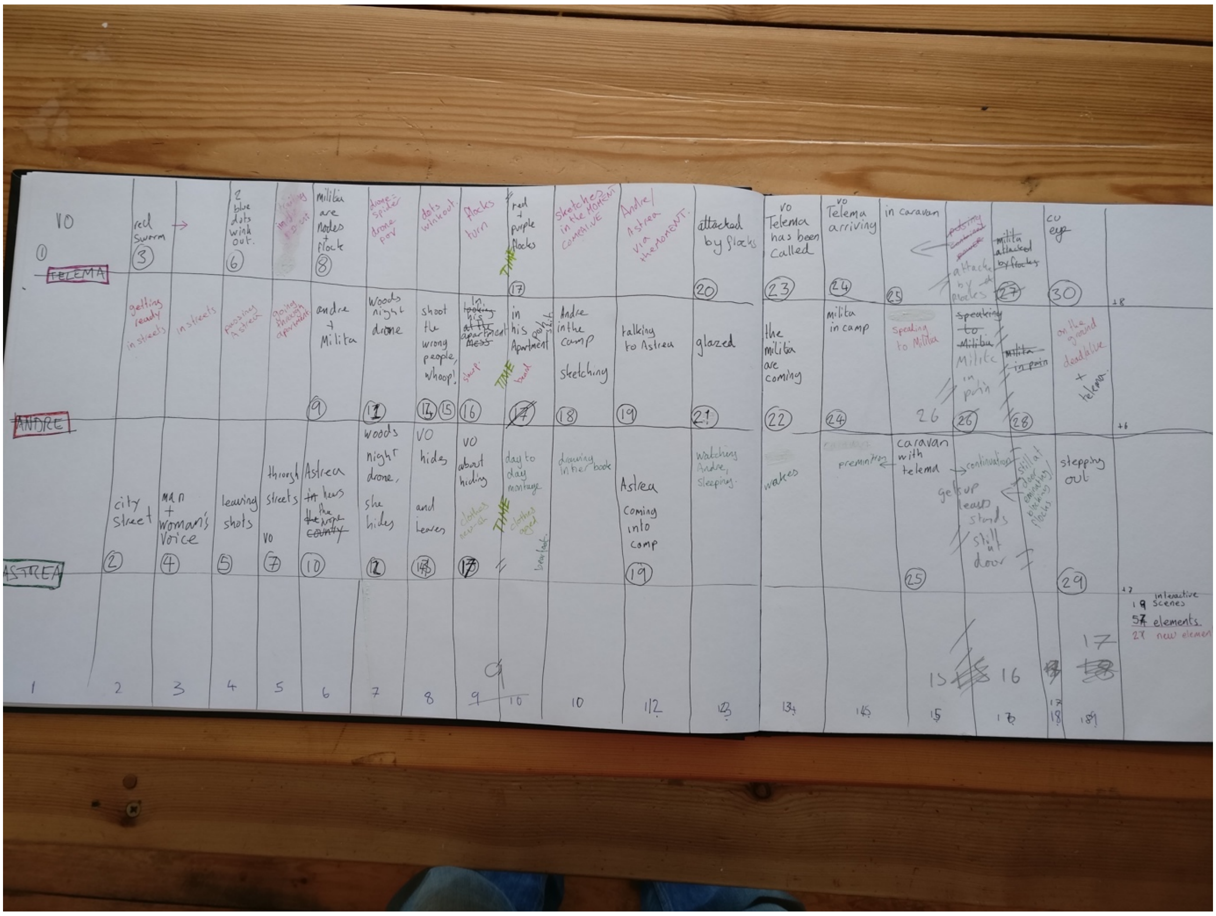

Figure 7.2: Story matrix of *The MOMENT* showing the three rows of narrative threads and 18 scene columns.

footage. The solution was to add separate meta scene headings, named interactive scenes, which collected each trio of parallel scenes. This allowed for the connections between the three characters to be developed in the context of the temporal flow of the film. The final draft of the script was 19 pages long, and contained 18 interactive scenes, consisting of 54 individual scenes. The script was written in Celtx, a free script writing program.

The film follows three characters, each with their own narrative thread. Their stories converge and separate throughout the script, although there is always an element that connects them even when they are not in the same place. These connections are predicated on cinematic techniques, and designed so when watched various kinds of match-cuts are produced. For example by matching compositions across scenes, a spatial match cut can be produced; by using the same character actions across scenes, a match action cut can be produced, or by using an unifying element, in this case an inverted triangle, which appears across all threads, the pervasive theme of the network of minds is reinforced.

The synopses of the three character's narrative threads are as follows:

Astrea's narrative thread

The main protagonist Astrea, and her father Lance are in their apartment, they know a Militia sent from the MOMENT, an online panopticon, are hunting *outliers* like them and are coming to delete them. Lance forces Astrea to leave just as The Militia break into the apartment she is seen by one of the militia Andre, who hesitates and Astrea escapes. Lance is processed by the militia. Astrea is now on the run, she finds herself in a forest, and is able to hide, we begin to see that she is communicating with something. She evades the Militia again. Time passes as Astrea lives a nomadic life in the countryside we see more clearly that she is being pulled towards something outside our physical realm. She finds a refugee camp, and meets Andrea, who is now a defeated man, she decides to stay with him even although he is a target for the militia. Astrea rests on the floor of an old caravan, she is awoken as the Militia arrive outside, but something is inside with her, it is Telema an artificial intelligence who has been backing up outliers needs Astrea's help. Telema and Astrea merge and Astrea exits the caravan as a changed being. She cuts down the militia one by one and leaves, turning only to bring life back to Andre.

Andrea's narrative thread

Andrea, is a member of the militia, they are in the city, on their way to Lance and Astreas apartment, They force entry and find Lance, Andre sees Astrea as she escapes but hesitates as he is called to prepare for Lances', deletion. Upon Lances demise he is elated and goes on the hunt for Astrea. When looking in the woods they find a girl and Hendricks, their leader indicate that it is Andre's turn to make the kill. Later Andre has a crisis of conscious, he is haunted by what he has done, and he is no longer able to connect to the MOMENT. He is becoming an outlier. Time passes and he is on living on the street. He finds a refugee camp and become obsessed with Telema. When Astrea arrives at the camp he is barely recognisable, he reveals his guilt and is resigned that the militia are coming for him. They arrive, and Hendricks begins to process him. At that moment Astrea appears and takes down the militia, Hendricks recognises something is Astrea and approaches her but she is cut down as well. Andre is lying prone on the ground seemingly dead. He takes a gasp before we cut to black.

Telema's narrative thread

Telema, exists in a world of connected nodes, an abstract vision of the real, the MOMENT, (Massive Online Multi-user Emotional NeT) reflects the intentions of the connected masses (flocks). As the Militia approach Lance and Astrea's apartment the flocks mirror the militias movements, we see a representation of Lance be copied in this space, then torn apart. Andre is supported and celebrated in the MOMENT. The flocks lead the militia on their hunt and we see the captured girl being dissembled. When Andre and Astrea are in their separate exiles Telema appears through the flocks observing them. During the militia's final hunt, Telema narrates her rebellion, and commits to helping Andre and Astrea. She appears to Astrea and merges with her gaining physical form. We see through her eyes as each member of the moment is psychically torn apart. Finally we see Telema as a powerful being, on fire as she announces her intention to remake the world.

7.3.2 Storyboards

Traditionally a storyboard is used to move the script from a purely literal to a visual language, so it has more information concentration, it shows actions, contains information for various departments, and a lot of the narrative beats are worked out at this point. The storyboard is used across all stages of production; in pre-production to generate designs, schedules and shot lists; in production to reference on set and in post-production by the editor.

> So when it comes to shooting the whole reason the storyboard and make shot list is because it gives you a blueprint for the film, because when you're shooting in the chaos of a shoot there's just never enough time and it's part of that solid preparation.- Mat Johns. DoP The MOMENT

In post-production storyboards can be used by the editor order shots, CGI artists use them as reference for special effects and they can be sequenced together to create an animatic (an animated version) of the film.

Just as the structure of the script document needed to be revised to fit for the purpose of making this interactive film, so too did the storyboard. The storyboard design allowed for the cross referencing of all three narratives, but in finer temporal detail, see Figure 7.3.

Rather than traditional A to Z linear storyboarding *The MOMENT* storyboards run in parallel: A1, A2, A3 to Z1, Z2, Z3. Where the letter is the same point in time and 1, 2 and 3 refer to the three narrative threads. See Figure 7.3. Where a traditional storyboard usually depicts the progression of time in the film, here it also depicts the progression of possibilities.

The storyboards were drawn 6 to a page so as to construct linear and parallel progression through the narrative. Linear progression runs from left to right and parallel progression

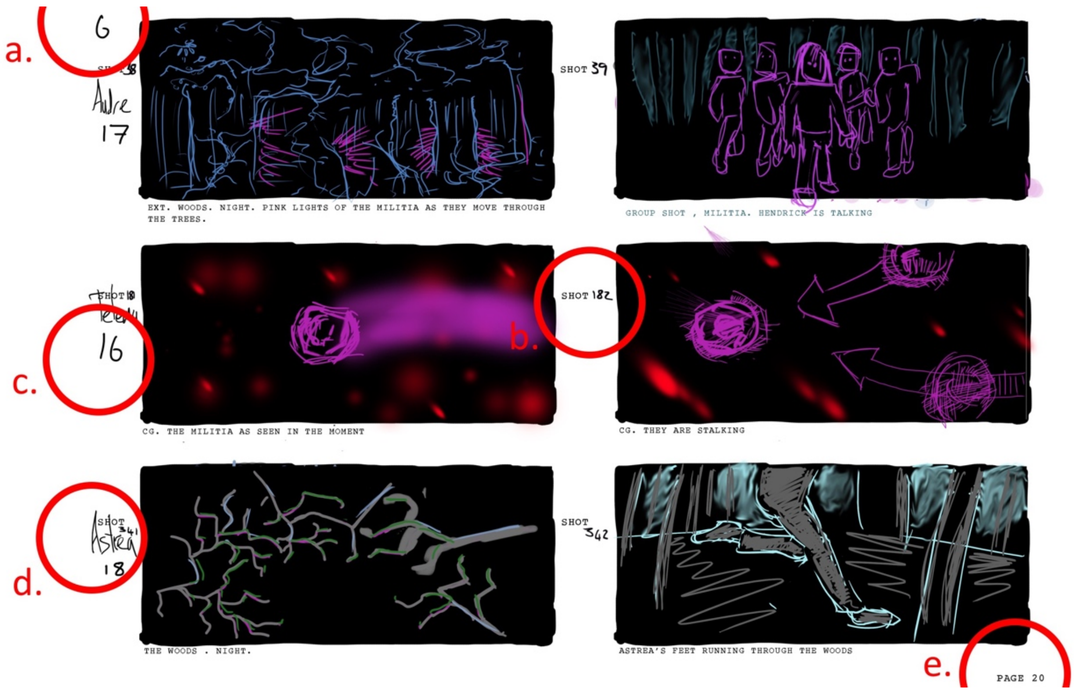

Figure 7.3: Storyboard page from *The MOMENT*.
Key to Figure 7.3

- a. Interactive Scene number.
- b. Board number (labelled as shot number).
- c. Scene number.
- d. Narrative thread.
- e. Storyboard page number.

vertically. This creates a storyboard matrix. The columns depict the same point in time and potential moments of narrative sequence. It was in the drawing of the storyboard panels that finer details of creative and dramatic construction of the interactive narrative was encoded. I had to think both in terms of linear and parallel narrative. Between the threads I employed cinematic techniques,such as duplicating compositions to create match cuts, contrasting compositions to create thematic tension, and scenes in which narrative threads are co-located would focus on their respective characters.

An example:

Andre's Thread: the Militia are walking through the woods towards camera hunting for someone.

Astrea's Thread: Astrea is running left to right,

Telema's Thread: the flocks are moving towards a point.

These cinematic techniques interact. They have dramatic effect when viewed in isolation, and when any two treads are inter-cut they have a new dramatic tension.

The storyboards consisted of 72 pages, 240 individual panels, the process needed to be complete in order to generate a shot-list and shooting schedule. The producer and I used the storyboards to estimate how long we would need at each location, Which actors would be needed for which locations and designing individual camera set ups within scenes.

An important point is that in a traditional storyboard each panel depicts a change in action, time, place or shot. Here, however, in order to preserve the vertical continuity, certain narrative threads would have little or no change while actions are played out on the counterpart threads. As action or change must be storyboarded, the narrative thread which has the most action or change must have counterpart frames, even if they would not be traditionally drawn. This was not foreseen when starting the storyboarding process and so each storyboard panel had its own individual shot number. This caused some confusion when it came to creating shot-lists and on set as some shots had several storyboard panels.

Figure 7.4: On set of *The MOMENT*, 1st AD Rick Sims and I cross reference the shot list with the storyboards.

7.3.3 Rehearsals

A rehearsal studio was booked in Manchester for five days. Five of the eight main actors attended to run through scenes, be fitted for costumes, and do makeup tests. The timings of shots and scenes where important for the movie to work when as interactive. During rehearsals, we were able to get scenes on their feet to let the actors feel and shape them. We worked from storyboards initially, at this point the DoP came in and test filmed some scenes, and we made first real timings for scenes, these timing notes went into the production plan to be referred to on set.

The rehearsals were important to have one to one face time with me as a director, in order to share the background concepts of this film, and to build confidence in this new process.

7.4 Production

The shoot for Astrea's and Andrea's threads took place over 6 days in October 2017 in Manchester UK, with a crew of twenty-five and nine actors. We had six locations, three internal, three external, and shot mainly nights between 15:00 and 06:00. CGI work for Telema's thread took place between February 2017 and March 2018 and additional filming with the actress playing Telema was done in studios at Nottingham Trent University in February 2018.

7.4.1 Cinematography

Out of all of the crew, besides the producer and the 1st assistant director (1st AD), the director of photography (DoP) is the person that I as the director worked closest with, and so the DoP needed to know the affordances to prepare and engage with the interactive aspect of the production. To introduce the craft of cinematography I will let the DP from *The MOMENT* , Mat Johns explain in his own words:

> The role of DP is basically to oversee all the visual elements of the film. When you watch a film it's made up of shapes, compositions and lighting and the DP heads that up. So working with the director you come up with colour palettes, lighting designs for certain locations, certain motifs for certain characters, use of colour those sorts of things. And you have a team on the shoot of camera operators and riggers and grips and stuff who help you say, right, okay so we need a light over there, it's got to be this light with that colour at this position that will do this. And then you just design the look of the film really with the director ... Technical and creative role which is what DP is. Because it has to be very technical, you have to know that we need this much cable and that many lights or whatever, but you're also trying to create something beautiful

> with all that.- Mat Johns, DoP *The MOMENT*.

Creative decisions

As Johns defined, the work of the DoP is both creative and technical. I will consider how the interactive aspect of production impacted on creative processes of cinematography, in pre-production and on set, and what technical challenges presented themselves.

Colour

Creative decisions made early on can relating to colour can help support the readability of the film. These early decisions can filter through to other departments such as costume and props.

> ...we wanted each character to have a certain colour and a motif. So we literally went to a coffee shop with a big sketch pad and a box of multi-coloured pens and we were like, okay what kind of palette do we want for Andre, what's Astrea going to have, how do we represent Telema and the militia and all that sort of stuff. So we literally just started scribbling down colours and figuring out who had what.- Mat Johns, DoP *The MOMENT*.

A stylised colour palate was decided on to help give the viewer clues of which narrative they were following. Putting these creative decisions into practice not only involved lighting design but set and costume as well. Coloured practical lighting (that is in scene lighting) was designed into the militia's costume and into location props where certain characters would be placed.

> Audiences understand it but I don't think they know they understand it, that these things have been around for a long time now that they're these techniques, of motifs and colour and identifiers.- Mat Johns, DoP *The MOMENT*.

These very deliberate creative choices are made with a knowledge that the audience will

Figure 7.5: Three examples of practical lights built into costume and props. From left to right, Astrea's green lantern, the militia's pink torches, and the blue mask.

be only semi aware at most of the impact when watching the film. Colour is used to separate the narrative threads, which then locates the audience within one of the three stories.

The decision to use a stylised pallet of colours, a characteristic of the Tech Noir sub-genre, meant we were able to narratively justify those lights as diegetic props, or set pieces within the film. The electric blue of the mask, Astrea's green lamp, the Militia's pink torches each was a light source in its own right. Additional off screen lights with the matching colour gels were used to expand the light sources, see Figure 7.5.

Figure 7.6 shows how the lighting interacts across threads, Johns talks about how this practical lighting technique can be used to effect:

> One thing that always stands out that I always remember which I really liked is in Lance and Astrea's apartment at the beginning when Lance and Astrea are having their to do and the militia are coming in and she makes a run through the kitchen. And this is where we really get to see Andre and Astrea's faces and we see the clashing of their narrative. Where he stops in the doorway, so he's got this pink light on him and she stops and hides behind the kitchen door. And there's this green light that we had rigged up that just starts introducing that motif.- Mat Johns, DoP *The MOMENT*.

Parallel synchronisation

When a problem needed to be solved in the course of production, perhaps a location

Figure 7.6: Astrea and Andre see each other for the first time.

wouldn't allow for the storyboarded shot, it needed to be checked what the knock on effect would be to other threads.

On set, planned shots change too, this could impact the parallel scenes not yet shot in terms of lighting cues and shot composition:

> Because things change on set as well and shots change and if ever that happened we'd just take pictures for reference. If we knew we were going to have to revisit that to shoot one of the parallel scenes, we take photographs so we could see, so we could match eye lines or...- Mat Johns, DoP *The MOMENT*.

It was necessary to document any changes as they happened, taking photos and notes of timings for lighting cues became a key responsibility of the 1st AD who would then make available this additional information when it came to shoot the parallel threads, see Figure 7.4.

A particular challenge was timings across the threads. Discovering which narrative elements had highest priority to sync, be it lighting cue, action cue, dialogue, or a mix of these, sometimes had to be worked out on set. In the penultimate scene, all three narratives converge, Astrea meets Telema in the real world and outside Andre, Hendricks and the militia have their scene. A combination of circumstances meant the lighting cues within this scene proved to be a particular challenge.

The venue we had hired for the first day of the shoot announced that there was a to be a wrestling match in the next hall with two-thousand members of the public which would make it impossible to shoot with sound. This threw us off schedule and meant we had to move all of our shots that had any dialogue to the beginning of the day, including the scene with Andre and the militia outside the caravan. The parallel scene to that, the internal caravan with Astrea and Telema was then shot at the end of the day with a very tired cast and crew. The knock on was that the lighting cues outside the caravan with the militia and inside the caravan were out of sync. There would be more problems with this scene which I will address in the *Editing* section. Before that lets continue looking at a cinematic technique that helped us with the problem of syncing narrative threads.

Slow motion

One solution to some of the timing issues was the use of slow motion photography, as previously utilised in *The Disadvantages of Time Travel* footage shot at a faster frames per second becomes temporally malleable in post production.

However, while slow motion footage can heighten drama and gravitas of a scenes it cannot be used in certain situations (for example during speech) and an overuse can act against the intentions of the story.

Composition

The other concession made by the DP to the interactive design of the cinematography was the matching and interaction of composition across the threads. As the film is designed to cut across the threads at any point, the compositions have a parallel meaningful relationship as well as linear. This ongoing compositional relationship is informed by cinematic language to make possible meaning when the film cuts between the threads.

> You could cut between them, yes, so the composition if it complements the others, it's not quite match cutting but there are parts where it does match. And there are other parts where it almost goes to a… Not a reversal but it's almost to the other side of the frame and back again. Because I think there's nothing in terms of that whole process with the storyboarding and how you come to

> assemble the film based around that. It's not really that different to making a traditional film, you're just doing it three times over.- Mat Johns, DoP *The MOMENT*.

The techniques used by the DoP used not unusual, they are standard to any practising DoP. Although each shot has an extra dependency, they are approached in a traditional manner. However, there is an implied flexibility of approach to craft that comes with understanding the workings of this interactive film.

7.4.2 Direction

When directing film, it is the director's job to mould to the production to their vision. The director should communicate their sensibilities to the cast and crew as it allows them to engage and work towards that vision. However when there are invisible constraints, which are outside of the norms of traditional filmmaking, a new strategy must be arrived at. Here I look at the What, Who and How this manifests on set: What new tactics enable interactive content creation on set? Who needs to know what and what are the considerations when working with actors? And how do these tactics practically impact on the shoot?

On set tactics

The two main considerations that became apparent on set were: one, close observation and control of the length of shots; and two, ongoing multi-tiered communication to individuals and departments about considerations relevant to the interactive aspect of the footage.

The timings of shots and scenes were crucial mechanisms for the narrative threads to match up, so special attention was paid to this. A particular challenge is to do with the timings within a shot. In post production when there is time to sit and observe and the qualities of that shot, the editor is able to assess of how much of that shot is usable, the pacing of action and duration. These timings had particularly dependencies in this production that would effect parallel shots later on in the shoot, as so the considerations of usability and length of shot was calculated on set, on the fly, as it happened. This information were captured as meta data by the 1st AD so as to be on hand when shooting corresponding parallel scenes. The DoP mentions some challenges of this constraint especially as to how it impacts on other, parallel scenes:

> The thing that locks you in is the timing of the scenes, so the scenes have to run for the same duration. And I know that that, on the shoot was a real challenge getting our head around, right and the militia coming up the stairs whilst Lance and Astrea are having this conversation. It's like how much time are we going to need and so that's the challenge is making sure that each scene is, kind of, bookended around the same point. So the content syncs up and then we move onto the next one.- Mat Johns, DoP *The MOMENT*.

As the director sometimes this meant holding a scene for longer than would feel natural or even adding a shot or two if a counterpart scene was longer than expected. These decisions may have felt counter intuitive to some of the cast and crew, depending on how much they knew about the unique aspects of the production.

There was a lot of cross referencing from notes but also from memory. When setting up a shot it was not just the current storyboard frame that was taken into consideration, but the parallel frame too, if that parallel frame had been shot already we would check if it was exactly as the storyboard frame dictated. Changes were often made on set, sometimes there wasn't time to make notes or so both the DoP and I would be holding these details in our head as production proceeded.

Crew's knowledge about interactivity.

7.7 shows how much each role needed to know about the combinatory parallel nature of the production to do an effective job. It shows that the director has the most knowledge, the DoP and 1st AD next share a level of knowledge although they have different responsibilities. The actors are next, they had to have enough understanding to be able

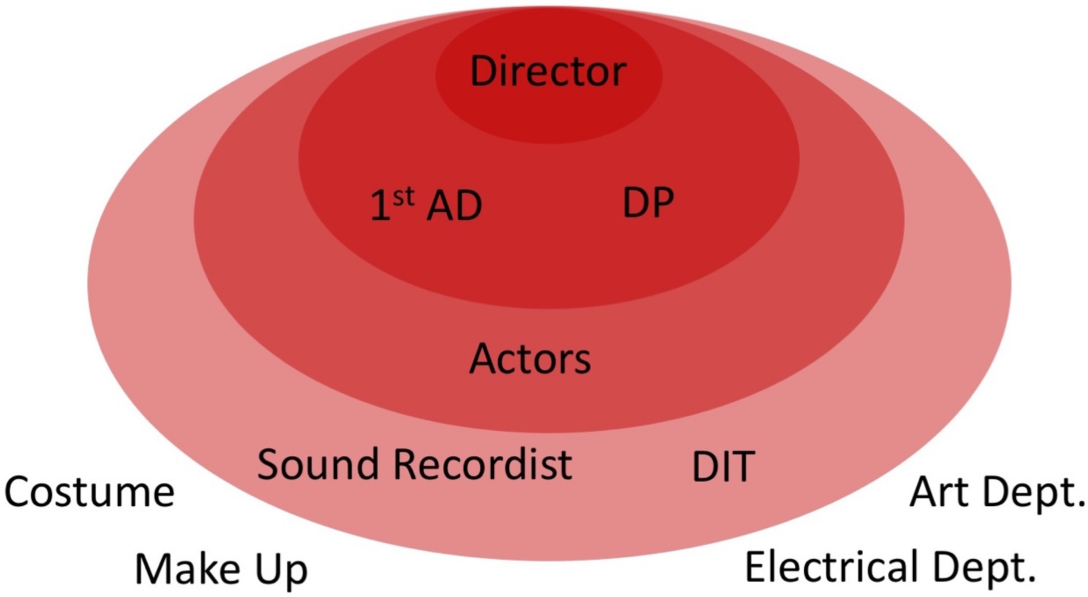

Figure 7.7: shows who needs a working knowledge of the interactivity on set.

to trust their director when a decision challenged their intuition, I will explore this more in the next section. The Digital Information Technician (DIT, who captures and backs up footage cards, and adds meta data to to footage reports) and the sound recordist are both logging recordings and so have some awareness of the parallel threads. For all other departments it is business as usual:

Richard Ramchurn

Yes, and I think we're almost like buffering other members from like that thought process because they didn't really need that, did they?

Mat Johns

...the people who were worrying about power distribution just need to worry about power distribution and that light was going over there, it was going over there for a reason that we knew. But yes we were really, you, me and Rick were really keeping an eye on that process.

Actors

It was important that the actors knew the process of how the film was being made, and was to be screened. Even though it did not directly effect their performance, the actors needed to trust their director who may be making some decisions that may not make sense for them on set.

during rehearsals when we met the actors in person, we talked about the process and how it was going to be different to give them time to get their heads around it. So when it came to being on set and decisions were being made where I couldn't take time to justify it to them. I was able to use the shorthand of, *"it's not going to work because of the other scene that's happening in parallel."*

The complicity of the actors in the process was key to running to schedule. This became apparent when an actor, who had missed rehearsals and so had a lessor grasp of this process. The actor employed their own performative approach, method acting, developed by Konstantin Stanislavski [2008], where the actor creates a state of near total immersion in the world of the character. The scene ran over schedule as the performer was not willing to compromise on their performance technique. As a crew we adapted, rather than sticking to the storyboard we shot *just one wide angle that was a five minute take and then we reviewed all the footage and went right, okay, we'll jump in and pick up this bit and we'll jump in and pick up this bit.*- Mat Johns. In my opinion as the director this was one of the strongest performances of the film, although it came at a cost.

What is apparent here is that the actors method of performance must be taken into account. *The MOMENT* was meticulously storyboarded, which in some cases can constrict a performance as it can allow less scope for the actors to discover the scene. All the actors must have the same level of understanding and willingness to perform in a agreed upon method in order for the production to run smoothly.

7.5 Post-production

The post production for *The MOMENT* was substantial, there was additional location and pick-up shots to film, Telema's narrative thread which is almost all performance based CGI was to be filmed and rendered, sound design and composing, as well as the film edit. In addition it was during this time that the algorithmic concept was put into practice. This took eight months to complete.

7.5.1 Sound design

In this section I will reflect on the processes we went through to create the musical score and sound design for *The MOMENT*. I have drawn on interviews with the composers, and logs from our online chats about their method of working and how it differed from a traditional process.

The MOMENT's music and sound was created by Hallvarður Ásgeirsson (the composer from *The Disadvantages of Time Travel*) and Scrubber Fox, a long-time collaborator. Work was done remotely between Nottingham, and Wigan, UK and Reykjavík, Iceland.

Sound is a very important part of the cinematic experience. In order to attempt to utilise the storytelling and cinematic potential of the sound design and soundtrack it was first necessary to disassemble the various cinematic audio techniques so that they could be remapped to the interactive framework of this film. By examining the language of sound on screen, and identifying specific techniques such as; Foley, motifs and themes, atmosphere, diegetic (in film) and non-diegetic (from outside the film world) sound, J and L cuts, a design was arrived at where these would be remixed on the fly as the viewer watched.

Designing the sound to feel intentionally composed was difficult because as it meant addressing technical and creative challenges such as: musical co-creation and design workflows, and preserving sync with sound, voice and image.

A typical sound design usually has around six number of types of sound. they are presented below in order of lowest in the mix to highest.

1. The background, or atmosphere, or room tone, this is the sound of the location it is usually recorded when there is no action.

2. Atmospheric music, this is subtle notes or sound intended to create a mood.

3. Sound effects/ Foley, added non musical sound of actions, objects, recorded specifically for the film, sometimes using the edited film as a guide for timing.

4. Location sync sound, usually several microphones are used, some of which are placed to record sounds of actions and interactions with the props or location.

5. Vocal or Vox, this is the dialogue which is usually filmed as sync sound and often re-recorded straight into the mic.

6. Score, music composed to the edit of the film.

My solution was for each narrative thread to have its soundtrack split into two, a primary design, combined of 3), 4) and 6) and a secondary combining 1) and 2). When the film plays It will have the Primary from one thread and the secondary from the other. meaning there are six possible sound design combinations for each scene. Film cuts from Attention data fade out the secondary sound design. The Vocal track is always played from both threads.

The sound design was split between the two musicians based on the styleistic qualities of their work and the complimentary themes of the narrative threads. Namely, the themes of human and artificial and the conflict of the these two themes that are present in each character. I also wanted to minimise the possibilities of a composers music playing for both primary and secondary for any scene to maximise musical conflict. Table 7.1 shows which treads and layers each musician was responsible for. Ásgeirsson comments how this mode of musical co-composing both supported and surprised him.

Table 7.1: Composers soundtrack layer responsibilities

Scrubber Fox	**Hallvardur Asgiersson**
Andre Primary	Astrea Primary
Andre Secondary	Astrea Secondary
Telema Primary	Telema Secondary

> I think it makes it more interesting because we have different styles of composition and you don't know exactly how it's going to turn out. Also it can be a bit of a safety net because stuff doesn't work out. Either one of us will come with something that will work. -Hallvarður Ásgeirsson, Composer, *The MOMENT*

Sound design done well can massively impact the effectiveness of a film. So it was of particular importance for the interactive sound design to be as effective as possible. Each of the six combinations of each scene have a unique sound design composition. The sound is used to facilitate the films' recombination, as cuts happen the secondary sound will fade giving weight to the visual changes, sometimes in a subtle way sometimes more pronounced. The primary sound is always on which acts as the foreground for the scene as a whole.

Figure 7.8 shows how the sound mix is automated in real-time. Each video file has embedded Vocal audio (a). There are six separate music and sound design files which are the full length of the film, three Primary and three Secondary (b). These all start at the same time at the beginning of the film to preserve sync. They are mixed so that only one Primary and one Secondary can be heard during a scene, with the secondary audio fading in and out (c) when the video cuts (d) from Attention drops from the NeuroSky headset. A second before the end of a scene, (e) the media algorithm chooses the next scene and audio combination to play, the Primary and Secondary audios cross dissolve to the new selected audio track (f). Finally the vocal tracks embedded in the video files dip dissolve to avoid audio popping when the new videos play (g).

Workflow

The two musicians and myself worked remotely throughout the project. Our main com-

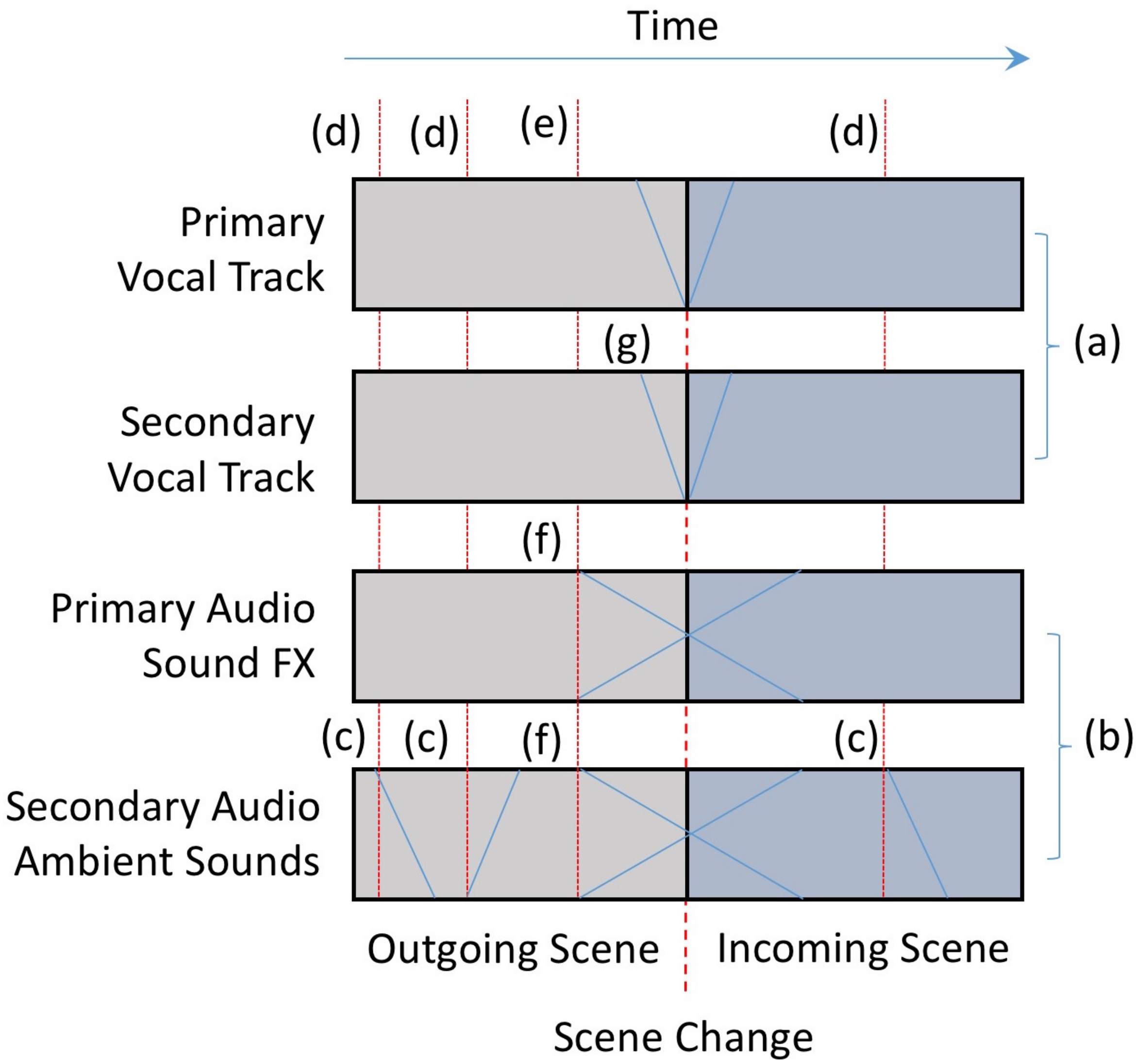

Figure 7.8: Shows how audio is managed at edit points and at scene boundaries during screenings of *The MOMENT*

munication was a rich, multimedia text chat on various platforms, and periodic video calls. Key documents were created for the musicians to refer to, including a scene by scene breakdown detailing key emotions, sound effects and Foley. Once rough cuts were ready they were sent to the composers to create music to, then the musicians would send back to me and each other audio ideas, mixes and stems. Scrubber Fox had the additional responsibility of doing Foley and sound effects, creating the audio world which the characters inhabit. Communicating the concept of the recombinatory sound design was no easy task, it wasn't until after the shoot and the composers could see what I meant that we were able to fully appreciate the design.

> It took me good few months to get my head round how it would work exactly, it's only when we started to get the video rushes in for each section you could then see how it fits with the other threads of the movie and how they connect and interact. -Scrubber Fox.

The design process that we all took was very iterative. There was much to be understood in the making; it was in the practical doing that processes were defined, redefined and set. Likewise, content was made and re-worked, as technical limitations refined the design parameters.

7.5.2 Editing

In this section I explore the editing process, drawing on the archived edit project, transcripts of a discussion with myself and the DoP and notes from preview screenings. The editing process took just under eight months to complete, it started on the 18th October, 2017, one week after shooting wrapped and the last amendments were on the 8th June 2018. The edit was built over thirty-seven sessions. The running time of the preview events was 27 minutes, From feedback and observations a scene was cut losing 3 minutes from the run-time. The final film runs at 24 minutes.

The post production followed a fairly typical process which I will briefly outline. An animatic was made from the storyboard shots. The 4k footage was re encoded to smaller proxy files which are easier and faster to work with. The footage was then reviewed, cross referenced from the DIT logs and meta data added to the sound and video files. An off line assembly edit was made and any pick-up or additional shots were identified. CGI footage was added throughout the process. Eventually an online, HD edit was created by replacing the proxy files with colour graded HD footage.

The main divergence from the norm was that all three films were cut on the same timeline. By using groups of tracks for each narrative thread I was able to manipulate and synchronise timings across the three threads. Video and audio tracks could be turned on and off to to work on each of the three edits.

The aspect ratio of the edit canvas was 16:9, the film footage was shot at a wider, 2.35:1 and so the canvas had black bars at the top and bottom of the frame (Letterbox). Only the video area would be exported for the master film, this allowed for scene numbers and notes to be overlaid on the bars for clarity.

The through pre-production preparation paid off, the first edit was put together much faster than I thought it was going to be. I worked straight off the storyboard animatic, replacing each panel with its corresponding shot.

During this post-production period the bulk of Telema's narrative thread was created. The CGI design process began well before shooting, it actually began in the first months of writing, Luke Dewhurst, the CGI artist was one of the first people to come on board. As soon as storyboards were completed he started building scenes in Cinema4D[1]. Now Andre's and Astrea's threads were edited we were able design and render CGI scenes in response to these threads.

Many creative decisions were removed from the edit room, by this I mean techniques such as pacing and narrative beats were not part of the edit process. As an editor this was quite a discomforting experience, there is a lot of joy to be had in crafting an edit to flow.

[1]maxon.net

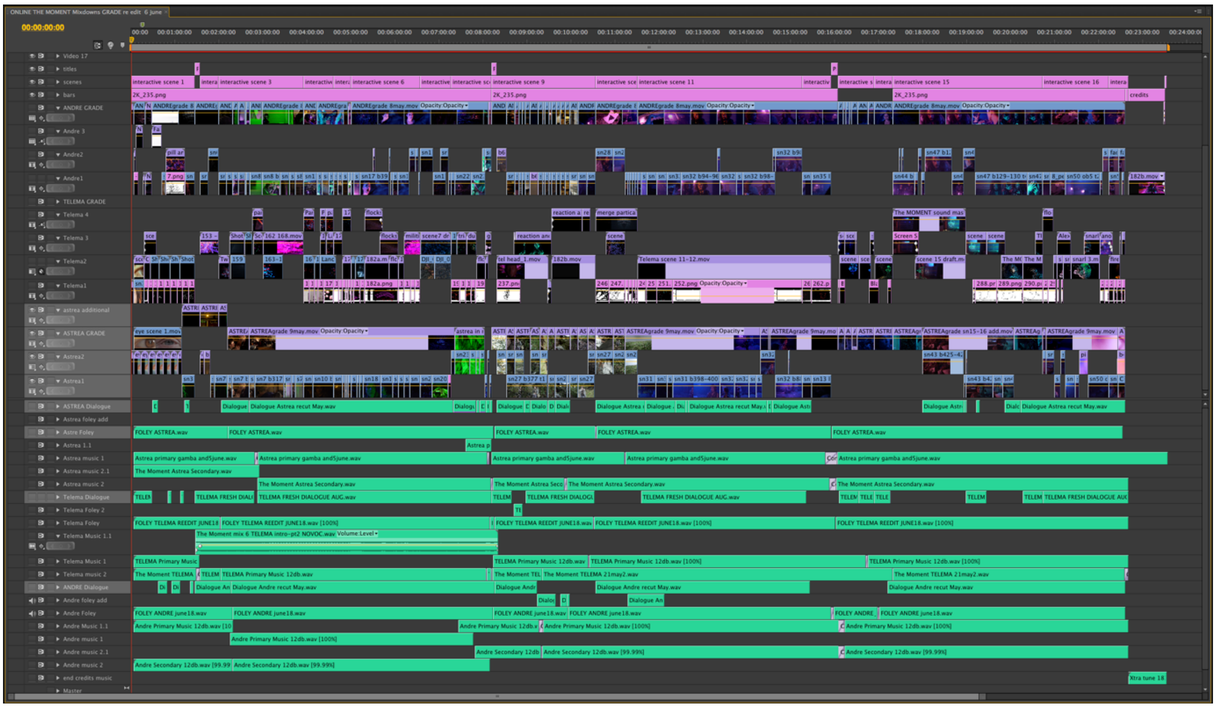

Figure 7.9: Adobe Premier sequence timeline of the finished edit of *The MOMENT*

Again, like in *The Disadvantages of Time Travel* the main edit decisions were about making the possibilities for combinations, narrative techniques to be created, by the audience at a later date. In a traditional process the director and editor can watch back edits, give notes and make changes to create the most perfect representation of the vision held. That process was amended to include the preview audiences, in a real way the audiences became the editors, and I took notes. These notes were not about specific cuts but the film as a whole, with the knowledge of how it was recreating itself. This was something that could not have done myself by watching it with the NeuroSky headset on, it needed a brain reacting to the film naturally, rather than mine which would be analysing and taking notes.

Public Previews took place at Lakeside Arts, Nottingham, over two days in April 2018. I brought the notes back to the edit suite for a further two months optimising the footage, timings, sound mix and CGI, ready for the premier.

Reediting content

The system was conceived to wait for Attention to drop before it cuts between threads, so I made the shots longer than would usually be expected. This turned out to be not the case, my observations were that scenes dropped in energy because even although they might be quite dynamic in terms of the cut, they went on for too long and nothing was actually changing narratively. These scenes and sequences were identified during the preview screenings and cut down before the premier.

However, making a single re-edit in the film was not trivial. For each change, 3 visual continuities, 6 layers of soundtrack, 3 Foley tracks and 3 dialogue tracks had to be checked that they stayed in sync within threads and across threads. Compounding this there was still new music arriving which had been recorded to the timing of previous cuts. Hence, these changes had to be noted sent to the composers. Another challenge was, that to cut down one scene meant the other two parallel scenes must be reduced in time as well. For the most part it was the leading scenes, the ones with dialogue, or the most action that defined the scene length for the other two. A specific issue was to do with the penultimate scene, I mentioned issues with the synchronisation of the lighting before, between Andre and the militia, and Telema and Astrea. The problem was that they were all speaking at the same time. I was able to get around this by cutting some of Telema's lines and shifting Astrea's dialogue in to the gaps in Andrea's thread. This produced interesting and unforeseen dialogue combinations, something that could be further explored in future designs.

Preparing media for the system

Once the edit was finalised each scene of the three threads was exported. Figure 7.9 shows the final cut in Adobe Premier CS6. By using the scene labels to mark in and out points for each interactive scene, and turn on each thread's audio and video separately I was able to consistently export each thread. Each thread-scene was exported at a resolution of 1920 by 837 (removing the bars and text labels), resulting in three separate .mov files for each of the seventeen scenes (plus credits), and the six full length audio layers. In total 54 video files and 6 audio files were produced for the *Media system*. Each video file is named with a two or three digit code, the first number is the scene number, from 1 to

18. The last digit represents the thread, Astrea=1, Telema=2, Andre=3. This turned out to be quite efficient as when a change was made it was just the specific thread-scene that would have to be exported, if a change was made to the overall length of the film then the 6 soundtrack files would also have to be exported. The audio and video files are then ready to be played through the *Media system* which is described in the following section.

- Astrea, 2 edit layers, 1 grade, 1 additional
- Telema, 4 edit layers
- Andre, 3 edit layers, 1 grade
- 1:235 bars
- Scene labels
- Vocal and Foley tracks
- thread audios which are the mixed down tracks labelled 1, 1.1, etc.

7.6 *Media system* development

The *media system* which gathers NeuroSky data, plays video and audio, cuts, recombines and mixes media is described next. Figure 7.10 shows the full system architecture of the production installation of *The MOMENT*. It is designed in MAX/MSP and runs on a MacBook Pro. In the years since making *The Disadvantages of Time Travel* higher end laptops were able to manipulate multiple HD video streams with an acceptable frame drop. This meant that *The MOMENT* could be screened at 1080p at 25 frames per second.

Data acquisition

The brain data from the NeuroSky headset needs to be made available to the *media system*. To do this bluetooth data was accessed and sent via the OSC (Open Sound

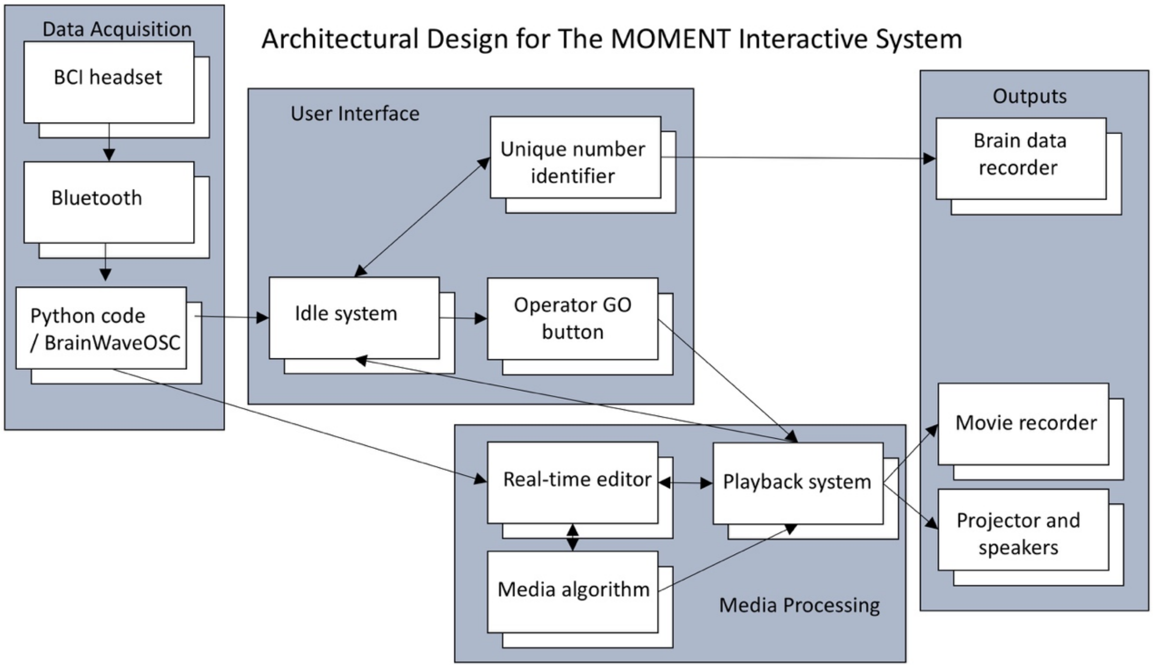

Figure 7.10: System architecture for *The MOMENT*

Control) protocol which is accessible to MAX/MSP via a port. Originally the system used Python code written by Pike. However this was not compatible with the newer MindWave 2 headset. When our 4 year old original MindWave headsets began to break it was decided to change headsets to the newer MindWave 2s. After some trial and error, and some slight re-coding to the MAX patch, the MindWave 2 headsets were able to send data to MAX via the open-source BrainWaveOSC.

User interface

The user interface was designed for the operator of the film installation, see Figure 7.11. The operator must be able to prepare each screening from this interface: they must be able to reset the system before playing of if there is false start, to input a unique screening number which will match the film recording number, CSV file name, and associated interview and questionnaire reference number. If a controlling viewer does not want their Attention data recorded the operator can turn this off from here too. The interface gives further feedback wither data is recording and if the signal from the headset is good or not.

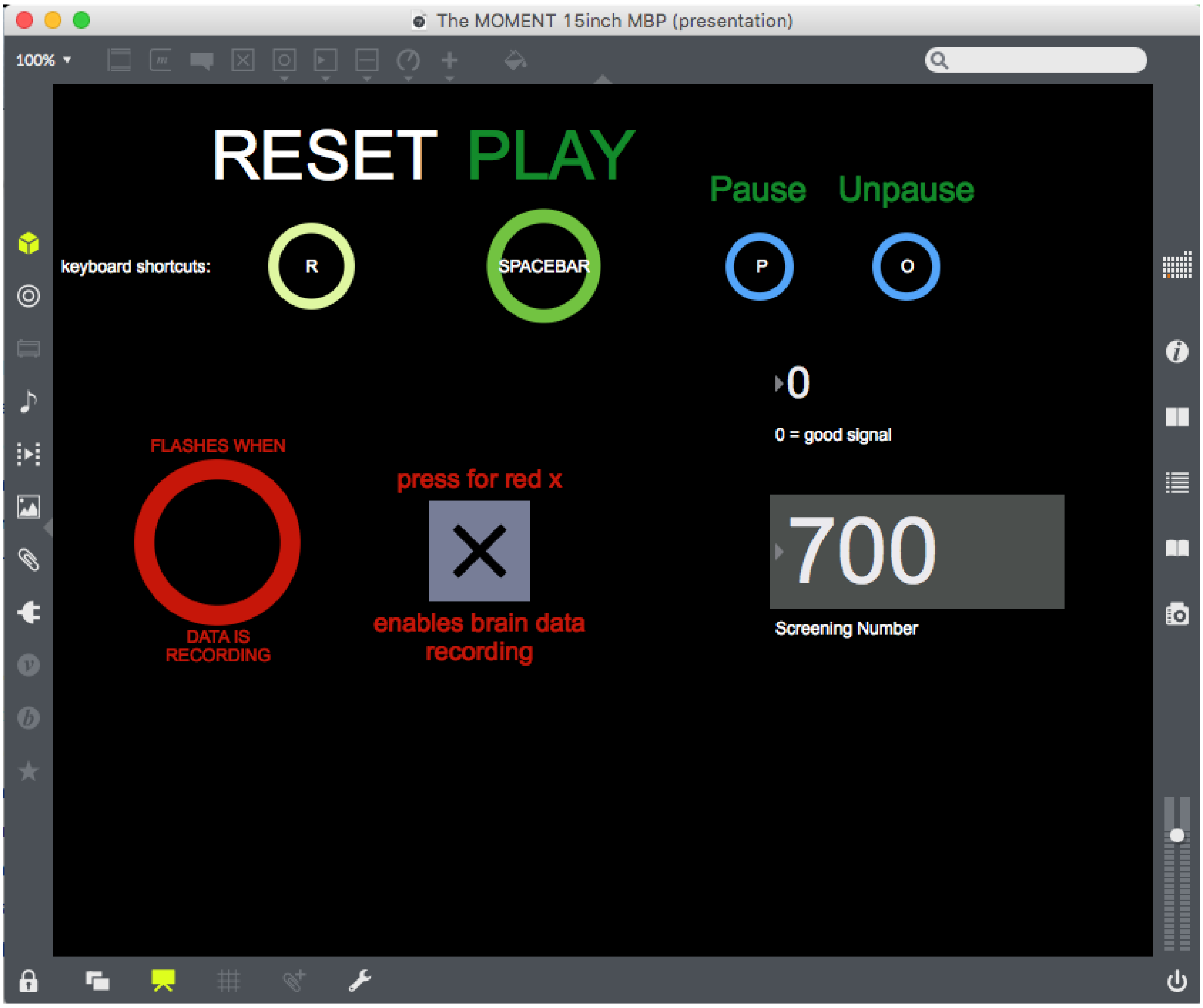

Figure 7.11: Operator user interface for *The MOMENT*

7.6.1 Media processing

Media algorithms

The *media system* receives OSC Attention data and playback instructions from the user via the User Interface. It computes when the film will cut between narrative threads, and what the new scene combinations will be. It also handles the video and audio mixing and playback. Each scene plays two threads, the primary thread is played with the primary sound design of that thread, the secondary thread is played with the secondary sound design. When a cuts are detected the secondary sound design fades out and in with it. The top level media algorithm patch can be seen in Figure 7.13.

There are two distinct yet interconnected algorithms designed into the system. The first, the *Real-time editor algorithm*, decides exactly when the film cuts between narrative threads, the second, the *Combination algorithm*, decides which threads will appear in the next narrative combination based on the behaviour of the aforementioned cuts. I will give an overview of my rational for this design and then reveal the workings of the algorithms.

It is my personal experience that it is possible to learn how to control NeuroSky's Attention data. The most uncontrollable moment however, is when that Attention starts to fall, this is also the Attention peak.

I was inspired by the neuroscientific concept of event segmentation further explored in neurocinematic literature which describes a change in attention at an event boundary (a perceived moment of transition from one action to another) which if a cut is placed at that moment it will feel natural [Zacks and Swallow, 2007, Magliano and Zacks, 2011, Cutting, 2014, Ben-Yakov and Henson, 2018].

My rationale for the design of the *Real-time editor algorithm* was; if a shot raises Attention data then cutting to a new shot immediately after that Attention peaks will match the rhythm of the persons neurological data to the montage. Each shot then starts as Attention is decreasing, will stay as Attention rises and will again cut when Attention drops.

Real-time editor algorithm

The real-time editor, see Figure 7.12 chooses the moment to send a cut message. It detects if, in the last second Attention data has gone from being higher, the same, or lower. When it detects the start of a downward gradient it sends a cut message. It will not be able to send another cut message until it detects a upward trend resetting the mechanism.

Combination algorithm

The *Combination algorithm* was designed to have set rules to keep the primary or secondary threads if they are viewed most and bring in the unseen thread if they are seen equally. This is based on a measure of the duration and frequency of Attention cycles (which are now mapped cinematically, and can be framed in cinematic form as shot length, and cut speed, respectively).

The *Combination algorithm*, which chooses the next scene's combination of narrative treads and primary or secondary sound designs, is based on two variables. The first is the cut rate, how *fast* or *slow* the film cuts. The patch can be seen in 7.15 As previously mentioned cuts are produced when the measured Attention data begins to fall. So the cut rate is also the frequency of attention peaks. The cut rate is calculated so:

- Gets the number of video frames within the scene.
- Counts the number of cuts within a scene.
- At the end of scene divides the number of video frames by the cut count.
- If it is above 105 frames (4.2 seconds) it is defined a *slow* cut speed, if it is below it is defined as *fast*.
- Resets the cut count.

The second variable is the narrative weighting of a scene, the ratio of how long each thread is on screen for within a scene is calculated as below. The Patch can be seen in Figure 7.14.

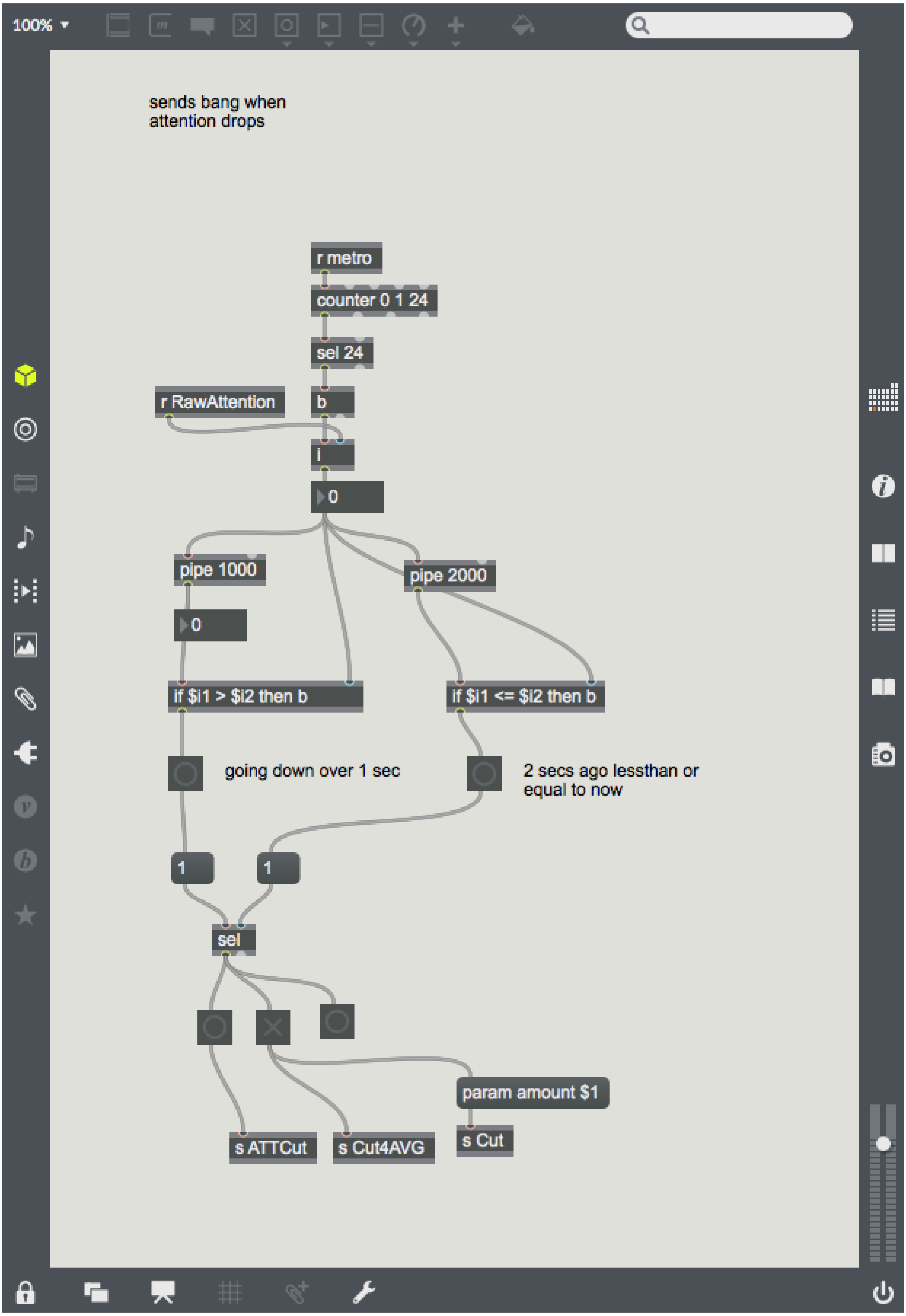

Figure 7.12: Real-time editor patch.

Combination	What happened in previous scene	Next scene combination
1	Viewed most Primary, Fast cuts	Same
2	Viewed most Primary, Slow cuts	New secondary
3	Viewed most Secondary, Fast cuts	New Secondary, previous Secondary to Primary
4	Viewed most Secondary, Slow cuts	Swap Primary and Secondary
5	Viewed Equal, Fast cuts	New Primary, previous Primary to Secondary
6	Viewed Equal, Slow cuts	New Primary

Table 7.2: Scene combination possibilities for *The MOMENT*

- Count duration each thread is on screen for.
- Primary count divided by secondary count.
- Ratio is under .75, then secondary thread is predominant, outputs 1. Ratio is between .75 and 1.5, primary and secondary are equal, outputs 2. Ratio is above 1.5 primary thread is predominant, outputs 3.
- Resets at end of scene.

These two measures can be combined in a total of 6 possible combinations, each is mapped to the narrative thread combination for the next scene.

Next Scene Trigger

Loads and plays threads from scenes in order. This component sends an instruction to run the *Combination algorithm* half a second before the end of each scene. It also detects the end of the film and instructs the CSV patch to write a file.

7.7 Presentation

Playback system

The playback system takes care of presenting the audio and visuals of the film, manipulating them in real time, see Figure 7.16. The video player plays back the two video layers in sync, on top of each other both at full opacity. When the player receives a cut message the topmost layer (primary thread) goes to zero opacity. The volume for sound

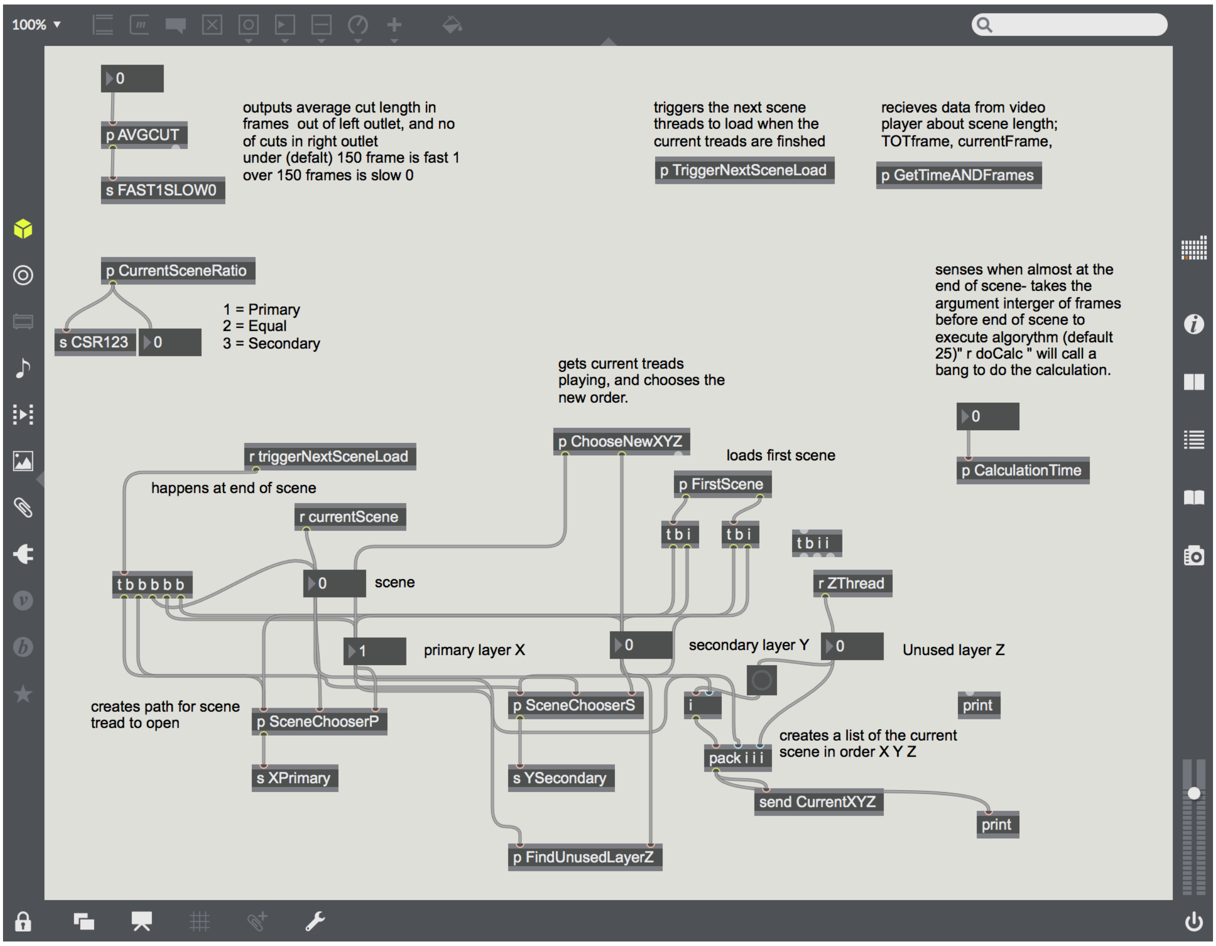

Figure 7.13: Main algorithm patch

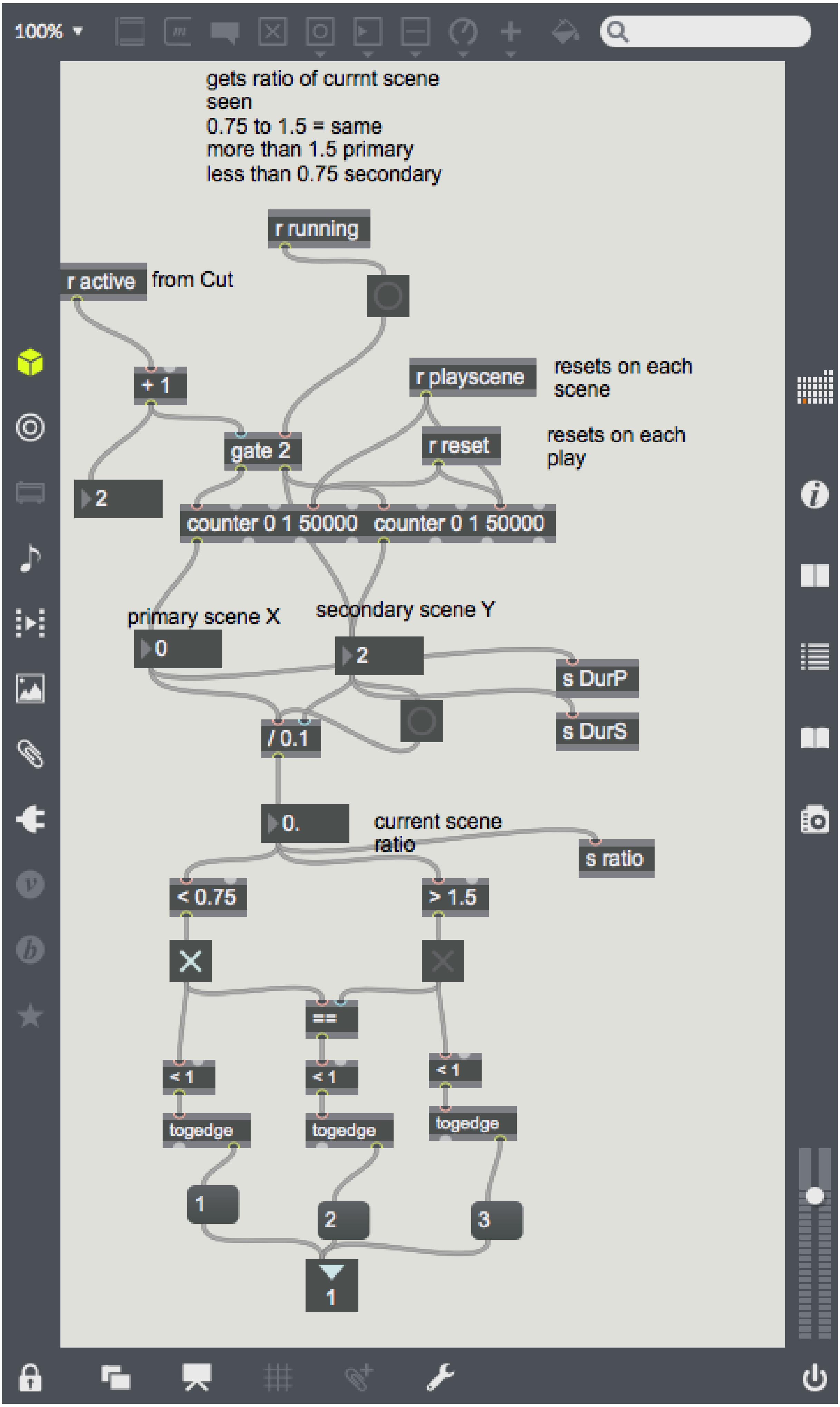

Figure 7.14: This patch calculates the duration ratio of the primary and secondary thread.

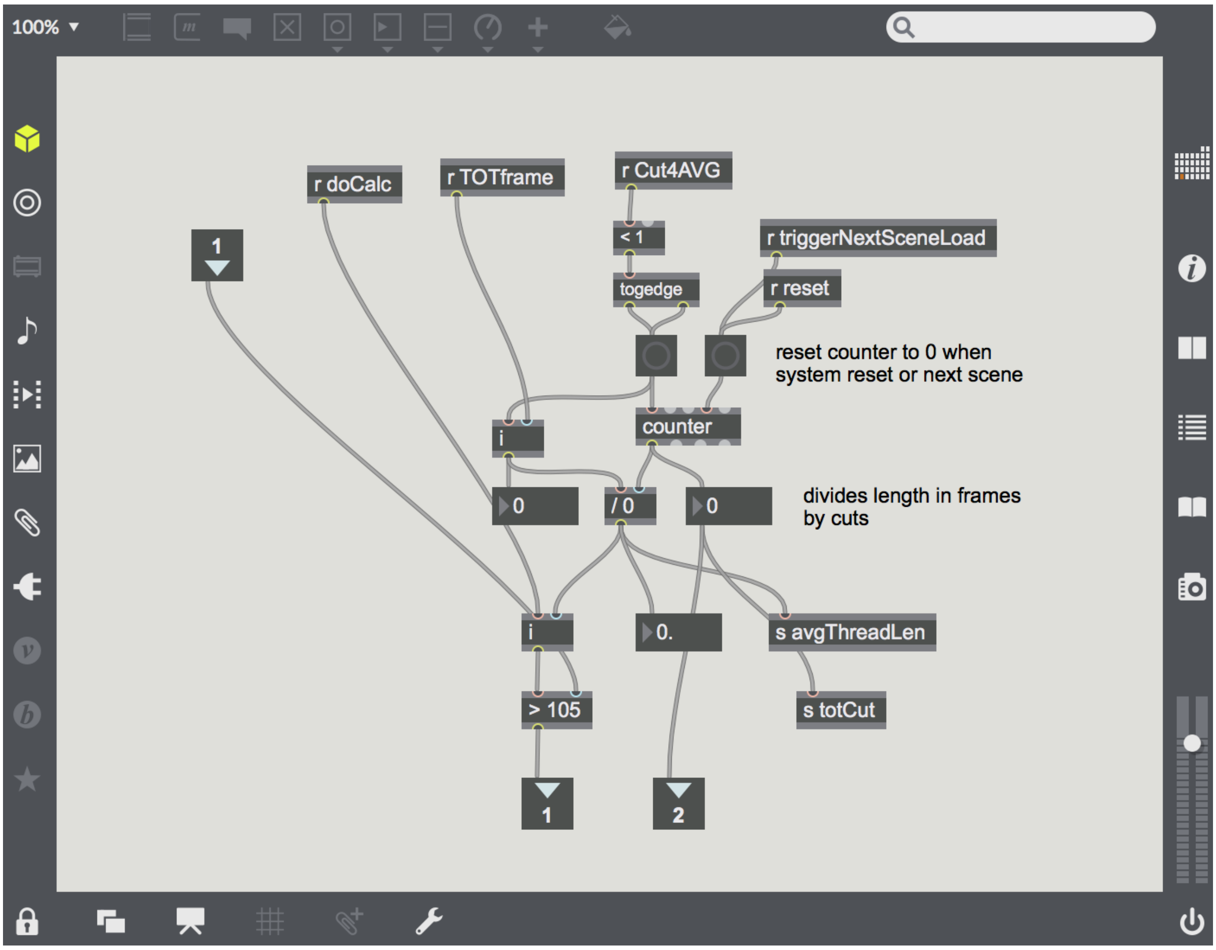

Figure 7.15: This patch calculates the the edit speed.

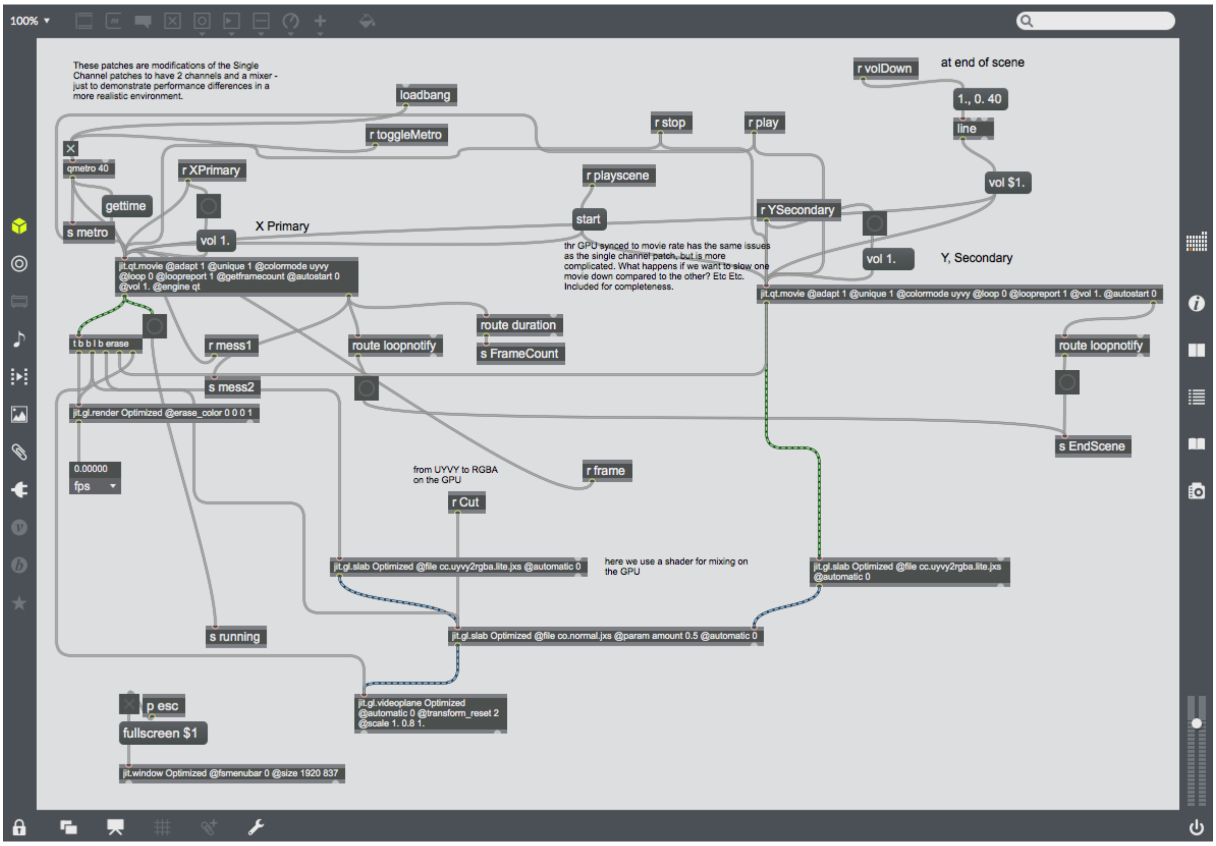

Figure 7.16: The patch which handles the playback of video *The MOMENT* video files.

encoded into the video files is set to full, at the end of a scene the volume fades over 1.8 seconds.

Sound mixer

The sound mixer, seen in Figure 7.17, will play the primary and secondary the sound files. It will mix between the current active threads. The patch receives the thread order and fades out the unused primary and secondary sound designs, when it receives the cut messages it fades out and in the secondary thread sound design.

Data recorder

During playback of *The MOMENT* a line of seventeen data values are collected each second. At the end of the screening a CSV report is written with an unique name delineated by screening number and date. Figure 7.18 shows the patch which handles this. Table 7.7 shows which data is written each second. In Figure 7.19 the patch shown packs the data points 1 to 17 ready to save as a CSV file.

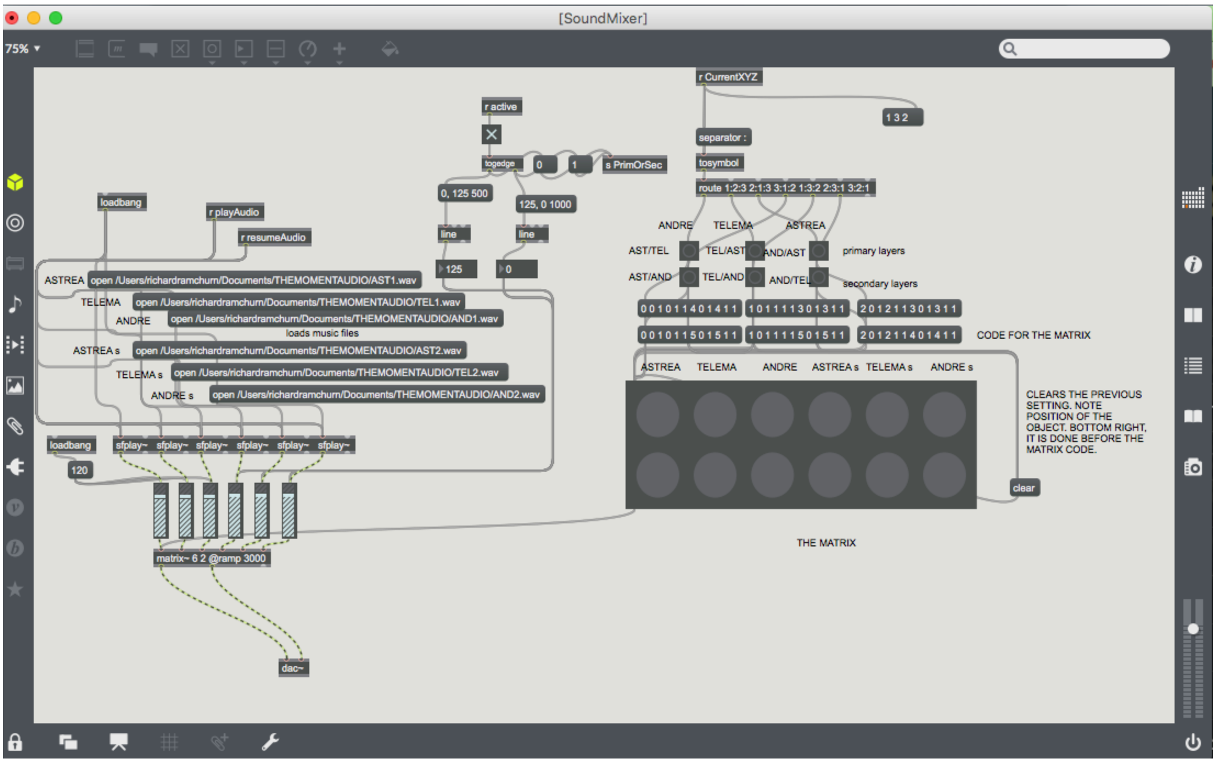

Figure 7.17: Patch which loads, plays and fades sound in *The MOMENT*

Table 7.3: The event log data recorded in the CSV file at the end of each screening of *The MOMENT*

CSV Column	Containing data
1	Row Number
2	Attention Data
3	Scene Number
4	Thread Combination
5	Cut? (Yes = 1 No = 0)
6	Average Scene Length (At end of scene.)
7	Duration on Primary
8	Duration on Secondary
9	Scene Ratio
10	Total Cuts in Scene
11	Screening Number
12-17	Date and Time

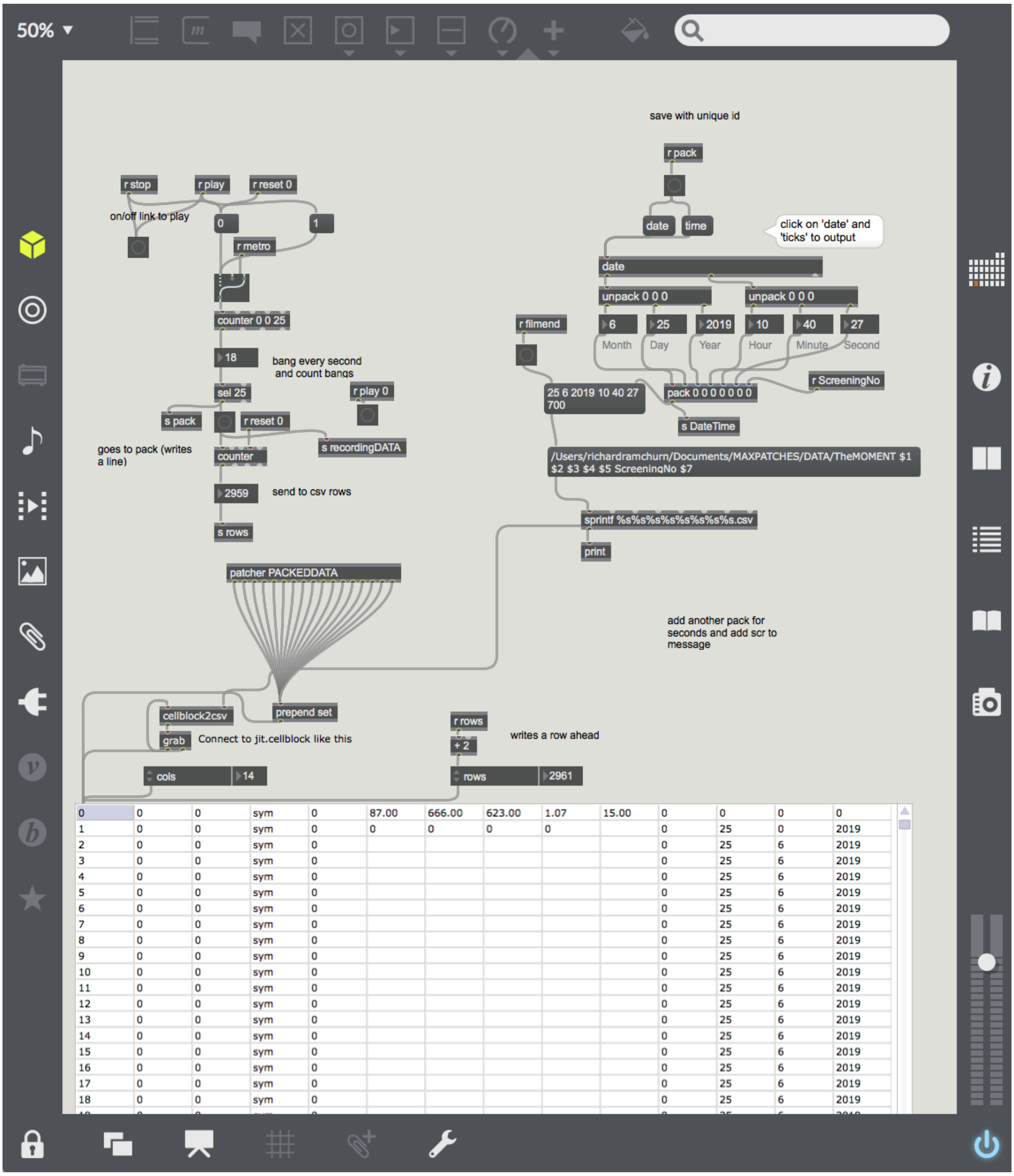

Figure 7.18: MAX patch which creates a CSV file log of each screening of *The MOMENT*

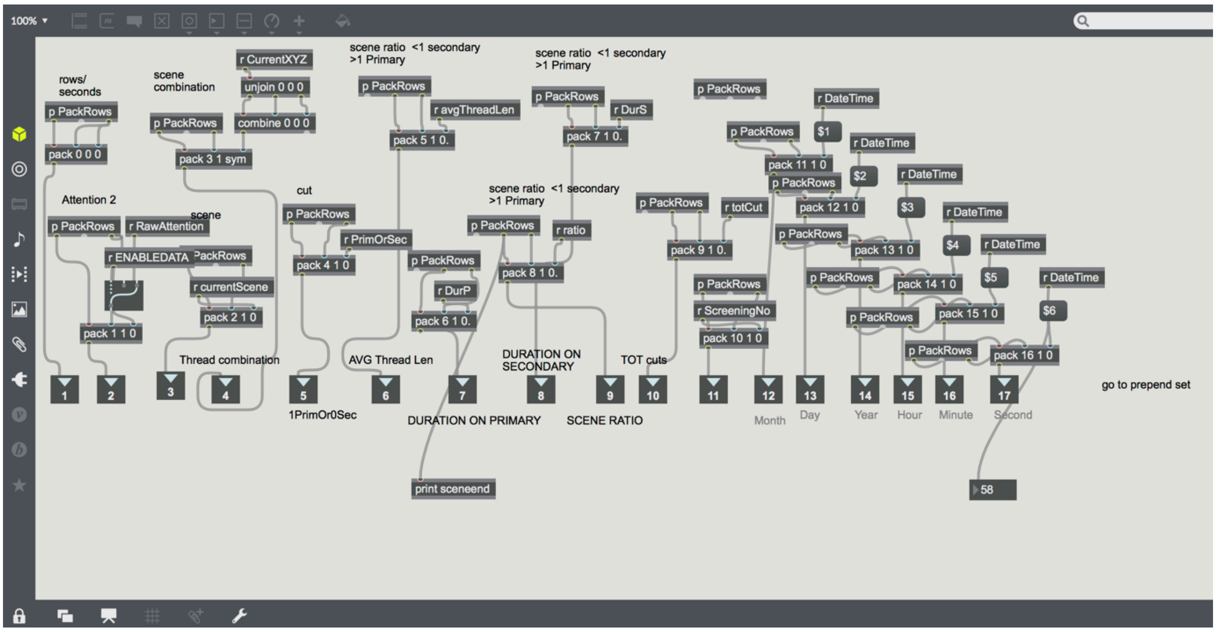

Figure 7.19: Data for each row of the CSV file.

Movie Recorder

Quicktime was used to record each movie screened. Soundflower, an internal sound routing program was also used in order to allow Quicktime to have access to the audio. Each recording was named as the same screening number visible in the UI.

Physical installation

The MOMENT was designed to physically tour the UK and Europe, and so It was decided that we needed a new portable cinema. We received a £10,000 prize funding from the EPSRC Telling Tales of Engagement fund which would allow us to refurbish a classic caravan into a plush velvet 8 capacity cinema. The caravan was designed by Arciform, Liverpool, to specifications based on our use of the cinema caravan provided by AND festival for *The Disadvantages of Time Travel*, significantly improving storage, projector placement and sound fidelity.

A 2000 lumen wide angle projector was used to project the film onto a eight foot screen. Sound was handled by 2x powered, 200w stereo speakers and a sub bass bin.

Artist Sumit Sakar[2] spray painted the design based on Luke Dewhurst's CGI render.

[2]kriksix.com

After our premier at Sheffield Doc/Fest we toured to 14 venues between 2018-2020, engaging approximately 1500 people over 300 screenings.

7.8 In-the-Wild study of *The MOMENT* (Study 3)

The MOMENT premiered in Sheffield, UK as a special event at Sheffield Doc/Fest for six days between the 7th and 12th of June, 2018. A total of 58 screenings took place within the cinema converted caravan. These screenings were free to festival attendees and the public. Controller or viewer places were booked with festival volunteers at the caravan up to one day in advance. They were asked to arrive 5 minutes before the film started where they would be handed a unique ticket, and places were filled if there were any no-shows. Upon entering the caravan the controller would be fitted with the headset. The method of interaction was explained to the whole audience. This introduction delivered the following key points of information:

- Here is your live Attention data (show the audience the BrainOSC app).
- The Attention data is derived by a black box algorithm provided by the headset maker NeuroSky from EEG waves.
- *The MOMENT* is a brain-controlled film, it will cut after a peak in Attention, when an Attention drop is detected.
- Each scene will cut between two parallel narrative threads. The next scene's combination depends on the duration between Attention drops and frequency of Attention drops.
- There are six different narrative thread combinations for each scene.

Once the introduction was completed and consent given (see appendix B) the film was started the screen set to record and door closed. Twenty-four minutes later when the film finished, we would open the door, remove the headset, and hand out questionnaires (see appendix A), which took five minutes to complete. Then the audience was invited to take part in semi structured interviews. It is worth noting that the questionnaire primed the interviewees to the themes of the interview. The interview also acted as a question and answer session for the audience.

The semi structured interviews were guided by the following questions:

Are you interested in how your film would compare to others? In what way?/why not? Who owns the data/the film that was created? What do you think it means if you have lots of drops and peaks of Attention? How did it feel to watch the film as a controller, did you feel any correlation between edits and your internal subconscious? Are you interested in an online archive of all the films created?

A total of 279 people saw the film over six days. The data reported is from 78 transcripts from semi structured group interviews with participants, both viewers and controllers, and 204 questionnaire responses (non-responses were typically from busy festival goers who had another event to attend). Additionally each screening was screen recorded and 29[3] CSV data log files were automatically created containing screening metadata such as scene combinations and Attention data; the data structure is summarised in table 7.7.

7.9 Research questions

We now reflect on what has been learned about our research questions from the making of our second brain controlled film. ***RQ1: What are the problems inherent to interactive cinema?***

The real-time dynamic form of interactive film that classifies *The Disadvantages of Time Travel*and *The MOMENT*has unique challenges in relation to the sound design. These

[3]A programming error caused every other CSV file to clear all fields before saving, causing the creation of 29 empty logs.

challenges were addressed by disassembling the components which makes up a sound design and creating a rule based autonomous system.

Where the production style of *The Disadvantages of Time Travel* was free form and improvised the scale of *The MOMENT* required a more structured narrative and interactive design blueprint. The narrative and interactive design were conceived in parallel. This is evidenced in the single dynamic PowerPoint slide (Figure 7.1) which changed as both designs developed, the narrative design matrix of scenes following three characters, the form of the script, and the parallel storyboarding process.

Preparing the footage for the interactive system was done by editing parallel timelines so that they match. This challenge was met by simplifying the editing workflow to that of *The Disadvantages of Time Travel*. The edit was built within one sequence, with in-sequence and on screen labels used to denote scene and tread. This differs from the approach taken with *The Disadvantages of Time Travel*which used nested edit sequences which was effective but cumbersome to work with.

RQ2: How can real-time interactions via a Brain Computer Interface (BCI) construct cinematic content?

Identifying that active control can disrupt cinematic engagement led to the choice of dropping blinking as a control modality, we found it overpowered cinematic engagement, and got in the way of exploring unconscious control, and passive interaction. Additionally, drawing on theories presented by neurocinematic researchers Magliano and Zacks [2011], Zacks and Swallow [2007], Cutting et al. [2018], Smith [2012], using frequencies of Attention mapped to montage rhythm led to two new algorithm designs. First, by identifying Attention peaks and matching these to the film edit, or cut. The second algorithm is used to choose the next scene's narrative combination. By analysing the frequencies of when the film cuts determines which combination of interactive scenes the following scene will be composed of.

Emphasising contrasting cinematic motifs such as colour and composition to locate the audience in the narrative. So as when a change made by the viewers data happens it has a noticeable effect.

RQ3: How do interacting individuals respond to various brain-controlled cinematic designs?

There are three ways in which a controller can experience this version of *The MOMENT*, as first time controller, as a controller who has previously viewed a version of the film and viewing the film after controlling.

RQ5: How can brain-controlled cinema add value to audience experience?

As *The MOMENT* was designed for repeat experiences, additional watches allows the viewer to finding out more in the narrative and different facets of the narrative, similar to Hollywood puzzle films such as *Memento* or *Dark City*.

The genre is that of a science fiction noir thriller, with the real world addition of a brain scanner this this makes a semantic bridge to the fabula of the film.

The live cinema aspect of brain controlled film demands some face to face interaction between the operator and the audience, for the most part the operator has knowledge about the film that is in demand to the audience. Having someone there who is able to answer questions, gives the audience an extra layer of value.

Chapter 8

Results 3: Controlling, watching and re-watching *The MOMENT* from Study 3

8.1 About the screenings of *The MOMENT*

Qualitative data from interviews was thematically analysed in the mode of Braun and Clarke [Braun and Clarke, 2012, 2006], and developed to a full paper published at CHI'19 [Ramchurn et al., 2019a]. Review of this sample allowed the large volume of qualitative material to be organised according to interview characteristics: type (individual or group); for group interviews, interviewee relationships (known, unknown or mixed); role (controller or non-controller); viewing instance (first time or repeat). The process produced 17 codes across 3 top level themes: "Controlling the film" (137 references in 25 transcripts); "Viewing without controlling" (99 references in 25 transcripts); 'Repeat Viewing' (90 references in 24 transcripts). These also reflect the three ways the movie can be experienced; by a controlling viewer, a non-controlling viewer and as a repeat viewing. Results are reported discursively according to these themes.

Quantitative data from questionnaires and CSV files are analysed and used to describe the character of screenings and add relevant detail to sub themes.

Participants are identified by their three digit ticket number. The first digit denotes the performance day (1-6), the second digit denotes which screening of the day (0-9), the final number denotes if the participant was a controller (0) or audience member (1-9). For example participant 290 is the controller of the tenth and last performance on the second day, whereas participant 432 is an audience member in the fourth performance on the fourth day. Where there are two or more numbers denotes the separate screenings the participant attended.

8.2 Controlling viewers

In this section we report conversations from a sample of the 40 controllers who wore the headset and whose data drove the film. Of the 123 people who responded, 100% wanted to control the film. We follow the controller's journeys throughout their experience. We report: how the introduction impacted their expectations; when they were in the process of watching, the pressures they felt; how they went about exercising their control; and their intentions and tactics to control and watch. We explore: what their control meant in this context; if they had seen the film before, how did that prior knowledge impact controlling the film; and how did they value that variety. Finally, how did it make them aware of their own thought processes.

8.2.1 Expectations

A consistent introduction was delivered before each screening, resulting in 95% of controllers reporting an understanding or partial understanding of the system's workings. Here we examine how this prior knowledge affected the controllers' approach to interaction. All 40 of the controllers reported in the questionnaire that they wanted to know how it worked. However in interviews some see the discovery of control as part of the fun. A non-controller reflects on this:

> I don't know, I think, like, you can get two outcomes out of it. So like maybe knowing a limited amount is good because then like you can surprise yourself with your own thoughts and like being translated to like editing on screen. But at the same time you might get more enjoyment knowing that your thoughts control the film and how exactly you do that. So I suppose it depends on the person how much you enjoy being in control of things. 213

This tension between being told how the system and control of the system works before the movie starts or not being told is also evident in controllers who have just experienced the film;

"*I think it's quite good to have the experience without knowing much at all*" 220.
And
"*I think it put you at ease a bit because you felt like a lot of pressure,*" 290.

8.2.2 Pressure to perform

We saw in the previous brain-controlled film a pressure to perform that controlling viewers feel when interacting with the movie. Here also we found that the majority of people felt a pressure or responsibility to make the film enjoyable and interesting for their fellow audience members (see figure 8.1), "*So I guess there's a bit of pressure from, like, a... if you know that you're having some kind of control to try and make the viewing as good as possible for everyone else. But yes, that was kind of what was going through my mind, I guess.*" 560

For others there was a perceived privilege of being the one to control:

"*I feel like I was lucky because I got to be to the controller and I suppose everybody wanted*

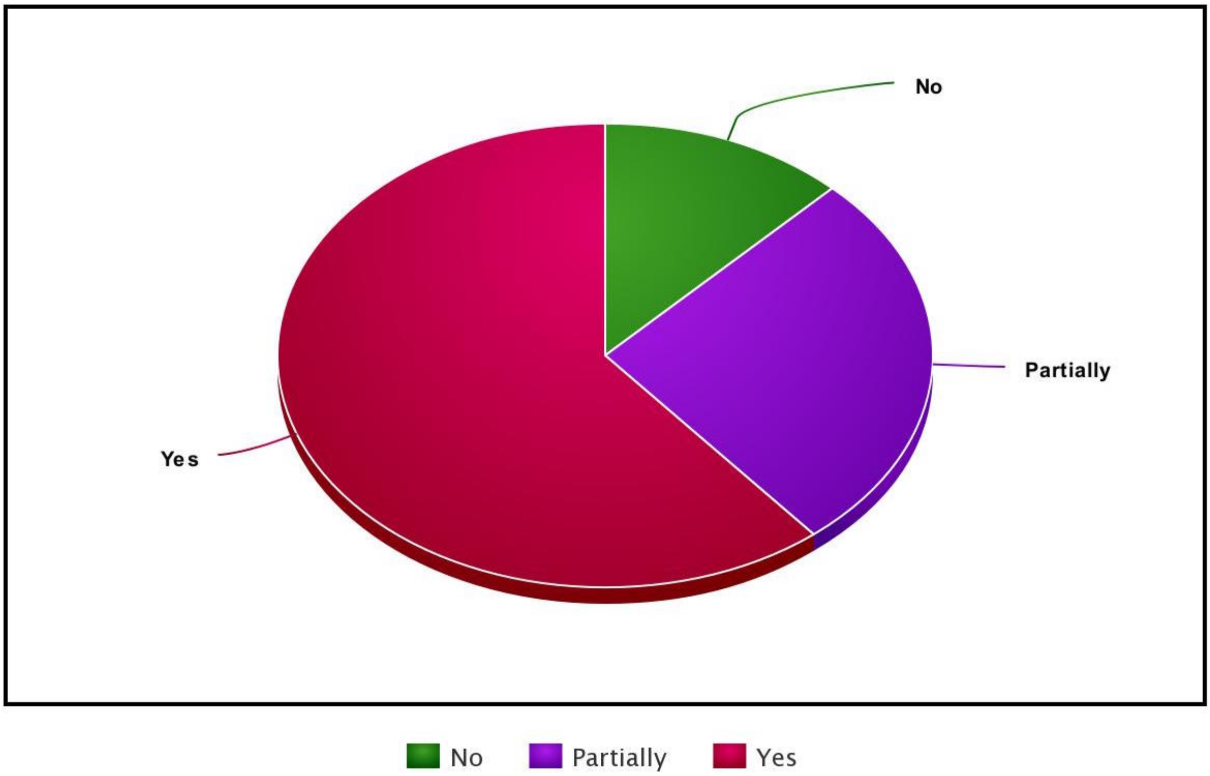

Figure 8.1: Did you feel a responsibility to make a good film experience?

that opportunity. So I wanted to make sure that I was doing it well" 480.

As well as wanting to make a 'good film' some controllers wanted to make sure the rest of the audience was paying attention. "*Yes, definitely, I was very sub-conscious of like people like keeping attention to the film. And for some reason, I thought that yes, there was a pressure to perform.*" 370

However, for some the pressure eased off once controllers became used to the interaction, and engaged with the narrative: "*It's not like watching a normal film because in a way you do feel like you are watching something yours so it's always like a bit nervous but it faded throughout the film.*" 610. "*Maybe at the beginning, and then maybe as I got into it, because it seemed to just go as a film.*" 380

So while a pressure to perform was still present it was not an overpowering attribute of the experience. Additionally, as people got used to the interaction and engaged in film watching the pressure to perform reduced.

8.2.3 Experimentation with control

Controlling viewers moved between two modes of engagement, some people would experiment; with deliberate attempts and techniques to try to control the film to understand how it works, whereas some were happy to be passive and watch without trying to control.

> So I absolutely tried to actively control the film so when there was something going on that I wanted to see more of on one of the tracks, I really tried to focus on it. But I don't know, again in the midst of me monitoring it, looking at the lighting and all that stuff, I don't think that worked. I tried blinking, my eye movement as well, I felt like sometimes some of these things did work but not all the time. 100 and 122.

For some the action of the film cutting and striving to make the meaning of the film moved controllers' intentions to a more passive state,

> At the beginning I felt it cut a lot and I was like, oh, I'm cutting it a lot and I want to... I felt... At the beginning, I would want to control, I wanted to control it more because I wanted to like kind of figure out what's going on with the film. And then I was just like, right, I'm just going to just watch it and see what happens. And then that's when the third character came in and I think things made sense for me a bit more. 290.

When the attempt to actively control film is not met with explicit feedback they may move into a more lean back mode, which in turn allowed them to enjoy it more. "*... once I did realise that I had no idea how to manipulate the thing, I just, kind of, started enjoying it for what it was, whatever came off the screen, you know.*" 220

For the few that did feel that they found something resembling control it is described as understated.

> "*And, it kind of did lean a bit more to what I was thinking. But, it wasn't too drastic. It was very subtle. And, I think it slowly turned into something that I was able to control.*" 250 and 276.

When controllers were asked if they felt the film responded to them 27.5% said yes, 52.5% responded that it partially did and 12.5% said that the felt no response. The majority were able to perceive at least some sense of control.

We see that when strategies to control the film failed controllers would engage with the cinematic content.

8.2.4 Intention

We further explore what controllers were thinking and how that impacted on their experience of the film. They are engaged in making meaning of the film narrative and making sense of how they are interacting at the same time. Sometimes these two things can become entangled and a conflict is struck between engaging with control and engaging with the narrative. By accepting that control is happening even though it is not explicitly felt and by letting go of the intention to control leads to a possibly fuller engagement with the unfolding narrative.

First time controllers and viewers negotiate what is possible within the screening, '*I was definitely thinking things like, oh, it'd be good if she escapes, and then she escaped*' ;

Either by willing changes in the scenario or mood of the film, "*I was trying to make it positive*" 630.

Sometimes an uncanny coincidence involving a controller and the content would cause alarm with the audience, "*you laughed out loud and then she laughed on the screen and that freaked me out*" 341.

While some come to an understanding of the system's limitations: *"It's not going to throw* *in a dinosaur for us because I imagine it"* 660. Others contrast the film experience to qualities of liveness: *"imagine it more like an improv show, where you've obviously got the audience feedback instantly"* 660.

However for some they feel that the controllers' input into the film is in conflict with the artistry of the creation process and undermines the directors vision:

> [The director]'s entirely dependent on the controller, isn't he? Because they're supposed to create the narrative, but I didn't feel like there was a clear narrative or a running message through the film. [...] He's filmed the whole thing, but he's filmed it from different people's point of view and the way that you watch it with the controller is skipping between those views. So, that can sometimes detract away from the message that he originally intended. 254 and 150.

Likewise, with controller 550, they think that actively controlling a film makes it not a film at all and that they would rather not be in full control:

> "*I don't think that's the experience of watching a film. And the point of watching it, at least for me anyway, is to try and disengage with what I would want and experience someone else's vision and then think about that afterwards. [...] I much prefer to be out of control in that situation, rather than decide.*" 550

The following three controllers tried to correlate their internal state of mind and the flow of the film: "*I was actively trying to look at things like pacing and whether that was related to my mood*" 140; "*there must be a correlation between how coherent the story is and how strong your attention is, there must be*" 254 and 150; "*I'm in a pretty calm mood because [...] woke up [early], I had a good breakfast so maybe it reflected on the pace of the film*" 230.

When the following controller became aware of their own sleepiness in the warm screening space they choose to self-moderate: "*I might have, like, been this close to dozing off a bit. Which is why I started fumbling with my bag and started trying to wake myself up*" 220

Believing that control is being exerted, even if the nature of that control is unknown, is a source of pleasure: "*when I thought that yes, okay, I think I'm doing something that makes a cut, it's [expletive] great! It's cool.*" 100 and 122

Likewise intentionally not controlling it because the mechanism is unknown is seen by some to create an authentic experience:

> I think that having the experience of controlling the picture and viewing the picture without knowing the algorithm is important. Because it creates more of an organic experience. I feel like, if you knew how it worked going into it, you would try and game the system and it wouldn't be as original. 270.

Indeed, knowing that the film is acting on Attention caused some to be mindful of their attention;

> I think you'd probably get a more accurate result if somebody doesn't know exactly what it's doing. The fact that it's not familiar is another stimulus really. So I sat more attentively than I would have done normally if I was watching a film. 270.

But for others, not knowing the mechanism actually caused stress; "*I just felt stressed [...] I didn't fully understand exactly how I was controlling it or to what degree it's making those decisions*" ; "*I was just doubting myself, was I in control*" 343(controller); "*I don't know how much control I was having over it. I didn't know whether I was controlling the switch between the graphical and real*" 400,102,157,216,254, and 601. These participants had been given the same introduction as others, and were told the workings of the system, and so they are referring to the real-time system feedback.

It was down to the individual to choose to let go of control and the worry of not being in full control, to enter a lean back approach, and allow the film to happen without trying to consciously change it. "*In the end I just stopped and just watched it for what it was*" 220. "*realising that I just didn't really know what my brain was controlling. [...] I think knowing something is doing something but not quite knowing why is alright.*" 320. "*This was something not really I created, but something I let happen [...] It felt less like control and more like influence. Rather than pushing the story, you kind of just nudge it*" 270. By recognising their influence as subconscious control, controllers are able to engage in viewing the film without extraneous attention spent on how it might work.

8.2.5 Self reflection

Watching and wearing the headset moved some controllers to become more aware of their own mind; they noticed if they were concentrating hard or finding it hard to concentrate. These next two people were open to talk about their mental health or neural atypicalness and were intrigued about if that influenced the film:

"*Well, I have very little attention, I'm ADHD so I've very little attention span, so that's probably why it was darting all over the show.*" 150.

"*I think I'd ha[d] weird anxiety this week. So I'm really struggling to concentrate on something. So I was wondering how much that was going to affect it,*" 320

But for most controllers the most exciting part of the experience was when they felt interaction: "*It's a really exciting process. It's a really exciting experience to think that on a very, almost unconscious or becoming conscious way, your brain is interacting with a piece of art someone else has made.*" 100 and 122. "*I think it was, for me, of the ground-breaking thing that you could actually see what is the difference between what you've been doing and then when it comes out in the screen.*" 343.

However, this interaction is not conscious control, and it made them aware of just how in control of their thoughts they are, and they enjoyed becoming aware of their ungoverned thoughts,

> I also quite enjoy the fact that it really shows the gap that exists between what we think our brain is doing and what is actually happening with it. Where our attention is or isn't. So yes, having more control is appealing in a way but I also quite like the mystery of it, of just saying no, let's see what my brain actually is tuning into. 100 and 122.

The feedback of non direct control through the filmic system allowed for mindful interactions as controllers reflected on how and what they were thinking during their experience.

8.2.6 Ownership

Some controllers felt joint ownership with the others in the screening, they described it as putting part of themselves into the film, they felt more ownership in discussions learning how the version they controlled was different for others. "*you are able to input yourself, your own ideas into it*" 130; "*It was quite fast-paced, the cuts and I think that was where my mind was at.*" 270. Controllers talked about the films that they controlled as their films, as they made a connection between how they felt their brain was working whilst watching and the qualities of the film. A controller who described themselves as neuro atypical felt that their condition affected the screening negatively and took responsibility for that;

> So, it was like literally my attention's all over the show. So, I think it's probably safe to say that every time my attention moved to something else, which was every four or five seconds or so, something else happened on the screen. So, yes, I feel really bad for the people who had to watch my version now, to be fair. 254 and 150.

Being able to see a different version of the film means they are able to compare which leads to an increased ownership of their version of the film. "*If I was to see it again or a couple of times again and seeing those different versions, it would feel more like my film.*" 220 "*I felt very engaged with it and very involved but I think because it's very new I find it hard to think, oh, this is my film. ... it feels more so now, hearing the feedback than it did whist I was involved, if you like.*" 300

While first time controllers may not feel immediate ownership, retrospective understanding from seeing or hearing about variant versions of the film may cause some controllers to feel more ownership over the film version they created.

8.2.7 Variety

Each time *The MOMENT* is viewed is a different edit. Figure 8.2 maps the narrative journeys of 29 screenings; no two screenings follow the same path. But how is that 'read' by the audience? Some saw the film first as an non-controlling audience member and came back to control, whereas some wanted to experience it again as an a non-controller. For controllers, how did they relate to other versions that they did not control?

> I found it very interesting to see how those new characters interacted with the story; because it seemed like a completely different story from the previous time I watched it, despite the fact that it's both the same film in a way. ... it was different from what I first saw. And there were a lot of moments that intrigued me in the thing and what I saw for the first time and for the second time [...] I think with the addition with the new characters that I mentioned I think it really changed my perspective on just who the characters were themselves. 250 and 276.

These additional viewings augment the narrative experience by giving deeper insights into characters, changed perspectives in the story, and heightened dramatic moments. Each

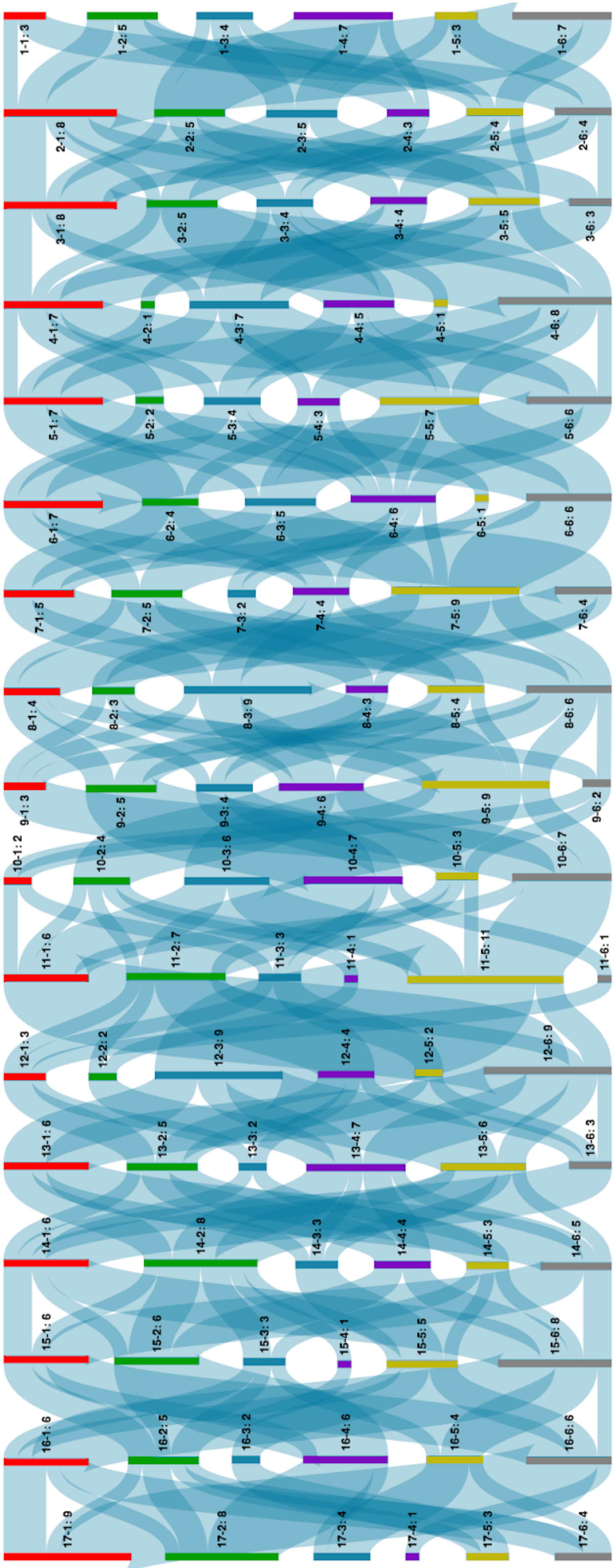

Figure 8.2: Narrative routes taken by 29 controllers of *The MOMENT*. The chart reads from top to bottom. The numbers are in the format: scene number 1-17 / narrative combination 1-6 / number of people to see this scene combination.

viewing was seen to be a new story or a new telling of the narrative. The audience was able to keep the two stories separate although they add value and meaning to each other.

> I found it a better storyline, so it actually followed the progression of the story. I feel like there was more detail to the story. So, for example, at the beginning and I think in the third part it zoomed into [...] Astrea. It followed her a lot more and then at the beginning you saw the bad people that walk in up the stairs and how they actually got into the house and all little details like that. And there was the woman with the curly hair, she acted as a kind of spirit or something to reassure Astrea. So, it was a bit different, wasn't it? I think before it just showed... The ones I've seen focus more on Andre, so it was like a completely different story to what I saw last time. 670 and 402.

While this storytelling form is new to audiences they are still able to comprehend the narrative, and deeper comprehension comes from subsequent viewings.

8.3 Non-controllers and social interaction

The majority of people in the screenings are audience, they are not controlling the film but watching, so how do these non-controllers relate to what is happening, both on the screen and with the controller. The interview excerpts in this section explore how the interactive design encourages variant meanings to be made. How non-controllers feel the interaction and behaviour of the film can give insights into the controllers minds. Viewers who are seeing it for a second or third time, see the post screening discussions as a chance to bring together the variant versions. All of these components together add value to the non-controllers experience.

8.3.1 How non-controllers make sense of interactions.

For the non-controllers to makes sense of what was happening they would imagine what the controllers were doing to make the system produce the film. Thus, the controller becomes an important and interesting person in the room. One viewer, when asked what was the most memorable part of the experience, replied, "*Watching him trying to figure out how it worked.*" 231. The controller's mental state shares the stage; it become an important part of the experience, "*there must be a correlation between how coherent the story is and how strong your attention is, there must be.*" 254 and 150.

In fact 57.6% of non controllers said they had insight or partial insight into the controller's mind.

Although some were more sceptical of the level of control the controller had;

(643)

I don't think there's any technology out there that's that responsive. Otherwise I probably would know about it. And it was so small and wireless. I was like, it can't be that advanced.

(644)

I feel like she could have been passively controlling it but not actively, so it's just reading signals.

(643)

Like subconsciously.

The audience sees correlations between what happens in the screening space and what happens on screen,

(251)

She did seem focused, because I walked across and she didn't fidget or...

(254)

She never fidgeted, she never did anything. The only time she ever moved was just to cool herself down with the fan because it was really hot in there.

(251)

Actually I think that's when the image came up, in retrospect. Think that's when one of the... It cut away from the...

(254)

The animation. So, the animation when she was... Yes. So, that would probably make sense, yes.

8.3.2 Insight- moving between the controller and the film

As we have seen there was a curiosity and interest about what the controllers were thinking; this was particularly true for filmmakers and editors who are used to deliberating and refining an edit: "*as an editor it was, kind of, fascinating to see the pace of something that's controlled by your own mind*". 213. "*I was trying to notice when that person's attention span moved at, if they did, and there were a couple of things that happened in it where conventional editing would have been a little different.*" 531. And so, being familiar with film construction sensitised some to the mechanisms of control and in turn the controller's mind.

It is also present that, similar to the controllers moving between attending the film and becoming aware of their thoughts, the non-controllers would be go between the film and the controller; "*I was wondering what he might be controlling, I suppose. And then sometimes forgetting that and just watching the film. Kind of wondering what was, what bits of it, he was affecting.*" 232. Other viewers felt a correlation between the story's structure and the state of the controllers mind, "*the person who tends to be the most frantic about things, apparently, had the most non-linear storyline. And the people who seem more* *stable, and just going linearly in many ways, seem to have very linear story lines.*" 284.

8.3.3 Narrative comprehension

For *The MOMENT* to work as a film it needs to be understood within the cinematic context; as cinema is a wide and differently understood medium the following results can situate *The MOMENT* in the wider classification. We have seen the movie is different every time and so is going understood differently by each audience member, as exampled by the following exchange between a controller and a viewer.

(253)

It kind of started to make sense as you went. In the beginning it felt like a few scenes here and there and it didn't really feel like there was a coherent story. But then as you get more and more into it with more and more detail, I think a story really started to form.

(250)

It was almost like a jigsaw puzzle in a way, where at the beginning you sort out the pieces into the various colours. And then as you progress further on, they start to come together and perform a cohesive whole.

On a smaller temporal scale, second by second the film is recombining live and designed so that recombination creates particular cinematic techniques: "*But there was a really nice cut in there where we see her jumping out and her face lighting up blue when she's outside the flat, and we know some bad [expletive]'s going on, there is a really quick cut to Lance, where he's got the mask on so we know that he means something to her.*" 122

Part of viewing a film is the work of actively constructing the narrative by the viewer; "*To be honest and I enjoyed, sort of, trying to fill in the blanks myself. I, kind of, went* *down a bit of a Dr Who flavoured rabbit hole in my head.*" 231; "*The whole cutting that random graphic face. At first, that I wasn't really understanding. But, by the end of it, it sort of made sense. The narrative, otherwise, more or less made sense,*" 272.

8.3.4 Added value

As we see, it is understood as a film, but it also interrupts some traditions associated with the concept of the active viewer and linear filmic experience. It builds on the concept of the viewer who actively co-constructs meaning by comprehending filmic content, "*breaking down of the traditional ideas of subject and object.*" 265

This additional characteristic of the film has been likened to painting, and to site specific interactive theatre; "*It's like an art form where if you ask three different people to paint a pot of, a vase of flowers, you get three really different outcomes. With this there's a real, like a sense, there is a sense of ownership I think. There is a sense of, that you do have a stake in what comes out at the end of this.*" 122. "*Much like going to... Like there's a company called Punch Drunk and you could go and see their shows. It's really hard to get at the story even though there's one there, but you have to so that you can fit, if you want to you can fill in the blanks.*" 231.

There is the view that a unique, distinct object has been made, one that people would like to show others; "*I think I would show people and I'd be like, yes, this is... I did that with my brain, sort of!*" 290

The non-branching narrative design is justified by the following response from a viewer about being able to consciously choose a direction of the film:

> Not really because I don't think that's the experience of watching a film. And the point of watching it, at least for me anyway, is to try and disengage with what I would want and experience someone else's vision and then think about that afterwards. So I wouldn't

> want to choose my own ending really. It reminded me a lot of when I was little – I used to read a lot of the [choose your own] adventure books where you got the choice as to what you did. And even though I read quite a lot of them, I didn't find them that satisfying because you could just, you could muddle it yourself, you know, once you knew what you were doing, and I much prefer to be out of control in that situation, rather than decide. 550

What is the added value for audiences watching this type of movie over a standard traditional film in a cinema? As we have seen, wearing the headset was sought after but here we see it is not integral to enjoying the experience. While there is evidence that the controllers have more investment in the film, the following non controllers describe what they gain from the experience of watching: "*I didn't want to do it, I didn't want the responsibility, I wanted to absorb and sit.*" 141. "*I definitely think the idea of choosing the story is really interesting. And even just watching it for the first time it's still crazy that the person sitting next to me was controlling, was the puppet master of sorts the whole time.*" 253. "*I mean, absolutely nothing compares to the experience of that, compared to just going to see a regular movie, you're completely not in control of a regular movie. Whereas this, at least there's a sense that the controller is in control of it. Bit, brilliant, absolutely excellent. Really loved it.*" 254 and 150. "*Strange, I've never seen any image like that in any film before, it had a strange, dream-like quality actually.*" 252 "*It keeps you interested. So you want to know what's coming next. So you've got to be interested in it*" 333

8.4 Repeat viewings

As part if its iterative design in Section 7.2 *The MOMENT* was designed to extend the viewing experience across multiple viewings and from questionnaire responses 94.1% of the audience indeed reported that they would like to see the film again in some form. Thus, the final part of our results section uncovers controller's and non-controller's experiences of repeat viewing. We start by exploring how participants compared the variant films, how they contrast one version with another and how slight variations can cause different meanings. These variant versions can be seen as personal films both to the controller and to the specific screenings' audience. On each viewing a new and changing perspectives would form, within the story world and from the point of view of the participants. From these variant versions and perspectives a holistic understanding of the wider film narrative will form. We report on why participants wanted to see it multiple times. Finally we present motivations for those participants who want to watch another version.

8.4.1 Contrast, comparing between multiple versions

Directors are known put hidden and layered meanings in their films, designed to come out in repeat viewings; watch a well-made film again and you will notice things you didn't before especially with the foreknowledge of the previous viewing. Filmic techniques such as leaving clues throughout which will amend context on subsequent viewings[Renner, 2006]. Watching *The MOMENT* for a second time mirrors this technique as one repeat viewer says:

> With this, it's that's just completely amplified. I mean, you can keep going back and watching this and seeing a different version until you could map out the story elements for each of these characters, I think in quite a clear way, with repeat viewings. ... even after two I think that made sense… 100 and 122

Of course in order to see these differences between the films one must watch it a number of times. During the screenings at Sheffield DOC/FEST twenty-four people voluntarily came back to see the film again, sometimes three or more times. How did these films contrast with each other? Seeing other sides of the same story will provide additional context about the characters, even creating different character arcs. The following two interview excerpts show two different characters seen in different ways from repeat screenings:

> I think in this version there was more backstory and more context because yesterday we were thrown into the deep end with the characters and their stories. Then this time there was backstory and there was more of a story of, kind of, guilt and redemption from [...] Andre [...]. There was more context. There was more emotional engagement because I understood the motivations behind the characters this time. 303 and 213

> I feel like she was more unknown in my version and she was more somebody who was coming from out of the blue. Whereas in your version, you got more backstory, you didn't know how it was going to go. In my version, she came across as like nature and a bit zen, [...] And in your version, because there was more backstory, you felt she was more fragile and you didn't know where she got her strength from. 400, 102,157,216,254, and 601

As well as adding context to previous screenings, different meanings can be made and the fate of characters may be seen to change because of what is seen or not. At the climax of the film there's one shot in which a character thought to be dead opens his eyes and is revived. In many versions of the film this shot doesn't feature; the variation creates an 'alternate ending' for those who've seen the film both with and without that single shot:

(353 and 331)

Actually, that was the bit with Andre at the very end.

(354 and 330)

Ah, that he came back.

(353 and 331)

Where he didn't wake up in the first version, and this one, he wakes up. And you think, was he pretending to be dead or did he

> wake up after [overtalking].
>
> **(354 and 330)**
>
> [overtalking] He must have taken a happy pill.
>
> **(353 and 331)**
>
> But yes, that was a totally different ending. And in the end, she says the thing but as a different meaning, which was quite cool.

Not only do people want to watch the film again, when they do they have a more fulfilling movie watching experience.

The variety in the films that were made encourages discussion between viewers of different versions. Audiences attempt to unify their theories relating to the narrative;

> I think in every version that we've seen, everyone's had a different interpretation of it. It's been really interesting to come out of it and actually discuss it, kind of, rationally. The cut I saw the other day, I didn't quite fully get the story but this time, going in with that pre-knowledge of what some of the story is about, at least what some people interpreted. I got that more and then I've got a bit more this time. I think it's a really good experience. 215 and 304.

"*There's so many possibilities. There's a whole character on the street we didn't see.*" 260 and 481.

"*The mask thing only came up at very end of mine. But it was a common theme in yours.*" 276 and 250

8.4.2 Personalised

The variation between different versions of the film was perceived by a number of viewers interviewed as the result of the controller's preferences (e.g. for particular characters or CGI content) and a reflection of their focus (e.g. a tired controller producing a slower paced version).

One interviewee expressed interest in "*watching them all... [I'm] just fascinated with how different people will bring different things out of it, I really am*" 300 and 214. In some ways this attitude seems to resemble the 'completist' impulse associated with fandom, especially record collecting [](Shuker, 2017). However, the attraction for this participant doesn't appear to be the hunt for rare or obscure content but the possibility of comparison and revelation across a large archive of material. The exploration and imaginative making of a story world is what would sustain the interest of this viewer across repeat viewings of different versions.

For another viewer an archive of films would allow for interesting meta-analysis of viewers rather than by way of their narratives: "*I think I would like to see my version in the first place from start to finish in order to remind myself what I was thinking at the time. And then I would like to see other people's cut as well because it might be changing according to gender, according to type of roles they're having in the community. So that might be having an impact on the narrative.*" 343.

It may be that viewers who know one another feel more of a sense of collective ownership over a particular version watched together: "*we know our story now*" 671

While the BCI works by using EEG data to select and cut between content, controllers understood their relationship with what appeared on screen in different ways. For one interviewee, this was more than mechanistic control, and involved a personally meaningful contribution: "*you are able to input yourself, your own ideas into it*" 100 and 122. And it is this cognitive investment that is an added feature setting interactive film apart: "*interactive film just is amazing to me, just because it's not only some medium that is entertaining but also can pose a lot of questions and make you think a lot*" 130. The 'work' of being a viewer is made more explicit within an interactive experience. It is now a two stage process: the controller shapes the content and then interprets what it means.

Observing the contrast between controlled and non-controlled versions of the film could be notable in terms of self-reflection: "*I saw none of that, I didn't see the father in mine at all. So I don't know what that meant, why I didn't see it*" 403. Indeed, for one interviewee, an archive is interesting primarily for accessing the controlled version again: "*I'm really interested in my own edit and watching that again because I want to see those points really where I think it changed because of what I was thinking at the time. That's really interesting*" 550

An interesting case is controllers who were involved in the film production and therefore know the full script and all the different content that was filmed. After the experience one such viewer commented that "*I remember thinking, like at the end, that I've missed a lot but I can't think, now, for the life of me what*" 630. For this knowledgeable viewer the BCI experience was partial and potentially lacking. However, this was a retrospective observation and doesn't seem to have prevented a lean back interaction with the film during the viewing itself. Moreover this viewer also expressed an attachment to the version they controlled and the particular selection of content it contained: " *This is my version of it, so it's really cool the way that happened*" 630.

8.4.3 Perspective

The value of expanded perspectives on the narrative doesn't apparently rely on being in control of those perspectives: "*I think, after being the viewer and the controller, I think it'd be interesting to be either one again. Probably, the viewer. Just so I get a different perspective*" 272. And it may persist beyond two viewings: "*Even after seeing it three times, I'm still curious to see how piecing it in different directions goes*" 276. The idea of seeing the same thing from different perspectives has some appeal for this interviewee who saw the film twice: "*I literally saw it from the other side with the second viewing when it wasn't my brain that was in control. It's really interesting. I loved it.*" 100 and 122.

For another viewer who had also seen the film twice, there were still more things to find out about particular characters: "*The woman with the curly hair is often the one who's least in the things. The first time, I saw like a bit more of her and I really liked that. So I would like to explore like different characters a bit more.*" 103, 401 and 653. Getting more information about characters through repeat viewing changed this interviewee's interpretation: "*I think with the addition with the new characters that I mentioned I think it really changed my perspective on just who the characters were themselves*" 250 and 276.

8.4.4 Iterative understanding

Actions of characters are more compelling when the backstory is clear, which may only happen after repeat viewings in this case: "*There was more context. There was more emotional engagement because I understood the motivations behind the characters this time*" 303 and 213.

Understanding what the film means could be something that accrues over multiple viewings: "*The cut I saw the other day, I didn't quite fully get the story but this time, going in with that pre-knowledge of what some of the story is about, I've got a bit more. I think it's a really good experience.*" 304 and 215. Or if meaning is experienced differently across viewings then the viewer must construct their own understanding: "*For me, it's like I add to the narrative and building in my head like each time when I see it. Or like either add to it or like change certain things because it gets contradicted by the new viewing*" 103, 401 and 653.

For one interviewee, experiencing *The MOMENT* as a *film* was something that came at the second viewing: "*This one, very much, felt like a film. Like what you'd get out of a story.*" 284 and 271

Changes in editing too, were noted between different versions; "*the first time, like the storyline, I don't know, it's like smoother. Whereas the second time, yes, like it cut a lot*" 400,102,157,216,254, and 601. A perceived rapid pace of editing was experienced as disjunctive by one viewer who identified as neurodiverse: "*when I was a controller on*

Thursday, it was like I was constantly changing TV channels all the time. [...] I found my version so much more difficult to watch, but because I'd only seen it once, at that point, I'd nothing to compare it to. But I'm so pleased I came back today and saw somebody else's brain-controlled version of it, someone who can clearly focus for a long period of time." 254 and 150.

Some subtleties of cinematic variation beyond character actions and story content might be more difficult to notice: "*I've always paid attention to it [film music], but to be honest, I only noticed it after like two or three times watching. So you have to see it a couple of times*" 400,102,157,216,254, and 601. Changes in the soundtrack were perceived to have significant effect on the experience: "*when that girl was getting killed it was a voice-over, so it added to the story. Where before it was just music*" 670.

One participant made an interesting point by wondering if prior knowledge of the story as a viewer would limit the variation of another version they controlled: "*I'd like to see if the same story came out for me, because I've got a story in my head that I think I've followed*" 644.

8.4.5 Necessity

Is the meaning or value of the film dependent on more than one viewing? One participant pointed out that they'd been taught to attend to different components of a film and that doing so effectively requires multiple viewings: "*I was at this task in high school when we had to basically discuss how music was used to the film. And since then, I've always paid attention to it, but to be honest, I only noticed it after like two or three times watching. So you have to see it a couple of times.*" 400,102,157,216,254, and 601.

Two users in different interviews talked about how *The MOMENT* "normal" film but will deliver different content within that framework each time, which is identified as an added benefit, e.g.: "*I'd thoroughly enjoy watching the film probably another dozen times. And then I'd get to see a different start middle and end. I'd get a different act one, different* *act two, different third act. It's all going to pull together to make different story, different narratives and give an overarching meaning to the message and everything.*" 254 and 150.

Repeat viewings allow users to judge the extent of control, regardless of whether they controlled the film or not. Those who have watched someone else controlling the film wonder how a version based on their responses would differ: "*like everyone else has said, watch it again as controller and see how it changes*" 214. Or even how any version would differ; "*I think what would be more interesting would be watching another to see how somebody else has done theirs.*" 761. Those who have controlled a version want to compare it with others in order to judge the extent of their control: "*at the moment, it's the only version I know. So it's as if I've just watched it and I wasn't controlling it*" 220.

Some users felt it was necessary to see more than one version of the film in order to make sense of the content: "*the big gist of it*" 276. Having personally generated the version does not necessarily mean the user feels it is inherently comprehensible: "*I think that I loved seeing it again and I want to see it again. Because I know for a fact that if I went in knowing nothing about it, and I saw my edit first, I'd be like, okay, I'm a bit [expletive] confused. If I went in and saw the second one, I'd be able to put those two together which is amazing.*" 100 and 122.

8.4.6 Novelty, the desire to see more

From the questionnaire responses and the interview data it is clear that people want to see the film again, "*It would be great to sit down for a week and just go through it again and again and again.*" 660. But why do these people want to see it again? The following two viewers say why they want to go on to control the film:

"*if I'm the viewer, I feel like I'd be able to get even more, see even more scenes that I hadn't seen before. And be able to see really more of how the story can shift.*"276

"*I'm hoping that it kind of forms into my own story as I've heard the story does change a* *bit. Like you see different characters and different narrations of the story. So I'm really excited to see when I control it, what characters are more prevalent in my story.*" 253. For these people each new encounter forms a new experience, the film is different each time and the viewers are keen to explore these new versions of the film.

8.4.7 Summary

In this chapter we reported data from interviews from public screenings of a brain-controlled film over the course of a six day film festival. Our three themes; users experiences of interacting, non controllers accounts of watching the film and what happened when people saw the film multiple times, encompasses the gamut of responses to *The MOMENT*. While participants were given a consistent introduction, the controllers understanding was of the system's workings was informed by their feeling of feedback. Most controllers wanted to make a good film for the others in the audience. Controllers would experiment with their control before letting go of their intention to control and adopting a lean back style of engagement. By stopping to try and direct their mind they were instead able to self reflect what their mind was doing. The non controlling audience would shift their attention between the film and the controlling individual wearing the NeuroSky headset. Narrative comprehension came slowly but the interactional choice to not include conscious decisions as part of the interactivity was appreciated. Audiences wanted to see the film again. For those who were able to come back, they saw value in being able to contrast and compare versions with other members of the audience. They also valued the thought of being able to watch versions again, to further explore the narrative in their own time. These repeat viewing encouraged iterative meaning making where each subsequent viewing adds layers of meaning.

In the next chapter we attempt to scale up on the presentation of brain-controlled cinema. We introduce elements of performance and put some of the findings here into practice, with a new implementation of *The MOMENT*.

Chapter 9

Study 4: *The MOMENT* Live Score

9.1 Introduction

The results from the study of the premiere of *The MOMENT* were encouraging. Controllers and non-controllers who only saw the film once wanted to see it again, those who did had rich narrative experiences as the contrast between screenings encouraged iterative understanding and further narrative engagement.

As *The MOMENT* went on to tour to several festivals in the cinema caravan it became apparent that audience demand out-stretched our capacity to screen the film. A full day of screenings we would be able to reach an audience of around seventy people. In an attempt to scale the experience, and offer more value to audiences, we exploit the 'liveness' inherent in screenings of *The MOMENT* with the concept of a live score, performed in auditoriums.

Some of the core creatives on the project, Ramchurn (myself), Hallvarður Ásgeirsson and Scrubber Fox are experienced live performers, and the concept of playing live with *The Disadvantages of Time Travel* was briefly explored in 2016.

Our results showed mixed feelings to being a controller as part of a large audience, but these responses had always been hypothetical. There was also the question of how to practically design and perform a live score of a brain-controlled film.

This research manifests as a small, self contained prototyping effort to test a different engagement modality, the research equivalent of a scratch performance. This study directly informs our response to ***RQ5: How can brain-controlled cinema add value to audience experience?*** .

We expand on Section 2.2.4 and look at what place the live score has in today's cultural landscape. We attempt to pry knowledge and guidance from live score practitioners which can then inform our design of a live score system.

We then report on our process of a co-designing a live score conducting system and reflect on the performances of two composing musicians and 'conductor' to play the score of an interactive movie in a live audience setting. We also include some audience responses to the performances.

9.1.1 The live score then and now

The tradition of musicians playing live music to a film is almost as old as the medium of film itself [Buhler et al., 2010]. The image of a pianist playing along to a black and white movie is an enduring one but one that is for the most part beyond current generations' first hand experience.

Now one can go and see a live score of a movie in their local performance halls, not just scores of classic black and white silent films, but also films that have well known scores by composers such as Jon Williams, *Indiana Jones and the Raiders of the Lost Ark* (Stephen Spielberg, 1981, US), *Star Wars* (George Lucas, 1977, US), or Howard Shore *Lord of the Rings* (Peter Jackson, 2000, US/NZ). And not just movies, a series of live scores of video game concerts exist where audiences can experience their favourite video game music played by orchestras[1].

As well as the live score there is the re-scoring of movies, musicians will interpret classic or cult movies and put their own musical score to them. Movies such as Cinematic Orchestras' 2003[2] *Man With A Movie Camera*(Dziga Vertov, 1929, SU) and Tennant and Lowe's 2005[3] *Battleship Potemkin*(Sergei M. Eisenstein, 1925, SU) have been given a new musical treatment. The band 65daysofstatic in 2011[4], re-scored the cult science fiction film *Silent Running*(Douglas Trumbull, 1972, US).

Live soundtracks make up 54% of augmented live cinema performances [Brook et al., 2016]. Websites exist devoted to cataloguing upcoming live scores which offer audiences the opportunity to see a classic or cult film, a movie that is no longer available in theatres, as well as the experience of attending a live musical performance, usually limited in its run, with a co-located live audience. Fans of film music, of the scores of specific films, get to listen, often to a multi-piece orchestra. In the case of re-scores there is the attraction of hearing a new composition, sometimes unreleased and so a rare performance.

We can look at existing film score performances for examples of preformative design considerations for scoring or re-scoring a film. 65daysofstatic speak about their experience of re-scoring *Silent Running* in their podcast. They speak about the technical challenges and how that impacts on their performance:

> syncing up with qlab time code with ableton...the technical hurdles were unique...we deliberately choose to soundtrack that film cos there was no overlapping dialogue and existing soundtrack...so we could have a version of the film that was just dialogue and no audio. We could soundtrack it properly...we kinda wrote music for where there was music in the film. But we couldn't change the edit we were at the mercy of that thing that was locked and we had to

[1] videogameslive.com
[2] Ninja Tune
[3] Parlophone
[4] Self released

> perform the whole thing from start to finish. We had to learn how to play it and learn how to play it seamlessly for 90 minutes...there's no scope for spontaneity. Paul Wolinski[5].

9.1.2 Interactive live score

All the above is relevant to performing a live score to a traditionally linear, non interactive film. Even computer game soundtrack performances are for the most part are played as single linear compositions. How, then, does a musical ensemble play to a film that is different each time it is shown? A film that constructs itself in real-time? Surely some techniques can be adapted from those playing 'traditional' live scores?

From observing live score performances, artist's experiences of re-scoring and performing, and literature, we can identify some key challenges, and assess their relevance to producing a live score to our brain-controlled film.

1. Musicians and conductors must be in sync with the movie as it plays. Bespoke techniques and systems must be made to facilitate this. Observing a live score of *Indiana Jones and the Raiders of the Lost Ark* the conductor had a video display of the film which was overlaid with timing markers which flashed up during musical segments. A playback system already exists for *The MOMENT*, so designing an interface to facilitate playing a score to the film can be built on top of that system. Musicians playing to a live interactive film can benefit from having access to information in advance about what the film is going to do, and is extraneous to the audiences' experience of the film. This could be decision points before they are actioned, and set cues. In the case of *The MOMENT* this information is the internal state of the film, the current combination, time left of the scene playing, these are considerations for the musicians and/or the designer of a system to facilitate their performance.

[5] 65daysofstatic.com/Bleak-Strategies BLEAK STRATEGIES - EPISODE 1, THE HELLSCAPE OF TWITTER, VORTEX OF DEBT, SILENT RUNNING AND HIGH ART. From 15:48 onward

2. Cost and copyright issues can be a barrier for producers to procuring a licence to re-score a film, see Brook et al. [2016]. As we are the creators of the *The MOMENT* and hold copyright this is not an issue.

3. The musical performance should be well rehearsed. Musicians are playing to set timings, of a pre-made film. This is where our live score diverges from existing examples, it is a challenge that we will address in our design. The performers are seeing this version of the film for the first time with the audience. The musicians should have solid knowledge of the possible narrative combinations. Ways of supporting or conducting this narrative level of performance can be found.

4. For non-silent films the vocal and sound effect track must be separated and played independently. This requires cooperation form the studio which made or owns the film. As the sound of *The MOMENT* is mixed separately from the video this can be done by redesigning the playback system.

5. Once the film starts it must continue until the pre-arranged break or the end of the film. It has been over 20 years since the intermission was a staple in cinemas in the UK, although it is still observed in some film scores. Most likely it is to do with allowing the musicians to rest between very tight performances, and traditions inherent of concert halls. *The MOMENT* is 24 minutes long, and as mentioned benefits from repeat screenings and so having a break between movies is not out of keeping in this context.

9.2 Study method

We report on the co-design and first two performances of the live score of *The MOMENT*. The first performance was at Bíó Paradís as part of the Reykjavík International Film Festival. The ensemble included a viola da gamba player alongside Hallvardur and Scrubber Fox. The second performance was an evening event at Lakeside Arts in Nottingham. The order of events for both performances was similar. They started with an introduction form Richard Ramchurn, two people were chosen at random to interact with the film. The first person was fitted with the headset and then the first of two screenings started. At the end of the first screening the headset was swapped to the second audience member and the process repeated. After the end of the second screening there was a question and answer session with the Musicians and director. The total run time of the event was approximately 1hr 18mins. In Reykjavík recorded conversations with the performers and director were made during the design, rehearsals and after the performance. At the Nottingham performance, recorded interviews with the musicians and director were made before and after the performance; additionally three post show audience group interviews were made. The resultant conversations and interviews were thematically analysed as a continuation of our analysis from Chapter 8.

The two composers of the film who are also the performers of the score and the Writer/Director and MAX developer all worked on finding the requirements for the system.

9.3 Defining Performance system requirements

To be specific to the live score of *The MOMENT* and to ask how performers are to play to the film, first it's important to recap how the film constructs itself both in video and audio. As the film plays it cuts between 2 narrative threads within a scene of fixed duration. On each cut the system fades sound cues in and out. The shot's duration and frequencies of cutting are being measured and used to define which new thread combinations will appear in the next scene. Half a second before the next scene the new musical thread combinations are chosen and the music segues to the new combination. A more detailed description of the system can be found in Section 7.6.

In order to explain the process of recreating the score of the film live it is necessary to unpack what the sound of the movie is made up of. These elements are: foley, atmos, vocal track, primary music, secondary music. We will take each element and situate them in the soundtrack and how they appear in the live score system. (A through description of the sound design can be found in Section 7.6)

Foley, atmos. Sound recorded on set excluding vocal recording. Atmos, also called room tone, this is the neutral location sound. And Foley is the post recorded sound that is made to match the action. In the live score this is not performed and so it is automated with the playback system.
Vocal track. The Vocal track is encoded within the video files.
Primary music. Prominent musical themes, taking cues from the action of the primary thread. Performed by the musicians live.
Secondary music. Ambient musical themes, taking cues from the emotional valence of the secondary thread. Performed by the musicians live.

So from this we can see what will be useful for the performers to know as they play:

- Which scene is playing?
- What is the current scene thread combination?
- How much time is left in the current scene?
- What is the next scene combination going to be?
- Has there been a change to the next scene combination?
- As well as requirements for the user (performer) interface, the new system has to play the vocal and sound effect tracks independently.

Taking each of these in turn will lay out the steps to creating a user interface and system for the performers to assist them with playing the live score.

Which scene is playing? *The MOMENT* playback system plays pairs of video files concurrently. The naming structure of these video files is (Scene Number, Thread Number) for example files 11.mov, 12.mov, and 13.mov are scene 1, Astrea, Telema, and Andre. The variable *currentScene* is called to the interface to show which scene is being played.

What is the current scene thread combination? The variable list *CurrentXYZ* consists of the current scene order in the format of (X=Primary, Y=Secondary, Z=Unused) the range of numbers are 1-3 which represent 1- Astrea, 2- Telema and 3- Andre. In the user interface the first two numbers labelled 'Current Primary' and 'Current Secondary'.

How much time is left in the current scene? To calculate how many seconds are left in the current scene, the system first takes the current frames away from the total number of frames in the current video being played, then it divides that number by 25 (the video files run at 25 frames per second). This number is displayed under the label 'Seconds remaining on scene'.

What is the next scene combination going to be? The system calculates the next scene combination in real time. This means that the value changes as the cut frequency and thread duration ratio is effected by the incoming NeuroSky Attention data. Until 1 second before the next scene, the next scene combination is is not fixed. The variable X and Y are sent each time they change and translated into the string they represent, Astrea, Telema, or Andre.

Has there been a change to the next scene combination? As the performers play and attend to their instruments, changes to the upcoming next scene combination may be missed. Whenever there is a change to the next scene combination a red flash appears on the screen to bring their attention to the change.

Play the vocal and sound effect tracks independently. In order to separate the vocal audio and sound effects, new audio tracks were exported from the video edit of *The MOMENT*, removing all music. The vocal track is encoded into the video track so no action was needed to ensure the vocal is still played independently However the sound effects are encoded into the Primary audio files. New Primary audio files were exported which only included sound effects. These new tracks were put in a folder and the MAX

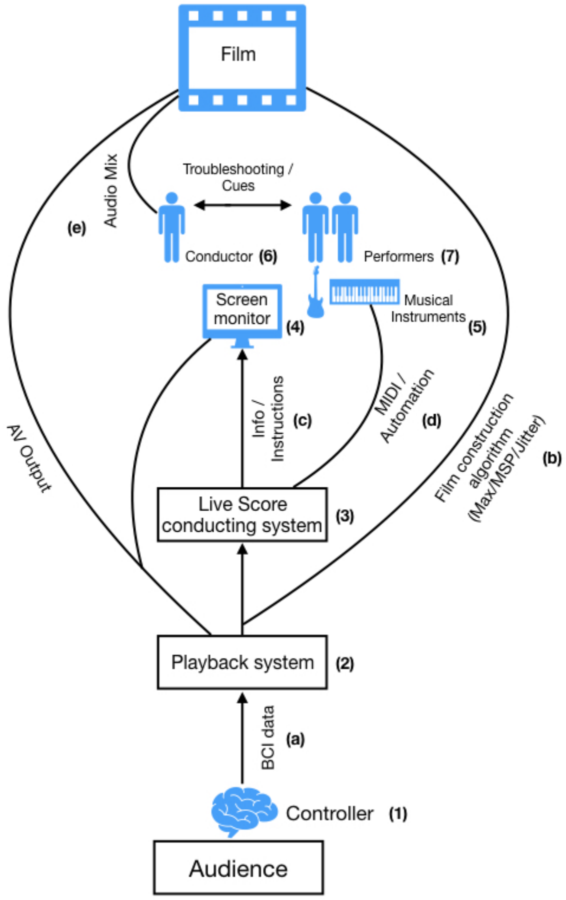

Figure 9.1: Diagram of the Live Score Performance System developed by the director and score composers during co-design sessions and rehearsals.

patch that plays the audio points to this folder instead of the original.

9.4 System overview

The components of the Live Score performance system is described below and reference in Figure 9.1 .

Playback system: The Playback system (2) is a MAX patch which generates a unique film from the data sent from the Neurosky headset worn by the controller. The playback system receives data from the BCI and sends video to the projector and performers video monitor, and dialogue audio to the mixer. It also sends data about the ongoing film to the Live Score Conducting System. Specifically, the scene number, time remaining on scene, current primary and secondary threads and next primary and secondary threads.

Live score conducting system: The Live Score conducting system (2) was created especially for the live performance of the live film score, it is built on top of the existing Playback system (2) and receives data from within the real time algorithms (b). It displays data (c) to the performers (7) and the Intermediary Conductor (6) about the current and future state of the film. It also sends automation volume control data via Midi to both performers instrument setups (d) as the Playback System decides when to cut based on the live BCI data.

Performers' instruments and tools: Hallvarður Ásgeirsson's set up consisted of guitar, various pedals (some custom made); a compressor, a few fuzz pedals, volume, octave, an overdrive and 3 delay pedals, a gate delay with modular inputs and outputs. A light sensor used for rhythms, soundcard, computer running 2 lines out LR quarter inch jack (5). And Scrubber Fox's setup: Laptop running Ableton, reaktor synthand sound generator collection with sounds used in score as presets, absynth running a sound bank, modular synth, FX and modules used on score, monome controlling modular rhythms, keyboard for synths (hardware and software) and jazzmutant lemur as main controller for the performance with all cc messages for the sections of the score and presets. Their Albelton projects received Midi data automating secondary audio layers (d). Audio was sent out the Intermediary Conductor (6) to mix(e).

Performers: The performers (7) (who are also the composers of the score) had a video monitor showing the film as it played (4). Here they could see the cuts happening between narrative threads in real time. As mentioned previously the audio of the secondary audio layers fades automatically with these cuts. However, sometimes the musicians would choose to use the rhythm of these cuts to produce beats. They could also see the display from the Live Score Conducting System (3) which they used to situate their performance within the version of the film being created. As they played there was a countdown of how many seconds were left in the current scene. When the countdown reached zero The *Current* layers are replaced with the *Coming Up* layers, the scene number would increment and the countdown would restart for the new scene.

Intermediary Conductor: The Intermediary Conductor (6) (also the director and MAX programmer) has 2 main jobs. First, as all the audio signals are coming to his station, is to mix the audio live (e). His main concern is to make the dialogue audible. As the film recombines differently each time the dialogue is different each time and so a responsive mix is needed to balance dialogue and music. Their second job is to keep an eye on the countdown and bring attention to any last second changes to the primary or secondary layers. He is also on hand if there are any live issues with the equipment and can direct the performers how to compensate if that happens.

Controller: The Controller (1) sits at the front of the auditorium in the front row of the audience, they are fitted with the Neurosky headset at the beginning of the concert by the Intermediary Conductor (6) who introduced the performance and checks the data. The Controller's data (a) is sent via Bluetooth to the Playback system (2) for the duration of the film. On the films completion the headset is swapped to the second controller.

9.5 How the musicians co-designed and played the live score of *The MOMENT*

When the original playback system of *The MOMENT* detects a downwards trend of Attention data the system cuts from one thread to the other in the current thread combination. Following this, the secondary audio thread fades in or out with the visual. As this happens based on the data from the NeuroSky headset, the performers cannot anticipate these cuts. Therefore, for the performers to respond to the second-by-second cutting of the film would be impractical. *"there's no way we could be watching volume faders, like, using our fingers to pull them up and down physically"*. For this reason fading the secondary thread up and down was automated. This automation meant that it freed up the musicians to respond to the unfolding narrative of *The MOMENT* as it played.

The unpredictability of the composition was described by Scrubber Fox as "*what's quite exciting I think*". He approached the performance by having "*a massive sound bank of sounds loaded up*" all produced during his composition of the films soundtrack. This large selection of sounds was because "*you want to be as flexible as you can, you know, [...] what you can do with your sound to make it different every time.*"

The performer designated with the primary thread becomes the 'lead' performer for that scene. As the performers are also the composers this is a preferred state "*We know how to make a sound that'll fit the picture, we can just play off each other's sounds*". When the primary thread "*stays on the same one [between scenes]. I can carry on what I'm doing here, I can continue with this theme, I don't have to quickly switch it up which is a nice change.*". However, when the primary thread changes between scenes the performers has a challenge because "*then I have to start playing something else, and I don't want to do the same thing again and again*". This is compounded when there is a lot of variation between scene combinations. Hallvarður found this mode of performing contrast with other concerts "*usually it would be just like start, middle, stop. But it's always like start and then you get disturbed and then you do another thing*". This unuseall structure of the score did not go unnoticed, an audience member said, *"so it's not something that goes from one point and gets a climax and then goes back. It had loads of different nuances."*

Some thread combinations mean that both the primary and secondary musical layers are played by one performer, theoretically leaving the other performer at a loose end, " *when it's playing Astrea [primary], and Telema secondary at the same time, I'm not meant to be doing anything, but that's when I started trying to just do some beats*". At these points the performer without assigned threads finds their own way to incorporate their performance: "*I'm just trying to improvise over the top*". At one point Scrubber Fox was playing beats to the rhythm of the cuts coming from the NeuroSky data. This was a choice Scrubber Fox in the moment as he had no other responsibility to play. He was able to respond to an element of the film that was not usually possible to respond to: "*when Astrea is heavy then I'm not doing as much over the top so I can experiment a bit more with some of* *the sounds I'm making to get them to fit, and it's the same with Vardy when it's heavy with Telema and Andre then he can step back and play along with the main theme of that bit*". During the unpredictable performance journey, the film content served as an anchor point for musical improvisation: "*we know how to make a sound that'll fit the picture, so we can just play off each other's sounds*". This did not go unnoticed to audience member A1.

> I think the music definitely reflects the image that we're seeing, because I feel like when it gets a bit more... when there is more graphic, the music tends to get a bit faster, and I feel like in the scene that the music gets a bit calmer you can see the graphic looks calmer as well. I don't know if that makes sense but I think they reflect on each other yes.

For another audience member the extent of the marriage of image and music came as a surprise,

> just reading what the description of the event was, it matched a lot more than I thought it would because I thought if someone else is controlling the music, how are you going to make that match, how the film is going to go? But actually it did seem to fit seamlessly which is why I can't really separate how it matched the film. It was just part of it. A7

The performers have previous knowledge of the video content as linear threads, they can see the resultant combined movie on their monitor however they do not know what combination the threads will take in any performance. The part of the system which is key to the performers understanding of the ongoing construction of the film is the upcoming thread indicator. They can see what is likely to appear in the next scene as the display informs them of the algorithms current status: "*it flashes up what the next scene's going to be, how long is left of the current scene, which is vital or there's no way we'd be* *able to know what was coming up because there's so many combinations*". The algorithm detects the rate that the film is cutting and the ratio of time spent on each narrative thread. It is using this information to decide the next narrative thread combination. On the boundaries between decisions the output may flip between options. This may happen throughout the scene, however the closer to the end of the scene the more likely the displayed next scene is to be true. An interesting and exciting point occurs when the algorithm decision is on the boundary with seconds left to the scene. At this point the Intermediary Conductor will bring this to the attention of the performers. Although "*I get lost in the film sometimes, or I'd be looking at the levels and I'll notice that the time's went past and I've missed a cue to give these guys*" between the performers, the intermediary conductor to and this system allowed those on stage to feel what was happening inside the algorithm or as Scrubber Fox described as "*Vibing off the cues*".

The musicians creation of atmosphere was picked up by an audience member who described the music as "*creating this dystopian, yes a kind of dystopian atmosphere but also I can't explain, magical isn't the word, but like paranormal almost is what it felt like.*" A6

At the moment of scene transitions the performers will be looking at the count down making sure there has been no last-minute change to the coming up scenes. These are moments of high tension as the performers must decide what to play next or to continue with the build up of the current theme. As Hallvarður says "*Sometimes you think it's going to switch and then it remains*".

As is often the case in live events, everything does not always go to plan. An instance of this is during the second screening in Iceland, Scrubber Fox's laptop crashed. This was during his time to play the primary track. He alerted the intermediary conductor who asked Hallvarður to take over while the laptop restarted. This had the knock on effect of sending some of Hallvarður's secondary tracks out of sync. "*the first thing we really realised was when it started playing the romantic music*". The Intermediary Conductor (Ramchurn) and Hallvarður negotiated this issue: "*You leaned over to me and said, is it okay? And I was like, yes, actually it's quite interesting what's happening there. But then* *after that there was some quite heavy stuff happening and it was out of sync and I think we both felt that. We dropped it down and then I think we made a decision there for you to improvise*". Both musicians are used to performing live and were comfortable to react fluidly to on-stage issues which Scrubber Fox describes as"*just going off visual cues [...] just going by feel*". Hallvardur reflects on this "*I really liked the improvised stuff though. It did have a totally different vibe*". Or as one audience member puts it, the *"style of the musical genre that this performance belongs to is probably not the typical soundtrack that accompanies a typical movie, because this wasn't a typical movie either."* A4

There was some ongoing concern that the experience of being the sole controller wearing the headset, with a full audience would cause undue pressure to perform, however the controlled we interviewed said they didn't feel like a performer at all, and that they felt pressure, *"initially when I was sat there with the thing on [my] head, [I]'ve got to do a thing, but then again I was trying to concentrate and figure out what was going on, so I forgot about that and just watched it"*. They forgot about any control they had and became immersed in the film.

At the Lakeside performance in Nottingham during the first screening of the double bill there was another laptop crash from Scrubber Fox. "*we had a nice run on the second one, where it all worked as it should have, so they [the audience] . . . had the full flow*". The performers seemed untroubled perhaps because of their previous experience.Scrubber Fox continues, "*it was just like, nodded yes it's crashed. And then we just... let's deal with this and get it back on track, improvising*". Hallvarður reflected afterwards on the collaborative nature of this performance "*it divides the responsibility. So it's nice backup to have I think*". Even though there was some technical issues the Scrubber Fox viewed this as part of the process of live performance. "*it wouldn't be live if things didn't go wrong, would it?*". And even saw positive implications: "*happy accidents that's what it's all about*".

9.6 summary

The performance can be described as a co-construction with a performance group of four and the brain-controlled cinema system. The controller was happy to be the one at the front of the audience wearing the headset, and did not report any feeling of pressure.

We learned from the performances of the live score that the musicians are able to improvise on there musical themes responding to the rhythms of each screening. That the musicians felt screenings had different emotional narratives because of the films recombination allowed them to to be in a constant state of adaptation. This was accentuated by the uncertainty of the upcoming scene's combination. By designing a system which automated elements of the soundtrack, such as the fading up and down with cuts allowed the musicians to concentrate on creating the soundtrack. Further designs should emphasise system stability, and encourage more opportunity to improvise.

Chapter 10

Discussion

In our discussion of our practice and results we will bring together the various filmmaking processes impacted by brain-controlled cinema, explore how users experienced control and engagement across the various designs and point to future practical recommendations and research implications.

10.1 Reflecting on practice

Here we discuss how our filmmaking practice was impacted through our brain-controlled movie designs, in order to propose future iterations of design.

Our prototype *#SCANNERS* was a proof of concept of a BCI used to interact with audio visual content. The first single controller version of *The Disadvantages of Time Travel* was an impressionistic art film. It aimed to recreate the feeling of being lost between reality and dream by using Attention, Meditation and blink data to modify the spatial, temporal montage and soundtrack. The next hyper-scanning versions attempted various approaches to interacting with the film as part of a group, separating single modalities mapped to cinematic constants, which were promising and developed into the next film design.

The MOMENT, a sci-fi thriller, intentionally aims to replicate cinematic tropes, a three part narrative, and archetypal characters, to offer a foundational understanding to the audience and a known structure to experiment within. The interaction design attempts to create a more lean-back experience for the controlling viewer and produce interesting and surprising narrative combinations for audiences as well. In an attempt to scale up and offer further value to audiences, the live score of *The MOMENT* introduces a co-creational contract with an ensemble of performers; the controller, the musicians, the intermediary conductor and the system's algorithms.

In the first section of our discussion we will reflect on the practice involved in making and designing these films, which motivates our future practice, research and design considerations for practitioners found at the end of this chapter.

10.1.1 Algorithm and mappings

There is a journey of design through our two films, and eight different modes. It traces the different modalities of data, Attention, Meditation and blinking that has been used to affect different cinematic techniques. Our initial prototype platform titled *#SCANNERS* attempted to filter blinks as high Attention and blinks with low Attention, and using only the high Attention blinks to cut the film. In the first version, the (Solo Interactor) and the (Coop/Cut/Blink) designs of *The Disadvantages of Time Travel* any blink would cut the film.

Attention was used in various ways: in the prototype to differentiate between blinks, as above; as a hidden control, an average across three people; as an direct mapping to blending; and finally as a carrier wave to identify peaks and map them to cuts. Meditation has been mapped to music mix, and as a hidden mapping to blending. The trajectory of these designs is to find more unconscious ways of interacting while matching physiological responses to cinematic content.

The algorithms have secondary attributes too. The first iteration of *The Disadvantages* *of Time Travel* would switch the active mapping from Attention to Meditation. The Competing mode of the hyper-scanning version switched sole control to the person with the highest Attention data. In *The MOMENT* an algorithm was responsible for the choice of next primary and secondary scene combinations, based on an analysis of the preceding scene. In *The Disadvantages of Time Travel* the aim was to make ambiguous to the controller what brain measure was currently actively making changes. In the *The MOMENT* on the other hand, the algorithm was designed to introduce new narratives if a status-quo was achieved while staying with the narratives which induced the longest periods of sustained Attention.

10.1.2 Script and storyboard

The two films had very different scripts in, tone, genre, detail; however an important similarity is how they were developed. By designing the algorithmic concepts before or during the script writing process, the structure of the script can be influenced by the interactive nature of the film and vice versa. This was evident in *The Disadvantages of Time Travel* as the main character's internal conflict is reflected in the mixing of video layers using spatial montage. With *The MOMENT* the trio of characters Astrea, Telema and Andre are written as parallel scenes in the script which relate to each other in any combination of pairs, reflected by the algorithm. These dual concepts were designed in tandem, going through several iterations, until a balance of narrative and interactivity was found.

Similarly the storyboards between the films are extremely different and reflect the directorial approach of each film. The cinematic techniques which materialised within certain combinations of *The MOMENT* were designed at the storyboard level.

10.1.3 Direction and production

The two main practice chapters are contrasted by the style of direction. With *The Disadvantages of Time Travel* we shot guerrilla; many of the creative decisions were made on set, problems were solved and worked around. For some productions this would not work, and thus it was important that the crew knew the method of making in advance, just as they needed to be aware of how interactivity impacted our shots. It didn't take long to for the crew to fall into the flow of having two camera setups that were ready to go, and for us to swap roles when needed.

The MOMENT was a much larger scale production in every aspect. Even though many of the key production roles were reprised, it was a very different process. A lengthy pre-production process meant that every set up and shot was planned and executed with precision. Only the core team needed to be aware of the interactive implications of the production. It was true however that in both processes the director was stretched on set, with the extra responsibility of overseeing interactive implications on top of working with the actors and cinematographer.

10.1.4 Cinematic techniques

Montage

The spatial montage treatment in *The Disadvantages of Time Travel* was a very specific and unique technique. While spatial montage has become more common within mainstream releases it is unusual to be used for an entire film. It places the film within the genre of experimental or Art Film which *"works the extremes [...] testing the boundaries' in terms of visual style, narrative and intelligibility."* [Betz, 2009, p.5]. For some audiences this can be a barrier to comprehension. While this is not of particular concern artistically, it can obscure interactions and preclude finer cinematic design techniques. Consequently, this motivated further drawing from continuity editing techniques as design inspiration.

By investigating cognitive affect theories of continuity editing on viewers [Bordwell and Thompson, 2001, Smith, 2012, Cutting et al., 2010] we were able to guide designs that synchronise viewer response to real-time temporal montage.

The use of filmic techniques, like those we gave the audience control over, often go towards defining a movie's genre. In providing the audience with influence over genre specific cinematic techniques, there may be configurations of control that lend themselves to specific genres of movie, for example techniques that encourage suspense for thrillers and horror movies. In audio, suspense is often built with reduced volume and use of silence. Horror movies, for example, may wish to consider how control over volume might be given to a mode of user control, especially if we want to allow people to 'customise the scariness' to their tastes. Such movies also often involve people closing their eyes or looking away during scary or violent scenes. Interactive treatments for these genres could utilise the vulnerability and responsibility reported by our participants to the advantage of creating an uncomfortable experience [Benford et al., 2013b]. Conversely, comedies and romantic dramas are designed to evoke different responses to movies, and might wish to focus on different social responses, like laughter, as control methods. Furthermore, rather than imitate classic Hollywood tropes, using configurations of control that act on genre could enable filmmakers to subvert the medium and move the art form forward.

Sound

In the original *The Disadvantages of Time Travel* the vocal, sound design and music would instantly cut with the image when the system detected a blink, sometimes in the middle of an actor's lines. In the second iteration, the three controller version, we mapped music to Meditation data, which caused the music stems to fade in and out independently of the other control modalities. We also implemented a fade-in fade-out mechanism for the vocal tracks. This improved the audio flow of the film, but still actors lines would fade out while they are still talking. This was less of a problem than one would think; it matched the dream-like feel of the film. While this technique is actually used in *Tree of*

Life (Terrence Malick, 2011, US), to similar effect, it is not something an audience would expect in every film.

When designing sound for *The MOMENT* we took inspiration from continuity editing and so took the opportunity to redesign the audio based on what was observed in *The Disadvantages of Time Travel*. As *The MOMENT* only had one control modality, that of Attention, sound had to be carefully designed in order to preserve interactivity and aural flow. We used sound to reinforce the narrative locale of each scene. The vocal track would play uninterrupted from two of the currently playing narrative threads which were designed to have no overlapping dialogue. The feeling of being in a particular narrative was reinforced by cross fading in and out of the secondary audio with cuts. This was inspired by J and L cuts, named so as the letters resemble the shape of video and audio on the editing timeline; sound will be heard before it is seen (J cut) of after the image changes (L cut). See Figure 7.8

When designing for the Live Score version of *The MOMENT*, the design was kept basically the same but the implementation was brought out of the MAX patch and into the hands of the musicians. The MAX patch was used to deliver instructions to the musicians via the conductor about which narrative music parts to play. The MAX patch also automated the fading in and out of the secondary sound design when the system produced a cut.

The design direction over the course of these films move towards creating audio flow by removing jarring artefacts, and synchronising the audio and visual (and Attentional) rhythms. Ultimately in *The MOMENT* it becomes a narrative tool; it places the viewer in a particular space in the story, and provides differing emotional contexts to the scenes.

10.1.5 Visual treatment

In *The Disadvantages of Time Travel* we needed four times the footage as the length of the film. However, this did not translate into taking four times as long on set; we found a number of ways to streamline the production. We defined set filming techniques to create a specific look for each layer of the film, shooting the same scenes and action using different lenses and grip equipment. This technique of simultaneous two camera shooting suited the looser free form approach. We also shot at 50fps when we wanted a normal and slow motion shot, and shot at a flat, low contrast image profile to allow for alternate colour grading of scenes. *The MOMENT* was much more stylised; each shot was storyboarded to coincide with parallel corresponding shots. Most of the look of the film was done 'in camera', using a high contrast colour profile. Lights with colour gels were used for different characters to help provide visual clues as to what narrative the viewer was following. These are examples of genre specific stylistic choices. Future films can explore specific genre characteristics and exploit them as part of the interactional system. Other options of using visual design as part of the interactivity could explore an adaptive, dynamic colour grading system [Gilroy et al., 2012b] to change the emotional tone of scenes.

10.2 Balancing control and experience

10.2.1 Meeting the expectations of being a film

Adding interactivity to films moves them closer towards other media forms such as video games. The convergence of ludic and narrative media has been much discussed. However, we argue that film remains a distinctive media form with its own important characteristics that need to be honoured even as a degree of interactivity is introduced. Films can of course be experienced in many ways beyond theatrical exhibition - ranging from on-demand viewing at home and on mobile devices, to large-scale live events involving costumes, props and performers - and we consider how BCI-controlled films could function across these contexts. However, the essential characteristics which define film as a medium are often summed up as 'lean-back', with connotations of admiring artistry on display, rather than discovering or creating content (lean-forward) [Dewdney and Ride, 2006]. This distinction applied to media hinges on consumer control; the extent to which duration, circumstances and content can be manipulated [Katz, 2016]. In the case of conventional film, once a ticket or recording is purchased, all consumers receive an identical product, fashioned according to a director's overarching artistic vision, which they lean-back and take in.

In the context of their screenings at FACT and Sheffield Doc/Fest, *The Disadvantages of Time Travel* and *The MOMENT* were carefully framed and presented as films. Their content conforms to genre conventions of Arthouse and Sci-Fi thrillers (dystopian politics, body horror, renegade AI). Though interactive, the films retain a set running length so they can fit the scheduling constraints of movie theatres and festivals. They were projected onto a large screen in a dedicated, darkened space in which an audience viewed the same content together. In short, while being interactive, the films fitted the context of a film performance, according to our study participants.

The MOMENT was booked out to full audiences across Doc/Fest film festival, the majority of whom did not get to interact directly, but witnessed a brain-controlled film based on someone else's EEG data. That proved to be a largely enjoyable experience, which is important because it shows that the experience accommodated the social aspects of filmgoing. On this basis, we believe that BCI film could still potentially play well in a conventional movie theatre with a larger non-interacting audience provided certain design tensions are accounted for.

We know from our questionnaire that some audience members found it harder to follow the narrative of *The MOMENT* than they would expect for a conventional film. We note that this might relate to a more rapid pace of brain-controlled editing as well as the high variance of narrative configuration. This highlights the importance of continuity editing norms for sense making of variant shot combinations [Bordwell and Thompson, 2001]. However, higher cognitive demands do not appear to have made the BCI films unwatchable. In our interviews, people spoke about satisfaction associated with building comprehension about the story and characters depicted in the film. This points to another important respect in which the film could be watchable when non-interactive: watched back after the event as a way of making sense of the interactions (that were not being thought about so much at the time) and/or the narrative.

In our first iterative development of theory we propose a taxonomy of control based on interactions with *The Disadvantages of Time Travel*. This framework, shown in Figure 10.5 was reported in [Pike et al., 2016a] and involves the definition and comparison of two key dimensions of control - the extent to which control when using BCI can be considered to be voluntary and the extent to which the user is aware of trying to control the system. These findings influenced our multi-user hyper-scanning designs for *The Disadvantages of Time Travel* and *The MOMENT* as we will detail as design journeys in the next section. We present the framework here, and further contextualise it by reflecting on our results of interactions with subsequent designs, *The Disadvantages of Time Travel* and *The MOMENT*. We further integrate our findings from our results in Chapter 8, some of which is reported in [Ramchurn et al., 2019a].

10.2.2 Extent of voluntary control

A key motivation for some BCI research, is that people are not fully or directly in control of their interactions, but that systems respond *reactively* to their brain activity [Zander and Kothe, 2011], such as with the control of artificial limbs [Muller-Putz and Pfurtscheller, 2007] , and *passively* [Cutrell and Tan, 2008] , such as implicitly assessing ongoing cognitive state for the purpose of enriching interaction. We would argue that our interacting participants control of our systems is not entirely voluntary, in the cases of *The MOMENT* and the (Coop/Att/Blend) and (Coop/Med/Music) participant even more so. Indeed, as Prpa and Pasquier [2019] noted in their comparison of artistic BCIs, participants may move between *reactive* and *passive* modes of control. Thus, while we have seen examples that viewers can learn to voluntarily control their blinking in order to try and prolong or break away from scenes in the film, we have also seen how blinking is also an semi-autonomic bodily response to drying eyes, dust and other factors, some of which may be cognitive, attentional responses to visual information [Nakano et al., 2013, Nakano, 2015a].

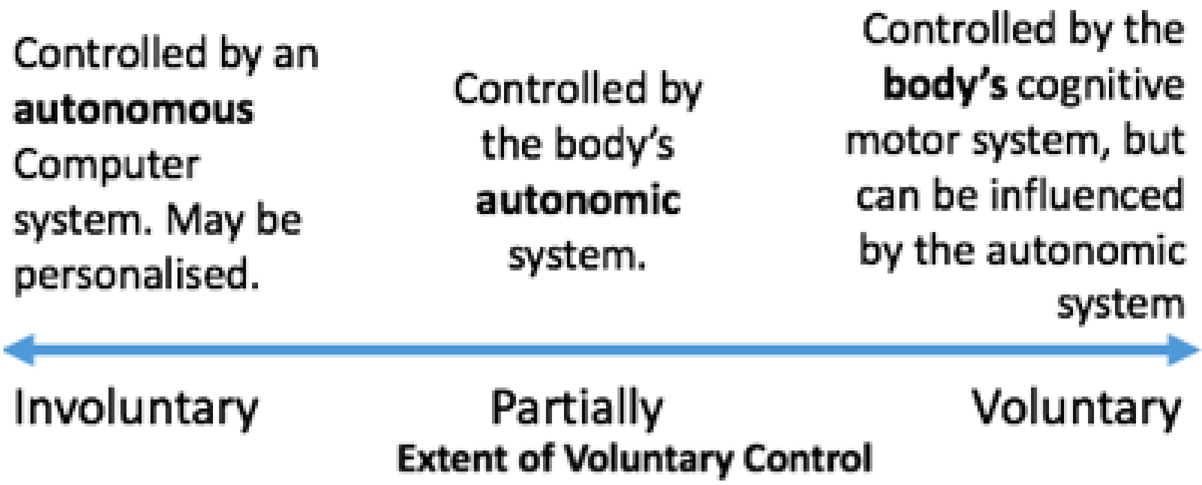

Figure 10.1: Extent of Voluntary Control as a dimension

Our findings suggest that our interpretations of Meditation and Attention were perhaps subject to even more tenuous voluntary control. While viewers often wanted to control them - and some claimed that they could - control was exerted through indirect means such as trying to slow breathing in order to calm down and be more meditative. Whilst users were more able to influence their Attention levels, especially with *The MOMENT* and the (Coop/Att/Blend) mode.

It is useful to think of there being a dimension of **Extent of Voluntary Control** see Figure 10.1. At one end we find forms of control that are largely voluntary, such as choosing to move a mouse, pressing a key on a keyboard. In BCI terms active and conscious control is termed *Active BCI* [Zander and Kothe, 2011]. At the other end of the dimention might be forms of control that are largely involuntary such as sensing the actions of the body's autonomic systems that continue to operate, *Passive BCI* [ibid]. Our interpretations of BCI in terms of blinking, Attention and Meditation are notable for occupying a middle ground along the spectrum where control is partially voluntary, like *Reactive BCI*, not only reacting to external stimulus but also indirectly modulated by the user [ibid]. Similar to the breath-controlled bucking bronco, by Marshall et al. [2011], the user can choose to blink at certain points, but cannot avoid blinking at others. The user can try to relax, but may be affected by surprise or fear during the film. The user can choose to be more attentive, but may struggle to maintain Attention during less action-

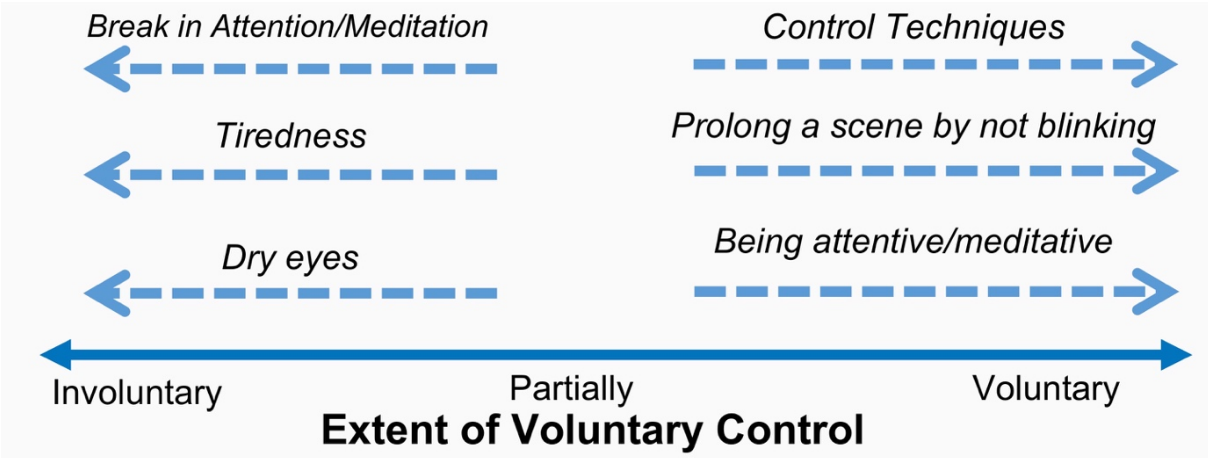

Figure 10.2: Triggers affecting voluntary control

oriented scenes. The user's position on this spectrum can vary during an experience. Our findings revealed both deliberate and accidental triggers that might cause movement along this spectrum (see Figure 10.2).

10.2.3 Extent of self-awareness

Our second dimension, shown in Figure 10.3, concerns the extent to which one is self-aware of one's level of control over one's body, including thinking about controlling the system. This **Extent of Self-Awareness** can vary between being fully conscious of what one is doing, such as when manipulating a mouse or keyboard, to when our attention is focused elsewhere, such when we are deeply immersed in a state of flow when watching a film [Csikszentmihalyi et al., 2005]; like riding a bike without thinking about how to ride it. Our findings reveal that our particular treatments of BCI in terms of blinking, Attention and Meditation span various points along this dimension. Users can be consciously aware of trying to control their blinking or unaware of their everyday blinking behaviour. They can be deliberately trying to play close attention or "zone out", whilst some became immersed in the film and forgot about trying to influence it. Moreover, we have seen how this level of consciousness may vary dynamically throughout an experience as a result of various internal and external triggers that are shown in Figure 10.4. We noted, for example, how changes in visual content such as a scene transition, or a hard cut might

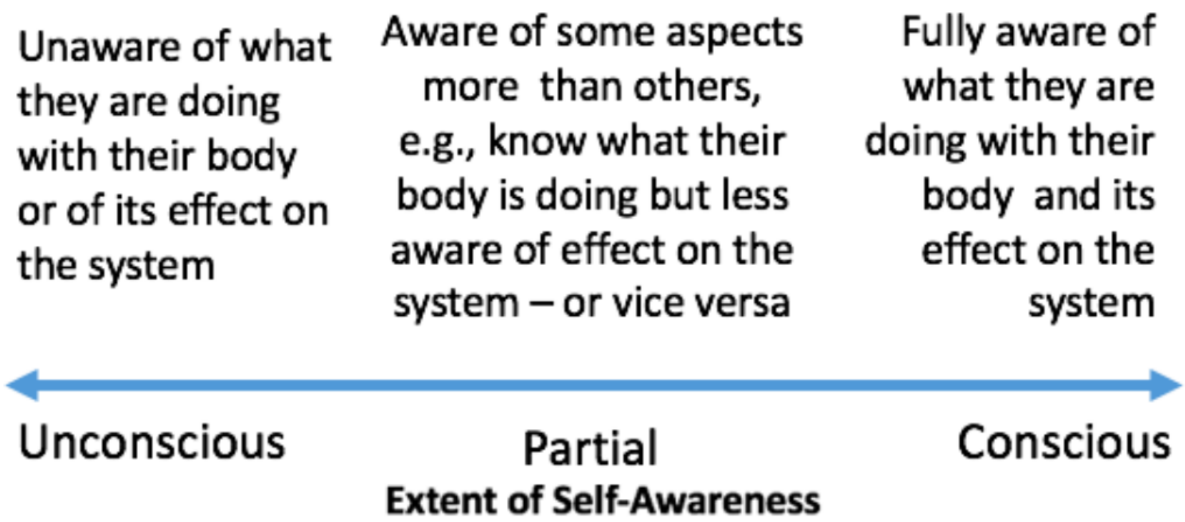

Figure 10.3: Extent of Self-Awareness of control as a dimension

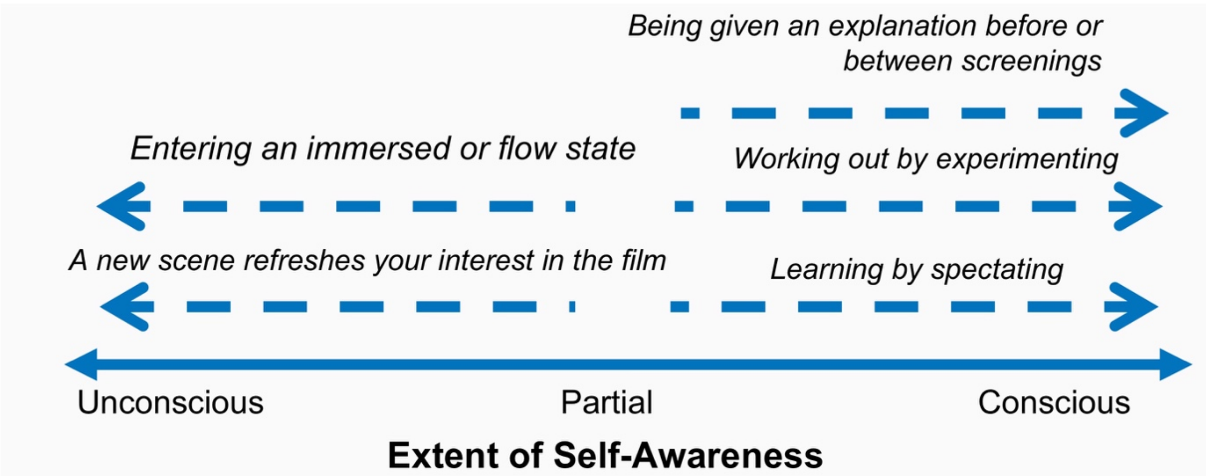

Figure 10.4: Triggers affecting Self-Awareness of control

potentially move the user in either direction, re-engaging their attention with the film or causing them to reflect on whether the transition was caused by their blinking.

10.2.4 Design space and control taxonomy

Combining these two dimensions in Figure 10.5 , reveals an important design space for the control of BCIs (and possibly other modalities too). Our experience revealed something of a tension in the use of BCIs where users move back and forth between voluntary and involuntary control and between conscious and unconscious self-awareness of different effects. Beyond helping explain our findings, we might also put this taxonomy to use as a design space for BCIs, especially for entertainment. The green diagonal line represents the traditional locus of control in HCI [Shneiderman and Plaisant, 2010]. This moves between internal locus of control (e.g., direct manipulation) and external locus of control (e.g., autonomous, context-aware and ubicomp sensing systems). We suggest that the space away from the central line offers a creative sweet-spot where designers can set up creative tensions and/or trigger users to move between different states: between immersion and self-reflection, and between being in control and surrendering it [Marshall et al., 2011, Benford et al., 2012]. This is a liminal space - a space of inbetweeness and ambiguity - that can be particularly productive in creative fields and may encourage people to create their own interpretations or 'stories' of control as we saw in our studies. Our results already suggest some general strategies that involve thinking off the line:

Fully-conscious and involuntary - where we explore physiological measures that people have even less understanding or voluntary control over, such as skin temperature, or conductiveness (GSR) and

Voluntary but unconscious - which encourage people into states, perhaps like experiencing flow [Csikszentmihalyi et al., 2005], where people could use voluntary control, but do not need to consciously think about doing it.

10.2.5 Journeys through control

We return to the idea that how controllers navigate their interactive intention is a dynamic picture - that participants can make various transitions around the space of self-awareness and voluntary control, see Figure 10.5. In an attempt to characterise the many paths taken by those who experienced the single controller version of *The Disadvantages of Time Travel* , we developed the state diagram seen in Figure 10.6. The diagram provides a visualisation of the potential state and transfer of state a viewer may experience during interactions with *The Disadvantages of Time Travel* . Reflecting on the interview data led us to propose the following states.

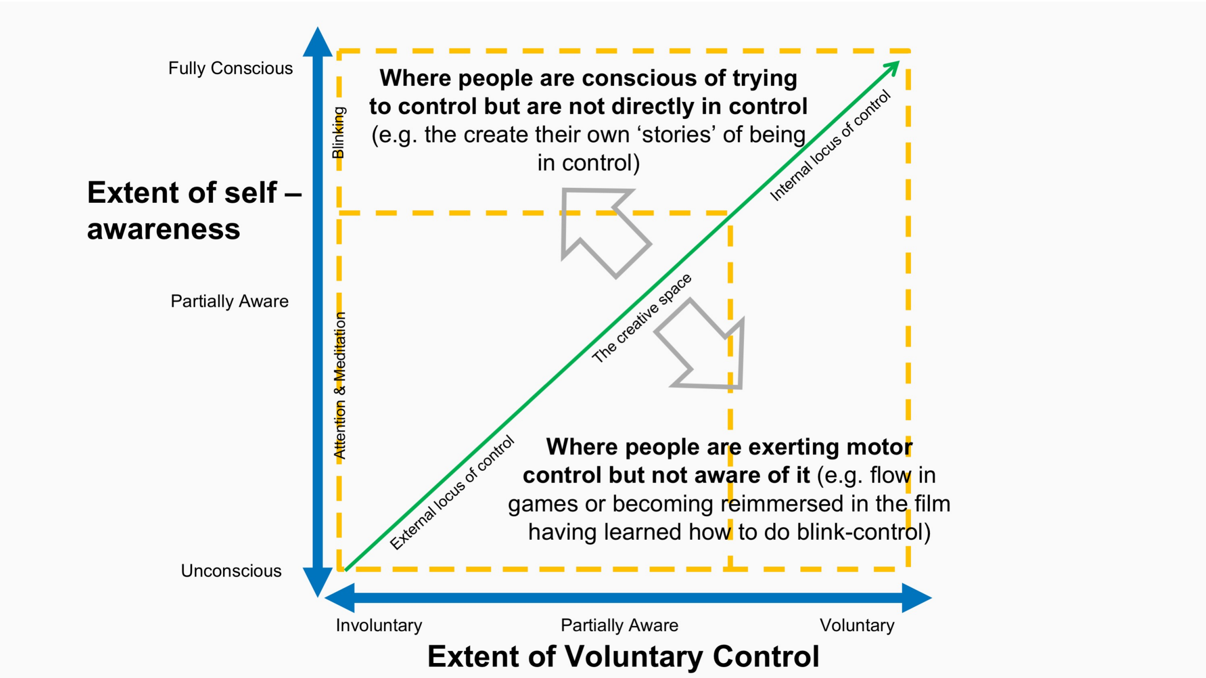

Figure 10.5: A design space for entertaining BCIs

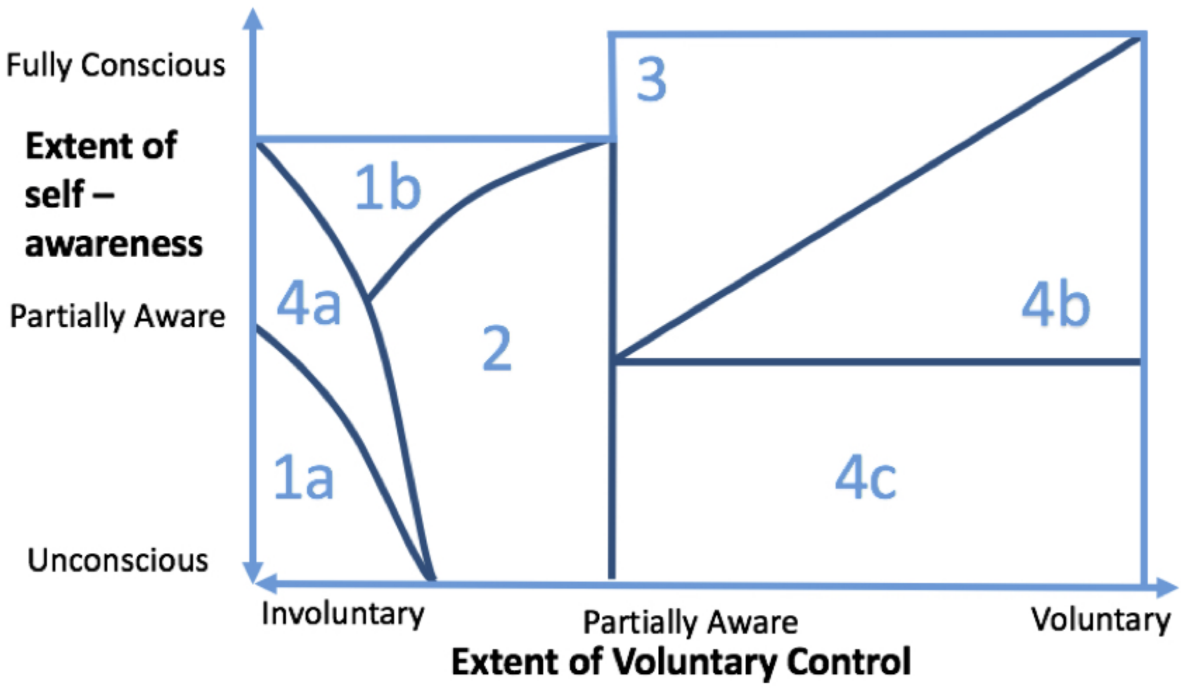

Figure 10.6: Major states participants travelled through whilst experiencing *The Disadvantages of Time Travel*

State (1) indicates one of two entry points into the experience. In (1a), viewers have zero prior knowledge of the system's operation. There may be some awareness of the possibility of some control, since they are wearing the headset, but no explicit knowledge is held. Conversely, (1b) represents the state of knowing. These are viewers who have varying degrees of knowledge as to the system's operation but have yet to exert any elements of control.

State (2) represents the state of pre-discovery. For viewers transitioning from (1a), this will be the beginning of their discovery; they will begin to notice certain associations between their physiology and manipulation of the experience. Transition from (1b) will begin with the process of confirming existing knowledge. Discovery is then witnessed in (3). This is the "ah-ha" moment where viewers figure out some/all elements of control associated with the film. Within this state, participants were typically thinking more about how they were controlling than they understood how it worked; people tried different ways to relax and tried focusing on different things, like controlling the storyline or the actors.

Post discovery occurs in (4). (4a) represents the viewer that never discovers more of the control (they have partial knowledge). They remain aware that something/they is effecting the experience but do not discover more. In (4b), some participants enter a stage of understanding with the system control, and begin to use it to control the system.

Similarly, those that understand elements of control (e.g. blinking effects the cutting of scenes in some way), may simply slowly relinquish explicit control and fall back into immersion, where their knowledge of control has increased, but they no longer think about doing it (4c).

From detailed analysis of each viewer's interview and video data we were able to identify 13 unique paths through the experience. Table 10.2.5 allows us identify some of the interesting characteristics associated with the experience. J1 and J2, for example, shows individuals that never moved beyond the initial state (1). For (1a) this experience would be analogous with watching a standard film (e.g. P16). Perhaps more interesting is P21

Table 10.1: Unique identified journeys whilst interacting with original version of *The Disadvantages of Time Travel*

ID	Path	Participant	Total
J1	1a	16, 19, 29	3
J2	1b	21	1
J3	1a→ 2→ 4a	10, 11, 15, 26	4
J4	1a→ 2→ 4b	33, 35	2
J5	1a→ 2	12	1
J6	1a→ 2→ 3→ 4b	18	1
J7	1a→ 2→ 3→ 4b→ 4c	1, 28, 30, 31	4
J8	1a→ 2→ 3→ 4c	3, 8	2
J9	1a→ 3→ 4b	22	1
J10	1b→ 3→ 4b	2, 5, 6, 13	4
J11	1b→ 2→ 4b→ 4b	23, 25	2
J12	1b→ 2→ 4c→ 4c	20	1
J13	1b→ 2→ 4b→ 4b→ 4c	7	1

who remained in (1b) i.e. they have prior knowledge of some of the systems control, but chose not to explore what exactly they could do with it. J3 and J4 were the most common journeys taken by viewers who did not have prior knowledge of the system's control. The journeys indicates that they discovered, based on the system's responses, behaviours that might create a change. Those that never quite work it out, then return to (4a), whilst those that do typically moved to (4b), where they begin to use control. Some, however, went as far as (4c), where in J7 they then forget about control and enter a state of immersion, where they know what is controlling the system but stop thinking it.

For those that knew in advance how the system worked (J10-13), the path was similar, but typically involved less time in the exploration state, and more time in the 4th states. Realising that some participants knew the operation of the system, however, we can begin to consider two types of transitions: intra-experience transitions that happen during a given experience (i.e., screening of the film) and inter-experience transitions that happen in between experiences, for example as a result of receiving an explanation of how the experience works or perhaps as a result of being a spectator to someone else's experience. In inter-experience contexts, viewers will likely trace a path around our design space as they engage in possibly repeat experiences. In this regards, P33 said "*I want to have another go to see what I can do, because I think I was quite passive. I was very aware of my emotional responses watching it. I was kind of..quite...I guess I was monitoring my emotional responses quite...and allowing them to be quite strong because I kind of had some vague idea that, that might, you know, provide more information for the feedback thing*".

These journeys were observed from the single controller experience of *The Disadvantages of Time Travel*, when we superimpose the journeys of controlling viewers of the *The MOMENT* we can see that they fall more into the states on the left of the space.

As the audiences' introduction at Doc/Fest explained how the film would cut after Attention peaks was kept intentionally consistent between screenings, the two entry points were: as a first time controller, and as first time controller after having seen *The MOMENT* a non-controlling audience member.

Some first time controllers who had not seen the film before initially tried to control their attention (3), however there is no direct feedback to their attention state and so they quickly just let the film do its thing (2): *"I just, kind of, started enjoying it for what it was, whatever came off the screen."* 220.

Controllers that had seen the film before, and had chosen to come back and try it out for themselves, were less likely to actively try and change their attention as they just wanted to see their version of the film (4a): *"you are able to input yourself, your own ideas into it"* 100 and 122.

When the film cut between narratives some would wonder about their state of attention and move to (2) before reengaging back to (4a) and finally (1a) *"This was something not really I created, but something I let happen [...] It felt less like control and more like influence."* 270.

Some controllers stayed within the creative space as defined in Figure 10.5 rather than the full space, and many would be in (1b), while avoiding (3), (4b) and (4c). Controllers who reported that they felt their attention disrupted and saw the film cut in response are moving from (4a) to (1b). This can be attributed to the removal of blinking in *The MOMENT* which can be used as a fully voluntary and conscious mode of control meant that controllers would not go so far as (3) or (4b). In a few cases however, controllers did find themselves in (4c). *"And, it kind of did lean a bit more to what I was thinking. But, it wasn't too drastic. It was very subtle. And, I think it slowly turned into something that I was able to control."* 250 and 276.

10.2.6 Being credibly controllable

While we are arguing for less overt and immediate control, our findings reveal that it is important to audiences that there is credible interaction taking place; that they believe that brain data is influencing the film they see, even if how this works is ambiguous to some extent. This is even more the case when blinking is not a interactive modality. The degree to which the BCI system needs to be explicit or known in advance to film viewers, or can be more ambiguous, is therefore also something of a tension. Some controllers wanted to go into the experience 'a bit blind' whereas others felt 'put at ease' by information about how their brain data would be used.

We suggest that a degree of uncertainty and ambiguity in this regard is in keeping with the lean-back experience of a film during which viewers 'go about finding their own pleasures' Staiger [2000]. Gaver et al. [2003] have proposed that ambiguity can be a powerful resource for designing interactive systems, while Sengers and Gaver [2006] built on this to argue that interactive systems might be 'open to interpretation', a view buttressed by concepts from literary scholars who proposed that meaning is actively co-constructed by the reader [Clark et al., 1991]. These arguments lead to us suggest that BCI interaction might involve enabling viewers to make meaningful interpretations of control that is credible, and accounts of how they controlled the film that allow them to reflect on its content and their relationship to it, and so invest meaning into the experience.

10.2.7 Enabling lean back control

From an HCI point of view, the lean-back nature of the experience presents an interesting challenge, suggesting new modes of interaction that do not demand users being in control all of the time, or even being conscious of their control, and yet also immerse them in the narrative. Indeed, this was a motivator for considering *Passive BCI* [Zander and Kothe, 2011], removing blinking in later design iterations, as it raises the possibility of a more contemplative and internalised form of control that connects to thoughts and feelings more than physical actions. Our interactive designs of *The Disadvantages of Time Travel* which used blinking to produce immediate feedback did show that it was possible to achieve these immersive interactions. However, they were often transient, with viewers journeying around a space of voluntary control and awareness of control. At the extremities of this space controllers sometimes found their blinking '*snowballing*' out of control, or disrupting other controllers' or non-controllers' engagement with the film. In response to these findings, control in *The MOMENT* was designed to be even less direct, avoiding explicit feedback from the trigger-like blinking mechanism.

While a direct comparison is not possible, *The MOMENT* did deliver a less overtly conscious form of control for much of the time, but a tension remained with people sometimes becoming conscious of control or trying to exert direct control.

This poses an unusual design challenge to HCI as it requires designing interactions that are neither direct and immediate or entirely calm [Rogers, 2006] and ambient [Weber and Rabaey, 2005] in the sense that the overall digital experience remains very much in the foreground, even if the control does not. At first sight, it also raises something of a paradox; how can one be in control of something and not be aware of it? The answer, as previously argued, lies in thinking in terms of flow experiences [Csikszentmihalyi et al., 2005] in which one controls at a subconscious level while attending to experience at a more conscious one. How to achieve these kinds of lean-back interactions in practice, however, remains a key tension.

When applying the lean-back characterisation it is important to reiterate that engagement with a film is not a "passive" experience, in the pejorative, vernacular sense of "mindless". Following a film requires concentration, which is one of the reasons they are traditionally watched in the dark on a large screen. Looking beyond HCI, film theory details the complex cognitive processes involved in film viewing: "Meanings are not found but made" Bordwell [1989, p. 3]. Communication theory challenges the apparently homogeneous nature of mass media by demonstrating the diverse ways in which audiences interpret and integrate media in their own lives [Katz et al., 1973]. The brain-controlled interaction in this case is designed to support a lean-back experience, not transform it into a lean-forward one. It foregrounds the interpretive 'work' involved in film viewing. And, as our data shows, controllers of *The MOMENT* particularly film are particularly aware that their attention matters.

Our studies reveal moments where people felt conscious of control and tried to experiment with the system, especially with iterations of *The Disadvantages of Time Travel* and early on in the experience of *The MOMENT*. However, we also have evidence that people experienced lean-back interaction: they were willing to influence the content without understanding how, and to concentrate on the content presented. Interviewees themselves argued that deliberate narrative choice is undesirable because users could game the system and undermine artistic intention. *"I much prefer to be out of control in that situation, rather than decide."* 550. Film history teaches us that technical developments of the medium can initially be a source of uncertainty and anxiety for audiences [Bottomore, 1999]. However, over time, new modes of interaction may be absorbed (just as sound and colour once were) into the formal systems for constructing and interpreting film meaning [Bordwell et al., 1985].

10.3 Social experiences of control

We explore what we can learn from new modes of group interaction. How controllers interact with each other becomes important. By disentangling these interactions we can uncover strategies to nudge experiences into lean back interactions.

As with single user interactions, modes of group interactions tend to be internalised, being concerned with thinking rather than physically moving. While this may be governed by context (our audience was seated in a darkened auditorium to watch a movie), and one can easily envisage other situations in which BCI might combine with physical movements (e.g., musical performance [Miranda and Brouse, 2005] or games [Nijholt et al., 2008, Marshall et al., 2013]), we suggest that it is generally the case that BCI drives attention and hence interaction towards – or suits situations in which – interaction is largely via internal thought processes.

Consequently, BCI control is also a reflective mode of interaction. It encourages 'thinking about thinking' and awareness of how one is feeling, leading some people to analyse their own reactions to the experience. While we acknowledge that this effect may fade over time as audiences become accustomed to this form of control, our experience from *The Disadvantages of Time Travel* and *The MOMENT* reveals a dynamic where participants move between immersion in the content and a meta-level reflection on their own engagement. A distinctive role for BCI may be to create experiences in which audiences dynamically and frequently tip back and forth between experiencing and thinking about how they are experiencing, which may in turn inform strategies for arriving at an interpretation of what they are seeing.

10.3.1 Revealing internal responses to other people

We begin with some reflection on the general character of shared BCI control. Our multi-user study of *The Disadvantages of Time Travel* highlights how interacting with a movie via a BCI device – including through blinking – provides a distinctive form of control with some particular characteristics.

There is some evidence from our study that shared BCI control might work well when people relax and go with the flow of the experience, implying that it may also suit lean-back styles of viewing [Vosmeer and Schouten, 2014, Dewdney and Ride, 2006] and that those creating experiences may wish to frame them in a way that encourages such an approach.

Control tends to be ambiguous. The nature of the mappings between EEG signals and higher level concepts such as Attention and Meditation is complex and difficult for audiences to directly interpret, especially when using relatively low-grade commercial devices that operate in a blackbox mode, i.e. that provide estimates of measures of Attention and Meditation without making the algorithmic basis of these explicitly clear. However, it is also likely to be true of higher fidelity and more open interfaces as the nature of higher level concepts such as Meditation is itself inherently ambiguous and open to interpretation. This is not to say that even lower-grade devices will not provide an appropriate level of control for delivering an interactive experience – indeed interactions with our brain-controlled films suggests that they can – but rather that there is an inherent degree of ambiguity over control. As has been pointed out by previous research, ambiguity need not be a problem in interaction design, and can in fact be a positive virtue, especially in cultural applications in which it may provoke interpretation by audiences [Gaver et al., 2003].

This form of control may increase competition for the user's attention. The user may be attending the content, to their control of the content, to their own reflections on the experience and, in shared modes, to how others may be controlling, feeling and acting too. While this competition may be present in all shared applications to a degree, direct manipulation interfaces, to take a popular example, off-load some aspects of interaction onto the user's sensorimotor system enabling them to become more subconscious. BCI control – at least as experienced in *The Disadvantages of Time Travel* and *The MOMENT*

– appears to raise them into the user's consciousness, though we acknowledge that this may change over time with training and familiarity.

These various characteristics spill over to affect shared control – the focus of this section of discussion. Reflection now extends to considering others' feelings in relation to one's own. How are others responding to and controlling the film? What is a good experience for them and how can I contribute to this? And also, what might my control – for example my levels of attention to different events within the narrative – lead them to think about me. Consequently, the introspective nature of watching the movie may become further amplified through feelings of responsibility and vulnerability. There is yet more competition for the viewer's attention and also even greater ambiguity as to how control is being affected once others are also involved. This may cause some to test control, leading to disruption and over-control rather than a more lean-back mode of relaxed engagement.

The absence of grossly observable physical feedback from others, for example gestures, exacerbates the ambiguity. It is difficult to directly observe others' largely internalised control, especially when seated next to or behind them in a darkened auditorium. However, our design choices have been to not provide explicit feed-through via the screen itself due to the risk of further distraction from the cinematic content; the the feed-through is in how the films construct themselves. These effects may vary over the different forms of control. Blinking is somewhat easier to disambiguate than Attention and Meditation, though may also lead to greater disruption, especially when mapped to temporal montage, i.e. cuts. Attention and Mediation are highly ambiguous; difficult to directly read without additional feed-through. The visual design further encouraged this ambiguity. Both high and low Attention provided a clear image; only when there was Attentional movement between these states did cross dissolves appear. Each viewer is forced into a position of having to imagine how others might be acting and responding to the movie. The clear separation of control across temporal and spatial montage and music may help disambiguate control to some extent as the viewer can at least separate the effects of their control from others.

10.3.2 Distribution of control

Our second reflection concerns the distribution of control among a group of viewers. Of the four approaches we tried with the hyper-scanning version of *The Disadvantages of Time Travel* the collaborative and cooperative mode seemed to strike a good balance between legibility, with each viewer aware of what they are controlling while the performative mode was relatively legible but somewhat frustrating for the non-interacting spectators not to be interacting. The competitive mode appears to have lacked the legibility of control of the other modes, leading to people accidentally or deliberately disrupting each others experience. This said, we argue that all four modes are of possible interest and that it is appropriate to think about how best to further develop each rather than prematurely choose among them. Table 4.4.1 on page 122 has a breakdown of each control mode.

Cooperative – while this approach fared relatively well in our test, it presents a significant challenge for scaling to larger groups. To directly map more individuals to specific cinematic techniques will require introducing new aspects of control beyond spatial and temporal montage and audio mixing. Other possible mappings could include: diegetic/non-diegetic sound manipulation, changes to colour grading, narrative scene order, frames per second and parallel editing. This would introduce a few more interactive viewers to the group and further diversify performances. To further scale to large theatre audiences and maximise interactors this mode could then be combined with the collaborative (averaging) technique to group multiple participants controlling a single cinematic technique.

Competitive - One of the more popular choices, but also one that had its own problems. The person with the highest Attention became the sole controller; this caused behavioural effects where controllers were trying to (not surprisingly) game the system, to find out if they had control or not. When a participant did feel control it would leave them as soon as it was discovered, as, presumably their Attention shifted as a result. This resulted in control ping-ponging from one participant to another adding another distraction from the main activity, engaging with a film. Another consequence of this control method was that as Attention was also controlling the visual blending, the media mapped to low Attention would be rarely seen. Some ways to improve this system could be to include some discrete haptic feedback to the controlling audience member who is currently in control. Alternatively, a film with shifting narrative threads such as in *The MOMENT* could use this competing method to choose which narratives to forefront, by assigning each controller to a specific character. Again, if we were to scale the number of interactors to the whole audience, they could be grouped before the film starts, effectively pitting teams of audience members against each other.

Performative – this mode is potentially scalable to audiences of any size as there is only one interactor. The challenge is how to pique the interest of the large numbers of non-interacting spectators. One solution may lie in emphasising performative qualities of the interaction, for example exploiting the sense of vulnerability that was reported by some of our participants. The interacting individual's reactions can be placed under scrutiny and become a matter of reflection and even discussion for the audience. This may require choosing participants with a clear and interesting connection to the movie, presenting their backstory to the audience and providing opportunities for discussion afterwards.

Collaborative – This mode used the averaged Attention and Meditation data and every third blink to cut the film. We saw some controllers over blinking to see the film cut, producing an overall faster cutting film. This could be improved if the system rather looked for simultaneous blinks to cut. The challenge here is perhaps to persuade audiences to relax, lean back and go with the flow. We have seen that audiences have natural tendency to experiment, to intentionally look for correlations, and so encouraging them to refrain from experimenting or trying to take control could become contentious if over-egged. There are several ways in which this could be addressed. The theme of letting go of control could be built into the film's narrative. Another option may be to reveal the mapping of the BCI control before or after the screening so that people can anticipate or look back at what happened and see their own role and contribution as part of the wider crowd. Understanding may potentially emerge over time or perhaps as a result of scale as the movie responds to aggregate measures that can smooth out the behaviours of outlying individuals.

In short, all four of the approaches that we tried would seem to offer some potential to bring interactivity to movies. Moreover, why do we need to choose between them? It may be that the approaches are best used in combination with people experiencing different modes across repeated screenings of the film, seeing new versions and gaining different insights each time. This would serve to encourage repeat viewings of a movie which may contribute to commercially viability, as well as also be desirable from an experiential point of view, given the potential for a viewer to see many different versions of the movie.

10.3.3 Multi-user taxonomy

We update our taxonomy of control discussed in Section 10.2 onward to include cinematic engagement and multi-user control. As we have seen, an incompatibility of high intention to control combined with an awareness of the physiology of oneself and that of others, can work against cinematic engagement. We describe three axes, *Intention to control*, *Others awareness of physiology* and *Cinematic engagement* and from them develop a 3 dimensional taxonomy. In it we will show how these three motive/affects interact, but first let us introduce describe and define the three axes:

Axis of *Cinematic engagement*
We define cinematic engagement as when controllers reported positive experiences or did not report narrative disruption from interaction. See Figure 10.7.

Axis of *Others awareness of physiology*
As in our previous taxonomy this axis relates to extent of self-awareness, but to describe a group of interacting individuals. The members of the group not only become aware of their own physiological state but that of others. See Figure 10.8

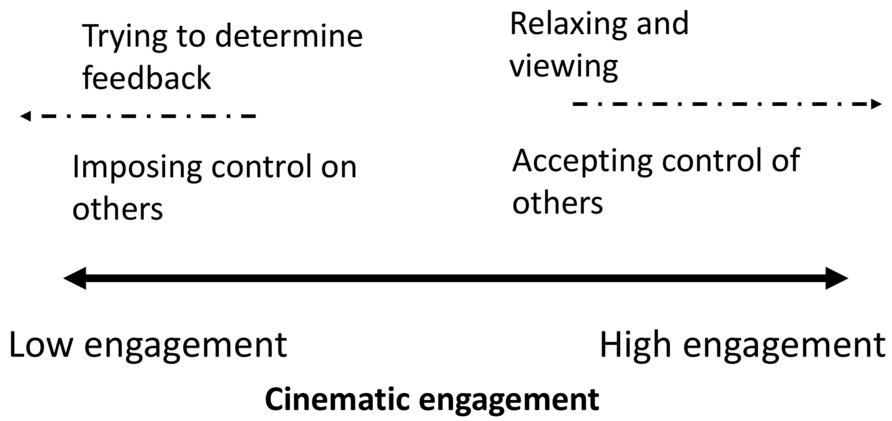

Figure 10.7: Intentions to interact which affect cinematic engagement

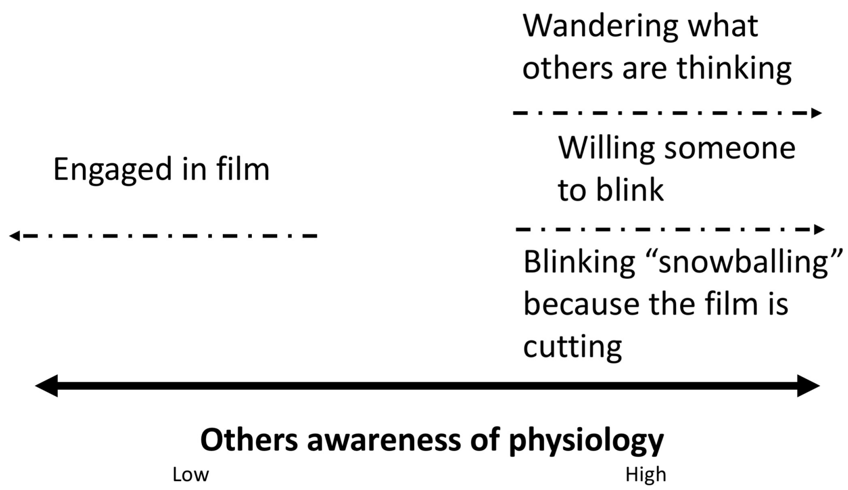

Figure 10.8: Causes of changes of awareness to others awareness of physiology.

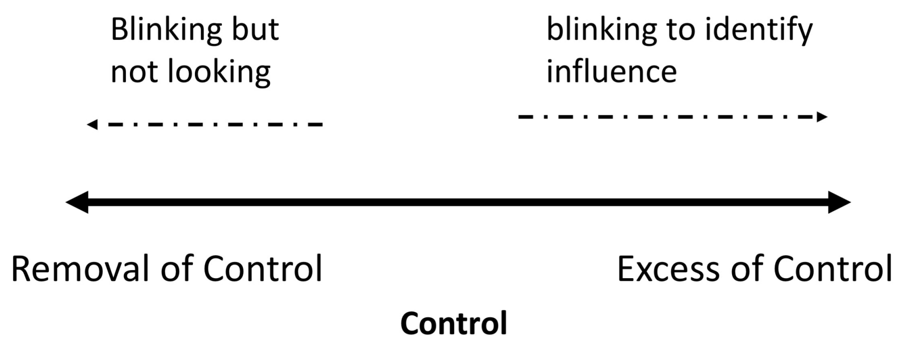

Figure 10.9: Causes of movement in the axis removal of control excess of control

Axis of Intention of control

To define intention to control we first explore two extremes on the continuum of control, visualised in Figure 10.9. We observed two distinct modes of control which we will describe here as excess of control and removal of control. We define moments of excess of control when participants expressly try to modify the film by consciously and intentionally adapting their physiological behaviour, for example, blinking excessively to "give a good experience" to others. This is often to the detriment of their own and unintentionally others' cinematic and narrative engagement with the film. We define removal of control as when controllers intentionally break the 2 way affective loop (2WAL) which we developed in [Pike et al., 2015a], as noticed when users choose to disengage from the cinematic narrative and exampled by looking away and blinking randomly, closing their eyes or focusing on different parts of the screening room to change their Attention.

Second, in Figure 10.10 we look at how cinematic engagement acts in response to controllers' decisions to either remove or over use their agency. We note that in both cases cinematic engagement is compromised. We see that it is not only the controllers that decide consciously to over or under control who report a related unengaging cinematic

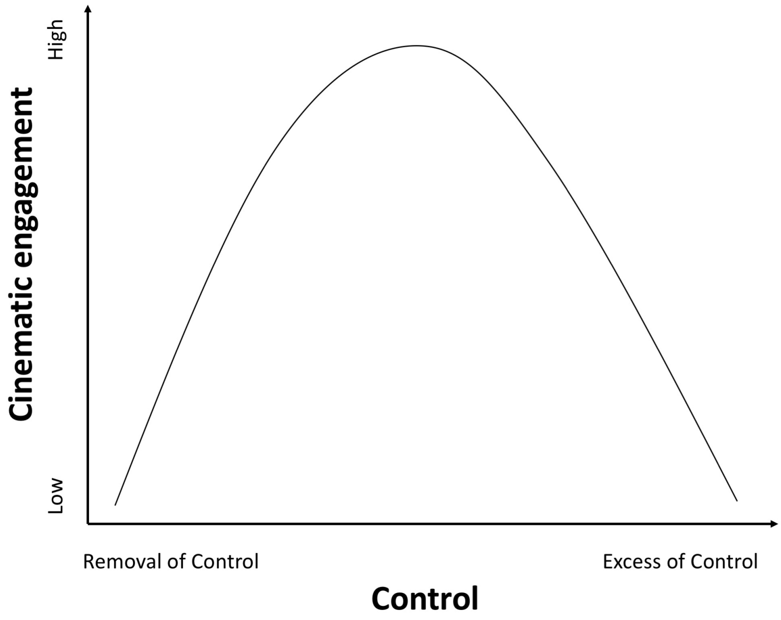

Figure 10.10: Cinematic engagement and control

experience, during these moments other controllers reported a cross effect of low cinematic engagement.

These moments of excess and removal of control can be both conceptualised as on an axis of intention to control, Figure 10.10, where an excess of control and removal of control are both a high intention to control. Thus Figure 10.10 can be presented in another way, where intention to control becomes the x axis and cinematic satisfaction on the y axis as in Figure 10.11

Awareness of physiology and intention to control

We saw that the level of intention with which group participants approached their control affected the others in the group. If they under controlled, other members became frustrated, willing the active controller to use their agency, to change their physiological state. Inversely, controllers who took it upon themselves to over control produced film versions which, cut too fast: "*it makes my mind and brain and eyes a bit more tired*, (P34 Collaboration). The affected controllers became aware of both their own physiology and that of the member who was disrupting their engagement. *"It was like I couldn't stop*

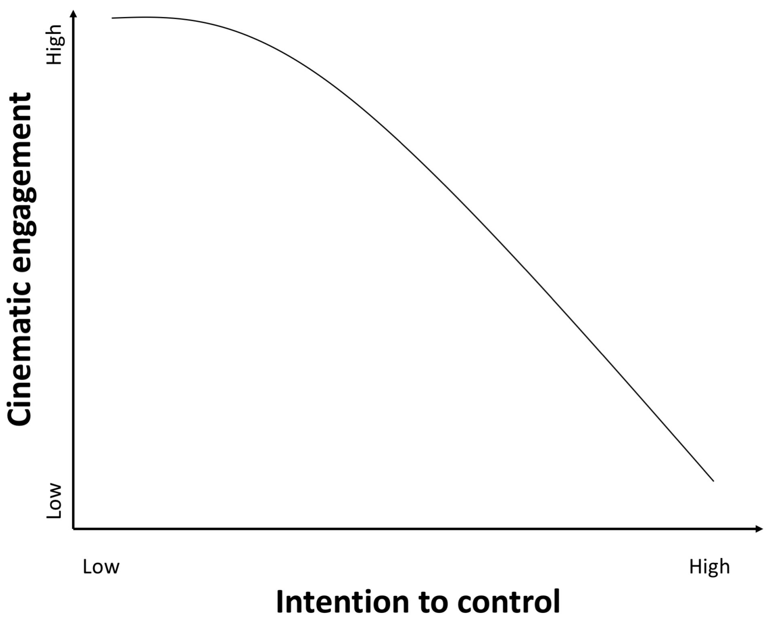

Figure 10.11: Intention to control as an axis related to cinematic engagement.

blinking" (P15 Spectator). It appears that intention to control from one member of the group is proportionally related to other's awareness of physiology as describe in Figure 10.12.

Taxonomy of group interactions

Now we have defined the three axes and how they interact with each other we present in Figure 10.13 a three dimensional taxonomy of group interactions with our brain-controlled film *The Disadvantages of Time Travel*. We also show an interactional space within this volume. We will first describe each vertex of the interactional space and then explore each side of the shape and provide examples which caused movement.

Below we describe each vertex of the interaction space.

1. Low intention to control, low awareness of physiology both of the controllers and non controllers, and low cinematic immersion *"I'm not even gonna look (laughing)"* (P25 Collaboration).

2. Low intention to control, low awareness of physiology both of the controllers and

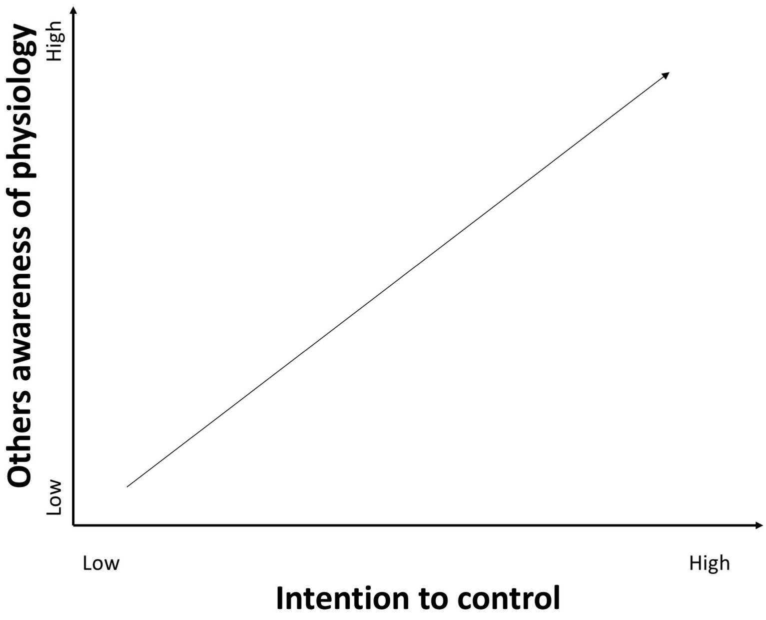

Figure 10.12: Awareness of Physiology and intention to control

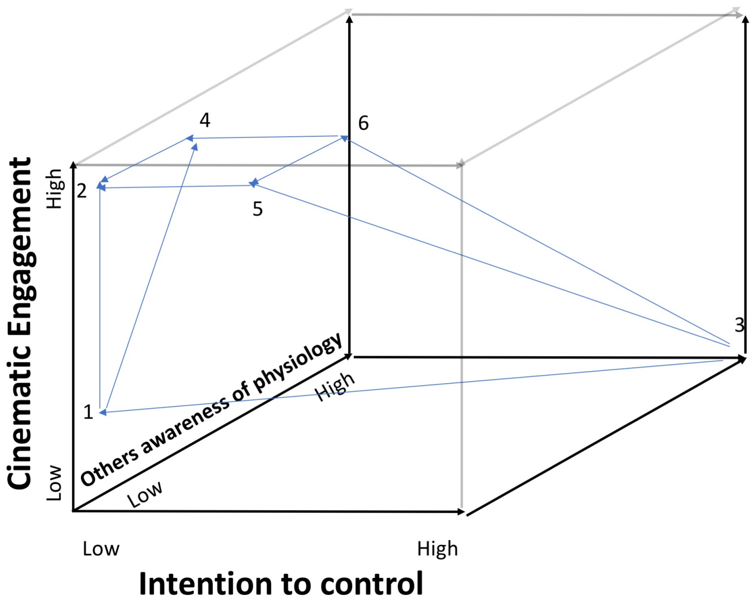

Figure 10.13: 3D taxonomy showing the interaction space groups found themselves in

non controllers and high cinematic immersion "*I think the strange thing is if you were to take that and upload it to YouTube or whatever it would feel like all of that was done for some artistic reason and it still felt cohesive even though we weren't talking to each other,*" (P44 Att/Blending/Coop).

3. High intention to control, highly aware of others physiology and low cinematic immersion *"I was switching from more a director view to a giving the experiences to other people and literally having moments to try and maybe give them a different experience so I was taken out of the story for bit."* (P36 Collaboration).

4. High cinematic engagement, medium awareness of physiology, and low intention to control "*And then you'd switch and you'd fade out and I was like wooooooah (laughing),*" (P12 Coop/Med/Music)

5. High cinematic engagement, medium intention to control, and low awareness of others physiology *"And I did at times feel that OK I need to alter the experience for those around me and stay focused at sometimes."* (P23 Coop/Att/Blend)

6. High cinematic engagement, medium awareness of others physiology and medium intention of control *"I want this to be clearer so they must want it to be clearer,"* (P16 Competing)

If designers consider how their interaction designs can move controllers from 1, and 3 towards 2, 4, 5 and 6 they can work towards preserving cinematic engagement while employing interactivity.

The five sides (A to E) of the interactive volume in Figure 10.14 represent the boundaries of intention, engagement and awareness. By explicating each side, the relational movements of these three concepts can be mapped.

Side A

Figure 10.15 shows the optimum space for cinematic immersion. The intention of users to control and the awareness of others in the group can both move from a low to medium

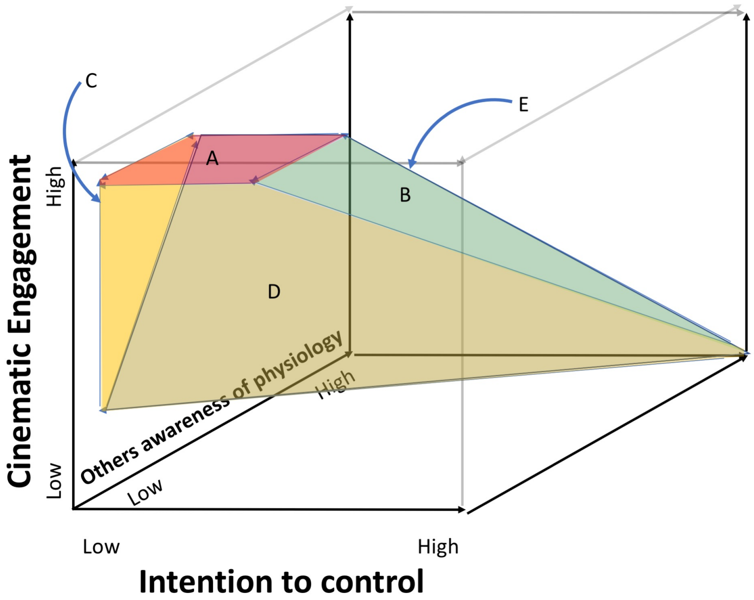

Figure 10.14: The 5 sides of the 3 dimensional interaction space

intensity while still not disrupting the cinematic immersion. This is similar to the creative space defined in Figure 10.5

Side B

Figure 10.16 shows cinematic immersion is inversely relational to intention to control, where high immersion is possible when there is a medium intention to control.

Side C

Figure 10.17 shows when there is a low intention to control the film users can move from low to high engagement with the film, this can be down to personal taste. There is no intentional control to disrupt their cinematic engagement. Also as engagement drops so does the group's awareness of each other's physiology.

Side D

Figure 10.18 shows while experiencing high cinematic engagement some focus can be given to attempting to control the film, however if more focus is given to controlling this impacts other's awareness of their own physiology, which can snowball into a negative feedback loop, blocking the other users from engaging with the film.

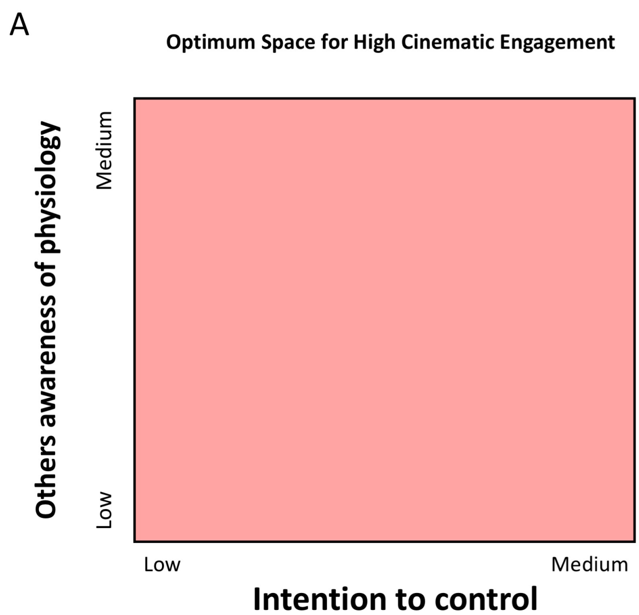

Figure 10.15: Side A of the interaction space

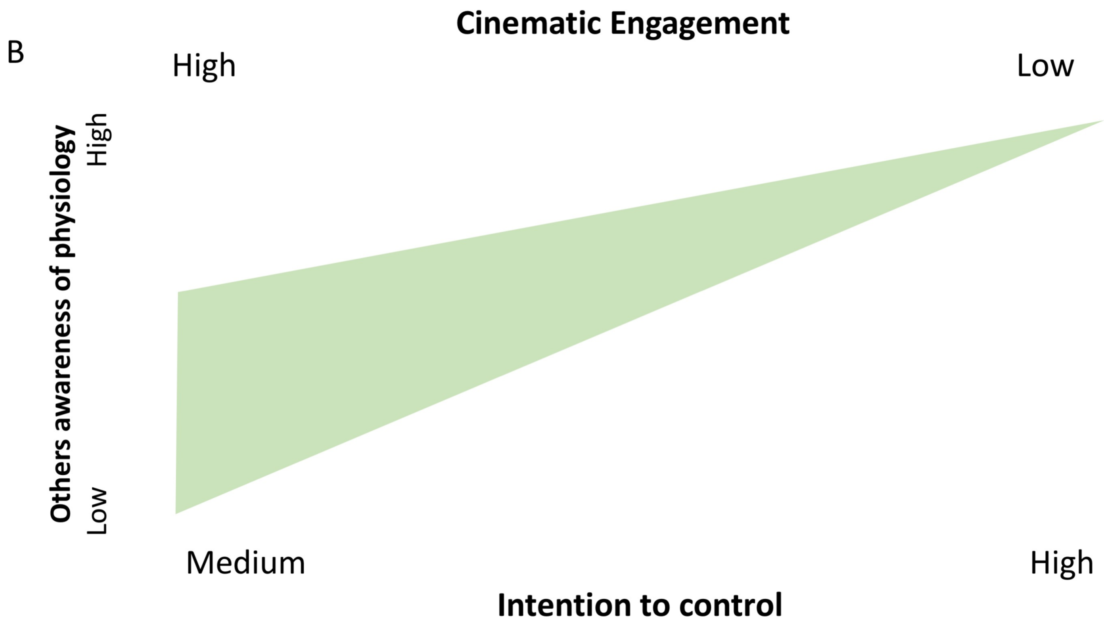

Figure 10.16: Side B of the interaction space

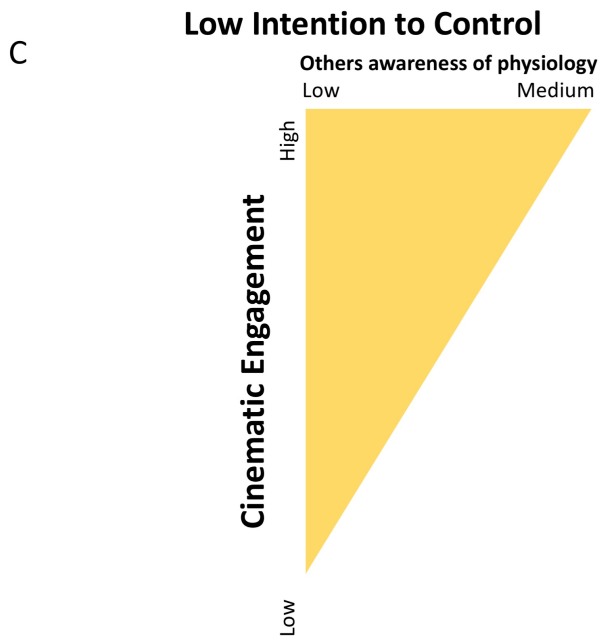

Figure 10.17: Side C of the interaction space

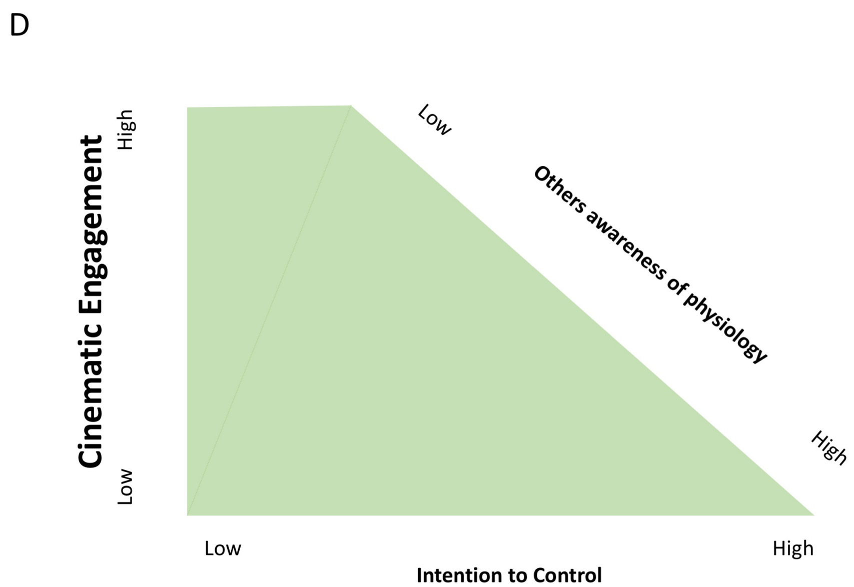

Figure 10.18: Side D of the interaction space

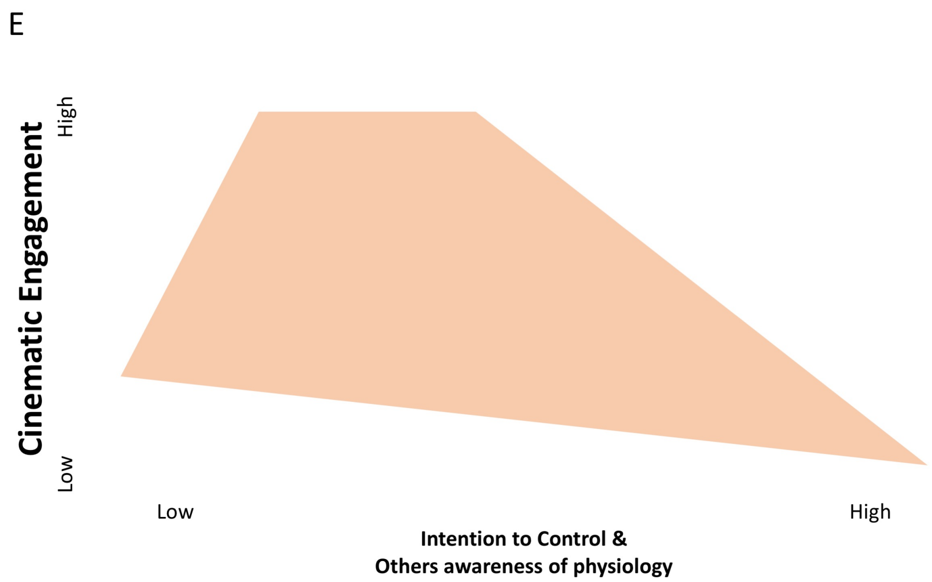

Figure 10.19: Side E of the interaction space

Side E

Figure 10.19 shows that intention to control and others awareness of physiology are related to each other, cinematic engagement is inversely related, and we did not observe engagement when either participant were highly aware of their own or others physiology. likewise, attempts to control caused moments of disengagement and vice versa.

10.3.4 Generating the user's cut

Although viewing *The MOMENT* as a non-controller was reported to be engaging, amongst all the audiences we studied, being a screening controller was characterised as both a privilege and responsibility. Those who took this role in *The MOMENT* rated the film more highly than other audience members did. This could be built upon so that the controller's particular perspective, and the film that it generates, become a focus for the audience. In much the same way as a director's cut is a saleable version of a pre-existing film, the experience of witnessing a notable (for some reason, e.g. featured actor, renowned critic, superfan, someone whose experience mirrors the themes in the film) controller's version of an interactive film might be appealing for the viewing audience, and invite them to make alternative interpretations. In practical terms, screenings that revolve around a celebrity interactor would fit with broader trends in the film industry towards exploiting live, experiential, participatory aspects of film going practices (e.g. Secret Cinema), analogous to immersive theatre [Atkinson and Kennedy, 2017].

However, the personal associations that were often made when viewing *The MOMENT* and *The Disadvantages of Time Travel* suggest the potential to extend this approach to every controller so that each generates their own cut of the film in which they are personally invested. This relies on: the BCI interaction mechanism generating sufficient variation to make many distinctively different versions of the film; viewers feeling ownership over the specific film that they have controlled; and viewers feeling that the resulting 'user cuts' reveal insights into the controllers and their responses to the film.

Such an approach may encourage repeat viewing, which is already a feature of film consumption over time, especially among fans [Klinger, 2006]. Enabling each viewer to generate a user's cut may encourage people to re-experience the film in different modes (controller and non-controller), compare their cuts with others, and try to interpret the film through other's eyes. It suggests maintaining an archive of all versions along with visualisation that allow people to compare their own experience to others as discussed by [Benford et al., 2018].

10.4 Implications of research and recommendations for practice

In this section we will explore what opportunities arise from our discussion which can be exploited both of theory and in practice.

10.4.1 Editing a film rather than controlling its screening

Our notion of the user's cut leads us to speculate about an interesting reversal of perspective. Up to now, we have seen brain-controlled film as being about audiences interactively controlling a movie while it is screened. However, our experience in this research suggests that this may remain a knotty challenge, even with the more lean-back forms of interaction we have introduced here. On the other hand, we have raised the alternative prospect that experiencing our brain-controlled films might be thought of as users investing in generating their own personalised cuts. This suggests to us that we might shift our view of brain-controlled film to consider the idea that our viewers are actually making films rather than only watching them. The director provides a pool of material and a narrative and interactional structure, but it is the viewers who then complete this to generate personal cuts and rhythms that can also be enjoyed by others. In fact, this idea reflects the argument that to watch (even a traditional 'passive') film is to actively engage in an act of co-construction [Bottomore, 1999]. BCI control of the kind proposed here may make this feedback loop more explicit and bring it into the repertoire of techniques that can be employed by filmmakers.

Such a shift of perspective potentially has implications for how HCI reconceptualises brain-controlled films, and perhaps other BCI or even generally interactive, media experiences. Recognising that we are enabling viewers to complete the making of films naturally emphasises the ideas of designing films to be personalised, divergent, archived, shareable and repeatable experiences. While it may still be important to design appropriately lean-back interactions as part of this, the bigger picture is perhaps about how we ultimately capture and share generated versions of experiences, so that people can comprehend both the versions they have edited, and the edits that they want to see.

10.4.2 Wider implications for HCI

Up to now our discussion has focused on the implications of our study for future brain-controlled movies. In the final part of this section, we turn our attention back to HCI to consider the wider implications for interaction design.

As a social experience, *The Disadvantages of Time Travel* presented an unusual, perhaps even extreme, interaction design challenge for a combination of reasons. First, it employs a largely invisible mode of interaction. Second, that mode of interaction is somewhat 'spongy', being both difficult to predict and control. Third, the experience is intended to be staged in a movie theatre where participants are seated in the dark and in rows so that they cannot naturally see one another and where the volume of the film and prevalent social norms may inhibit them from talking to one another. Fourth, in order to preserve the integrity of the cinematic medium and not stray into the realm of gaming the interaction design omitted overt forms of feed-through directly onto the screen. Rather, feed-through in *The Disadvantages of Time Travel* was designed to be mostly hidden from other interactors, what Reeves et al. [2005] would call a secretive and magical approach. Where the influence on the movie was visible, neither the exact interaction, nor the exact interactor, are explicitly visualised, decisions that cut against typical group awareness recommendations from the literature.

It is perhaps no surprise that due to the combination of these four factors interaction was often ambiguous at best, with participants being unsure as to who was in control and what level of control was being exerted. Yet, the experience appeared to work for many in spite, or perhaps because of the level of ambiguity. As Gaver et al. [2003] suggested, ambiguity in interaction design serves to provoke interpretation, which media theorists would seem to suggest is a key goal for watching movies. Their paper identified three forms of ambiguity: ambiguity of information, of context and of relationship. The ambiguity that we have reported in this thesis is primarily an example of the latter; ambiguity of the control relationships between the the controlling viewers and the system. The controlling viewers and the larger audience is provoked into interpreting their own and other's relationships to the content. However, while celebrating ambiguity is one possible approach, there are others. An alternative design direction would be to improve the nature of feedthrough. Rather than layering feedthrough on top of the content, as is the case in many groupware systems, why not embed it within the content. Might actors in the film for example, offer subtle cues as to the external influence of viewers, perhaps by recording alternative performances of scenes or shifting the locus of narrative perspective. Finally, might the technologies improve to the point where the ambiguity disappears. It seems possible that commodity brain computer interfaces will improve in their capabilities[1]. However, we note that the ambiguity may reside as much in the mind of the viewer as it does in the technology. It is unclear to what extent the tipping back and forth between engagement with the content and reflections on control are an unavoidable aspect of the human response to BCI. Maybe viewers can train themselves to control their thoughts or maybe this is an inherent property of this form of interaction.

10.4.3 Implications for future BCI-controlled movies

We now draw out some specific implications for the future deployment of our brain-controlled movies and potentially for the design of other brain-controlled movies. Our first is to consider the potential benefits of using BCI at all. We suggest that there may be four:

1. The largely cerebral and minimally physical style of interaction inherent to BCI may be a good match to some movie watching situations.

2. A single physical device may deliver multiple modes of interaction that can be mapped to the different structures of a movie and/or allocated to different participants during social viewing, e.g., mapping blinking, Attention and Mediation to spatial and temporal montage and sound.

[1] neuralink.com

3. It may ultimately be possible to extract higher level cognitive and even emotional states from such devices that relate meaningfully to the content of the movie.

4. The idea of controlling by thinking, combined with the somewhat ambiguous nature of BCI control, may lead participants to reflect on how they or others are watching a movie which might support them in making interpretations. This idea may help resolve the apparent tension between the filmmaker's authorial control and the viewer's interactive control noted by Manovich [2001], Ben-Shaul [2008], Lunenfeld [2004], as the role of the filmmaker now becomes providing the content and supporting scaffold for the viewer to arrive at one or more interpretations.

Design recommendations for practitioners

In order to design interactive films as described in this thesis, filmmakers would have to first deconstruct each filmic technique into its discrete units and evaluate how the interactive manipulation of that technique could be used to communicate meaning in the film world. Choosing the modes of interaction that will be provided to viewers has practical implications throughout the filmmaking process. Our films had a continuous story portrayed through different layers. The films also needed layers of audio that could be controlled in a dynamic sound design mix. It is ideally a predetermined design challenge, for example, to create audio that could be changed, but remain consistent independently of the visual scenes being selected by a different control method.

Algorithms, mappings and sensors

The real-time mappings of our seven designs were all dependent on the technology used. The NeuroSky Mindwave's Attention, Meditation and blink data were mapped to different cinematic modifiers: sound mix, cut between scenes, opacity of overlays. These data mappings come from recording differences in electrical potential at location FP1. Literature suggests that other locations of the cortex such as the occupital cortex [Singh et al., 2003, Jääskeläinen et al., 2008, Shimamura et al., 2013, Kauttonen et al., 2015] and motor cortex [Heimann et al., 2014, 2017] could also be fruitful in sensing event related potentials (ERPs) related to viewing cinematic content, while affordable open source sensor technology exists which can be modified to record from corresponding scalp positions or could be specifically designed to do so[2].

In our designs we have aimed at matching the timing of films rhythms of cutting between shots to users physiological rhythms, of Attention and blinking. [Bordwell and Thompson, 2001] refer to it as pace. However the 'pace' of a film owes more to just the rate of cutting, the rate of movement and change within a shot also adds to the feeling of rhythm. Pearlman [2012] refines this idea to include: character actions, emotions, dialogue, plot points. We would add sound to this list. Future algorithms could, instead of cutting the film, select shots which have a specific rhythm embedded within them that match the viewers physiology. A further design track could focus on the building and release of tension, by switching between several algorithmic 'modes'. Yet another design could look for specific cut patterns or shot combinations to select narrative detours Verdugo et al. [2011] if specific combinations are achieved, similar to musicodes described by Greenhalgh et al. [2017]. A structural move towards database narratives (as opposed to the parallel narrative that both *The Disadvantages of Time Travel* and *The MOMENT* use) could allow for increased variability of story and of narrative structure. Algorithms could also be a way of following an internal logic to a film, a cause and effect, similar to the detour narrative explored by Verdugo et al. [2011] which exploited the Kulshov Effect. Remembering what detour shots were shown within a scene could result in specific combinations for the final sequence.

Scripts and narratives

The penultimate scene in *The MOMENT* where there are different combinations of dialogue, documented in Section 7.5.2. This was an unforeseen effect that could be exploited

[2] openbci.com

if built into a script from the beginning. For example a three part parallel script, could be written so that the same dialogue has different meanings as it is re-combined.

Script and storyboards

Storyboards can be used as interactive animatics. By designing a working prototype of the interactive system during the storyboarding process, dynamic combinations of shots can be refined at the pre-production stage.

Directing and production

A new role of interaction supervisor could be introduced to work beside the director at the same level as the 1st AD. Their responsibilities would be to record timings and meta data related to interactive aspects of shots, overseeing continuity between parallel scenes and shots. They would liaise with the 1st AD and the director.

Editing

Further practical research could explore fractal patterns of editing [Cutting et al., 2010, Cutting, 2019], detour narrative [Verdugo et al., 2011], and subvert or exploit genre preconditions. If we wanted to move away form aping continuity editing rules we could exploit the viewers predisposition for mind wandering during long takes to create meaningful character studies and immersive vignettes [Poulaki, 2014]. Of course these potential montage techniques could be combined in different configurations or at different points in the same film as part of an interactive palette.

10.4.4 Putting our frameworks to future use

We now consider the utility of our frameworks from sections 10.2 and 10.3- how might they be useful. The first possibility is a "sensitising concept" to assist in the design or analysis stages of future studies. We might for example, design future studies to explore in greater detail the relationships between voluntary and involuntary control or between conscious and unconscious control, or to explore some of the specific transitions that we have identified in greater depth. Our concepts might also prove useful for analysis of data captured from other BCI controlled entertainment experiences. This latter point raises two questions about the generality of our frameworks:

1. To what extent might it apply to other kinds of control that have similar characteristics to BCI? With much other work looking at interactions via other physiological data, our framework might equally apply to other forms of broadly physiological control such as breathing and heart rate, but might also be expanded by them.

2. To what extent might it apply to other entertainment and non-entertainment applications? Our framework might apply to interactive entertainment like gaming and music creation, but might also apply simply to non-entertainment control concerns such as controlling prosthetics or to help "locked out" users control computers.

The second possibility is as a framework for generating new design ideas. Here we follow Höök and Lowgren's notion of strong concept [Höök and Löwgren, 2012], a form of "*intermediate design knowledge*" that embodies a core design idea; bridges between specific instances and generalised theory; concerns interactivity; and can help generate new designs. With this in mind, we suggest three ways in which our framework might enable the design of future experiences.

First is the design of interactive content - the structure of interactive media can respond to inter-experience transitions. We have documented how we scripted, shot and edited *The Disadvantages of Time Travel* and *The MOMENT*. These examples reveals various creative strategies, but different types of films might be suitable to different types of physiological control. Suspense thrillers, for example, might monitor users for a difference between being bored and enthralled in order to shorted or extend the scene, where stress is detected from EEG and blink rates [Haak et al., 2009]. Similarly, designers may ask how to respond to a user that voluntarily closes their eyes for sustained periods of time. During horror films, this could be used as an active controller to skip scenes, or passively to make the film sound scarier.

Second is the repeat screening or staging of experiences. We have begun to explore these with *The MOMENT* and *The MOMENT* live score. Our recognition of inter-experience transitions suggests that more attention needs to be paid to the screening of experiences. Of particular importance here is developing strategies for moving people between different modes of engagement as they re-encounter the experience anew. Should their first experience be a “naive” one before they then find out how it learns? Should they move between spectating and driving as argued by Reeves et al. [2005] in their proposals for designing spectator interfaces? What might be the best orders for combining all of these? The notion of varying repeat experiences in this is unusual in film where film-makers are not usually directly concerned whether we enjoy it differently on subsequent viewings. Exceptions would be films that employ clues throughout and end with a ‘twist’, making subsequent viewings rich, also films such as *Memento* and *Timecode* make the viewer work hard on the first watch and give satisfaction as plot points click into place on subsequent watches. It is perhaps more common to consider the longevity of enjoying games, but even then the focus is more on progressing through levels than on systematically varying the experience each time.

Third is to explore collective experiences. Our recognition that films are often watched in groups, whether at the cinema or at home, led us to our multi-user versions of *The Disadvantages of Time Travel* and *The MOMENT* live score. Within our single user deployments, even, watching *The Disadvantages of Time Travel* and*The MOMENT* can be - and was - witnessed by many viewers concurrently. There is a large opportunity, therefore, to further investigate how multimedia might respond to the biological responses of a collective audience. Experiences might monitor the average response across an audience, where Kirke et al. [2018], for example, have recently explored the use of audience arousal to vary a film experience with multiple possible endings. Conversely, different people could control different aspects of the experience, where Leslie and Mullen [2011], for example, provided separate control over music streams to each participant.

10.4.5 Planned practice and research

Online Archive

Each screening of *The MOMENT* has been recorded, and work has begun on an online archive. This will be used as a research tool as well as a way to engage the public form different communities. By utilising the CSV logs of each screening we are able to visualise each film's narrative path weighting. This additional data can be used towards creating a new experience from existing recordings, and engaging ways of navigating the archive. This archive can of interest to new viewers and repeat viewers who have already seen *The MOMENT* once and would like to see it again.

Live score tour

A live score tour investigating repeat experiences, and value to audiences is planned. Ten venues have been booked to receive *The MOMENT* across the UK. Researchers are planned to accompany the musicians and undertake interviews with audience and controllers. However, At the time or writing COVID19 has had the UK shut down for two weeks, with estimates of a six to eighteen month shut down. As we investigate contingency plans of live streaming, drive-in cinemas, and performances to blocks of flats we become aware that adapting to societal shifts will offer opportunities as well as challenges in the coming years [Bendell, 2018].

Summary

Reflecting on practice, we brought together the various processes of practice which were changed from making our brain-controlled films.

We discuss how our various designs of interaction encouraged variant behaviours of controllers. We mapped these controls into a design space and showed that our film *The MOMENT* was able to encourage cinematic engagement.

We further developed our taxonomy of control into three dimensions to include cinematic engagement. we saw that groups of interactors have cross effects of physiological affect and their awareness of this combined with intention to control is disruptive to cinematic engagement.

Our implications are that users interactions with BCI films are passively editing them creating media of meaning and value. The mode of interaction in an HCI sense can be described as magical or ambiguous with feedthrough incorporated in the cinematic content which can go unnoticed if too subtle and disrupt if too prominent.

We offer design implications and recommendations for practitioners, based on our experience of making films, neurocinematic and film theory. We also suggest how researches can use our frameworks to sensitise studies, to evaluate other physiological interactions and design future experiences.

Chapter 11

Conclusion

11.1 Summary of work

The work detailed in this thesis describes our research within the field of Human Computer Interaction (HCI) exploring the practical and theoretical implications of making and deploying brain-controlled cinema.Guided by new media and film theory, and interactive cinematic design we explored the designs and critiques of existing cinema and interactive cinema. We then synthesised Neurocinematic and Brain Computer Interface (BCI) literature as a grounding for interactive brain-controlled cinematic design. We documented the making of and interaction with several iterations of two brain-controlled movies. Our studies of the five iterations of *The Disadvantages of Time Travel* and two iterations of *The MOMENT* explore interactions and then scale the interactive experiences.

RQ1: What are the problems inherent to interactive cinema?

We identified how interactive cinema has presented itself over the years, we identify branching narrative active, conscious control as the predominant manifestation, used since 1968 to present day. We drew together criticism from academics and film critics towards interactive film. These criticisms are threefold, the first is related to cost and complexity, the second is critical response, and the third is the ludo narrative paradox, the inherent incompatibility of interaction and cinematic engagement.

RQ2: How can real-time interactions via a Brain Computer Interface (BCI) construct cinematic content?

By combining theory from Neurocinematics, HCI, BCI, Film and Media Studies, and observations of example of novel interactive cinema and artistic BCI artworks, we synthesised design opportunities of narrative construction, passive interaction, and practical considerations for making brain-controlled films.

We evidence in our own practice, designs to create real-time interactions via a commercial EEG BCI device . The interactive designs and filmmaking processes detailed in Chapters 4, 7 and 9 were guided by the goal of outputting cinematic experiences, influenced by the physiological data of the viewer. *The Disadvantages of Time Travel* used Attention, Meditation and blink data to manipulate audio and visual cinematic language. We further expanded multiple designs of this film to include three controllers who interact simultaneously. *The MOMENT* exploited the time based nature of physiological data, namely Attention data to create cinematic rhythm and scene combinations in real-time. Our final iteration saw the co-design of a live score performance of *The MOMENT* involving a full auditorium audience, controllers, a conductor and musicians.

We also point to further design approaches based on our experience of making and our developed and existing theory.

RQ3: How do interacting individuals respond to various brain-controlled cinematic designs?

Studies 1 to 3 provide the data to answer **RQ3**. In the first design, single controllers of *The Disadvantages of Time Travel*, we explored the users control and developed a taxonomy comprising of awareness of control and extent of voluntary control. We saw that controllers would journey around this space as they discovered, used and forgot about control. Study 2 allowed a closer exploration of how individuals experienced mappings of their blinking, Attention and Meditation data to cinematic interfaces. In Study 3 we saw how a change in design to a more passive mode of BCI interaction produced a straighter line to cinematic engagement, influence over the film was felt but not disruptively so.

RQ4: How do groups of individuals experience brain-controlled cinema designed for shared or distributed control? Further analysis of Study 2 explores the social aspects of four different group designs of *The Disadvantages of Time Travel*. From this data we saw interactions within the groups mediated by cinematic content. Controllers reported working together to produce engaging content whereas individuals in the groups who focused on taking or removing themselves from control produced unintended consequences. We developed a three dimensional taxonomy of cinematic engagement, intent to control and awareness of others physiology.

RQ5: How can brain-controlled cinema add value to audience experience? In Study 3 we studied the deployment of *The MOMENT* at an international film festival. Our analysis of the results show that viewer/interactors adopted lean back control and constructed credible and meaningful interpretations of control. The resultant movies were reported as cinematically satisfying to a non-interactive audience, for controllers their satisfaction was higher.

The journey to answer **RQ5** is embedded in the iterative practical designs, of both films and their interactions. A core element of the *Performance Led Research in-the-Wild* methodology is the pro-active response to theory, practice and studies which is actioned in practice. A large part of the motivation for design of *The MOMENT* was to increase cinematic engagement and thus value to the audience. We have shown that by adopting a passive model of BCI engagement, and removing blinking as a semi-conscious interaction method controllers are more contained within the creative space defined in our design space seen in Figure 10.5. The design also minimises physiological cross effects from the controller to the audience that we observed in Studies 1 and 2.

We explored scaling up of our brain-controlled cinematic experiences in two different ways. Study 2 increases the number of users to three, in several configurations of control. Study 4 moves further into the domain of live cinema as it includes live performers and a controller as components of the cinematic system. These live score performances are designed to engage large auditorium audiences as they experience double bill screenings and offer an increased spectacle. It expands the concept of performing the film and paves the way for future research.

Our development of design choices evidence value by the positive responses and reflections on negative user experiences from studies 3 and 4 directly answer **RQ5**.

11.2 Key research contributions

RC1 Insights into seven designs of two brain-controlled films.
We have described the processes involved in creating two different brain-controlled films and seven different interaction designs. We have paid particular care to the impact of the interactive design on specific production process.

RC2 Taxonomy of control.
We found that, while the BCI based adaptation made the experience more immersive for many viewers, thinking about control often brought them out of the experience. This led us to propose a two-dimensional taxonomy of control, considering both the understanding of the control, and how much users think about control. A traditional belief in HCI is that Direct Manipulation (being able to control exactly what you want to control) sits at the top of both these dimensions. We examined, however, how users deviate from that line, and enjoyed the experience more by either not knowing exactly how it worked, or by giving up control and becoming re-immersed in the experience. We conclude that these deviations from the line between knowledge and conscious control over interaction are the most interesting design opportunities to explore within future BCI adaptive multimedia experiences.

RC3 Taxonomy of group control.

The idea of brain-controlled movies is an intriguing one, bringing the possibility of delivering a suitably gentle and reflective form of interaction that might potentially fit well with the often quiet and thoughtful way of watching and ultimately interpreting films. While our previous artistic experimentation and research work has begun to explore the potential of the approach and produce early examples, it has also raised the question of how brain control can be extended to social viewing that is often an important aspect of the movie experience.

The artistic exploration of this question that we reported above raises various new possibilities. Moreover, our audience study has also suggested that the reflective nature of control can also spill out into the social situation, with viewers reflecting on others thoughts about the film or indeed how others might think of their own. From our group cinematic interaction study and building on our previous taxonomy we presented a second taxonomy which considered the affect on cinematic engagement of intention to control and the awareness of other's physiological behaviour and state.

RC4 Insights into value to audiences of brain-controlled films.

We found that the designs of brain-controlled films detailed here, particularly *The MOMENT*, offer value to controlling and non-controlling audiences. Unconscious influence over the film narratives was seen as non-disruptive to cinematic immersion, and allowed users build their own narrative meanings. Audiences expressed an interest to see it again, and found pleasure in constructing the narratives of these repeat screenings while watching, and in discussions afterwards between viewers.

RC5 Development of affective loops of physiological response and cinematic content.

Throughout this thesis we explore affective loops [Höök, 2008] in film. We have used as inspiration, nonscientific findings from physiological responses to specific cinematic techniques and film and media theory to design interactions via a commercial BCI device. applying them as inputs and editing theory.

In our various designs of *The Disadvantages of Time Travel* we combined concepts from neurocinematics of the attentional blink [Nakano, 2015a], inter blink interval and movies [Shin et al., 2015] and inter-subject correlation [Hasson et al., 2012] and combined them with editing theory from Murch [1992].

Our design of *The MOMENT* exploited the concepts of event segmentation [Magliano and Zacks, 2011], and event boundaries [Zacks and Swallow, 2007], attentional syncrony [Cutting et al., 2018], with cognitive media theory such as attentional theory of cinematic continuity [Smith, 2012] and film rhythms [Cutting, 2016].

RC6 New design directions.

We also suggested several further design directions based on one, our findings of subconscious control and its effect on cinematic engagement of controlling viewers and audiences of brain-controlled films, and two, our design recommendations for future BCI driven cinema.

RC7 Practical implications for interactive filmmakers.

Our observations on the production of brain-controlled films has broader implications for the filmmaking process, which is normally a process of controlling the envisioned viewer's experience, where facilitating a designed interaction extends back through the filming and production all the way to the scripting of the film. Our practical theory, informed by HCI, BCI, and Neurocinematics and media studies has produced a Boundary Object [Star and Griesemer, 1989], relevant each. If producers can create content that is then selected from and combined - in other words edited - by audiences at the point of consumption, the numbers of possible perspectives on a film might multiply. The scale and speed of the resulting feedback might lend itself to agile creative responses from producers, who could alter existing content or be inspired to create new content based on more granular audience data. Perhaps this kind of interactive feedback loop between artists and audiences might eventually completely change types of stories and ways they are told.

We finish with a final thought on where we hope this work may take us in the future.

Control over media content usually resides with creative producers, often governed by multinational conglomerates, with audiences exerting interpretive agency within limited parameters (indirectly feeding back into what gets made). The upshot is that particular cultural perspectives dominate normative storytelling. Media scholars have long evidenced [Collins, 2011] and argued against a lack of diversity in media representations [Hall, 1989]. In the film industry, movements like #blacklivesmatter and #timesup are being used to campaign for better representation in front and behind the camera. Perhaps ultimately, important and overdue moves towards greater equality and more varied storytelling might be enabled through interactive technologies that open up editorial control? Real-time editing platforms, like the one developed for *The MOMENT* and *The Disadvantages of Time Travel*, can allow artists to make available more content and, by extension, more varied perspectives within their stories. Lean-back interactivity through BCI can offer audiences greater agency by reflecting their internal attention and preferences on screen.

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Appendix A

The MOMENT Questionnaire

Doc/Fest: The MOMENT Date: Ticket number:

This questionnaire should take no more than 6 minutes to fill in. Only fill in if you have read and signed the information and consent form.

How would you rate your experience of the venue? *(please tick one option only)*				
☐ Very poor	☐ Poor	☐ Neither good nor poor	☐ Good	☐ Very good
How would you rate your experience of the film? *(please tick one option only)*				
☐ Very poor	☐ Poor	☐ Neither good nor poor	☐ Good	☐ Very good
Do you think this film screening achieved any of the below: *(please tick all that apply)*				
☐ Introduced you to new types of film	☐ Encouraged you to attend similar events	☐ Increased your awareness of film heritage	☐ Taught you something new about film	☐ Provided a worthwhile cultural experience
☐ Increased you appetite for independent British and international films			☐ Not sure	☐ None of these
What made you want to see the film? *(please tick all that apply)*				
☐ Brain Controlled	☐ Film Genre	☐ Premiere	☐ Venue Programme	☐ New Filmmaker
☐ Interactive Film	☐ Film Poster	☐ Website / Mailing List	☐ Other: *(please specify)*	
What would you consider the films' genre/type? *(please tick all that apply)*				
☐ Comedy	☐ Sci-Fi	☐ Thriller	☐ Horror	☐ Romance
☐ Interactive	☐ Game	☐ Revenge	☐ Art	☐ Tragedy
Other: *(please specify)*				
Seeing a unique version of the film based on the controller's brain data makes it special. *(please tick one option only)*				
☐ Disagree	☐ Somewhat disagree	☐ Neutral / unsure	☐ Somewhat agree	☐ Agree
The film kept the continuity I would expect from watching a narrative film. *(please tick one option only)*				
☐ Disagree	☐ Somewhat disagree	☐ Neutral / unsure	☐ Somewhat agree	☐ Agree
The film held my interest. *(please tick one option only)*				
☐ Disagree	☐ Somewhat disagree	☐ Neutral / unsure	☐ Somewhat agree	☐ Agree

Appendix B

The MOMENT Questionnaire results from Doc/Fest

Sheffield Doc Fest

total repondants	Audience	Controllers	rating the venue: Very Good	Good	Neither Good nor poor	poor	very poor	rating the film: Very Good	Good	Neither Good nor poor	poor	very poor
204	163	41	75	87	27	13	2	57	80	43	20	3

what would you concider the films gendre/type

Comedy	Sci-fi	Thriller	Horror	Romance	Interactive	Game	Revenge	Art	Tragedy
1	172	86	34	4	105	22	11	69	18

seeing a unique version of the film based on the controllers brain data makes it special

Agree	somewhat agree	Neutral / unsure	Somewhat disagree	Disagree
125	46	20	9	3

The film kept continunity I would expect from a Narrative film

Agree	somewhat agree	Neutral / unsure	Somewhat disagree	Disagree
39	70	29	41	25

The film held my interest

Agree	somewhat agree	Neutral / unsure	Somewhat disagree	Disagree
76	59	30	21	18

Which Charactors Perspective did you see the most

Telema	Astrea	Andre	Hendricks
9	138	29	19

Did you have a favorite Charactor

Telema	Astrea	Andre	Hendricks
20	75	49	27

non controllers:

Would you have liked to be in control?

yes	No
123	0

did you feel the film gave an insight into the controllers mind?

yes	Partially	No
28	59	64

CONTROLLERS

Did you know how it worked before the film started?

yes	Partially	No
18	20	2

Did you/ do you want to know how it works?

yes	Partially	No
35	5	0

Did you try to consciously control the film

yes	Partially	No
21	14	5

Did you feel that the film responded to you

yes	Partially	No
11	21	8

Did you feel a responcibility to make a good film experience?

yes	Partially	No
25	11	4

How did being the controller compare to other film viewing?

worse	similar	better
6	12	18

Would you like to see the film again?

Yes: new live version I controlled	Yes: new live version controlled by someone else	Yes: replay using someone else's brain data	Yes: replay of the version I saw live today	Yes: replayable Director's Cut	Yes: live someone elses	Yes: with a live score	No
139	95	59	36	61	31	36	12

Where would you like to see it again?

At home	Caravan	Cinema	Other venue	None
97	119	83	41	10

Gender

Female	Male	Non-Binary	Prefer not to say
82	102	1	1

AGE

18-24	25-34	35-44	45-54	55-64	65-74	75+
75	66	22	14	11	3	0

Appendix C

The MOMENT Information for participants, Study 3

The MOMENT

The MOMENT is an interactive movie experience, driven by your brain data.

Information Sheet & Privacy Notice

While watching The MOMENT, your brain data is analysed using a simple commercial Neurosky device, which is based upon EEG technology; painlessly measuring variation in natural electrical brain activity. As well as watching the film, we would like you to take part in a short research study. We aim to understand people's experience whilst interacting with The MOMENT. The whole experience will take around 45 mins, including setup, which may take up to 10 minutes. The film lasts around 24 minutes, and then we'd like to hear your feedback afterwards in a short, voluntary interview and questionnaire.

Data Collection:
We would like to collect several bits of data: 1) your **attention data** from the Neurosky device 2) an **audio or video recording of an interview**, if you have time 3) a completed questionnaire 4) photos or video recording for illustrative purposes. The data collected will be used to analyse usage, and to understand people's experience of interacting with The MOMENT.

Data Storage:
Your original raw data will be stored in accordance with the Data Protection Act 1998, namely on a password protected drive, and only for the duration for which it is required. The original raw data will only be accessible by those directly involved in the research at the University of Nottingham. As described below, with your approval, your processed anonymised data will be archived on the University of Nottingham's online dataset repository for other scientists to review.

Data Usage:
We aim to publish findings about The MOMENT at academic conferences. Brain data will be anonymised, we will produce transcripts of audio/video interviews, original recordings will not be shared or published. Video footage or photos of you interacting may be used for evaluation, marketing or illustration purposes only with your consent. We are obliged to provide datasets from our research online for other researchers to examine our findings. This means that an anonymised version of your brain data, transcript of interview and questionnaire data will be placed on our University archives. You may opt out of having your data included in this online dataset below. You may also request to have it removed, by contacting us, at a later date. However, although we can remove it from the online dataset, we cannot remove it from people's own copies if they have already downloaded the dataset.

Your Rights - Consent:
You have self-selected to take part in The MOMENT experience, but you can additionally consent to which data is recorded. Equally, you may withdraw consent from the experience at any time without penalty, including asking us not to use the data we recorded, by contacting us on the address below after today. In this event all your data will be erased where possible as described above.

Contact Details – for more information or to withdraw:

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