Lens-less capture and emerging moving imaging technologies: An investigation into the ways in which digital pinhole capture and advances in lens-less capture in imaging technologies may affect the form and content of moving images

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A thesis submitted in partial fulfilment of the requirements of the University of the West of England, Bristol for the degree of Doctor of Philosophy – May 2021

Funded by the AHRC 3D3 Doctoral Training Centre

Faculty of Arts, Creative Industries and Education

Abstract

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This thesis is a practice-led enquiry that investigates the creative potential of pinhole video, a new imaging technique which is undocumented elsewhere. Although fixed pinhole image capture has been possible since the advent of chemical photography in the 1830s, it currently occupies a niche area maintained by artists and enthusiasts working in analogue rather than digital photography and film. Through the researcher's creative practice – a set of research-driven experiments using digital movie cameras combined with pinhole apertures and documented through autoethnographic method – the thesis establishes a guide to the creative capabilities of pinhole video capture and how a lens-less video aesthetic might be generated. The researcher's practice is contextualised in relation to the work of two moving image artists working in 16mm film: Christopher Harris and Jennifer Nightingale, and also Jason Joseffer, a professional cinematographer who works in video. It is informed by conceptual frameworks derived from Media Archaeology, remediation and historical enquiries into the nature of perception by, in particular, Jonathan Crary. The investigation also encompasses the relationship between this lens-less video practice and existing digital image capture, particularly motion capture using the Lightfield camera's three-dimensional technology, and situates these within changing definitions of the 'camera' and the 'lens'.

The thesis contributes new knowledge and a craft method via the insights provided in the experimentation and reflective observation of how pinhole video capture is achieved, thereby demonstrating the range and creative potential of video works produced by this method. It argues that although pinhole video technique and scientific lens-less imaging technologies approach image capture from different directions, both are important attempts to open out new possibilities that enlarge perception and increase understanding of how light operates, offering an exciting artistic potential that can be taken further.

Acknowledgments

I would like to acknowledge the financial and academic support that I have received for this doctoral research through the Arts and Humanities Research Council's 3D3 Centre for Doctoral Training (CDT). The benefit of a scholarship has not only made my research possible but allowed me to undertake a month-long field trip to the USA in 2018, supported by the 3D3 Student Development Fund. I am particularly grateful for the support and sustained encouragement given by Professor Terry Flaxton and Dr Sarah Sparke, both of the now-closed Centre for Moving Image Research at the University of the West of England (UWE).

I would like to extend much gratitude to my supervisory team at UWE: Professor Andrew Spicer and Dr Kayla Parker. I have benefited greatly from their insight and experience and their careful, thoughtful guidance. Additionally, I would like to thank colleagues who encouraged my work over the years of study: Cathy Greenhalgh, Shaun Grimsley, Stuart Moore, Dr Monika Oechsler, Claudia Pilsl and Janet Tovey. Special thanks are extended to David Stump, Christopher Harris, Jason Joseffer and Jennifer Nightingale. Many thanks are due also to my daughter Lia for her patience and support.

Acknowledgments and thanks for image usage are due to The College of Optometrists, London and The Getty Institute Research Library.

Contents

List of Illustrations

Practice Element

Readers are advised to view the three pinhole videos in the order indicated below.

Because of the nature of the pinhole image the videos are best viewed on the highest definition screen available together with stereo headphones.

Light of Day I & II (2017) 9’ 19” - Single channel HD video with bespoke soundtrack.
A Pinhole Video (in two parts and presented as a work-in-progress).

Set in Venice, Italy this work is structured around the four classical elements: Earth, Air, Fire and Water which are seen as necessary for the tradition of glass-blowing associated with the Venetian island of Murano. Originally prompted by my family roots and their connection to the glass industry on Murano, the video uses the four elements as the basis for a visual exploration to offer the viewer a material sense of ‘place’: the ambient light, water, colour and atmosphere of the city. The images are enhanced with an evocative and textured soundtrack. *Light of Day I & II* is to be integrated into a longer work, as a more personal video essay and expanded with further pinhole video material.

Billy Goat Hill (2018) 4’ 44’’ **-** Single channel HD video, sound.
A Pinhole Panorama vídeo.

A short video work which particularly reveals digital pinhole’s versatility in capturing minute detail and texture in an outdoor scene. Intended to be looped for display, it features a continuous urban panoramic view from the top of a hill in San Francisco. The camera is the fulcrum for a constant circular movement giving views from the macro to the micro with fast and slow panning shots and skewed perspectives simulating a ‘live’ moving panorama.

Mouthpiece (2018-19) 4’ 16’’- Single channel HD video, sound**.**
A Vídeo Portrait work (pinhole and lensed).

Mouthpiece is a conceptual piece featuring a set of moving image portraits. Close-up portraits of nine participants are captured in both pinhole and lensed format, edited to compare and contrast the two forms. The video aims to draw attention to pinhole’s softer focus, muted colour and wide angle view and contrast these with the sharp images and framing of the lensed shots, whilst capturing some facial characteristics of the participants within a triptych format. Each of the participants recites the phrase ‘Everyone is Telling a Story’ with these words repeated and threaded throughout the piece. The phrase addresses my idea that every public utterance is a form of a type of story-telling of ‘oneself’ – thus the phrase in this context exists as an assertion and is emphasised in the different ways in which each participant unconsciously expresses the words.

Preface

I first engaged with photography in making photoslide-tape works (where projected image and recorded sound texts are juxtaposed) at London's St Martins School of Art. Although I was attached to the Sculpture School there, I opted to work with analogue photography and produced early installations using my own photographs attached to shaped forms, unfolding the two dimensional image into a three-dimensional display. My graduation work involved printing over one hundred original black and white photographs presented as a multi-image display of sections of a nude figure, her extended form covering a long, high wall. After a stint as a 16mm camera operator on student films, I gained various opportunities to work in still photography in community and professional darkrooms. This access led to experimentation with lens-less imaging techniques using home-made pinhole cameras and making camera-less images inspired by those of Man Ray (1890-1976) and artists of the Bauhaus School in 1930s Germany. My practice in analogue pinhole photography developed further when I created images for site-specific interventions, for example pinhole documentation of buildings due to be pulled down which became projections onto its walls during the period of demolition – these black and white pinhole images offering a record of the passage of time from building to rubble.

The underlying drive for all my work then and indeed now, has been a frustration with the single fixed viewpoint in photography and a desire to disrupt this through different representations. In my professional art practice, I achieved this via collage work influenced by Cubist painting which multiplied perspective and altered scale, separating figure and ground - techniques which aimed to reposition the viewer, challenge perception by prompting the eye make sense of the fragmentation and the brain to make new connections. Over many years I produced a large body of two dimensional collage works which continued these disruptive techniques, recontextualising 'found' images along with my own photographs to create new meanings in their juxtaposition. I was a passionate filmgoer and watched and studied avant-garde artists' films but never considered my work beyond the context of the still image. I started to understand my particular style of photocollage as related to film after working at the British Film Institute Stills Archive with access to a huge collection of film stills. My photocollages were achieved by cutting and rearranging multiple photographs together and I could

see them as related to film montage which assembles separate pieces of thematically related film into a sequence, for example in the ground-breaking style of the Soviet films of Dziga Vertov, particularly *Man with a Movie Camera* (1917). When I explored further, I realised my work had a resonance with film editing techniques such as transitions, double exposures and fades. These connections led me to consider whether I should try to create a 'moving collage' to expand my artistic concerns into a new medium.

Alongside conventional photography, as part of my practice I had experimented with making home-made water lenses[1] and when I started making my own pinhole cameras I produced still images in the darkroom but I had never ventured into film or video. However, in 2008 I used a self-made pinhole camera to capture black and white portraits of people in Venice as part of my involvement in a wider arts project entitled *Ritratti di Cannaregio* (Portraits of Cannaregio) where I worked alongside a video artist and crew who were making portraits of local Venetians with high definition video equipment. This was my first real exposure to digital moving images. When I saw those produced on the shoot, I began to consider how I might use a pinhole with a video camera to compliment these high definition digital moving images.

Although I continued my still image practice for some years afterwards I maintained an ambition to replace the lens on a movie camera with a pinhole aperture. Consequently I undertook some online research, which revealed just a few examples of test or amateur pinhole video. I saw an opportunity to combine my knowledge of the physics of pinhole capture with a step into digital moving image, to consider: first what might be involved mechanically and second what a colour pinhole moving image might look like. After a number of unsatisfactory tests in a lighting studio with a DSLR video camera I had an opportunity to experiment properly in 2013, when I gained a production bursary from the Centre for Moving Image Research based at University of the West of England (UWE) to make my first high definition pinhole video piece (*Aperture*, 2014). Sample image shown below.

[1] A lens formed from transparent plastic components in which water replaces the optical effect of glass.

Fig. 1: Still from pinhole video *Aperture*, 2014

This first experimental video was shot using a self-made pinhole aperture (made from the punctured base of a tin can) with a 4K Sony RED cinematography camera in an outdoor location in bright sunlight. Based on the idea of creating a moving 'still life' animating a classic genre of painting, it featured the characteristics of pinhole imaging's soft focus and painterly colour in the image of a rotating empty bowl gradually filling up to an assembly of different fruits. This short work established that pinhole video using ambient light was achievable but I noted that the pinhole aperture itself was ragged and crude and that this would need to be improved. I also considered that perhaps the successful image was due to the access afforded by UWE to the Sony RED, a professional High Definition movie camera - one which has greater sensitivity to the lower levels of light delivered by the pinhole aperture. I wanted to extend the work of this first video and this led to a successful application for an AHRC-funded 3D3 Centre for Doctoral Training Doctorate at UWE to explore the technique further and to evidence the results in the creation of new video works. This meant having time to make bespoke pinhole apertures uniting them with a wide range of video cameras and to explore analogous links with other examples of lens-less digital image capture. Crucially, the doctorate presented the possibility of continuing with artistic concerns that have driven my art practice over the years and provided a way to express some of these in the potentially new medium of pinhole video capture.

Chapter 1: Introduction

My doctoral study consists of two parts: theoretical research into the context of the inquiry and the practice element - the video works, along with accompanying worklogs and unstructured interviews - these are included as ‘evidence’ within the thesis.

The research is a practice-led inquiry by an artist into the potential of pinhole imaging using digital technologies. It investigates how the image might be transformed in significant ways through this new means of capture, foregrounding the creation of video artworks that embody these new visual experiences. The study combines a number of components including studio practice, observation and experimentation and a review of the relevant theoretical literature. These are framed by the main Research Question:

> What is the creative potential of digital pinhole video capture?

And a secondary Research Question:

> In what ways might the pinhole video technique be related to the work produced by new forms of image capture?

The enquiry sets out to articulate the research through activities and methods starting with testing the capacity of the pinhole aperture to achieve capture with a variety of high definition moving image cameras in which the tests are a way to open out its applicability and artistic possibilities. The aim was the generation of questions as to how the technique could be articulated through my practice. I felt that because the inquiry would be filtered through my artistic vision that indicative questions rather than answers would be generated. The project is a direct continuation of the artistic concerns described in the preface that have driven my artistic practice over the years, underpinned by my expertise in photographic capture and image-making, an understanding of cinematography and extensive knowledge of art history and film history. The practical insights gained during the investigation are combined with consideration of the evolution of imaging technologies, the pertinent theoretical

positions, a comparative study of other practitioners and research undertaken into the scientific material available on lens-less imaging developments.
It is particularly important to define how I understand the following key terms. The ‘camera obscura’ is defined as the effect of a natural optical phenomenon that occurs when the light from scene passes through a small aperture or pinhole and appears as a projected image on a surface. I also utilise this term for the device or the housing which carries the aperture. The term ‘pinhole’ is used to indicate both the small aperture in the device through which light passes to offer a projected, reversed and inverted image (left to right and upside down) and the image produced by the aperture.
‘Lens-less’ is used as a generic term to describe images captured through the action of light in a camera or device which does not carry a lens. The term ‘moving image’ designates motion image capture via any medium, analogue or digital.

The pinhole in the form of the camera obscura has been understood as both device and effect with many historical and conceptual interpretations over the centuries and discussion of some of these is threaded throughout several chapters. Although I do not attempt to cover all of these aspects, what guided me was a grasp of the camera obscura's connection with immediacy and its lifelike ‘projections’ and how these were situated in relation to perceptions of visuality in the development of photography and moving image.

As my project involves the combination of an analogue effect and digital capture, although it may seem evident, I think it is important to be explicit on their respective specificities. The analogue image is achieved by incoming light through an aperture as a physical effect on a light-sensitive surface. The digital image is light captured from the aperture via a sensor, which is converted directly into electronic signals that are then recorded and stored as data. In other words, analogue capture is physical and digital capture is computational. I place emphasis on this difference because my project is located within a hybrid practice which combines analogue and digital imaging means. This has involved a new technique which uses ‘archaic’ pinhole technology combined with high-end digital camera apparatus to make moving images, a physical process paired with one based on data. I term this previously undocumented technique, ‘lens-less video capture’ achieved through a re-purposing of the camera. The central question of the inquiry is whether the technique produces functional capture, what its parameters

might be and what kind of adaptations might be needed to improve its artistic applicability. It is an extension of a technique that I had partially tested in 2014 but which was undertaken on a very small scale. As well as establishing the technique as an expressive medium for video, this project explores its intersection as an artistic practice with the latest innovations in image capture, specifically those utilising previously uncombined elements or which do not rely on a lens to capture an image.

The field of pinhole imaging has been defined primarily by its use in still photography, with the most recent users being professionals, amateurs and artist-practitioners. While recently some of these have experimented with a pinhole attached directly to a digital camera, online and literature sources reveal users work predominantly in analogue still form. In this field the pinhole appears to be employed for a lyrical effect which exploits its soft focus, wide depth of field and is perhaps influenced by an approach which seeks to evoke early Victorian photography, particularly the soft focus style of the Pictorialist[2] photographers. However, when one investigates further, it is clear that there is scant critical work on current analogue pinhole photography despite online and published evidence of its persistence. In fact, it has only received attention for its alleged authentic quality in ongoing analogue versus digital imaging debates and in reference to its forerunner, the camera obscura. Whilst there is some evidence of a digital practice in pinhole photography, like its photo-chemical twin it has yet to receive critical attention. As regards the research related to pinhole video itself, a review of literature and online material revealed some evidence of moving image capture using a pinhole technique. However, as in the case of analogue practice, these too have been mainly amateur experiments with little evidence of other practices beyond these. As such it is a very slender field of practice and this raises important issues, which I discuss in the Dialogues section of the chapter entitled Research Context Pt I: Dialogues and Encounters, where I consider the existing pinhole films and video of three moving image practitioners that my research has uncovered.

In order to frame the inquiry, it was important to locate a suitable methodology which encompass art, science and history and could be tailored to an investigation which lies

[2] Pictorialism, a late 19th century photographic movement which stressed photography's artistic, evocative and interpretive qualities rather than its documentary ones.

between technical innovation and artistic practice. In considering a methodological position that could underpin the practice, I was drawn to a Practice-as-Research (PaR) framework as defined by Robin Nelson (*Practice as Research in the Arts, Principles, Protocols, Pedagogies, Resistances*, 2013), which particularly relates to artistic projects as it recognises different kinds of knowledge production and charts the interactions between them to generate insights. Familiarising myself with its reflective approach, I saw immediately it would evidence the progress of my practice making all the results of the inquiry and the process explicit. It is a framework which allows a questioning of how my video technique could be articulated in an inquiry filtered through my artistic vision. The combination of PaR methods: a studio practice, experimentation, empirical observation, the recording and evaluating of various recursive processes and a comparative study was particularly engaging and I enthusiastically embraced these as methods to record the activity and the progress of the project. This activity is recorded in autoethnographic accounts, diaristic in nature and which contain test results, studio practice notes, interviews, thoughts and photographs of the practice experiments They are an important strand of the inquiry and are referred to as 'worklogs' within the thesis.

The impact of a number of theoretical positions is discussed in the arguments forwarded by Jay David Bolter, Jonathan Crary, Thomas Elsaesser, Richard Grusin, Tom Gunning, Erkii Huhtamo, David Hockney and Jussi Parikka. These theorists and practitioners are pertinent to the inquiry because they represent different positions within the fields of media theory, technology and history. Their relative arguments in relation to the nature of perception and the evolution of the technical image are assessed for their applicability to the project in the Methodology chapter of the thesis.

As regards the secondary research question of how my pinhole video technique is related to the moving image work produced by new forms of computational photography, I review recent scientific technologies utilising new forms of imaging device and data generating techniques which I feel relate to pinhole capture, especially those challenging the conventional apparatus of the camera. An important interview undertaken with David Stump, an established and respected US film industry professional, sheds much light on current digital moving image development as well as offering an understanding of the potential and a possible timeline for moving image artists to access the new developments in image capture. An important outcome of the

meeting with Stump gives rise to a significant discussion in this chapter on the nature of intentionality in creating these new forms of moving image.

An account of the practice experiments undertaken for this inquiry lays out what was learned during first-hand primary research and covers the process of testing and assessing the capabilities of the pinhole video technique, the parameters for image capture, the practical and technical issues for using different camera types and the importance of light levels. Presented as an informal method, they are followed by descriptions of the creative application of the technique for the three video works which form the practice element of the thesis. These works are the outcome of the extended experimentation in the studio and the reflective practice which has advanced the project. They demonstrate the creative use of pinhole techniques, revealing its unique and artistic characteristics. As examples of pinhole as new and original medium for video, they offer a basis on which moving image practitioners may proceed in the future with the technique.

Structure of the Thesis

Chapter 1 is the Introduction, which sets out the general aims and objectives of the enquiry.

In Chapter 2: Methodology, the process and activity I have undertaken as an artist-practitioner are examined. I offer the rationale for my choice of a particular model of PaR and identify how I have utilised it as a methodological framework. This includes highlighting an important strand of the enquiry in the form of the ethnographic fieldwork recorded in my practice worklogs. Edited extracts from these are woven into the thesis at the relevant points and figure especially in this chapter. Designed to capture and record the variety of processes and possibilities within my enquiry, these extracts are emphasised to indicate their importance in the overall research. Furthermore, the inquiry is situated in theoretical terms through drawing from those sources in academic and artistic circles who have been of influence, particularly the academic literature which has arisen from Media Archaeology, remediation theory and historical enquiries into the nature of perception. This is concentrated particularly on the work of media theorists Bolter, Crary, Grusin, Gunning, Huhtamo and Jussi Parikka and the related art investigations of Hockney.

Chapter 3: Research Context Pt I: Dialogues and Encounters presents firstly a discussion of how the project engaged with a variety of audiences in order to test the

reception of videos made using my digital pinhole technique. The chapter assesses the outcomes of these audience interactions and discusses the changes in practice which came about as a result. Secondly I present a critical commentary on the work and approach of three contemporary practitioners working in the field of pinhole moving image. I contrast their work and approaches with my own practice, drawing comparison between single works from each of them and a first video piece, *Light of Day I & II* completed after the experimental stage of the enquiry. I describe what was learned through a commentary and how this commentary affected the practice of the subsequent practice element works as well as contributing to an understanding of my place within pinhole moving image practice.

In Chapter 4: Research Context Pt II, I consider the world of artistic and scientific imaging in parallel, in a new approach that artists in my field might not necessarily have explored. The chapter explores the secondary research question via an investigation of the current scientific developments in technological image capture, particularly in motion capture. In order to contextualise the pinhole video technique, the chapter starts with a discussion of pinhole's first iteration, the camera obscura, in order to understand it as both device and effect within a broader context of changes in perception.

I consider the ways in which my pinhole video technique is related to the moving image work produced by new forms of imaging, particularly technologies in the scientific arena which do not employ a lens, and where new forms of device challenge the conventional apparatus of the camera. I offer an overview of relevant and related forms of scientific lens-less imaging. Using an account of a key interview with David Stump, a professional cinematographer in Lightfield technology, I concentrate the discussion on the particular implications of Lightfield's capture of light in relation to moving image application and pinhole videography. Although coming from different directions, I make a central argument that artists and scientific imaging developers share a mutual impulse to explore and capture light to push the limits of perception, beyond that which the eye normally perceives.

Chapter 5: Practice Experiments lays out the process and results of my practice experiments in first-hand primary research – the production and testing of bespoke pinhole aperture with digital movie cameras and assesses these as workable possibilities. What was learned through each stage of making and testing of a number of pinhole and camera combinations and the lighting and ambient conditions necessary, is

explained and supported by extracts from related worklogs and illustrated with still images from video footage captured during the experimental phase. In this way a working method for pinhole video capture is delineated. The chapter provides the background and concepts which drove the practice element video works. Each of the three video works, *Light of Day I & II*, *Billy Goat Hill* and *Mouthpiece* are described in detail, supported by worklog entries. I explain how each of the works apply what was learned via the experimental phase and the ways in which each are linked in terms of the practice and in the stages of production. I assert that each video reveals pinhole video's artistic characteristics, demonstrating the technique's potential as a new and original medium which can be embraced by other moving image practitioners.

Chapter 6: Conclusion delineates the contribution to knowledge made by my doctoral research. I argue that image capture as a whole is being transformed by two crucial factors: it no longer necessarily involves or is dependent on the lens, and that the purpose of the device we term a camera is undergoing a rapid transformation as the new technologies expand their remit from two dimensional imaging into areas of three-dimensional capture, as evidenced in the growth of Lightfield camera technology. The push to develop new imaging devices is attributed to a need to explore and capture light in all its behaviours and I assert this is the common factor which unites the efforts of artist-practitioners and technical imaging developers.

I affirm that the impact of my project's contribution has shown that in changing the essential element of the camera (and by implication the image itself) through the complete removal of the lens, one can achieve a functional video image. The combination of practice element and written thesis contributes to new knowledge and insight in several ways. First, by providing the first practical investigation into pinhole video capture, a craft method is offered for other practitioners to learn from and follow. Second, that the artistic and creative potential of the technique evidenced in the video works, demonstrates it is a new and original medium for moving image. Third, by situating the pinhole video technique within scientific imaging developments and revealing correlations and common elements in the capture of light, the inquiry has opened up the possibility of dialogues between an artistic practice in video and that of scientific imaging developers which can be mutually beneficial. My hope is that this

research will be taken up by practitioners both in artistic and commercial spheres who are actively exploring new ways to capture light and moving image.

Chapter 2: Methodology

> If you attempt to marry and equate art with science, then you fail. If you allow what is not similar about art and science, and their different methods and processes, to co-exist and thrive, then a real art/science collaboration and aesthetic will emerge. But at the end of the day, art and science are united by one logic and one impulse - both are attempts to understand what it is to be human and the world around us (Tyson, 2010).

Conceptual artist Keith Tyson's assertion underpins my inquiry, which has involved an interplay between an artistic practice and a technical innovation. In this inquiry the elements of this practice and the science of light capture share equal importance although they come from different directions and do not necessarily or comfortably align. As an artist investigating lens-less imaging using digital technologies, what resonates in Tyson's statement in the context of this study is that a new aesthetic might develop from a collaboration of these two fields.

The primary research comprised video capture utilising self-made pinhole apertures of variable size, which were tested with a range of high definition video cameras to establish the parameters of use for this hybrid technique. It is important to bear in mind that this combination was previously untried and meant that it was crucial to test any restrictions in the first phase of the experiments. The results prompted reflection on how the lens-less imaging technique might be applied to the proposed practice elements, and how these might, in turn, open out the artistic possibilities. The practice phase is presented in Chapter 5: Practice Experiments with an acknowledgment that despite a consistent method during the tests, there were occasions when these were modified due to changed conditions either with the camera equipment or the available light sources. This meant adopting a flexible approach when, for example, some of the practical test footage produced few usable results. However, I saw this as part of my artistic practice with the tests never intended to replicate laboratory conditions or generate solid data. What I intended was to generate questions as to how the technique could be articulated through my practice; and because my inquiry was filtered through my artistic practice I

felt it would reveal questions rather than offer definitive answers. This naturally prompted thoughts of what art might reveal that science cannot and I would here suggest that most artists might say they do not to have to prove anything but that they do aim to reveal as contended by visual artist Marc Quinn after his collaborative work with geneticist John Sulston*, '*Scientists are looking for answers and artists are looking for questions' (quoted in Jeffries, 2011). However, to echo Tyson, I might add that both share an intent to reveal new knowledge or experiences of the world.

The practice component of the thesis was supported by investigation into early applications of the camera obscura device. The first projected images in Europe were made via a basic pinhole aperture within a darkened room (the literal translation of the Latin 'camera obscura') in the 1400s until the pinhole became a device with the addition of lenses and mirrors in the post-Renaissance and this led to fixing the imaging via the early chemical photography of the 1830s (Renner, 2014). Although I knew of the basic physics and had myself captured and printed many pinhole photo-chemical images, part of my practical research meant re-acquainting myself with the science of how light travels and is captured through a pinhole aperture. This included the creation of my own home-made pinhole camera obscura within my house.

Additionally, I felt it was important to learn more about the physics of vision and consulted literature on the neuroscience of perception. The most useful of these were Ian McGilchrist's *The Master and His Emissary: The Divided Brain and the Making of the Western World* (2009) in which he analyses the left versus right split in our brains using his investigations in neurological science to understand the history of Western art and culture in new ways. I also read Beau Lotto's *Deviate*: *The Science of Seeing Differently* (2017), which uses optical and perception exercises to explore how the brain affects perception. James Elkins' *The Object Stares Back* (1996) usefully emphasises the differences between the act of seeing and 'just looking'. Investigating the structure and function of the eye via Simon Ings' book, *A Natural History of Vision: The Art and Science of Vision* (2000), led me to examine items such as early eyeglasses and lenses at London's Museum of Ophthalmology. On my field trip to the Getty Institute Collection I was able to handle early optical devices and I also viewed related historical documentation at San Francisco's Museum of Vision. These visits contributed to my general knowledge of how human vision functions but also supported my awareness of

how and where lenses were first made. In medieval Europe, they were notably made by early glass artisans in Venice, Italy. The early lenses made in Murano[3], Venice were in widespread use from the 1400s including those used in Galileo's early binoculars and telescopes (Toso, p.102). The Venice connection struck a chord for me because I am half-Venetian and am in fact descended from a family of Murano glass blowers. This personal realisation and other serendipitous links I found to glass and lenses are discussed in a related commentary in Appendix 1. The research led to the creation of a pinhole video work which would be about glass but made without glass. Further material on the realisation of this video entitled *Light of Day I & II* (*LoDI&II*) appears in Chapter 5: Practice Experiments as it forms part of the practice element presented as part of the overall submission.

2.1. Practice as Research

Carol Gray and Julian Malins have argued that, 'The characteristics of an 'artistic' methodology are a pluralist approach and the use of a multi-method technique, tailored to each individual project' (Gray and Malins 2004: p.135). These characteristics seemed to underlie my inquiry: a research which uses qualitative analysis together with number of different techniques as a means of addressing the research questions. I found Gray and Malins's definition of artistic methodology productive because it implies that the tailored elements are balanced, none are primary but are focused collectively on a creative open-ended aim. The employment of a range of different techniques enabled me to map the process as, for example, in my studio practice when recording test results in a consistent manner; or in undertaking a comparative study to situate my video work within the field of other pinhole practitioners more appositely. An important part of the process was the use of diaristic entries - the worklogs - to anchor my progress and enable me to reveal explicitly the process of creating, the notion of 'thinking-doing' as developed by Robin Nelson and Donald Schön to establish the boundaries of the practice.

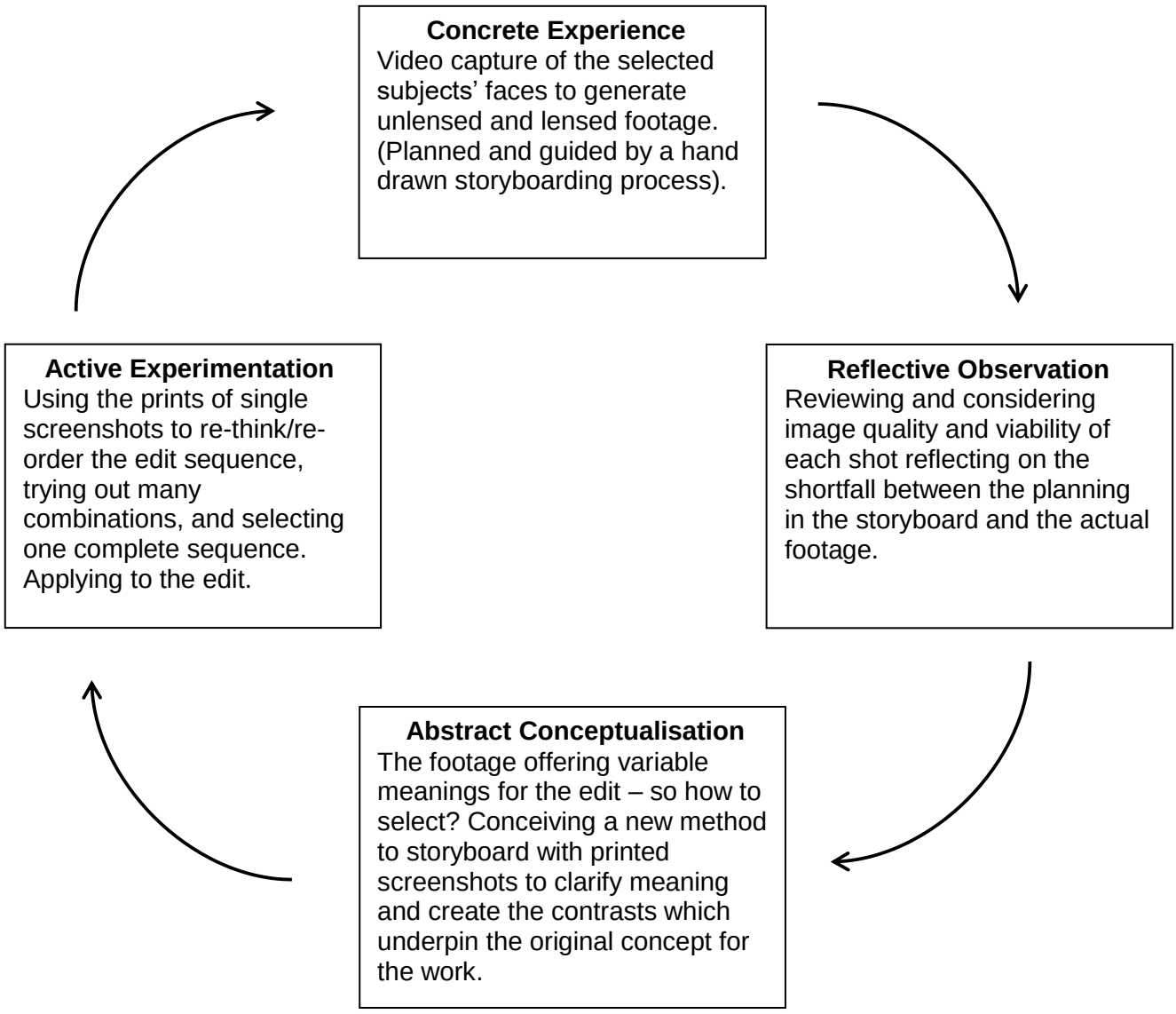
These methods, alongside a pluralist approach, allowed me to acknowledge all the component parts and strengthened my thinking in relation to the artistic and theoretical issues which emerged over the course of the project. These were the conditions which

[3] The island of Murano has been the centre of glass production in Venice since the 12th century.

drove the practice forward. For this project, one of the methods I utilised was a continuous studio practice of reflecting-on-action and in-action. In the experimental phase this covered designing and producing pinhole apertures in different materials to be tested using a range of camera equipment to produce short video sketches. The results of the tests, the notes and commentaries derived from a review of relevant literature, served to address the main practical features of the new technique. This material was recorded in the worklogs, written extracts of which are interspersed within the body of the thesis. I also recorded documentary photography of the pinhole manufacture and testing process, examples of which appear within Chapter 5: Practice Experiments chapter. This consistent reflection and documenting of the experimental phase was a contrast to my usual practice of conceiving, gathering and straightforwardly creating with the materials to realise a work, a process rarely accompanied by documentation. Within my professional art career, my practice had generally been goal-orientated, a kind of problem-solving to match my vision leading to the final artefact. However, in working on this doctoral project, the variety of approaches and methods I encountered has changed how I now see my work as an artist, with a deeper acknowledgment of all processes and influences that are in play. I have become more open as a result, essentially shifting from being practitioner to becoming a practitioner-researcher.

A useful way to reveal the nature of this process between action and reflection is shown in my annotated infographic below. This is an adaptation of educational theorist David Kolb's learning styles diagrams in his book *Experiential Learning: Experience as the Source of Learning and Development* (2015), which uses the basic theoretical components of experience – reflective observation, abstract conceptualisation, and active experimentation – to reveal how one learns from experience. Thus Kolb's four phases are here applied to the conception, creation and editing of one of my pinhole videos, *Mouthpiece* (2019). The detail of the reflection in-action and post-action of making *Mouthpiece* is presented (Fig. 2) in a succinct way which serves to track the process. The material from the video shoot was reflected upon and it prompted a re-configuration of my approach, altering my understanding of the work conceptually, resulting in a transformation of the final edit.

Fig. 2: *Mouthpiece* (2019) - video production phase



To frame my inquiry, I was primarily drawn to make use of Robin Nelson's model of Practice as Research as defined in his book, *Practice as Research in the Arts, Principles, Protocols, Pedagogies, Resistances* (2013). This model has been embraced frequently because of its flexibility and particular applicability for artists and other creative practitioners undertaking academic research. Nelson's framework has emerged as a response to the number of artist-practitioners being admitted into research contexts, and to the investigative projects they were generating.

Practice as Research (PaR) is a broad umbrella which encompasses a set of methods which can be observational, evaluative, dialogic or graphic. Although Nelson's field is not visual art but theatre and performance studies, his PaR methodology lends itself to other creative activity because of the manner in which it formalises the interplay between different types of knowledge-production within an arts inquiry, enabling insights to become explicit. In this model, the three interconnected elements are: an artistic practice (tacit knowledge and technical skill possessed by the creative practitioner), a field of practice (her/his knowledge and understanding of other relevant artist practitioners to establish a relationship with the work); and a theoretical framework (offered by established academic sources). A triangulation of these comprises the overall framework, underpinned by a multi-method approach, which serves to make the implicit more definite. Thinking through this framework, I identified it would draw on my skill and understanding as a visual artist, evidence my knowledge of the history and practice of photographic and moving image capture and allow a criticality of my continuous studio practice as part of my methodology. Nelson's work in this area was fairly new to me and appeared useful for my inquiry because I had not encountered the concepts of thinking-doing directly.

Nelson's arguments are partly derived from Donald Schön's concepts of reflection in-action and on-action in *The Reflective Practitioner* (1983). I felt these to be pertinent as his area (cognitive design theory) is perhaps closer to an art practice and because he considers design in its broadest sense, asserting that reflection-in-action is central to a type of professional expertise. He comments,

> Doing and thinking are complementary. Doing extends thinking in the tests, moves, and probes of experimental action, and reflection feeds on doing and its results. Each feeds the other, and each sets boundaries for the other (1983, p.280).

Nelson, echoing a point mentioned by Schön, suggests that this framework is a challenge to the tradition of measurable knowledge and conventional research culture. On the practice of authorship and writing, writer and theorist Lyle Skains also supports this assertion as a relevant position for a creative PaR methodology in her article Creative Practice as Research: Discourse on Methodology, stating that,

> What emerges, then, from this methodology, is the exegesis that accompanies the creative work: that knowledge that has remained implicitly within the artist, is made explicit and seated within the context of the scholarly field (Skains, 2018).

This aspect of explicitly revealing arts practice within a scholarly discipline appealed to me, although I am unsure of its potential to challenge traditional research; I would rather see it as complimentary. Nelson's framework provided what I needed to respond to my research questions because of its flexible and bespoke approach for a variety of projects. This meant that as artist-practitioner I could integrate my own methods and experiences into a framework in which no single method is primary, underlying that the research goal of creating new knowledge can be achieved from different points of view.

One notable tool in the Nelson model of PaR is autoethnographic documentation. It is interesting to note this is a form of recording experience which some artists integrate into their practice. Indeed, for some, the documentation of process *is* the artform. An example of this is Mary Kelley's *Post-Partum,* her 1970s art work that documented her young child's development as a series of sequential photographs and progress charts (www.marykellyartist.com/post-partum-document-1973-79). This type of documentation can often reveal behaviours and intuitions that some artists generate and trust as given, but may never have been examined consciously. However, in this model of PaR the creator's assertion of 'it works, I just can't say why it does', can be demonstrated actively, reflected on and opened out in a new fashion. For the arts practitioner-researcher, utilising autoethnographic methods becomes part of a different goal of generating defensible positions and new knowledge. Rather than recording intuitive behaviour which is an embodied part of the process, critical autoethnographic methods allow new knowledge to be contextualised and reflected upon within the overall inquiry. There are currently a number of definitions for autoethnography but in the context of an artistic inquiry I found Margot Duncan's article Autoethnography*:* Critical Appreciation of an Emerging Art (2004) particularly useful. For Duncan the strength of autoethnography 'lies in mastering the art of self-reflection. A system of keeping reflections must be found that suits the nature of the research setting' (p.32). In this context Duncan writes of her creative practice in hypermedia design as 'intensely research-like in nature, involving constant experimentation, exploration, and hypothesis testing' (p.31) and further that although some activity is difficult to articulate, it is

possible through self-reflection to describe these intuitive behaviours. Similarly, Deborah Reed-Danahay's *Auto/Ethnography: Re-writing the Self* (1997) discusses self-reflexivity in the realm of written texts. Reed-Danahay describes 'one of the main one of the characteristics of an autoethnographic perspective is that the autoethnographer is a boundary-crosser and that the role can be characterised as that of a dual identity (Reed-Danahay, p.3). Although these practitioners demonstrate that in different contexts the methods vary, this idea of boundary crossing and a number of identities seemed appropriate to my inquiry. The dualistic role of working inside and outside of the practice I felt would allow me to work in a more structured way to describe, reflect on and reveal personal experience in a non-self-indulgent manner and link these experiences to their wider cultural and social contexts. Revealing my practice via a number of autoethnographic methods would open up my artistic process in parallel with the dissemination of the technical results and practical conclusions. This furthered my aim of establishing the lens-less video technique, revealing it as a medium with an emerging aesthetic whilst perhaps echoing other practitioners' behaviours and practices.

In arts practice research, a further strength is the contribution of the artist's personal knowledge, their interests and background - all vitally at play in creativity - and how these become integral to the recursive dialogue between that knowledge and the many insights one experiences and notes in the creative process. The documentation process for the project was inevitably both qualitative and reflective and it allowed me to acknowledge my direct experience of making, such as the accidental moments or the failures of equipment which are included and reflected upon at critical moments. This was for me the important difference when utilising autoethnographic research methods and was one of several reasons why these were the most useful in responding to my research questions.

Additionally, I was influenced through positive discussion by other PhD students within my cohort at UWE to consider autoethnography. Those in my cohort who had embraced it as a method were using it in various ways in parallel projects and also in digital moving image work. I quickly understood that for ethnographic methods to be effective in my project, I had to be more rigorous in my behaviour, to examine my thinking more closely. I am by nature an intuitive artist whose first trials often become the final pieces, side-stepping any remaking or the 'final polish'. Until the start of my doctoral studies I

had not really consciously thought of myself as a reflective practitioner or whether documenting my process was important. In fact, my aspiration was always for the artwork to be robust enough to stand alone without supporting material. Although I am engaged constantly in a dialogue with each work, I can often quite arbitrarily and instinctively jump into a new area of development without being able to offer any obvious rationale. Adopting this PaR framework allowed me to insert myself into the process and externalise my thoughts and decisions. Its adoption meant I had a position both within and outside the inquiry and this pushed the boundaries of my abilities, challenging my pre-conceptions and some established patterns of behaviour in my practice. I had to adapt to new ways of working and thinking for this doctoral study and this resulted in my research goal of creating new knowledge being achieved via a number of different standpoints: the studio practice and experimentation, the reflection in and on action recorded in the worklogs, together with a comparative study of the work of other practitioners and the research into the new fields of scientific imaging.

The practice worklogs included content predominantly though not exclusively from the practice experiments stage, each one related to an identified phase or one of the video works. They are composed of written and photographic entries (also captured as conventional video aide-memoires), recorded within computer word documents and in physical sketchbook form with notes, ephemera and photographs. They contained accounts of interviews and dialogues I had with other practitioners, verbatim audience responses, field trip notes, thoughts, ideas and notes on pertinent historical and art research. They were the vehicle for recording what I had learned as the project progressed, for deeper reflection and assessment of each stage of the video practice experiments and were key in advancing the practice towards the production of the final video pieces. Some of the worklog accounts record unsolved areas in the inquiry or at experimental junctures I had reached and how I achieved solutions, whilst others record what I had learned very specifically about the pinhole technique. They were invaluable in keeping my thinking on track in relation to the research questions and for the overall progress of the inquiry.

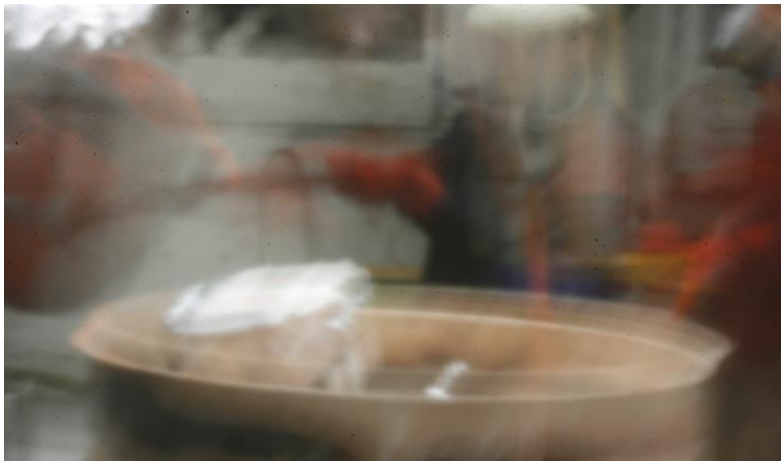
During the Practice Experiments stage, the entries started with the image capture process, added continuously up to and including post-production and then used to guide my decisions and assess lessons for progress. Each worklog generally closed with

concluding thoughts on what I had learned, which could be carried through to the next stage of inquiry. An example of this revealed in the worklog extract below. It covers my growing realisation of some of the physical restrictions pertaining to pinhole video capture and discusses the absolute necessity for strong natural light sources for pinhole usage. It records one of several experiments to enlarge the scope for pinhole video capture and ascertain the effect of different light sources and the consequence on the image. This example has been edited for clarity but its inclusion in the methodology chapter demonstrates the weight of its importance.

Worklog - April/May 2017

The challenge of using a pinhole disc is that successful and optimum image capture is most likely to be achieved with a consistent, bright, sunlight source. Indeed, from some of my first tests I found that even under maximum artificial film lighting (at UWE's film studio in 2014) a viable pinhole image capture could not be achieved. I soon realised that I could only successfully shoot during seasonal sunlight periods i.e. late Spring and Summer and that my pinhole video output would effectively be curtailed to around 5 months each year. However, it was not until after completing the practical test phase of my inquiry that I understood the full implications. To remedy the problematic timeline of usage and expand the shooting possibilities, I started considering other bright light sources which might replace sunlight. I posited that the incandescent light of heat produced, say in a glassworks or metal furnace might be sufficient for pinhole capture especially with a video camera which operates well in low light conditions. I also considered pinhole video shots using artificial light sources such as the electrical sparks or the burning given off by an oxy acetylene torch. I also investigated potentially pinhole video of electrical sparks from a Faraday Cage set-up (and a shoot took place but was not a useful step forward – that experiment is recorded in a separate worklog). The furnace idea led to contact with ex-colleague, then forge manager at the Royal College of Art (RCA) and artist metal worker himself. In May 2017 he invited me to visit the forge in London for an exploratory visit.
My first surprise there was the issue of extreme heat apparent when I hand-held my pinhole HD camera only 10 feet away from the open furnace door and the pouring of molten metal from the crucible. At first this distance was essentially for safety purposes as I had no protective gear but there were further implications for image capture. I

began to foresee problems concerning camera proximity caused by the heat (up to 1300 degrees) given off by the furnace. This type of shoot would normally be accommodated by use of a telephoto lens but with a lens-less camera the proximity to heat source could risk damage as well as affect image capture. The inability to use a zoom lens meant moving the camera even closer for each shot. For my second test visit, I used a standard DSLR camera (set at 800 ISO with 0.35mm pinhole)) and placed it on a tripod 6-7 feet from where the crucible contents (molten copper) were being poured into clay moulds. I was kitted out and wore a protective jerkin and visor but framing the shots was almost impossible. Not only is it always difficult looking through the viewfinder via a pinhole (one must first locate a strong source of light to establish the frame - it is often a case of guesswork), but also in this case I am glasses wearer so there was another layer of glass to look as well as a plastic visor. The extreme heat in the whole furnace room also meant sweat around the eyes!



Pinhole stills from RCA Forge shoot.

A review of the forge footage was disappointing – I had really hoped for better resolution given the intensity of the light source and I initially considered this shoot unsatisfactory for the following reasons:

1. *It was virtually impossible to frame the image properly due to the low light given off by the furnace and the proximity of heat. I felt the resulting moving images were indistinct and I felt, not really useful.*
2. *I was mistaken in thinking there might be artificial light sources as powerful as sunlight. This now seems obvious but I had aimed for an alternative to extend the technical*

parameters of pinhole capture and test the aesthetic possibilities as well as extend the shoot periods.

It is clear that any further search for alternative light sources was pointless. I was frustrated to have to rely solely on sunlight for pinhole image capture and I now realise that making pinhole videos in the UK at least, would only be in seasonal periods and at times and locations which offered a lot of natural light.
This effectively means about half a year of usable shooting time and that can vary by year and geographically. I understood that there would always likely be a gap in my expectation of viable capture and frustration with fluctuating light levels. Careful planning for each shoot plus working seasonally on location appeared to be the permanent restrictions on what I could achieve in my video work. How would this affect the content of the work and how could it affect its visual nature? I started to consider that it might be an opportunity and not a barrier. Prior to this I had aimed to demonstrate that a high level of digital pinhole capture could perhaps challenge lensed work through the sensitivity of a high end sensor and the type of video camera selected. After extensive testing I had to abandon this possibility for the present.

Concluding comments

I had been introduced to a temperatures chart showing the incandescent colours molten metal produces - apparently a good furnace worker can tell immediately which metal is in the crucible and at what stage it is by the colour given off. This prompted further thoughts on differences of colour, in light and in heat – heat colour is very different to light and to pigment and I started to think on how other types of colour could be integrated into video work as animated sections or as coloured double exposures or dissolves. This tied in with the possibility of playing to the light restrictions and integrating the resulting imperfections as creative tools rather than disregarding them. On reflection I have come to see the blurry furnace images differently, not as inferior to sharp focus but creatively as abstract smears, patterns and streams of passing colour and form, which in this case texturally communicate the very environmental conditions I had experienced inside the forge. This realisation could become apparent in other video pieces with these 'imperfections' and could be a way to use pinhole video in a haptic

manner to transmit sensation rather than accurate image, to capture luminosity or lack of it and a different sense of colour and texture. In other words, to creatively take forward the results from the restrictions of this particular shoot and consider how might this might affect the new works in terms of content.

The tactile nature of the forge footage also raised some comparison with the expanded technologies present in some other artists' video because of similarities in the way the image is broken down by the technique and I started re-investigating the history of expanded cinema and materialist film makers for precedents, including a renewed consideration of the notable analogue film work of amongst others pioneer artist Stan Brakhage and film maker Malcolm LeGrice.

It should be noted here that my renewed interest in expanded film mentioned above, led to a consideration of UK artist Jennifer Nightingale's pinhole practice using 16mm film, and a particular work, *Pinhole Film No 1* where she presents a pinhole work disconnected from its subject matter and whose qualities contribute a kind of impressionistic abstraction. Watching her early work led me to feel an affinity with Nightingale, and *Pinhole Film No 1* was subsequently included in the comparative study which included an interview with Nightingale in the Dialogues section of Chapter 3: Research Context Pt I.

2.2. Commentary on historical research

My digital lens-less technique is obviously tied to the past as it utilises the same physics of light as the camera obscura device. Therefore, I felt it was important to discover how this and other past innovatory technologies had impacted on imaging. I hoped this research would shed light on how future technologies might also affect the reception of the image. The first phase of investigation consisted of uncovering early uses of the camera obscura device primarily in its application to fine art practices as a means of fixing an image sufficiently for drafting and drawing and its role in depicting the motion of a three-dimensional world onto a two-dimensional surface which presaged early pre-cinematic devices such as the magic lantern and stereoscope. The investigation was supported by direct access to a number of early camera obscuras and related information in museums in the UK, Italy and the USA.

My visit to The Museo Correr in Venice in 2017 was specifically to examine the portable camera obscura devices of the late 1770s Venetian painters, the *vedutisti*[4] Francesco Canaletto and Antonio Guardi (Erkelens, 2019). The visit was important as it enabled me to handle these devices and see them set up 'in action' in a daylight situation. Additionally, during my research trip to California in November 2018, I visited the Getty Research Institute Library to examine some related camera obscura images and to handle some rare early optical devices from the Werner Nekes Collection held there. This hands-on experience was an important part of the primary research and gave me an appreciation of the basic physical properties of early image capture and particularly the visual effect produced by early optical devices.

My interest in these devices had been prompted by a re-examination of the work of artist David Hockney's investigations into the impact of the camera obscura in Renaissance and post-Renaissance painting in his book *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters* (2001). Via his own experience and skill in drawing and draughtsmanship, Hockney had tracked the high levels of verisimilitude, precision and accurate detail found in Renaissance period painting, a verisimilitude he asserted as due to the application of the camera obscura's optically projected image. He supported this contention with a number of physical reconstructions of a camera obscura to effect his own drawings alongside painstaking analyses of the perspective and optics at work within paintings over a timeline covering several centuries (2001: pp.7-11). The timeline analysed paintings and drawings which were differentiated by Hockney as either 'eyeballed' (drawn by eye) and seemed awkward and those optically produced (lensed) images which seemed to be 'photographic' (2001: pp.184-5).

This research was offered as proof of the widespread use of the camera obscura device in Renaissance painting, first employed without a lens and subsequently with the addition of a convex lens and/or mirror to sharpen and invert the projected image. Hockney also contended that the long-term effect of the camera obscura device was to embed the rules of monocular perspective and to equate optical images with those produced through human vision. His further assertion was that photography and film are the logical heirs of optical imitation in western art.

[4] Veduta is Italian for view hence 'vedutisti' the name given to painters of 18th century views of Venice.

I was influenced significantly by Hockney's work in this area and it has impacted on some of the methods employed within my project. For example, I reproduced some of his experiments by creating my own camera obscura projected images within a room so I could ascertain the correct size of the aperture and focal distance for the projected image. It was first time I directly experienced the effect and colour rendering of the camera obscura image. Further, reviewing Hockney's survey of painting genres which utilised the camera obscura device, prompted thoughts as to how his examples of classical painting genres of landscape, portraiture and still life might be updated in a contemporary way. This inspired my decisions on the themes for my video work, ones that would allow an exploration of pinhole video's soft focus and impressionistic effect within the context of video art.

A further explanation for Hockney's influence on me was his mid-late1980s photographic collages, which were analogous to my own early work as referred to in the Preface and made during the same period when I was at art school. I could see a direct link between my own photographic multiple image-making and Hockney's Polaroid photographic collages, which he termed 'joiners' - stretched and fragmented multiple viewpoints scenes collaged in a Cubist fashion (Joyce,1999), which aimed to offer a conceptual rather than perceptual reality. In addition, Hockney's position is pertinent because he is an artist who straddles disciplines, lately combining the physical act of drawing by hand with a digital practice in computer applications to 'paint' and generate images as huge prints, for example for his *A Bigger Picture* exhibition (2013). It is also appropriate to note here there is a link between the hand-made collage technique and digital image editing on a screen, a point Lev Manovich makes when he writes of how 'the avant-garde strategy of collage re-emerged as a "cut and paste" command, the most basic operation one can perform on digital data' (2016: p.48). These links remain meaningful in my practice, their influence evident in the approach undertaken for the doctorate.

In continuing my research into the effect of the camera obscura device, I investigated Jonathan Crary's theories of perception in his *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (2001). Although starting later in the timeline than Hockney, Crary's reading is that the camera obscura device offered a simple image of a natural physical phenomenon, producing objective projections without human

influence. He disagrees with Hockney's proposal that the optics of the camera obscura subsequently became embedded via the 'rules' of perspective, and that they assumed depth and distance in the image as the natural product of vision. He argues, 'one must be careful of conflating the meaning and effects of the camera obscura with the techniques of linear perspective' (2001: p.34). Crary's principal argument is that although the camera obscura was a practical tool, more importantly its use led to the realisation of a visual conception which eliminated subjectivity in the production of images. His interpretation of its impact is that the device was not solely used by artists post-Renaissance and in later periods to generate an image, but that it also became integrated as a concept by Enlightenment theorists and thinkers to study the relationship between the image and the observer. As William Uricchio puts it in his essay, There's More to the Camera's Obscura Than Meets the Eye, 'The Enlightenment ... read the camera obscura in much the same manner as it read nature: as a machine with rules and logic. What was seen was of secondary importance to the rules of seeing, the logic of vision' (in Albera et al, 2002: p.110).

Although one might disagree with Crary's assertions on the subjectivity of the observer because he does not extend the ideas into the period of the first photography, one can appreciate that the impact of the camera obscura was that it initiated a new relationship with the image – introducing use of the monocular vision of the single 'lens' versus the binocular vision of human eyes. This shift presaged a new awareness of the observer's experience so that knowledge of visual sensation could be separated from the technical assemblage or device where it was generated. As artist Carsten Werth in his essay entitled, The Camera Obscura as a Model of a New Concept of Mimesis in Seventeenth-Century Painting explains,

> the camera obscura places the viewer in the eye itself, letting him look at the retina. The viewer is offered a vision of where and how seeing takes place: The camera obscura portrays the optical process of vision, making it a conscious experience so it can be studied by observation (in Lefevre, 2007: p.159).

Commenting on a later timeline for image capture, theorist Tom Gunning agrees with this argument about emergence of subjective vision and identifies the camera obscura as one of the pre-cinematic devices which offered a visual experience that simultaneously drew attention to the effect (the image) and how it was produced. He makes a wider point that the image is 'radically revised through new interfaces with the

processes of perception and the precision of technology' (Gunning 2012: p.495).

Theorist Oliver Grau had also emphasised the overall significance of the camera obscura when he wrote that,

> The camera obscura represented a pioneering achievement in the history of cinematographic modes of perception because it introduced a restructuring of possibilities for visual experience through optical techniques. It was an innovation comparable with the discovery of perspective, and an important precondition for its development was a further stage in the process of individualising the observer. (Grau, 2003: p.54).

A consideration of the camera obscura's cultural impact and reception in the past, its effect on the subjectivity of the viewer and its subsequent abandonment became part of my re-examination of older forms of lens-less capture in relation to the pinhole video camera apparatus.

2.2.1 Media Archaeology

Consideration of Crary's theory of the idea of subjective vision through the use and effect of the camera obscura and Gunning's revision of the genealogy of visual pre-cinematic devices led me to the sub-field of Media Archaeology. An exploration of this theoretical field, which combines aspects of cinema and cultural studies, art history and new materialism, became part of my research to understand how technological shifts affect our ability to communicate. An initial reading of media-archaeological perspectives indicated how I might 'unpack' some pre-cinematic technologies and early imaging practices as a guide for my inquiry.

There are a number of disciplines which figure within MA, but I concentrated on the work of Erkii Huhtamo and Jussi Parikka, co-authors of the seminal *Media Archaeology: Approaches, Applications, and Implications* (2011) and of Parikka in *What is Media Archaeology*? (2012). They are the main exponents of MA's archaeological approach to the study of media, one that offers set of theoretical tools to examine through the evidence how media were designed, used and often discarded. Media and film theorist Thomas Elsaesser, whose work is allied to MA, was also considered because of his work on moving image technologies and the history of cinema.

MA offers a broad engagement with the material culture of media technologies and is primarily concerned with tracing the uneven development of previously ignored obsolescent media devices and failed technologies. Its main proposition is that the materiality of these devices carry culturally and socially assigned codes that exert a presence in altered form in new media and that revealing these codes enables a new understanding of technical convergence and transference. In order to examine these ideas, MA rejects any reading of continuous technological progress and offers ways to map media methodologically by thinking of the new and the old in parallel lines to open up contemporary technologies through new kinds of genealogies. As Parikka puts it, 'Media archaeology sees media cultures as sedimented and layered, a fold of time and materiality where the past might be suddenly discovered anew, and the new technologies grow obsolete increasingly fast' (2012: p.3).

Thus, MA appeared a useful methodological and pertinent approach which could support my inquiry. The pinhole video camera is, I feel a key example of a 'new media' artefact developed from the ancient camera obscura device, one that was initially rendered obsolete by the advent of chemical photography. Utilising an MA understanding of its uneven trajectory of development could indicate how and why the camera obscura's cultural identity and the basic physics of its capture have persisted. Its continuity today is evident in a revival of analogue photographic practices and perhaps surprisingly in practical scientific applications where, for example, pinhole technology is being utilised in the form of coded apertures for astronomical capture of black holes in Space (Renner, 2009: p.31).

As a methodology, MA emphasises experimentation, cross-disciplinary work and detailed research and investigation of archival material and artefacts. It is a dialogue with the past which Huhtamo argues 'only opens up for the active participant, who is ready to leave one's customary chronological ordering of things, and the safety of his/her own socially and cultural defined observation post, heading out to explore potential dimensions in a conversational relationship with the work'. (Huhtamo,1995, p.3). In their book *New Media Archaeologies*, Roberts and Goodall comment on the wider applications of its cross-disciplinary approach, asserting that,

> Media archaeologists, especially *experimental* media archaeologists, see the potential for work that is engaging with the historical past to be transformed into new ideas for the future. This, in turn, can influence a range of practices inside and outside of the field relating to arts projects, museum and curatorial practices, textual production, and extra-disciplinary areas of study (actual archaeology for example) (2019, p.12 emphasis in original).

Parikka additionally points out that MA is 'a good methodology for an analysis of how our senses are articulated in media contexts: modes of sensation themselves can be seen as historically structured' (2012: p.20).

Even though MA has emerged as a theoretical sub-field over the past twenty years, one troubling aspect was the role it has played in a recent trend of utilising outmoded machinery/failed technologies, reviving them for creative purposes with an implication that they are somehow more 'authentic' because of their obsolete status. Although not all specifically cited as MA artists, contemporary artists in this field might include Dutch artist Joost Rekveld, South African artist William Kentridge and American artists Zoe Beloff and Paul DeMarinis, all of whom utilise old mechanics and/or retro cultural references in a range of contexts. I was wary that my lens-less video camera and the video artworks might be associated with this uptake of old media forms especially when some MA theorists have presented these practices as a 'challenge' to new technologies. My instinct is to oppose any claim that these practices are intrinsically oppositional and I separate myself from this position.

However, MA's emphasis on the material nature and persistence of media drove my exploration of 'other' alternate means of image and light capture. In particular, this centred on looking at deconstructed or modified imaging devices to gain a better understanding of how they functioned and the cultural moments in which they emerged. This revealed some forgotten unconventional items such as a man's suit with many pinhole cameras attached in the round, a shutterless film camera, a film cartridge itself used as a camera and 'films' produced through projected light, no camera being used at all. Some of these were one-off experiments while others emerged as 'new' technologies within particular political and cultural settings, for example in the US experimental film movements of the 1960s and in the UK with Structural /Materialist film makers of the 1970s. Parallel research in current 'amateur' pinhole still photography

further revealed the existence of a range of unusual self-made devices, employed in a variety of contexts.

Thus my historical research stimulated an appreciation of media-archaeological perspectives and led me to consider in more depth how past technologies and exemplars might be present technically in both the physical build and operation of my lens-less video camera and how culturally these might also shape the conception of my video works. Reflecting further on the links to past and alternate camera assemblages, I came to regard my lens-less apparatus as an important step forwards as a 'hybrid' version of what we understand as a camera. In fact, I started to conceive that what I had actually been doing was a re-purposing of the camera itself, because to remove the lens is to fundamentally alter the camera as apparatus and so it follows that this apparatus mediates between viewer and image differently as compared with a lens.

To conclude my exploration of Media Archaeological perspectives offered limited but important productiveness, as it allowed me to consider its propositions in relation to the development of my enquiry.

2.2.2. Remediation

Some artists (myself included) might conceive of the re-purposing of media forms in terms of 'remediation' theory, as advanced by Jay David Bolter and Richard Grusin in *Remediation: Understanding New Media* (2000). This concept has its roots in Marshall McLuhan's law of obsolescence expounded in *Understanding Media: The Extensions of Man* (1964) in which McLuhan states that old media become the content of new media, thus losing their originality without being fully eradicated. Bolter and Grusin present an uneven yet linear chronology of image capture, and propose that the impetus behind every technological change is a desire for a more direct contact with reality – a desire for realism they identify as apparent since the birth of Renaissance painting.

Concentrating primarily on the visual, remediation is described as the representation of one medium by another and the authors argue that no single medium works in isolation. They contend that via the process of remediation an old medium is not totally eroded but that the 'new' medium 'remains dependent on the older one in acknowledged or

unacknowledged ways' (2000: p.47). This is a two-way process, they assert, 'as new media re-fashions old media so do older media re-fashion themselves to meet the challenges of new media' (2000: p.15). Bolter and Grusin advance this premise of remediation in the face of rapid technological changes in the cultural sphere, making reference to both the content and process of representational forms. As I use an amalgam of 'old means of capture' (the pinhole aperture) with a 'new means of capture' (the digital sensor) to re-purpose the camera, I felt that their critical framework might be relevant.

Bolter and Grusin's three key concepts are immediacy, defined as a visual representation which closes the gap between reality and the medium (i.e. it invites the viewer to forget the medium); hyperimmediacy as a representation to prompt both awareness and fascination with the medium; and finally, remediation is defined as combining the two strategies of immediacy and the erasure of medium's artifice (2000: pp.19-22). Remediation occurs when the 'new' medium tries to completely erase the older medium and this process allows the new media to comment on, reproduce or replace previous forms. For the authors, this is an oscillating and continual process. Some arguments they advance have informed my thinking and appeared relevant to dovetail with my artistic inquiry. For example, I have empathy with their ideas on the art of photomontage (as referred to in thesis Preface) as presenting a challenge to the photographic surface and an expression of a duality of looking at and through the photograph (2000: p.39) representing a drive to go beyond surface realism. However, after further consideration of their formulation of remediation, I do not consider that it necessarily follows that my hybrid pinhole video camera fits their model of replacement of one medium of representation by another or indeed the eventual erasure of artifice.

Although Bolter and Grusin's writing remains influential in understanding new media, some of its limitations have been critiqued. For example, in her essay New Lamps for Old (in Acland, 2008), Michelle Henning asserts that technological changes in media are actually social transformations which cannot be detached from changes in working processes. She also points out that new digital techniques 'refashion' rather than replace old media forms, a point to which I shall return. Others, such as David Bate in his essay on the digital condition of photography (in Lister, 2013), have commented that technological improvements to the camera for example, have arisen as solutions to

ongoing problems or new material conditions rather than being significant technological changes.

However, a more significant critique of the premise of remediation comes from an interview with Huhtamo when he asserts that,

> a technological device, a piece of hardware, is not a medium, it cannot be a medium. It only becomes part of media culture when it is put into practice. This practice has material aspects of course, but it also unfolds on much more abstract levels when a medium gets transfigured by the people who use it (2016: p.5).

As an artist I approach this from a slightly different viewpoint in that creativity arises precisely from the combination of the particular qualities of the device/medium and the individual traits and imagination of the artist, this determines how the device or medium is responded to. In addition, Bolter and Grusin's concept of remediation demonstrates a certain lack of attention to the issue of individual agency, one that can undoubtedly affect the medium. Other commentators such as Seth Giddings have also noted this as a problem, particularly in his essay, Drawing Without Light: Simulated Photography in Videogames (in Lister, 2013: p.53). What I perceive as an omission in Bolter and Grusin is very little acknowledgment of how the artist's intuition and imagination might affect technological shifts. Although the Modernist claim that a medium must appear new in order to be significant is rejected by the authors (2000: p.270), I cannot understand why there is scant recognition of how significant innovations or new forms might spring from unconscious sources or intangible conditions such as the experience and skilled eye of the creator. For me, the agency and intentionality of a maker/artist/inventor are undeniably influential in altering technological form.

Reflecting on the theoretical drive for immediacy and hyperimmediacy in representation, which the authors assert leads to remediation, it is important to see how this may or may not relate to the practice of pinhole video and re-iterate some points about the particular quality of pinhole light capture made in Chapter 4: Research Context Pt II: Technologies. This is significant because the image capture in pinhole video is at base analogue and 'unmediated' by a lens with the source light flooding uninterrupted directly to the camera sensor. This is light as 'raw material' which is then recorded as data.

However, as ‘normal’ camera controls are bi-passed, the readings of focal data are missing so the data capture of the image is necessarily different compared to lensed capture. Therefore, I wish to argue that the pinhole image data captured by the sensor can be regarded as ‘pure’ and unmediated, only transformed beyond the camera in the post-capture processing. It is worth noting here that any sampling of the sensor data will affect the initial pinhole capture but in post-processing there are beneficial and detrimental elements to the image whatever the medium of capture.

Two points I feel, seem to underscore that the re-purposed video camera as a medium does not quite fit within the equation of remediation theory. First, as described in the operation of this camera, the pinhole image is ‘unmediated’ by a lens and second the ‘raw’ light data gathered by the sensor in pinhole video camera is not necessarily used, as the concept of remediation would have it, to attempt an erasure of the artifice of the image. Second, the pinhole video assemblage is not offered as a new, improved version or replacement of the conventional camera set up, but one which functions in parallel with other visual media.

Reflecting on these issues led me to consider an alternative to remediation and remediated forms. Taking into account the importance of human agency in creativity, I moved away from definitions of remediated forms to the idea of ‘re-purposed forms’, ones which stressed the primacy of the individual’s (in my case the artist’s) intentionality as well as the capabilities of the medium.

Artistic ‘intent’ is often a factor in the re-purposing of mediums, which is a common practice amongst those working in performance, popular music, sound design and in literature and theatre. Sampling of musical themes is an example when performed with different tempos or played with archaic instrumentation and/or captured on analogue recording kit. Re-purposing for me is a concern with altering the *creative* (my emphasis) intention of usage rather than with an improvement or re-fashioning of an object or item for practical or stylistic purposes. Echoing Henning’s claims of technological change in media being linked directly to new working processes, in my practice I see my re-purposing of the camera as a means to explore representation and light capture to develop new creative forms. As I have demonstrated in Chapter 4: Research Context Pt

II: Technologies, this is an aspiration that I believe is shared by the scientific imaging developers who are exploring light in all its behaviours.

A combined study of both Media Archaeology and remediation theory has been important and productive for my inquiry as it allowed me to consider and unravel the differences between their respective propositions and to situate the development and practice of pinhole videography and the image it generates. This has produced a methodological approach which I believe to be relevant and of use to other media artists and practitioners.

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Chapter 3: Research Context Pt I: Dialogues and Encounters

This doctoral study has engaged with a variety of audiences in order to test the reception of video using my lens-less video technique. This chapter covers both audience response and the dialogues held with individual practitioners in pinhole moving image. The public screenings of several pinhole works were an important way to test the visual effects of pinhole and to look for certain words or evidences of these in the feedback comments. This would allow me to reflect on and push the practice forward as well as provide material evidence for the thesis. The presentations and screenings of my video work as outlined in the following table.

At this point, please re-view *Light of Day I & II:* https://vimeo.com/439395300 PIN1234

3.1. Presentations of pinhole video work

Table 1: Pinhole video presentations.

Pinhole video work	**Date of screening**	**Venue**	**Audience**
Venice Sunrise (2014)	April 2017	London Pinhole Festival, London E2.	Pinhole artists, general public
Light of Day I & II (2017)	Sept 2017	DRHA Data Ache Conference, Plymouth	Academics, artists, general public
Light of Day I & II (2017)	Oct 2017	Bristol Expanded Experimental Film (BEEF) Bristol	UWE PhD students, Academic staff
Lap Dissolve (2018) new version of Light of Day I & II	May 2018	Sigur Gallery, London NW1	Artists, general public
Lap Dissolve (2018) new version of Light of Day I & II	Sept 2018	Liquidscapes Conference, Devon	Academics, artists

Light of Day I & II (2017-18)	Sept 2018	ASA Oxford University Conference: 'Sociality, Matter & the Imagination: Re-Creating Anthropology	Academics, social anthropologists, artists
Light of Day I & II (2017-18)	Nov 2018	Echo Park Film Center Los Angeles	Artists, film makers

Artists were the main audience at the first screening events such as The London Pinhole Festival in 2017 and the general public at a London-based private gallery show in 2018. An early pinhole work, *Venice Sunset* (2015)[5] and *Lap Dissolve* (2018)[6] were the sole examples of moving image pinhole work at these shows. From the audiences there I received informal comments referring to the 'look' of the videos: 'Your work looks like an Impressionist painting', 'Is it shot first on damaged film stock?' 'I think it looks like an 8mm home movie'. These suggest that most of these viewers saw the pinhole videos as associated with the soft focus images of early movies. Some commented directly on the focus aspect: 'it's like looking though a crystal' and even 'the blur makes my head hurt'.

At the 21st Digital Research in the Humanities and Arts, Data Ache conference in Plymouth in September 2017, the first long video work produced in this study (*Light of Day I & II*) was screened in a public-facing gallery attracting an audience of peers, academics and artist attendees. It was an important opportunity to reach a large number of people and I gained a number of supportive comments and as before these were a general appreciation of its 'look'. My work was shown as part of a UWE PhD student-led, curated one-day research event in Bristol in October 2017, which took place at the Bristol Experimental and Expanded Film (BEEF) premises at the Brunswick Club, Bristol. I installed, presented and spoke about *Light of Day I&II* (*LoDI&II*) as a work-in-progress to a group of my peers and UWE lecturers. This was important for the research context, as I was drawn into discussion with others who are actively engaged in experimental work in moving image. In responding to questions about how the digital

[5] https://vimeo.com/162536878
[6] https://vimeo.com/288953976

pinhole form related to the theme of the work, I stressed its visual and evocative qualities (muted colour, soft focus, ephemeral quality) plus bespoke soundtrack, explaining I felt these were ideally suited to capturing Venice's special quality of sunlight and the sensory effect of the city. I explained there were autobiographical ideas at play in the choice of locations which drove some of my production decisions, and it was suggested I might consider adding obvious autoethnographical elements to expand the work into a personal 'project' rather than a standalone video work. In some ways these discussions re-framed my understanding and prompted a recognition that the work was not complete artistically and was one step in an ongoing creative process. This was one of several reasons which led to not continuing with more work on this piece. There was a further opportunity for audience response at a multi-disciplinary conference entitled *Liquidscapes* held in Devon in July 2018. *Lap Dissolve*[7] (2018), was shown on rolling display to a mixed audience of artists and academics gathered to discuss diverse aspects of water and water in culture. This video was created from footage in *LoDl&ll* and concentrated on imagery of Venice's waterways and the lagoon and included a bespoke soundtrack. Although this exposure offered me the opportunity to get responses from a wider audience from different disciplines, I was disappointed that it produced little of critical value, the most common responses being that the work was 'lovely', with an acknowledgement that most water images tend to be aesthetically pleasing.

In September 2018 I had the occasion to present *LoDl&ll* to a completely different group of academic peers at the ASA (Association of Social Anthropologists) conference, *Sociality, Matter and the Imagination: Re-Creating Anthropology* at the University of Oxford. The conference was concerned with the 'temporal nature of phenomena that anthropologists analyse, and featured panels exploring temporalities and transformations in material formations and acts of imagining' (ASA 2018 Conference Proceedings: p.11). I was both presenter and co-convenor of the panel: 'The Anthropology of Light: art, skills and practices', which covered approaches to light requiring forms of artful, skilled vision and a creative eye. The context was in keeping with my experiments with light and pinhole capture and was the ideal occasion to

[7] https://vimeo.com/288953976

present the work more as a visual ‘essay’ centred on the capture of light to an audience of anthropologists and related academics. This audience gave me some useful responses, revealing a fascination at the efficacy of this ancient method of image capture along with informal comments including that ‘its overall look and texture was ‘poetic’ from Danish anthropologist and film maker Christian Suhr, who also commented later in an email,

> I’m interested in the way in which cameras are able to show the world in a different way than we perceive it with our human eyes. So in your film, the way in which the camera captures the light of Venice in a very different way than we are able to experience without it (Suhr, C. 2018, personal correspondence, 24 September).

With regard to the additional control and preparation needed for pinhole imaging, because of the unpredictability of its set-up, Suhr also described,

> an interesting oscillation between a human attempt to capture and depict a certain kind of light and then the reconfiguration of these attempts by the intervention of a camera and the light that do their own things independently of you as the director (Suhr, ibid).

Of course, the notion of being at the mercy of the light source is nothing new to cinematographers or photographers, but with pinhole imaging the capture is all the more unpredictable because the strength of the ambient light source can vary and cause real difficulty in framing and composing shots. Another point I gathered here, prompted by Suhr’s email comments and the time that had elapsed since the screening, is that it seemed to indicate that perhaps viewers may not always express their reactions at the time of experiencing the work but need time to reflect. Finally, during my field trip to the USA in late 2018, I was able to introduce and screen my work at an established experimental film group, the Echo Park Film Center (EPFC) based in Los Angeles. The EPFC has a predominantly analogue focus and hosted a screening *LoDl&ll* as part of a salon, which included mostly analogue film work. It was well received by a mixed audience but once again responses exhibited a general interest in the visual effect effectively detached from the content, with the exception of one viewer who felt the work needed some explanatory captions to really work.

During the first two years of my doctoral study I received generally positive responses to my pinhole videos, but overall what I had found useful for my inquiry from a range of screenings was very limited. I had not been clear when presenting the video works that they were incomplete and I began to consider that the audience responses were somehow evidence of a lack of their impact, which I felt as a disappointment. However, my understanding changed when I realised my expectations were based on a long-held idea perhaps inculcated from my time at art school, that each of my works had to be 'a major statement', to 'standalone' to 'be important'. Subsequently my expectation was that audiences would implicitly realise this and respond to the works almost immediately. I came to see this position was holding me back and how the kind of inquiry I had thought I was following was changing.

I had to alter my approach and on reflection I started to think instead of presenting to an audience as a kind of opening out of my thinking, of my process and not the end point. I thought that in some sense I might be able to bring varying views into 'conversation' through me as a kind of catalyst. I posited that this might prompt links to knowledge in other fields, for example in anthropology linking the pinhole effect to ideas of 'haptic visuality' developed by Laura U. Marks in her book *The Skin of the Film* (2000). I had read some of Marks' theoretical work which exists within the area of intercultural post-colonial cinema. She uses the term haptic visuality to describe how film makers can engage the viewer bodily to convey cultural experience and memory. Using techniques such as pixellation, image grain, close-up textures and focal changes to generate sensory responses, haptic imaging encourages looking as 'more inclined to move than focus, more inclined to graze than gaze' (2000: p.162). What interested me in Marks' work was that the effects she describes are generated characteristically by pinhole video capture. For example, when light levels are low, the pinhole's unique image quality breaks up, appearing pixellated and less complete. I felt that the idea of a 'graze rather than gaze' response summed up one of my aims for *LoDI&II*: that the viewer would become immersed and through the pinhole imagery consider the material presence of Venice. In addition, I came to understand that the notion of haptic visuality might have links to a tradition of critical aesthetics present in experimental film practices. This idea is further touched upon later in this chapter in the Practitioner Dialogues section.

I started to acknowledge that audience exposure per se was not the issue and that perhaps more might be learned from interviews and encounters with other practitioners in the same field of lens-less moving image. I resolved to identify pinhole practitioners working in an art context and this led me to a rather limited body of information on current pinhole photography. A key practice in this field is in still imaging which has emerged as a popular trend over the last twenty years along with renewed interest in other analogue practices and is evidenced by younger practitioners re-discovering and taking up work in photo-chemical imaging. However, I found scant critical work on the practice of still pinhole photography despite evidence of its persistence amongst artists and presence online via amateur photographers. A review of literature uncovered a few recent examples of amateur or test material using a digital pinhole technique for *moving image*, but this presented me with a quandary – how to contextualise my work within a very slender field of practice. Research revealed the work of three contemporary practitioners working directly with pinhole technology and moving image, both within analogue and digital media. In order to advance my inquiry, I decided to utilise my first pinhole video, *LoDI&II* as a comparative piece to contrast with these practitioners' works. It was chosen because it was the longest piece made immediately after the practice experiments stage and encapsulated what I had learned about pinhole capture as a result. A fuller description of the background to *LoDI&II* appears in Chapter 5: Practice Experiments and extracts from its related worklog appear in Appendix 1.

LoDI&II as longer piece allowed me a measure against the work of the following moving image practitioners. I reviewed their available pinhole works and immediately noted parallels both in content and approach that could reveal the creative possibilities. The comparative study I subsequently undertook allowed me to assess the impact of my new technique by addressing a number of issues raised in a dialogue with these practitioners. It should also be noted that after reflecting on this dialogue I gained a better understanding of the value of contrasting one's work with that of other practitioners, and that awareness of analogous work was important because it can often create a cross-fertilisation of ideas.

3.2. Practitioner Dialogues

Selected from both internet research and a visit to the British Artists' Film and Video Study Collection in London, the selected practitioners' works seemed to be partially analogous to mine and their individual practices would, I felt, offer me a range of responses. The practitioners were: Christopher Harris an American moving image artist and academic based at the University of Iowa; Jennifer Nightingale, a UK artist and lecturer at the Royal College of Art, London; and Jason Joseffer, a San Francisco-based professional commercial cinematographer.

My approach was to enter into a dialogue with each practitioner by selecting one lens-less moving image work, not solely for any affinity with *LoDI&II* but to contextualise their work within the field of lens-less moving image, and to identify why and how the choice of pinhole capture related to the content of each work. My work was therefore contrasted with two 16mm pinhole films and one pinhole video work. The selected practitioners were important to my research as each has an ongoing practice in experimental moving image capture applied in different ways. Thus, I chose a single example of pinhole technology moving image starting with Harris's 16mm pinhole film, *Sunshine State-Extended Forecast* (2007) which had I felt, lyrical and expressive qualities similar to my own work. Nightingale was an early practitioner in 16mm experimental film, notably in *Pinhole Work No 1* (2001), and has continued a Materialist[8] practice in moving image. Joseffer, who has experimented in this area for some years, employs self-made specialist pinhole attachments for high-end cinematography cameras as in his recent video, *On the Road'* (2016) made for American musician, Seth Lael. The selected works spanned a fairly long timeline and I saw this as perhaps as indicating some inconsistency in pinhole's use by these practitioners.

Establishing an individual connection was an important element in the selection so that I might be able to explore their motives in a more person-to-person way. Thus as Nightingale is London-based, I was able to interview her in person. Harris and Joseffer are American-based: I met and interviewed the latter on my field trip and in the case of Harris, I established an email correspondence, finally meeting him briefly at a film presentation in London in March 2019. The rationale for selecting these three practitioners was their current and direct engagement with pinhole moving image and

[8] See Glossary

was encouraged that when contacted they all expressed a willingness to meet (where possible) and discuss their work. Additionally, each of their works I selected loosely fitted some categories within moving image: poetic essay (Harris); free-form work made with a re-configured camera (Nightingale); and conventional narrative (Joseffer). The latter's inclusion was important as his is the sole example of digital pinhole work I uncovered up to that point. Because it is a narrative piece, it differs in important ways from the art video work of Harris and Nightingale. I felt their work offered potential approaches which I might adopt for future works but for the purposes of the thesis the focus for comparison was with *LoDI&II*. For the interviews with these practitioners, I developed a loose set of questions on the capture process and what they felt that lens-less capture brought to the content of the work.

3.2.1. Christopher Harris

Work in focus: *Sunshine State* (*Extended Forecast*) (2007) 8' colour 16mm,
Excerpt only available to view at: https://www.lightwork.org/archive/christopher-harris-extended-forecast/.

Permission given by C. Harris for use of 'screenshots' and email correspondence material.

Research into notable 16mm pinhole film practitioners such as Robert Schaller[9] and Thomas Comerford[10] had led me to the work of US artist and film maker Christopher Harris, who was inspired to use pinhole by Comerford. After establishing email contact with Christopher Harris, I obtained a private password to view *Sunshine State* (*Extended Forecast*) online and after viewing a number of times I sent him questions by email. I received full answers including one response informing me that although it had featured at numerous film festivals, this film had not been commented on or written about at all. This posed a challenge not only to make significant comparisons for my inquiry but also perhaps produce a meaningful commentary for Harris himself. This established perhaps a more significant relationship compared with the other practitioners as I developed my

[9] https://www.robertschaller.org/film/
[10] http://www.thomascomerford.net/film_photo.html

response to the work into a longer commentary on *Sunshine State* (*Extended Forecast*). This commentary appears in Appendix 2.

Harris is a film maker and lecturer whose films and video installations are concerned with the poetics and aesthetics of experimental cinema. He works directly with the tactility of celluloid, usually 16mm found footage, manually and photo-chemically altered, integrating the camera as a critical aspect of his process. For his installations, he re-stages events derived from archival sources which relate specifically to African-American historiography. He has said that he sees the film as an object in which to embed his experience and then this experience is shared with the audience. Through his work he undermines formal conventions with a stated aim in all the work, 'to strive to find a formal/material structure that addresses the spectator in a divided way. I try to make work that does not structure the spectator as a unified subject'. (Harris, C. 2019, email correspondence, 27 January). He describes this as a process in which, 'the viewer must hold in their mind the readily apparent internal division of the film's structure' (ibid). This is not a novel position for moving image makers. Indeed, Nightingale and other artist film makers such Vicky Smith[11] work on the premise referred to by film maker Peter Gidal that, 'the mental activation of the viewer is necessary for the procedure of the film's existence' (Gidal, 1976).

Sunshine State (Extended Forecast) was made in 2007 at a time when Harris became fascinated with the quality of the pinhole image. It was his first experiment with pinhole and is his only lens-less piece to date but it prefigures some aspects of his latter works. The work displays Harris's interest in the textures of light and plays on the viewer's capacity to interpret forms with little obvious information. A further example is *Bedouin Spark* (2009, 16mm lensed film), a short film edited in-camera, in which Harris manipulates the light around a children's hanging mobile so that the plastic silver stars suggest a fluid, glinting night sky. *Sunshine State* (*Extended Forecast*) is a short visual essay, almost a diary entry which appears to be about the cosmic consequences of the sun's collapse. There are shots of the sky and a green front yard of a house and one long sequence shows a static overhead view of the suburban blue-tiled swimming pool with beach balls slowly floating across its surface and out of frame. This slow, fixed shot

[11] https://lightcone.org/en/filmmaker-13429-vicky-smith

of the pool is interspersed with idyllic footage of the Florida garden, blue sky and of a young black girl (the film maker's daughter) in a white dress playing around in a sunlit yard, chalking a yellow sun on the ground while a yellow pinwheel ornament spins in the wind. The camera is generally static with the only movement shown taking place in and out of frame. In the pool the balls drift with the water movement and appear trapped within the grid lines of the pool floor whilst the sun is shown as a reflected hot white blob in the water surface or high in a pin-blue sky. The larger beach balls suggest celestial orbs, the water as Outer Space, whilst the darker shadows of the balls on the pool floor add another layer of meaning to an accompanying soundtrack, which warns of a deadly sun – possibly of global warming. These images are complimented by a soundtrack described in Schlemowitz's book *Experimental Filmmaking and the Motion Picture Camera*, as 'a cut-up of science documentaries – describing the cosmic mortality of the sun's finite hydrogen fuel – mixed with Florida weather reports' (2019: p.223).

Figs 3-5: *Stills from Sunshine State (Extended Forecast)*

With regard to the subject matter Harris comments, ‘In the case of *Sunshine State (Extended Forecast)* the interest is in the way that the everyday can stand in for the cosmic - inspired directly by the coffee cup cosmos shot in Jean-Luc Godard’s *Two or Three Things I Know about Her* (1967) (ibid) and that the soundtrack of unscripted television broadcasts and radio static was intended, ‘to re-write the images so to speak, so that the quotidian spaces and objects were revised as heavenly bodies’ (ibid). The Godard shot Harris refers to is an extreme overhead close-up of a coffee cup its surface froth swirling round to which Godard adds his own voiceover commenting on the limits of language. The intention here in Harris’s film is to suggest the cosmological resonances of the seemingly mundane, a thread which is present in his other film works.

On the question of what pinhole imaging was offering to the work, Harris stated,

> I felt that something about the quality of the pinhole imagery was right for the sense of temporal dislocation that I wanted. What I mean is that the scale of *Sunshine State* is simultaneously micro (one suburban Florida house on a lazy summer afternoon) and macro (the cosmic scale of stellar, galactic and universal collapse across an unimaginable expanse of time). The pinhole imagery gave me a way to represent the "present" of the film's summer afternoon as if it were a low definition image of an already a distant past (ibid).

He added that*, Sunshine State (Extended Forecast)* and his other Florida films,

> are a response to living in Florida that would never have been made had I not lived in Florida at the time. *Sunshine State* is obliquely autobiographical in the sense that it is more or less direct expression of my response to life in suburban Florida (ibid).

The film plays on Florida's name (The Sunshine State) and this is emphasised in his use of a sunlit exterior which is the most optimum condition for pinhole capture. The bright natural light together with limited movement of a single fixed camera not only mirrors my approach for *LoDI&II* but also echoes, I realised, the conditions for filming early movies in America. By materially evidencing the sunlight through pinhole and linking to it to a location, I feel Harris draws the viewer into both a literal place and a metaphorical space.

There are parallels as I attempted something similar with my Venice video work, *LoDI&II*, which was directly concerned with the action of sunlight to produce image; and, like Harris, I captured moving image, which allowed the prevailing light and water movement to be suggestive of ambience. My pinhole video also contains obliquely autobiographical elements together alongside a need to transmit a sense of a place. In both our cases, the choice of pinhole technology harnesses pinhole as creative medium to capture the sense of a place and, in *Sunshine State*, a record of time. For Harris the film offers a sense of life in Florida and what he describes as a need to mark a particular moment in time, whereas for me the pinhole effect in *LoDI&II* was not intended to suggest something of the past but rather to transmit a living, material sense of the moment of a particular place. It is to be acknowledged that this notion of place finds an

echo within a specific tradition in experimental film, which allows a contemplation of the image as material presence and which I would argue is present in both of our respective pinhole works.

While Christopher Harris has not further pursued pinhole capture for his other evocative essay pieces, when asked if he would employ pinhole imaging again he commented, 'I tend to try new technical, formal challenges for each new work so that I can learn a new process and then move on to other things. If the right occasion came along, I would definitely be open to using pinhole again' (Harris, C. 2019 email correspondence, 27 January). Harris selects a new technique for each new work, while for me the choice of pinhole technology for content is to expand its capability further. I felt this to be a crucial difference in our respective degrees of commitment to the medium of pinhole video.

3.2.2 Jennifer Nightingale

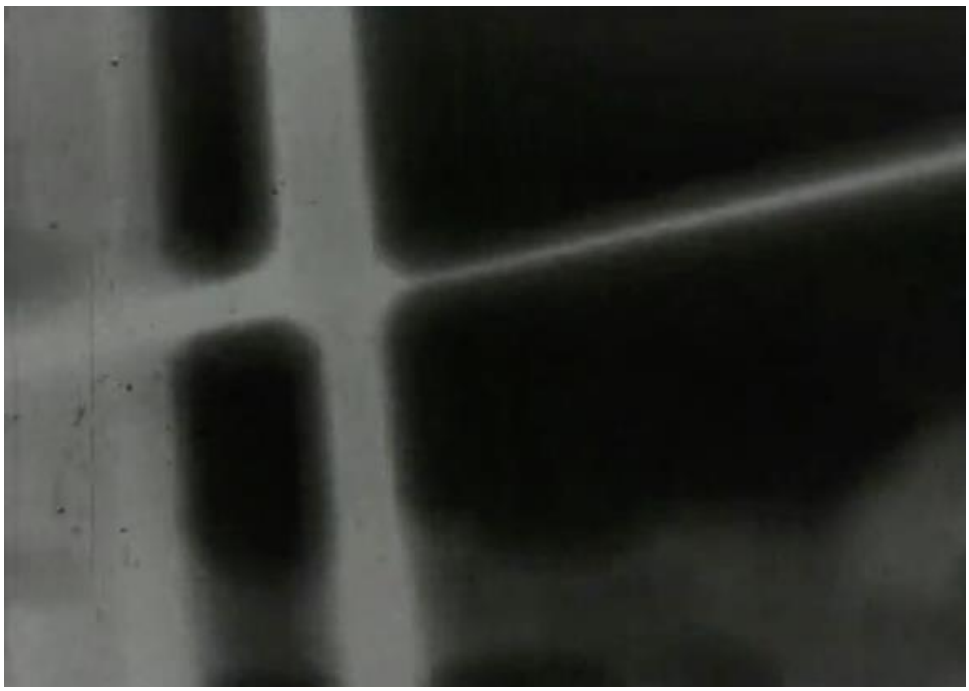
Work in focus: *Pinhole Film No 1* (2001) 2' 30" silent 16mm B&W negative. Available at: https://vimeo.com/62657544 (although entitled online as *Pinhole Film No 2*).

Permission given for use of 'screenshots'.

Jennifer Nightingale is a UK-based artist, film maker and lecturer. Her background is in 8mm and 16mm film, with a practice which strips away all the mechanics of the camera to create images traced from light directly in contact with the celluloid material of the film. Her practice in lens-less capture continues today utilising 35mm film stock. I was drawn to her work because of its free-form appearance and what I felt to be a similarity of a practice in the re-configuring of the apparatus of the camera. In my case the pinhole image recorded digitally within the camera and in Nightingale's case a de-constructing of the body of the camera to create lens-less (and eventually camera-less) moving image work. I learned from discussion with her that her work operates within the practice of materialist film, elements of which are touched upon within my video work. For Nightingale, *Pinhole Film No 1* was a first experiment to strip the camera back to its essentials to explore the contact of light directly onto celluloid material. She explained in our interview that her aim was to test the pinhole aiming to re-configure the camera

apparatus and make a record of the duration of a film maker's actions. Nightingale explained that the content for *Pinhole Film No 1* was driven by a question of 'I wonder what would happen if?' and how much the image would be de-stabilised under lens-less conditions. She commented that the work is presented as a black and white negative, 'because I never made a positive as I actually didn't want any colour, I enjoyed the de-familiarity of the image' (Nightingale, J. (2018), interview by Williams, L., London 22 October). The notion of de-familiarisation intentionally makes forms difficult to perceive and challenges what one takes as real and is fundamental to a materialist film approach. At the time of making this film she said she had little prior knowledge of this approach and of how her work aligned with similar practices in film. However, she acknowledged that Stan Brakhage's camera-less movies developed as an inspiration (ibid). Speaking to Jennifer, it was clear we had had similar art school backgrounds, both starting in fine art departments but moving into a practice involving experimental photographic techniques and film. Both our practices have been characterised by an engagement with lens-less capture but there are some differences in intention and technique.

Figs. 6-7: Stills: *Pinhole Film No 1* (2001)



For *Pinhole Film No 1*, Nightingale's Bolex 16mm camera had a hand-made pinhole aperture in place of a conventional lens and captured images via whatever variable light sources were available. The effect on screen is of uninterrupted blobs swimming across the picture plane, shapes that move and fuse as the camera (and implicitly the operator) seems to travel towards a window or doorway and the image appears to tilt up and away by 180 degrees confusing any idea of stable spatiality. The film is a series of moving semi-abstract shapes but once one is accustomed to seeing these in negative form, one can discern or imagine recognisable shapes; for example, corridor lights or light fluctuating outside window frames. As film maker Nicky Hamlyn describes it in *Film Art Phenomena*, 'Pinhole Film No 1 is consistently out of focus … but not so out of focus that it is ever so divorced from its subject that an illusory deep space can be read' (2003: p.37).

Technically Nightingale and I have had a similar approach to shooting with pinhole working with its various restrictions and I felt we shared a certain intuitive response in which camera position allows movement and effect to play out with as little interference as possible from the camera operator during production. Nightingale sees movement in this work as gesture which produces optical effects, and as evidence of the film maker's action directly affecting the surface. Nightingale stated in our interview that she 'was

interested in the ontology of the photo image and of the contact of light on material of the film strip' (ibid). Nightingale has elsewhere stressed the importance of the trace of the presence of the artist's gesture in this process (Rogers, 2015 p.52). In this respect, I diverge from Nightingale's approach for although I too am both operator and director, for *LoDI&II* I made the decisions on where to frame, how long to hold a shot and allowing random light change and movement to stay in frame. I tried to avoid any obvious trace of gesture which I felt might function as a distraction.

Although Nightingale and I share an appreciation of the haptic qualities of pinhole capture: soft focus, muted colour and a certain textural surface and the de-stabilising of the representation of space, Nightingale's intention is that *Pinhole Film No 1* is a material experience but one I would suggest, that is somewhat detached from its source i.e. it seems of little importance where exactly the capture was made. My method in *LoDI&II* was comprised of mostly static framing allowing movement and action to occur in frame according to the light levels and the live situation, yet for my video site-specificity was all important. Thus whilst shooting over several occasions in Venice, using the pinhole aperture became a kind of conduit for whatever might randomly occur at chosen times and locations, and the shoot evolved accordingly into a visual and textural impression of the Venetian environment. Nevertheless, the materialist approach which underpins Nightingale's work was important to acknowledge as one to which my work is related.

The idea of transmitting a sense of a particular place through the quality of pinhole continued in the making of a second pinhole video, *Billy Goat Hill* (2018), shot in summer in the hills above the city of San Francisco. This was a next step on from the framing and approach of *LoDI&II* and was a more fluid piece creating movement using the camera as a pivot, turning and capturing an open-air scene in 360 degrees - its resulting free-form approach in *Billy Goat Hill* was thus closer in sensibility to Nightingale's work.

3.2.3. Jason Joseffer

Work in focus: Music video, '*On the Road by Seth Lael'* (2016) 3' 34" B&W pinhole video) Available at: https://vimeo.com/189262812

Permission given for use of images and screenshot.

Jason Joseffer began work in 2005 as a news cameraman, an area he soon left to pursue working on films. Currently Joseffer works professionally as a cinematographer shooting films, documentaries, music videos and commercials. His interest in pinhole imaging started in high school but when he became a cinematographer he realised he had an opportunity to experiment with digital cameras and a pinhole aperture. Joseffer approaches digital pinhole imaging in a playful and experimental manner which is the complete opposite to his professional practice that is concerned with high definition video imaging. He is receptive to and revels in pinhole's 'soft' focus and this has led to attaching his own bespoke pinhole apertures to other forms of camera i.e. one attached to a drone to test how lens-less imaging might be captured with maximum light in open sky. In 2016 Joseffer produced one of the first examples of a professional lens-less video (*On the Road by Seth Lael)* and having discovered it, I realised it was important to understand how it was achieved and investigate his process. This started with his manufacturing of bespoke machine-tooled pinholes for use with high-end HD cinematography cameras (Fauer, 2017). In my interview with Joseffer he explained,

> with the advancement of digital sensors and low-light sensitivity I had the desire to test pinhole in motion picture photography…My first experiment was to drill a precision hole into a Canon lens cap. The results were poor and I learned that the thickness of the material to drill the hole had a direct result on the clarity of the image. At the same time a musician friend expressed the desire to shoot a music video and his song had a nostalgic feel which seemed in tune with the images my tests had provided. I realised that a lens built to industry standards would be necessary to work with the speed and precision I wanted. I machined a variable focal length lens (25, 50 and 75mm) with a rotating aperture wheel. This allowed speed and accuracy while filming (Joseffer, J. (2018) Interview by Williams, L. San Francisco 28 October).

Fig. 8: Component parts of Joseffer's variable focal length pinhole attachment

Before I met Joseffer I had considered trying to make a similar adjustable pinhole lens which would give different focal lengths but I realised that I did not have the expertise or the access to machinery to be able to create this type of housing. So I was pleased when I heard that he had been able to make one to fit his own camera. His production of variable focal length pinholes for digital cameras actually constituted a considerable step forward in pinhole moving image, and the fact that this was achieved by a cinematographer with technical knowledge of the latest developments in digital image capture, rather than an experimental artist was, I felt, significant for pinhole's future capability. In his music video, *On the Road by Seth Lael* Joseffer employed his variable focal length pinhole aperture which allowed a flexibility of shots and added to the static wide angle view common to a fixed pinhole aperture,

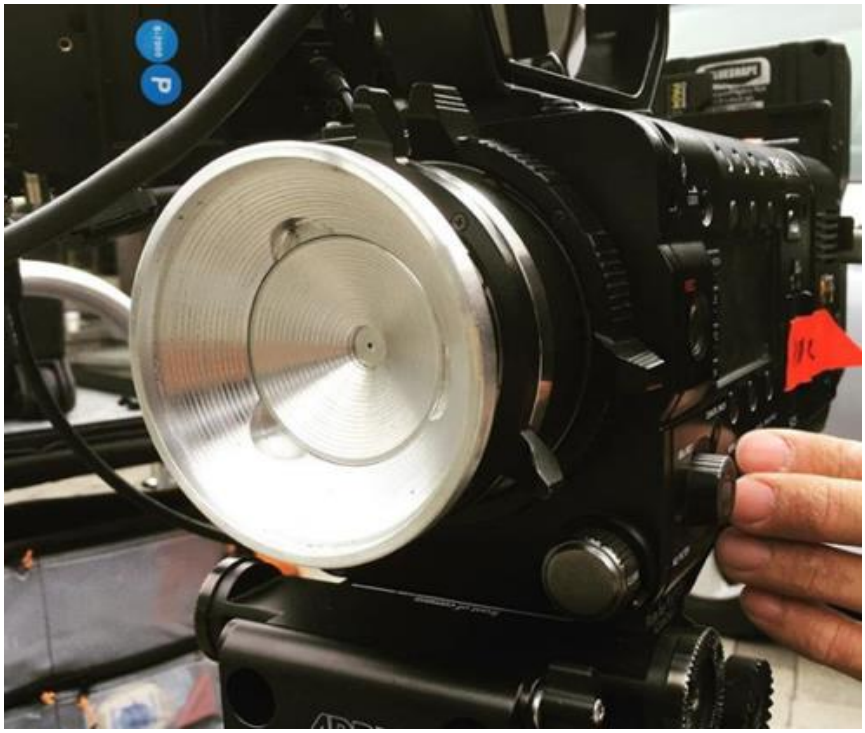


Fig.9: Joseffer's 75mm pinhole aperture camera attachment.

For *On the Road by Seth Lael*, Joseffer eventually de-saturated the video footage to black and white explaining that this conversion added to the song's nostalgic feel as the songwriter is shown wandering through the older and new parts of San Francisco. Referring to this aspect of pinhole image as nostalgia, I asked him in an email correspondence if pinhole could be used to go beyond its perceived nostalgic effect. He replied that,

> I agree that lensing a film with pinhole lenses is not only necessary to achieve nostalgic tones. While I did use it for nostalgic effect which felt justified by the nature of the song I feel that pinhole cinematography has potential to achieve a wide range of emotions. Pinhole bends reality and presents the world in an exciting and new light (Joseffer, J. 2019, personal correspondence, 1 April).

Joseffer's idea of bending reality relates to Nightingale's de-stabilising of the representation of space. However, as no actual image distortion occurs in pinhole capture as it does with a lens, it is perhaps that we just accept the sharp lensed image as closer to a notion of the real. In relation to the use of pinhole for nostalgic effect. I had tried to avoid this in *LoDI&II* by laying emphasis on the textural quality of the images,

moving towards a more sensory effect and as regards de-saturation of colour images for effect, I felt this did not suit my concept and would only ‘historicise’ images of Venice, a city already defined by its very existence as ‘old’.

Fig.10: Still: Joseffer*, On the Road by Seth Lael* (2016)

Joseffer further raised an interesting point about imperfection, responding to the effect of the pinhole soft focus commenting, ‘What I enjoy most about pinhole is its imperfection and ability to surprise. The Japanese expression of wabi-sabi feels most appropriate’ (ibid). Wabi sabi, which I understand as a semi-philosophical approach which deliberately leaves an object slightly unfinished or created in its simplest form, might be difficult to apply to the ephemeral moving image. However, that ability to surprise which Joseffer mentions, might rest in appreciating pinhole’s image imperfections when compared with our expectations of the perfectly focused image.

Because of the transitory (and in my opinion perhaps maligned) status of the music video it may appear problematic to include *On the Road by Seth Lael* for comparison with my work alongside the other practitioners selected. My own lens-less work and that of Harris and Nightingale all exist within the field of artistic moving image, while Joseffer’s music video exists in the arena of streamed promotional content and mainstream cinematography. Nevertheless, its application in this form shows versatility and indicates potential for use in narrative film. Joseffer’s pinhole attachment allows a variation of shots more common in film language, concentrating further attention on pinhole video’s soft image and visual texture. Although *On the Road by Seth Lael* may be perceived as lacking the cultural significance of video art, it is nevertheless a first

example of a digital pinhole video which has reached a wider audience. Additionally, Joseffer expressed some optimism about future possibilities:

> I hope to shoot a feature length film entirely in pinhole someday. I'm drawn to the mystery and imperfection. I would love to explore the medium as a long form and explore the language pinhole yields. I'm curious how an audience will respond to a feature length presentation in pinholes (ibid).

In relation to the visual impact of pinhole films, he commented,

> Once the shock of its beauty wears off and is normalised, perhaps its organic perception of the world will take on a new meaning. Just as your ears adjust to the quality of sound from good or bad speakers, I too think the eyes will adjust allowing pinhole to move away from drawing attention to itself and move towards the subconscious (ibid).

I recognise that the effect of soft focus filters has been an important cinematic device, for romantic sequences or to offer a sense of the surreal as in *Jacob's Ladder* (1990) but the notion of pinhole as the sole medium for a conventional film would, I feel be a challenge for most viewers. Nevertheless, Joseffer recognises and welcomes the creative qualities of pinhole video and I am encouraged that this recognition came not from an artist practitioner but from a cinematographer located in a commercial context. Each of the three practitioners offered me different perspectives on the small field of pinhole moving image. Harris and Nightingale conveyed an artistic sensibility and accumulated knowledge of the history and their place (echoing my own positions) in relation to experimental film; whereas Joseffer offered an advanced, practical technical approach whilst demonstrating a desire to be more visually expressive. Harris and Nightingale position themselves as artists within a continuous practice in experimental film, particularly the breaking down of image into pure forms, with visual elements achieved either in-camera or in the manipulation of the physical film. The expansion of the nature of the image is evidently an enduring preoccupation for both. Although Harris is engaged predominantly in re-interpreting alternative Black American histories in a poetic way, in *Sunshine State (Extended Forecast)* he uses pinhole moving image to reflect on a personal theme about where he was living and his subjective response the physical nature of the place, its heat, sunlight, colour. However, Harris subtly undermines the oblique autobiographical aspect through a dissonant soundtrack, which

allows the audience to imagine the pinhole images are not quite what they seem. His stated aim is that the viewer must hold in their mind this sense of contradiction within the film.

Nightingale's entire practice is engaged with the nature of the image captured outside of conventional methods. Her film *Pinhole Film No 1* uses pinhole's qualities to suggest pure form and an almost tactile sensation with an emphasis on the capture as an expression of artistic gesture. The source for the images is in a sense somewhat detached, its specificity matters not and together with a decision to leave the film in its raw negative state what is generated is a kind of dreamy abstraction which plays with the viewer's perception of space. However, the film was made as a first experiment not a finished piece but one which led Nightingale to a sustained practice using pinhole film capture. To some extent, *Pinhole Film No 1*'s status as a first artistic experiment has made it difficult to compare with mine and the other two pinhole pieces considered here. Nevertheless, it resides in an artistic practice which compels the viewer to consider more closely what is represented.

Joseffer is a professional cinematographer and his contribution is both the invention of variable length pinhole apertures as video camera attachments and their use (albeit in a conventional narrative way) within *On the Road by Seth Lael*. Joseffer is interested in the temporal aspects that pinhole can add to a narrative and this is emphasised by pairing pinhole soft focus with an intentional desaturation of colour in his video. This modest music video is I believe genuinely ground-breaking as a digital pinhole work, and demonstrates how pinhole capture might expand into long-form narrative work. The variety of capture his variable focal length pinhole offers is an important step for the future of pinhole as a medium for both video art and mainstream cinema. The latter as a possibility was borne out with a recently announced initiative for an 18mm-36mm pinhole zoom lens offering even more flexibility for shooting a cinematic effect for pinhole capture (Artaius, 2019). Although aimed primarily at photographers and enthusiasts, this zoom lens could become an important addition to pinhole videography as it allows the camera operator the flexibility to capture tighter shots or close ups and frees pinhole video capture from its somewhat static framing. That this 'new' piece of kit was being launched at all indicated an interest and scope for taking pinhole capture further and will likely be useful to both artist-practitioners and professional

cinematographers such as Joseffer interested in unusual ways to capture moving image.

A review of the work of these three practitioners and consideration of their methods as artists and film makers, led me to understand how my lens-less video work might be situated in this small sub-field of moving image. In relation particularly to *LoDI&II*, I identified these elements in common with all three practitioners: a lyrical sense of place and atmosphere of Harris, the fluid semi-abstraction of Nightingale and, in Joseffer, an indication of how much more dynamic using variable focal length pinholes could be. In considering how their work converged with my aspirations for digital pinhole practice, I discovered a resonance with their concerns and I felt to some extent that I was somehow bridging the two areas of the artistic and the commercial. What linked us all was an expressed intention to expand the visual effect of moving image using a pinhole technique, to make the viewer re-interpret what they are seeing in an imaginative way, perhaps to prompt awareness of that perceptual gap when images are not quite in focus. This is not a new idea in the context of previous moving image experimentation but perhaps it was the aspiration which connected all the works considered here and an agreement that the imperfect quality of pinhole might offer something lyrical, mysterious even working subconsciously to affect the audience. Soft focus as conventional cinematic device has long been employed to connote dreams, romance and the surreal and one of the assertions of this study is that the similar qualities of the pinhole image will add similar subtleties to moving image work. This comparative study of the work and the approaches of the above practitioners was of significance for me as it supported some of my assertions for the creative potential for pinhole capture and offered me a sense of being part of a small but meaningful field of practice.

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Chapter 4: Research Context Pt II: Technologies

In Chapter 2 the project was positioned in relation to the relevant methodological and theoretical models while the artistic practice was discussed in Chapter 3: Research Context through a comparative study with a group of my peers working with pinhole moving image. Chapter 4 explores the secondary research question via an investigation of the current scientific developments in technological imaging, particularly motion capture. The chapter considers the world of artistic and scientific imaging in parallel in an approach which my research has revealed as quite unusual in the field I have been investigating.

4.1 The Camera Obscura and moving image

In order to contextualise the pinhole video technique it is necessary to trace a history of its forerunner the camera obscura. The purpose here of a 'history' is to understand the camera obscura within a broader context of changes in perception and its place in relation to the development of moving image capture.

Concentrating particularly on the camera obscura in relationship to the moving image, one of the first mentions is by Renaissance polymath Giambattista Della Porta who, as early as 1558, wrote about 'natural magic', recommending a walk-in camera obscura for presenting projections with a convex lens for inversion that could transform both objects and people into moving pictures, even citing its potential use for theatrical productions (Price,1957: pp.364-5). This fitting of the lens eventually led Athanasius Kircher (1602-1680) to convert the camera obscura into a dual lens-magnifying projection device, which in turn much later led to the Magic Lantern. (Elsaesser, 2016: p.202). After the Renaissance, the camera obscura became an important device for painters to envision and directly draft exterior scenes for artworks. As discussed in Chapter 2, David Hockney stresses this aspect of the device as a key moment in the departure from the binocular vision of human eyes to monocular vision, a significant change which, along with the impact of the optical effect of its wide-angle view, led to the development of the rules of Western perspective.

As emphasised by Williams Uricchio in his essay, There's More to the Camera's Obscura Than Meets the Eye*,* the camera obscura has been,

> a metaphor for vision and consciousness generally, its use as a conceptual model for photography and film, and its specific application as a device for painting, suggest the term's range of meanings and its centrality to our culture (Albera et al. 2002: p.110).

The camera obscura's 'live' projected images had always evidenced the elements of movement and temporality missing from painting and in early scientific imaging, however exploration of these elements was being demonstrated simultaneously alongside artistic use. An example was its use in astronomy to study solar eclipses, the movement of the rotation of the sun and sunspots in 1610 by Galileo (Lefevre, 2007: p.26) achieved by projecting the pinhole image onto a screen i.e. the camera obscura in use as a live projective system. One could speculate that it was at this point that the camera obscura started to advance as an independent medium rather than simply a tool for artists. In the 1830s through its use for presentations of public entertainment and spectacle and as a projective system, the camera obscura became less an apparatus for investigating the nature of vision, and more an entertainment device. Tom Gunning's article, 'Hand and Eye: Excavating a New Technology of the Image in the Victorian Era' defines early visual technologies, the 'philosophical toys' of the late 18th century including the portable camera obscura, as pre-cinematic devices. A typical example of these 'toys' shown below is the Polyorama Panoptique device from the 1850s, with its adjustable lens with an opening lid as a light source to view painted, perforated image cards. It is part of the Werner Nekes collection of pre-cinematic artefacts, which I was able to view at the Getty Institute, Los Angeles during my field trip in 2018.

Fig.11: Polyorama Panoptique (Getty Research Institute Collection)

Gunning stresses that a variety of visual media had appeared over approximately one hundred years and ‘that the fundamental technology of ‘motion picture cameras, the film projector and celluloid actually emerged shortly before or during the 1890s’ (Gunning, 2012: p.495). Gunning explains how these visual media gave rise to a new phenomenon he terms ‘the technological image’ (ibid. p.499), adding that, ‘this phrase encompasses not only images produced by technological means but images that owe their existence to a device and are optically produced by it rather than simply reproduced (ibid. p.500). This is an important point, one which Gunning delineates as ‘a broad transformation in the nature of images, of which cinema was one development’ (ibid. p.495). He comments that this transformation was gradual one, which continues today within new media, and asserts that, ‘Modes of representation and narration become radically revised through new interfaces with the processes of perception and the precision of technology’ (ibid p.495). Gunning underlies the importance of the reception of the image generated by these new devices, pointing out these first technological images were often displayed as a ‘novelty’ or as part of ‘popular science’ but that they also changed the viewer’s perception offering a double grasp of both the device and the image. With reference particularly to the camera obscura Uricchio put it thus, ‘the camera obscura has three main features: The viewing subject is in a fixed location, hidden from the world; the viewer's relation to the world is spatially contiguous and temporally simultaneous; and the viewing subject is at the center of the world viewed’ (ibid. pp.111-12). Gunning argued that the similar qualities of these imaging devices meant a richer experience for the viewer and transformed them into a perception maker by directly addressing them and generating a conscious awareness of the production of the image.

This concept is further developed by Jonathan Crary, whose theoretical work in this area forms part of arguments explored in Chapter 2: Methodology. For Crary, the camera obscura was linked conceptually to the philosophical debates of the Enlightenment and was not necessarily a creative tool, but one that led to the realisation of a visual conception which excluded subjectivity in the production of images. Crary discusses its part in the development of perspective in images, which introduced the role of the observer into a new relationship, one in which the projected live image conveyed a sense that what was being seen was actually ‘there’.

Crary comments that,

> the camera obscura defines the position of an interiorised observer to exterior world, not just a two-dimensional representation, as is the case with perspective. Thus the camera obscura is synonymous with a much broader kind of subject-effect: it is about far more than the relation of an observer to a certain procedure of picture making. Many contemporary accounts of the camera obscura single out as its most impressive feature its representation of movement (1990: p.34).

This new understanding of the position of the observer and the simultaneous temporal awareness of the device and image was integral to the effect of early projected moving image devices, including the camera obscura. Awareness of this duality remained evident in the much later practices of early twentieth century avant-garde artists. Indeed, this concept remains present in modernist positions as well as in contemporary conceptual approaches of many moving image artists, those which direct attention to the experience of representation.

4.2. Perception and new technologies

The combination of aperture and lens gave birth to the art and science of analogue photography and eventually film. Although both elements have remained central to image capture, the important factor for this inquiry has been that new technological assemblages are challenging the previous necessity of a lens to produce an image. Although these new assemblages have arisen from the commercial sector, they are not necessarily separate from artistic applications such as my pinhole technique, because they are driven by an exploration of how light and images are captured to expand human perception. The conventional expectation is that those working in technological companies are solely working to tight commercial briefs. However, they are in fact researching how light behaves in a number of contexts, often revealing the visible within the invisible. To address the secondary research question of the potential parallel of digital pinhole capture with these new imaging technologies, this section investigated some of their features which are analogous to my work. The focus was particularly on Lightfield technology for its facility in moving image, achieved via multi-image three-dimensional capture of all the light rays travelling in all directions. Lightfield technology represents a completely innovative way to generate an image especially for motion capture and genuinely breaks new ground.

In order to appreciate similarities between my digital pinhole technique and new types of computational capture, I consulted both published and online scientific material and via the 3D3 Student Development Fund, I was able to attend the 2017 Camerimage Cinematography Festival in Bydgoszcz, Poland to meet cinematographers and update my knowledge on developments in computational capture for the latest professional cameras. I also attended the British Society of Cinematographers London Expo for new 'kit' in both 2018 and 2019 to ensure further awareness of new advances in image capture. Researching new technologies, especially those either not dependent on a traditional lens or which sought to replace it, led to me to scientific image capture generated by new types of data. I realised that a common element with my pinhole video technique was that new forms of computational capture were challenging the definitions of the assemblage of the 'camera' and consequently expanding the idea of what constitutes an image.

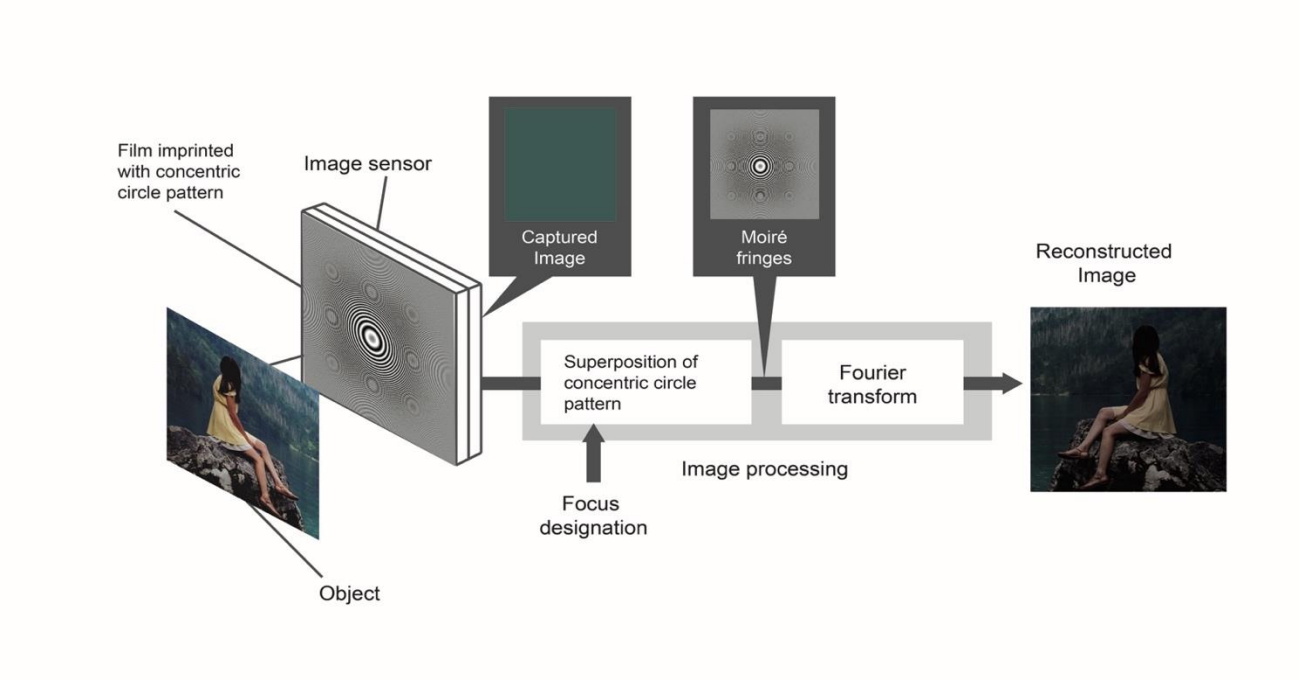
Examples I found that were particularly relevant are the advances in optics that have been achieved within scientific laboratories such as the Camera Culture Group at Massachusetts Institute of Technology (MIT) Media Lab. New tools to capture and share visual information more effectively are being pioneered, driven by the aim 'to create an entirely new class of computational and sensory platforms that have an understanding of the world that far exceeds human ability and produce meaningful abstractions that are well within human comprehensibility' (MIT Media Lab, 2020). The Camera Culture Group works across a number of disciplinary areas and its innovations in optics include the development of a trillion-frames-per-second movie camera system to track how light pulses across a scene and observe aspects which are invisible to a normal camera (Hardesty, 2011).

Another important technique is the lens-less 'camera' developed in 2016 by Hitachi engineers. This is less a camera than a device which replaces a lens with a series of moiré[12] patterned printed meshes to give patterns of light to be realigned in post-production. This mesh capture felt analogous with my pinhole technique because no lens is involved and the mesh itself could be seen as an array of tiny entry points of

[12] Moiré patterns or moiré fringes are large-scale interference patterns that can be produced when an opaque ruled pattern with transparent gaps is overlaid on another similar pattern.

light gathered as patterns on the sensor to be re-constructed entirely in post-production. The illustration below explains the placement of the moiré mesh and the means by which the image is reconstructed after capture and includes in the final processing a Fourier transform, a mathematical technique for converting a time function into one expressed in terms of frequency.

Fig. 12: Hitachi's lens-less camera operation



However, more relevant to my inquiry was 'compressive sensing', a computational means of reconstructing an image but obtained from very small amounts of data. This drew my attention as having a potential relationship to the pinhole aperture. The technology affords the appearance of a new class of lens-less imaging device. No longer taking the form of a 'camera', this technology employs glass at point of light entry but the glass is not there to direct the light rays in the normal fashion and here is merely a part of a device housed in an assemblage comprised of just two elements: a Liquid Crystal Display (LCD) panel that acts as an array of apertures, each allowing light to pass through to the second element, a single light-sensitive sensor which detects light in three colours. The multiple individual apertures can be opened and closed at random, transmitting new light data each time in each configuration to the sensor. The image is then re-constructed by computer by matching batches of data captured by the various

patterns of opening shown below. The quality of capture is exactly as shown i.e. image is slightly soft focus at the 2016 stage of the development at Bell Labs, USA.

Fig. 13: Compressive Sensing Device (Image: PetaPixel 2013)

This type of image capture had I felt a resonance with my inquiry because it operates as a kind of dynamic multi-pinhole where the light rays are not bent as they are with the action of a lens, but captured by passing through the variable opening and closing of the apertures. In compressive sensing, the light capture is re-constructed computationally to produce a single image in focus across the full plane - this is essentially the same as that which occurs in the single pinhole capture in my video technique. Thus, compressive sensing appeared to me not as mere homology but one that, along with Hitachi's mesh capture, employs an analogous technique to achieving capture beyond the single lens.

Compressive sensing led me to Lightfield or Plenoptics, a technology in which an image is achieved by an array of tiny lenses to create multi-view point imaging. In this technology light rays initially pass through a single lens which uses a wide aperture and then through to each of many thousands of micro lenses, after which they hit a sensor. By calculating the path between each micro lens and the sensor, the precise direction of every light ray in a scene can be reconstructed. The technology essentially uses all data of the available light in a scene to separate objects by depth and store them in a three-dimensional grid. The innovation is that in post-production all of the objects in the scene can be selected for framing, for re-focusing and altering the depth of field. In Lightfield, the image is a three-dimensional representation of how light actually exists in the real world and thus is very close to how the human eye perceives it.

My research firstly revealed the existence of a Lightfield 'Lytro' brand stills camera, which appeared in 2014 (Cade, 2014) and was introduced at consumer level as the very first camera with re-focus and depth of field capability post-capture. However, it achieved little commercial success due to its awkward design and operation and eventually failed despite modifications. The example shown is a still image derived from its micro-lenses, with the 'bug's eye' view: each micro lens offers a slightly different view of the same scene. In Lightfield technology each image can be re-focused computationally.

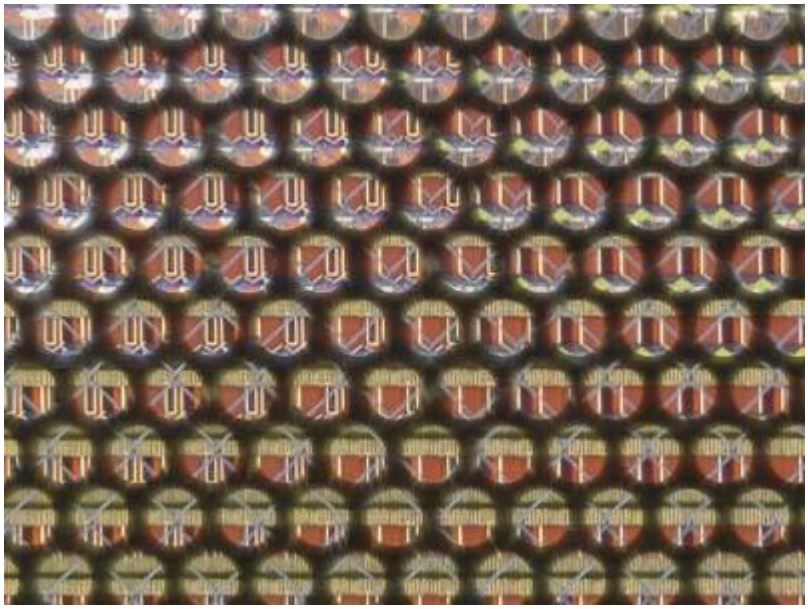


Fig.14: Lightfield multi-lens view. (Image: Lytro 2016).

Despite the failure of the Lightfield stills camera, I was interested in the potential of Lightfield for moving image application and gained a contact through a colleague for a Lightfield cinematographer who had worked closely with the technology. Thus the area was more fully revealed when I undertook a US field trip in 2018 and interviewed respected Hollywood cinematographer David Stump, ASC (American Society of Cinematographers), who pioneered the use of Lightfield imaging in motion capture. Stump has worked on numerous motion pictures and television productions as a Director of Photography and as Visual Effects Director of Photography. He is an active member of the American Society of Cinematographers' Technical Committee and of the Academy Color Encoding System (ACES) Project. As Stump explained in our interview, he became one of the first cinematographers in Special Effects to work with Lightfield in 2016 and gained intimate knowledge of its operation. He was thus able to provide me with exceptional insight into Lightfield's development, emphasising the complexity of its computational capture thus,

> Lightfield technology captures a mesh of light rays and a widely varied mesh of rays from multiple apertures – the more the apertures the better but this is not a trivial amount of calculation in post-production because what shows up on these multiple apertures are (depending on number of apertures) hundreds or even thousands of little out-of-focus images of the same image /scene from view different positions in space (Stump, D. (2018) Interview by Williams, L. Los Angeles, 3 November).

It is then possible to determine where the light ray would have struck if the focal plane had been moved and moving the focal plane is like refocusing a lens, so any point in the light field can then be brought into sharp focus. In other words, images can be refocused after capture and crucially the relative position of the camera can be changed.
Stump added that,

> Ultimately one of the main values of doing Lightfield photography is that you know the position in space of every derived pixel which makes them something more valuable especially to us in motion imaging, because they become volumetric pixels or voxels[13] so you can derive from the info/ light arriving from the scene to the sensor the depth of any particular point within the scene (ibid).

This versatility indicated great potential for both conventional moving image and new visual forms such as volumetric capture (see Glossary). For cinematography, Lightfield settings could not only be altered to re-focus, re-position and re-colour the image from a huge number of viewpoints, but they also allowed the creation of shots which would be physically impossible, dangerous or in challenging environments where using a lens might be problematic. The technology also reduces any need for re-shoots and offers an abundance of light data to calculate for example, a 3D camera track or a re-master of footage for different formats or frame rates. Lightfield capture offers what one could term a dynamic transformation in conventional fixed camera settings. As Jim Thacker (2016) notes, 'The resulting output is not limited by the physics of a real lens, or the capabilities of a real camera operator'.

Stump further explained that in 2016 Lytro offered him use of their 1200lb Lightfield Immerge cinematography camera which he installed in a specially constructed studio and where he and others made '*Life'* a short experimental video captured with the Lytro Cinema system. He described this video as a mini-narrative video which tried out a number of experiments to stretch the boundaries of what could be achieved with both Lightfield cameras and other cinema cameras.

[13] A unit of graphic information that defines a point in three-dimensional space where the coordinates are defined in terms of its position, colour and density.

Fig.15: Lytro Immerge Camera with its multi-lens array generating light data which involves a huge amount of post-capture calculation. (Image: Lytro, 2016).

This experimental video (no longer available for public viewing) demonstrated the huge flexibility offered by Lightfield capture as Stump noted in 2016 in an ASC Magazine online article,

> the depth data that Lytro Cinema affords is remarkable. It will give us the ability to generate 3D movies from a single camera, with left- and right-eye points of view from the same lens; to derive depth information to generate 3D in-camera far more accurately. All of these creative capabilities, along with the many tricks with focus that can be done in post using synthetic depth of field, introduce so many new possibilities to filmmaking (Stump, 2016).

Stump further spent part of a year setting up a designer and a company which could re-house this Lytro camera, and built a moving platform to move it around for shots. But despite hopes for its application within the film industry, ultimately its bulky assemblage, huge data load (of 755 megapixels in the case of the seven-minute video, *Life*) and complex computational processing were seen as a disadvantage. In 2018 Lytro closed down operations. Regardless of this outcome, Stump explained that such was the interest that other companies, including Google, immediately acquired Lightfield

apparatus and employed Lytro's top engineers who are currently further developing the technology over a number of its platforms. Stump was disappointed by Lytro Cinema's failure especially for its use for cinematography but reflected that, 'the value of Lightfield has not yet been realised fully on a commercial basis'. He also stated that, 'Lightfield motion imaging is a tiny, tiny piece of the overall photographic market and things like cells/mobiles is where it is likely to turn up first or in satellites in space where they are pointed at Earth for specific reasons or pointed to the heavens for other reasons' (ibid).

Stump suggested that it would be useful to look into some background information on the origins of Lightfield as a means to achieve multiple images of a scene in one capture. This form had a precedent in a technique developed in Paris in the early 1900s by a Nobel prize-winning scientist, Gabriel Lippmann. Lippmann proposed 'integral photography' or three-dimensional imaging via small lenses each cut into a square shape, fitted together onto one surface mounted in front of the camera body. Each mini lens would transmit light to a photoplate as a number of similar images, each from a slightly different point of view. The aim was to produce photographs, which meant that using a special viewer the observer could experience a changing view when moving their eyes horizontally and vertically. This is known as parallax, the optical effect of a perspectival shift of view without any change in the position of the viewer. Lippman's approach presaged stereoscopy and especially three-dimensional imaging, which was subsequently revived as holographic imaging in the 1960s. His work offered a similar multi-image comparable to a bug's eye view, exactly as it does in Lightfield capture.

I have given a detailed account of Lightfield capture and of the observations of David Stump in this chapter because I contend that Lightfield imaging has parallels with my pinhole video technique. Primarily both technologies represent a radical departure by discarding the traditional single lens or viewpoint altogether and thus they effect a fundamental alteration to the assemblage of the camera, one which has held for more than 100 years. In common with the other lens-less devices I have cited here, both Lightfield and pinhole video eschew the single lens and gather 'raw' light as material to be manipulated computationally to produce the image. In the Lightfield camera the image is achieved through a multi-lens array generating an abundance of all the 'raw' light rays as data which permits a huge range of possibilities post-capture. In the pinhole video technique the light capture is 'raw' unmediated by a lens and although also

obviously comprised of data, this ‘raw’ capture allows practitioners to work creatively and flexibly with pinhole’s particular visual qualities in the post-capture process.

Although in a digital camera the sensor operation is the same whether using a pinhole or a lens, i.e. individual pixels as light-sensitive elements record the light that hits them as a signal, every digital camera has an in-built micro-processor and software which controls the function and settings embedded in the camera controls. The difference in pinhole digital capture is that one vital control, focus, is missing because there is no lens and thus no focus reading for the software to respond to. This means that in practice in the digital pinhole technique one is effectively bi-passing one of the camera’s main in-built functions. For pinhole practitioners, this can liberate image processing through data sampling from the sensor for more flexible control and response to the qualities of the ‘raw’ ‘unfocused’ pinhole image in post-production. This offers a range of possibilities both technical and creative which echoes those that Lightfield imaging affords.

Further, in relation to practical application, one of the crucial questions for me as an arts practitioner was whether advanced technologies like Lightfield might be available sooner rather than later to a wider public to experiment with creatively. I put this to Stump, who replied that Intellectual Property and copyright issues might affect usage initially, but ‘that the trajectory for this work to come to the public realm outside of military translates to a cycle of arrival to consumer level is about 12 years’ (ibid). I was surprised to learn of this cycle of transfer and felt it had clear implications for artist-practitioners such as myself who might want to start artistic explorations. When I further asked if there was a finite point which scientific imaging would eventually reach Stump replied, ‘Well, we are already there – we haven’t come to a stop with the technology but there are inflection points now many directions to go in’ (ibid).

The camera as human eye as an analogy of photographic vision, which started with modern era of photography in the 1920s (Bate in Lister, p.81) but the idea of extending human visual boundaries seems to persist in a shared continuity of intent across many areas dealing with image generation. I felt that the inflection points Stump mentioned indicate there are subsequently many possibilities, to not just approximate or reproduce the features of human vision but to go beyond them with the aim of completely closing the gap between the visual experience and reality. This idea is not an original one,

indeed it is raised in Bolter and Grusin's assertions that the impetus behind every technological change is a desire for more direct contact with reality. The point here is that this closer connection with reality manifests as a drive to go beyond the limits of human vision both in the creative sphere and in scientific research, although these areas operate in very different contexts. Whether the optical toys of the 18th and 19th century, Lippman's analogue three-dimensional images in 1900 or the current digital multi-viewpoint image of Lightfield, these forms demonstrate that there exists a 'continuity of intention' to explore how light behaves often with no definite end in mind. I would argue that this intent has been present for decades in many imaging forms and devices and it exemplifies our endless fascination with optical phenomena which expand our perception of light, movement and colour. This fascination and the need to go further than the conventional boundaries of vision have been instinctively present throughout my practice but I only came to articulate this fully when I had situated my digital pinhole work within an impressive range of technologies being utilised in scientific imaging.

I had drawn on technical literature to compare the technique used in my pinhole video imaging with the wider world of lens-less capture and technological imaging and through this process I felt I had opened up a potential dialogue between these two fields. In stressing that an artistic practice of re-purposing of the camera can lead to new explorations of light capture and representation, I began to consider an exciting future convergence between the imagination of the artist-practitioner and preoccupations of scientific imaging developers.

At present, the most advanced imaging technology is in the hands of laboratories but in a few years, as Stump asserted, new devices and forms of imaging will be available to a wider number of people. This means that in the near future artist-practitioners will be able to incorporate ground-breaking technologies into their work, expanding their artistic vision along with new ways to disseminate the results. However, it is relevant to point out that artists do not simply adopt or integrate new technologies for their work. What they do, which departs from science, is to explore the particular features of a medium to express ideas. It is to be borne in mind that even the admittedly astonishing new technological developments described here are simply very superior tools for creating images.

A final point to make is that although my research revealed substantial factual material available on new image capture within scientific arenas, to date it appears there is little theoretical consideration of its wider impact on our perception of images. A further factor is that new developments in technological imaging are progressing with scarcely any time to reflect on them, which is worrying because our thinking and consciousness are perforce lagging behind. Although my thesis concerned the interface between artistic practice and a technological innovation, I felt it was at least important to have awareness of this lag without having to address it in great depth. The new developments are generating their own momentum of technological change however it is beyond the scope of this thesis to chart these developments.

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Chapter 5: Practice Experiments

This chapter explains the trajectory of the practical research and how the results were observed and reflected upon. The aim of the experiments was to establish that replacing the lens with a pinhole aperture could result in a functional moving image and to lay out the parameters for its digital capture. It describes and assesses the efficacy of the practical pinhole experiments undertaken in the study, what was learned and subsequently applied in the practice elements that form part of the thesis submission.

5.1. Part I: The Experimental phase

I realised that to evidence my assertion that pinhole video capture could be a new creative form, I would need to demonstrate to its qualities in action. In my original application for a doctorate, I had proposed applying pinhole moving image to works whose themes echoed some fine art genres. I felt this offered a kind of continuity because of the links between the camera obscura and its use by artists in classical painting. This idea was also allied to *Aperture*, the still life pinhole video work I made in 2014 with a basic home-made pinhole aperture, which could function as a thematic continuity in which calibrated pinhole apertures could be made, tested and applied to video work in genres such as landscape and portraiture.

In order to contextualise the experimental practice, it is important to understand the essential characteristics of pinhole imaging whose components encompass optics, mechanics and how ambient light behaves. With pinhole capture, the main characteristic is that every image has infinite depth of field, is a wide angle, has a softness of focus and has rectilinearity (straight lines in the scene appear straight in the image). The image can be sufficiently realised by establishing the optimal pinhole diameter for sharpness, which depends on the focal length of the camera, i.e. the distance from the pinhole itself to the sensor surface in a digital camera. However, if the pinhole aperture is too small, the image becomes less sharp because of diffraction, an effect which happens when the incoming light rays are bent around the edge of the pinhole aperture. Additionally, although a small pinhole aperture in principle can give a more focused image, it admits less light and the image becomes darker affecting the colour tone; conversely the larger the aperture the brighter the image but also the blurrier it can become. Thus, light levels are crucial and pinhole image capture always depends on the

amount of light available, size of aperture in use and the focal distance of the camera. The image quality derived in outdoor scenes can also fluctuate during ambient light changes and inadvertent effects such as rainbow flaring, which in the case of digital pinhole capture occurs as light bounces back from the sensor. These examples show the close detail achieved via a digital camera EOS 5D and 0.35mm pinhole in bright sun (permission given for use of these images).


Figs. 16-17: Sample pinhole stills

That both the device and its effect are identified by the term ‘camera obscura’ can create complications when consulting both historical and theoretical literature. As a device, it is usually shown as comprising a tiny hole in one wall of a darkened room through which light passes, causing a brightly lit and ‘live’ image of the scene outside the room to be projected onto a surface within. As a visual effect, the image that appears is upside down and reversed. A single lens or mirror is then applied correcting the image to upright view with either of these two additions boosting the low light throughput of the pinhole.

As previously discussed in Chapter 4: Technologies, I learned more on this aspect of the camera obscura image via David Hockney’s book, *Secret Knowledge, Rediscovering The Lost Techniques of the Old Masters* (Hockney, 2001), where he suggested our received notions of ‘perspective’ amongst other elements of visual composition have been conditioned by the use of a monocular lens in use with the pinhole aperture. I was influenced by the images he generated in pinhole recreations of classical paintings and an interest in referencing classical painting genres remained a creative thread in the conception of the subsequent pinhole video works. I was later able to appreciate directly the quality of the pinhole image when, as part of my research, I

gained hands-on access to two portable camera obscures owned by the seventeenth century painters Guardi and Canaletto as referenced to in Chapter 2: Methodology. In 2018 I witnessed the imaging effect of both these devices in a ‘live’ situation at the Museo Correr in Venice.

To experience further its effect and test different sized apertures, I set up my own version of a camera obscura in my room blacking out the only window on a bright day. As expected, the outside scene appeared back to front and upside down on the wall opposite the window shown below. I recorded the inverted pinhole image with a digital camera (left) and upended it (right) as shown below.

Figs 18-19: Images from self-made camera obscura

My experiments with pinholes and the reflection on the results were recorded in my worklogs over the first year of my inquiry when I combined my own self-produced pinholes discs with digital HD capture. This started as an initial improvisational practice through to testing in a more systematic manner. I had made previous pinhole discs for still photography from very thin sheet metal such as tin, but I decided to make my own discs from ‘brass shim’ – a thin but easy to work material used by sculptors when making and shaping plaster moulds. Using a range of tiny delicate drill bits, I made different sizes pinhole discs with apertures ranging from 0.3mm to 0.9 mm in size (twelve sizes in total). The manufacture of the pinhole discs undertaken at UWE’s technical workshops, was one of trial and error as I recorded in this extract from my worklog of March 2017 (edited for clarity):

The drilling of the holes was fairly tricky due the tiny size of the bits – I needed a magnifying glass to be able to attach them tight into the chuck and the very fine bits

repeatedly broke when not used carefully. In addition, because the brass shim is thin yet flexible, I had to separately cut out a solid Plexiglass disc to hold the brass disc flat and in place while scoring lines for an exact centrally drilled hole. I went through several sets of fine drill bits to finally achieve a range of apertures in the shim discs.

I understood from the science of pinhole capture that light passes through the aperture in nearly parallel rays and that any bend in the disc itself affects the rays distorting the image. So the surface of the pinhole disc needed to be ultra-thin, rigid and flat and although I considered the possibility of using other materials to manufacture my discs, I realised alternate sheet metals were too heavy or thick while plastics were too malleable or could shatter. Finally, I produced a set of twelve pinhole discs from the shim which I then flattened and I ensured the shiny surface of the disc was sanded on both sides to remove any problem with reflected light. I also made sure which the aperture itself was as clean as I could make it, this was crucial because any raggedness in the metal interferes with light passing through and results in partial blockage of light entry. In addition I made a number of discs with more than one pinhole (I posited this might offer a new multiple kaleidoscope-type effect) which might also test the point at which excess light might flood the sensor, resulting in an overexposed image. The manufacture of the apertures was a long process but was important because each stage was key to my learning and to developing my understanding and grasp of the technique. Examples of the drill bits and 6cm diameter shim discs and a multi-perforated disc are shown in the following images.

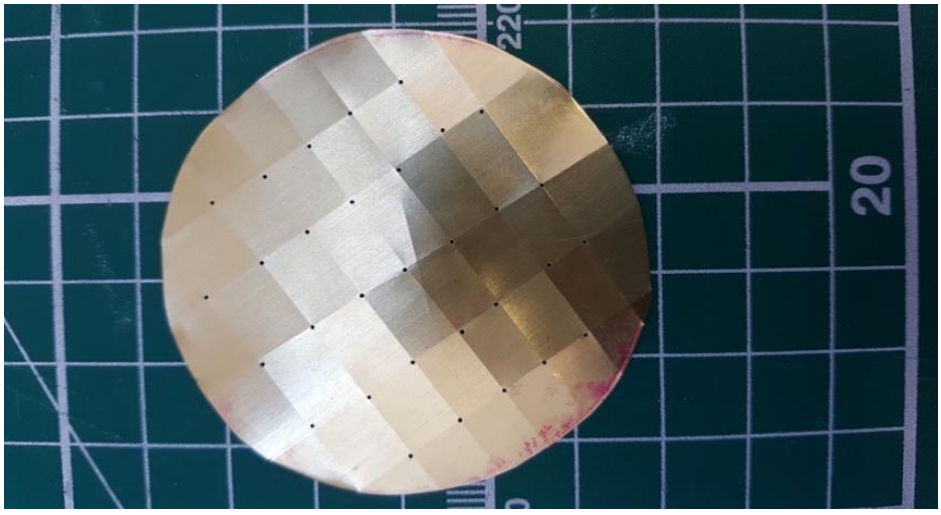


Fig. 20: Multiple aperture 0.4mm pinhole disc

Fig. 21: Making the first test pinhole discs from brass shim sheet (shown in a roll above right)

This extract from pinhole production worklog (April 2017) demonstrates further issues encountered:

I soon realised there was to be a complication which might limit the testing and this concerned an aspect of the mechanics of cameras I had not considered. I recognised after making a first set of discs to fit an EOS camera, that I might need to drill discs of different diameters for each brand and type of camera I wanted to test. The throat or opening to camera bodies seems to vary enormously although it might be possible be to attach the pinhole discs to a Metabones adapter (a commonly-used movie camera lens adapter ring) for some of the cameras. An alternative might be to consider building a metal housing which could accommodate discs of different sizes and which could then be attached light- tight to various camera bodies.

I also learned after a number of failed attempts that the distance from the aperture to the sensor was also important. An illustrative example was the Ursa Black Magic cinematography camera, which achieved an image using a multiple pinhole disc (thus allowing a better throughput of light). This extract from the same worklog reveals another problem raised with this camera:

The problem with the Ursa itself was the degree of sensitivity in low light (i.e. under restriction of the pinhole). This camera cannot be set to boost the image beyond the ISO 800 setting so there was no possibility to improve the capture even though there was adequate sunlight. An examination of the Ursa with its lens removed revealed that the sensor was placed further back from the camera mouth than previous cameras I have used i.e. a variety of DSLRs and the Sony FS7 and I learned that the proximity of pinhole aperture to sensor would also affect capture. (Ursa Black Magic test worklog, May 2017).

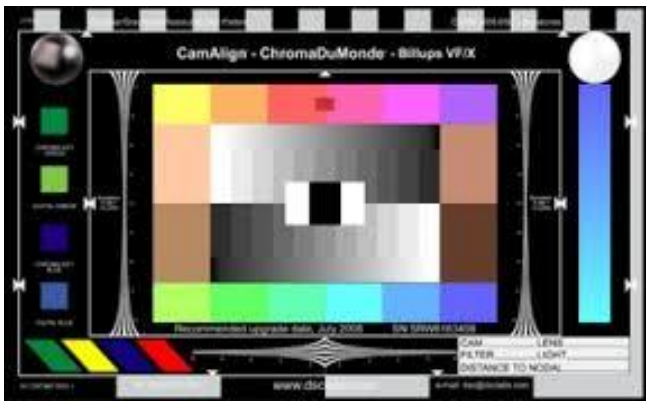
I realised through researching other camera specifications online for various video-capable cameras that the distance from the camera mouth (the body opening) to the sensor surface, known as the flange distance, actually varies considerably (Smith, 2016). This meant further complications along with the issue that the diameter size of each disc would also vary depending on the size of the body opening in each camera. An example is that the Ursa camera has 46mm body opening but the EOS 5D has a 40mm one, thus the diameter size is crucial if the pinhole disc is to fit light-tight and flat to the camera body. I acknowledged at this point that these issues further complicated the testing and would mean cutting out and drilling a new set of different diameter discs for each individual camera. I came to the conclusion that to test my pinhole discs (with the twelve different sized apertures) and to consider the flange distance from aperture to sensor, would mean testing with so many variables and thus be a long process with each camera model. Along with testing under exactly the same lighting conditions, I felt this process might produce more problems than results. Thus I decided to establish the most effective size of aperture in a smaller range of cameras, ones that were at immediately at my disposal (via the University and a film industry contact) and where the flange distance to the sensor was similar.

Thus I undertook the first series of moving image tests in Spring 2017 in a bright exterior at noon using just one video camera, the EOS 600D, to assess colour and tonal range as well as focal length in pinhole. This was achieved using a cinematography colour test chart and used 12 different size pinhole discs. I followed this with two exterior location tests with a 4K cinematography camera, the Ursa Black Magic and later I used a Sony FS7. With each of the subsequent set of camera tests, it became apparent that with these cameras the 0.35mm pinhole achieved the clearest image. What was learned

through the experimental phase is shown in the following chart from the test worklog: the imaging effect of different sized apertures in conjunction with a selection of digital camera types.

Table 2: Camera tests 2017

Canon 600D



Set at ISO 400 in sunny exterior (noon March 2017), using a CamAlign ChromaDuMonde chart – a standard camera testchart for cinematography. These tests were done with self-made shim pinhole apertures ranging from diameters of 0.02 to 0.90mm.

0.65mm aperture

0.50mm aperture

Ursa Black Magic Camera

4K Black Magic cinematography camera with self-produced multiple pinhole disc (0.35mm) 800 ISO (noon sun, May 2017).

Multiple (6) pinhole

Multiple pinhole (6) in full sun.

Sony FS7 Camera

2K camera, with 0.35mm self produced pinhole. 800 ISO (Venice, Aug 2017).

Canon EOS 5D

EOS 5D 1000 ISO with 0.35mm double etched pinhole aperture. Venice (Sept 2018).

Canon EOS 5D 1000 ISO with 0.35 mm bespoke pinhole. ext bright Sun (Sept 2018)

These examples are presented as an informal guide for others experimenting with pinhole video capture.

Although the results of the tests demonstrated that pinhole image capture was achieved with this small range of cameras, I realised that the enquiry was curtailed to some degree as access to the desired high specification cameras was not possible at the time of testing. Nevertheless, the range of cameras tested was broad enough to provide a general guide for other artist-practitioners wishing to explore the pinhole video technique.

A number of guidance rules for pinhole video capture emerged from these tests:

- Exterior scenes with graphic shapes and deep shadow contrast and bright colours work best for pinhole video. Scenes with soft colour or mid-greys do not capture well and can look muggy and indistinct. The framing of shots is made especially problematic if there is not sufficient contrast in the scene.

- The DSLR cameras and the other models I used have digital viewfinders and are not necessarily affected by parallax[14] so the scene framed does not perceptibly differ from the scene the sensor records. However, using a parallax viewfinder in film camera plus pinhole may result in slightly a different view.

- Multi-pinhole apertures give a multiple overlap effect (kaleidoscope-like) and these work well with bright sun and contrast in a scene, but in full sun multiple apertures can to flood the sensor with too much light.

- It is important to keep the sensor clean when attaching and dismantling a pinhole aperture: even a small amount of air can carry dust through the aperture to the sensor surface. Tiny particles can cast a shadow on the sensor and are captured as much larger as dots or squiggles on the image, although with care this can be advantageous if that is an effect required (it resembles dirty, scratched celluloid film).

[14] A parallax error occurs when framing through the viewfinder of the camera, the resulting image looks slightly different because the viewfinder captures the scene from a separate slightly different position to the camera lens.

- Some older models of digital camera were shown to shut down operation immediately when the lens was removed. Swopping off lens for the pinhole disc should be done quickly for this reason and in general to limit any damage to the sensor.

An unusual aspect I learned through the tests was that normally when light travels through a pinhole the image is captured as inverted and upside down, surprisingly in each of the tests with digital cameras the image displayed in the viewfinder (and thus saved to the camera memory) appeared in its upright form despite no lens being present. On checking the specifications for the range of cameras I used, I found that they use the internal mirror system which reflects light from the lens into the viewfinder. Clicking the shutter button, the mirror lifts up allowing the light in 'Live View' mode to continuously hit the sensor and in this mode that in pinhole video the image shows as upright. This indicated that the internal mirror was not instrumental in correcting what should be an inverted image in pinhole capture. I have not been able to account for this incongruity but it clearly makes the process of 'live' pinhole video capture less problematic.

After the testing phase I wanted to apply what I had learned in more direct and creative ways. So following on from the colour chart test I made a short video, *Hypnosis* [15] (see below) which offered a more experimental approach using a cinematographic black and white focus chart with a number of pinhole sizes. Each of the four sections was shot with different size pinholes ranging from 0.35mm to 0.5mm. Unexpectedly, it had a resemblance to the early optical films of artist Marcel Duchamp such as *Anemic Cinema* (1926) and to the 1930s abstract animations of Oskar Fischinger, all works which to some extent presaged visuals in computer graphics. This prompted further thoughts on the links between early avant-garde and contemporary forms in moving image.

[15] https://vimeo.com/214371828

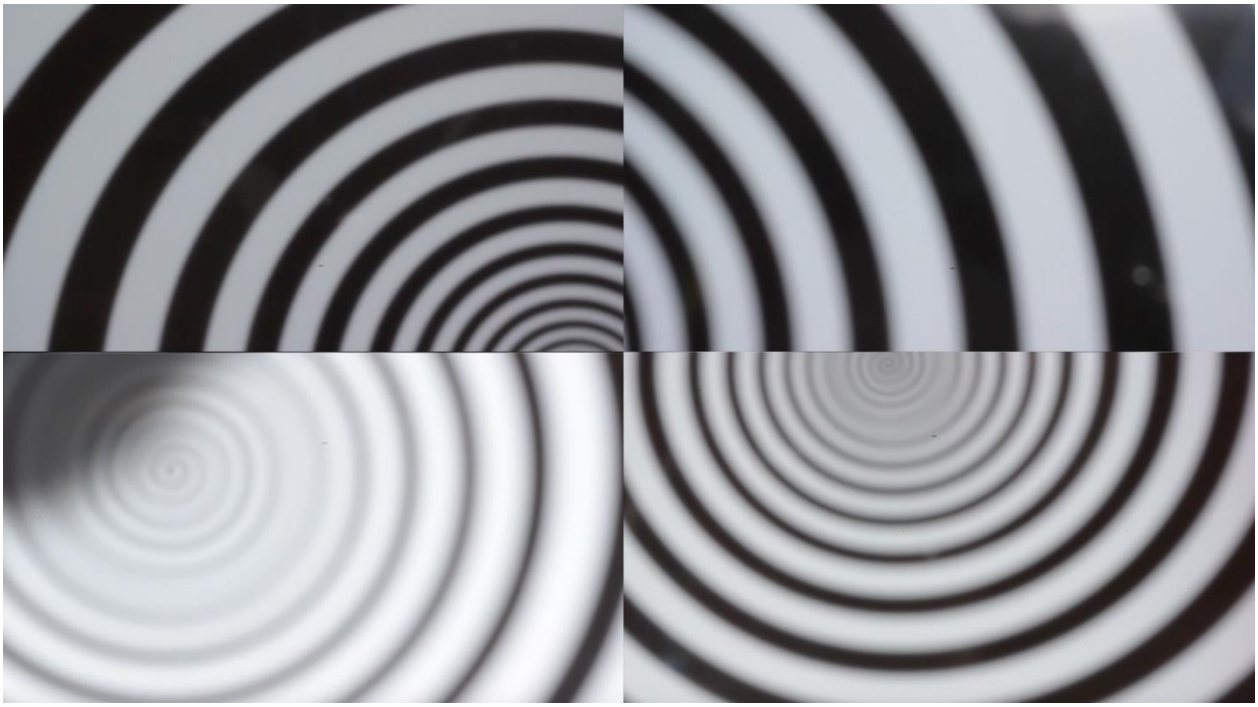


Fig. 22: Hypnosis (2017)

I continued with testing a variety of pinholes and shot a longer video experiment, *Spring Walk* (2017) [16], which was edited to contrast pinhole versus lensed capture. For this video, I intercut unlensed with lensed shots, the cuts timed to coincide with each footfall of the walker. This was an early iteration of the idea of combining and contrasting shots, later realised in the final video piece *Mouthpiece* made towards the end of the project. Ultimately, I learned that the 0.35mm pinhole was the most efficient and flexible for use with my available camera models and I commissioned a new diamond-drilled double etched pinhole in that size, which could be attached directly to any camera body as part of a common T-Mount camera fitting. This bespoke pinhole item was made for me by a specialist maker and, unlike my self-made ones, the disc was perfectly flat with an aperture that was accurate and clean. This was a distinct improvement and meant that light leakage and distortion was substantially reduced. I subsequently used this bespoke pinhole for the three videos submitted as the practice element of the thesis.

My experiments had indicated how important a powerful natural light source was to pinhole video capture. However, I wanted to expand the repertoire of possibilities and decrease the reliance on natural light, so I began to consider other light sources, ones

[16] https://vimeo.com/225081717

which were non-ambient but which might approximate the strength of sunlight. In mid-2017 as part of preparation for a work which would be entitled *Light of Day*, I started by videoing the light emanating from molten glass at a furnace in Venice with some success in capture. Afterwards I posited that with access to a similar heat source I might be able use pinhole to video the intense high temperature light emitted from molten metal in a crucible (worklog extracts on the subsequent shoot I undertook at a forge appear in Chapter 2: Methodology). I had an opportunity to try to capture electricity emitted as ultra violet sparks by a newly-constructed Faraday Cage, which I had helped to facilitate for a gallery show in London. This Faraday Cage was part of an art and sound installation where a purpose-built metal cage distributed an electromagnetic radiation charge around the cage core, so that when words were spoken into a microphone the set up allowed the words to create new electrical patterns, visible as ultraviolet light. A Faraday Cage structure is normally used to discharge electricity safely and found for example, in the manufacture of lifts. However, despite my perception that the cage's ultraviolet electrical sparks would provide an intense enough light source, the footage generated by an EOS 600D camera and a 0.35mm pinhole set at ISO 1000 in situ, produced little trace of the sparking electrical patterns shown in the conventional images below. I was disappointed that I could not capture their semi-abstract and ever-changing visual effect using the pinhole technique.

Fig. 23: Faraday Cage, Fitzrovia Noir installation, London 2017

Fig. 24: Faraday Cage, installation, London 2017

I had hoped finding alternate sources might be a new way to harness pinhole to creatively capture light, but the various restrictions: type of camera, correct diameter pinhole disc and the disparities within both ambient and other light sources led to a feeling that my aspirations and vision for pinhole video might be frustrated. However, I came to accept that although all my pinhole testing had been small-scale and conducted across a limited range of cameras, I could work creatively within the parameters I had demonstrated. Nevertheless, I hoped eventually to be able to test the pinhole technique with movie light as my parallel cinematography research had started to reveal both the new capabilities of moving image cameras and new innovations in more powerful movie lighting. These were reasons enough to be optimistic for the future capability of my pinhole video technique if it could be paired with the newer generation of camera sensors. This optimism was sustained in the second year by research into and deeper understanding of the latest imaging technologies. With support from the CDT Student Development Fund, I was able to undertake a field trip travel to California where I organised access to more technical information directly through interview with one key film industry professional. The results of this interaction are discussed more fully in Chapter 4: Technologies.

With an acknowledgment of the limitations of my digital pinhole technique at this stage of its potential development, I realised I that achieving the ‘optimum’ pinhole moving image within the context of this study was to some extent a misplaced aspiration. This awareness impacted on the practice in the following ways:

- Planning shoots for video capture together with a more careful consideration of the seasons, times of day and locations for maximum ambient light.

- To accept the element of chance in pinhole capture, creatively exploiting the unexpected effects which randomly occur in pinhole capture accepting these as part of an overall aesthetic, incorporating footage ‘as is’ to allow the imperfections in the image where possible to be expressive of the content.

- Maximising image capture by simultaneous usage of two or more cameras for longer pinhole video works might mitigate any changing ambient light levels and would offer more flexibility.

- Accessing 4K video cameras with a high ISO range, these models I feel could work better for me in the dual role of operator and director for the scale of my video works.

- Researching the relative flange distance (as noted on p. 84) for different camera models which might affect capture.

- Continuing to update my understanding regarding the latest high-sensitivity video cameras, and the latest artificial light sources to decrease the reliance on sunlight for pinhole capture.

As raised in the Methodology chapter, pinhole video as an apparatus is linked to notions of ‘the old into the new’ proposed by Media Archaeology (MA). Although I make a point of distancing myself from this position, related issues on its effect as a medium arose from audience comments on the pinhole image, particularly the degree of focus. Informal comments from viewers for *LoDI&II* suggested a perception of pinhole’s softer

focus as suggestive of analogue film stock, indicative of ‘belonging’ to the past. The lack of sharp focus noted by some viewers seemed to communicate an incomplete quality, redolent of early movie footage and that there might be something ‘wrong’ because the focus was not sharp. As one viewer put it at the US screening, ‘it looks like an image or photo that’s not quite developed’ (Echo Park Film Centre screening 2018, Los Angeles). Thus, the question arose as to whether future audiences, within both the art and/or mainstream contexts might accept pinhole’s soft focus without the immediate sensation that the work looks 'retro’. However, given that ‘retro’ effects are routinely achieved in post-production, the lesson I took from these comments was to consider how the theme or content of one’s work might be made more actively complimentary to pinhole video’s aesthetic effect.

I felt the key to overcoming the ‘retro’ associations was to consider how the content of pinhole videos might be more tailored to its visual effect. Pinhole video imaging might, I posited, be used to compliment lensed capture or used for its tactile and sensuous qualities in video essays or in work in narrative form. Thinking through this issue and with an awareness of the trope of soft focus in mainstream cinema for types of lyricism, I considered that pinhole might, for example, replace the existing lens effect of ‘Bokeh’, an out-of-focus effect, commonly used in cinematography, which appears as a background and/or foreground blur which creates soft points of light and an impressionistic feel. I became convinced that pinhole’s soft focus and often unpredictable effect could yield comparable aesthetic possibilities, offering a tactile experience of the image just as suggestive and inventive as some visual effects seen in mainstream film making.

This project has been conducted during a cultural period when mainstream film makers have started to incorporate a variety of analogue film and digital formats within the same narrative structures. Films such as *Steve Jobs* (2015) by director Danny Boyle, which used different formats to cover a period of 15 years in Job’s life, 16mm film for the early period of the development of the Apple computer, 35mm for its launch and 4K digital capture for the scenes on the newest model of the computer. The order of these formats reflects the real timeline, and adds particular visual texture so the chosen medium supports the narrative structure. A recent example is Spike Lee’s *Da 5 Bluds* (2020), which uses 16mm for the past sequences (the Vietnam war) and 35mm for the current day action, complimented by the use of different screen ratios, which also visually

support the timeframe and then its presentation is in digital format. The fact that mainstream movies have now been shot on the iPhone such as *Unsane* (2018) and *High Flying Bird* (2019) attest to the change of attitude in the 'movie' environment, with cinematographers and directors selecting new means to expand their visual palette and they may well discover and employ the new format of pinhole video for its differentiated aesthetic and narrative possibilities. It is my contention that when this form of video capture is better realised technically and allied with the most sensitive sensors and enhanced movie lighting, it will become recognised as medium in its own right and that both mainstream and experimental practitioners will want to utilise it or combine it with lensed capture to realise fully their visual ideas.

5.2. Part II: The Practice Elements

The three submitted videos fulfilled my aim of working with genres related to classical painting albeit more loosely interpreted as the project progressed. For example, the first piece in the submission *Light of Day I & II* (2017-18) is a semi-abstract impressionistic work, while *Billy Goat Hill* (2018) is a moving image landscape suggestive of a 'live' panorama in constant movement. The final video *Mouthpiece* (2019), is a set of moving image portraits, underpinned by a concept of 'telling a story' in portraiture. All the presented works are evidence of what has been learned through the process of the experimental phase and they reveal the material and suggestive quality of pinhole imaging: the wide angle view, soft focus across the image plane, a grainy texture with muted and colour, matched with content in a lyrical form.

5.2.1. *Light of Day I & II* (2017-18)

Reading on the history of Western glass usage (Tait, 2012) particularly thinking about the development of lens-making, I had been reminded of my own connection to the glass-making craft of Venice, Italy and I started to conceive of a pinhole video which would link to my family background of glass blowers. Following visits to the glassmakers' island of Murano in Venice where my family members had worked for three generations, I started planning a video work centring myself as the connection. I gathered information from my Venetian family about my grandfather and great uncle's roles in the glass industry, accessing photos and a family tree and this furthered the

idea for a video work. I was intrigued by the idea of video art piece which could combine personal material with views of the city and images of the Murano glass furnaces in action. The variety of ambient light sources afforded by the city, long appreciated by painters and cinematographers, alongside the red hot glow generated by the furnace and molten glass, would also offer me an opportunity to test the pinhole capability further with the light-sensitive sensors of high-end cameras such as the 4K Sony FS7. I posited that the pinhole effect might be used to represent creatively the special ambience of the city of Venice, a material sense of it as 'place' and underscore its relation to the development of glass-working and lenses - it would be a video work about glass made without glass.

I undertook further research into the history of glass-making via visits to the Museum of Glass in Murano, Venice and in London on the history of the lens during a visit to Museum of Ophthalmology. Serendipitous links emerged which linked the science of vision to Venice. For example, in 1658 a Venetian, Daniele Barbaro, was one of the first known people to utilise a lens in conjunction with a camera obscura (Smith, 1985: p.12) and that Murano artisans had produced some of the first lenses for spectacles and for Galileo's telescopes (Toso, 2000: p.102). This information further strengthened the concept for a video work which could draw together all these elements. The detailed research notes undertaken for this video are included in Appendix 1. Thus *Light of Day I & II* (*LoDI&II*) was conceived and planned as four visual chapters representing the elements required for glassmaking (air, earth, fire, water) which linked to a variety of research areas as shown in the matrix below.

Table 3: Matrix for LoDI&II

Element	**Visual**	**Research area**
Earth	Textures of Sand, Silica, Rock Crystal	History of glass and lenses
Air	Human Breath: inhalation /exhalation/the blowing of glass	Venetian family history: glass-maker antecedents
Fire	Light, colour, heat waves of furnace	Pinhole capture under various alternative light sources
Water	Reflective surfaces, water cooling of wooden glass-blowing tools, water ebb and flow.	Venice's relationship with its Lagoon and canal waters

From the outset I had consciously selected locations I knew for material which closely (and often literally) matched the four-part structure: the movement of water in canals, the fire of the furnace, the sand on a beach and wind blowing and waving washing lines or flags. Utilising three different cameras for the various shoots, the images captured provided me with a much fuller experience of the visual qualities of pinhole video than the tests had afforded and were a revelation because each camera gave a slightly different image quality. For example, the Sony FS7 Camera although a higher specification 2K movie camera gave darker and slightly more indistinct images, while the Canon 600D and the Canon EOS 5D gave a brighter image and both were generally more flexible paired with the 0.35mm pinhole. This variation of image quality was notable when viewing the footage on my return to the UK. For the final trip to Venice I used the EOS 5D, shooting additional footage with more emphasis on texture, reflected light and colour with fairly static shots. Through a constant process of reflection on the experience of each shoot and close attention to the material, I began to change my approach to the final edit. I found the images I had gathered diverted away from the obvious and the overall concept was becoming looser.

Thus I gradually moved away from obvious links to glass and glass-making in Venice, because the material suggested a more lyrical approach with pinhole video imaging as a form to evoke the city itself rather than any adherence to the original theme. I saw that the textures, shapes and colours captured in pinhole's soft quality suggested a semi-abstract approach; and with the right edit I felt they could offer a new interpretation. I began to arrange the edit in such a way that those textural elements would be emphasised more on screen and rely less on ideas of 'photo-reality'.

Fig. 25: Still of glass furnace interior using multi-pinholes.

After a first edit of the footage in which there was no sound (it was shot mute), I decided to add a bespoke soundtrack to further evoke the city. I co-designed this with a sound engineer. In thinking about the sound design, I wanted to depart from 'real' sound and pair my images with sounds which were textural in character. I hoped these would prompt a new reading of the visual elements. I worked with the engineer reviewing the material and chose some non-diegetic sounds to 'mirror' water movement or light in frame with for example electronic 'pings' emulating the pulsing light of the sun on the water surface and the sound of the slow ripping of paper as the camera tracked close-up along the cracks and broken seams of the city's walls. In other sections, for example, I recorded a real Venetian bell toll and edited the sound to beat in time to the movement of gondola prows bobbing up and down in frame. I knew I did not want real sound or a music soundtrack and instinctively settled for sound textures that would complement the soft yet grainy surface quality of the pinhole footage. Putting myself in the position of the viewer, I felt it was not enough to provide semi-abstract pinhole images of one of the most photographed cities in the world, and hoped that a textural soundtrack design would add a spatial and acoustic dimension to enhance the lyrical semi-abstraction of the images. The experience of working with this material visually and complimenting it sonically prompted a greater understanding of my multiple roles as a subjective observer and as an interpreter. I became more conscious of these new positions, which caused me to re-think some of my previous practices and behaviours.

The eventual video work covered 18 months of activity. This longer engagement led to a greater awareness of myself as a kind of conduit, and a more multi-layered approach. The work gradually evolved into a semi-abstract piece, which I hoped would immerse the viewer in a visual exploration of the atmosphere of Venice. As I worked on the edit, the form had loosened further and I realised there was a methodological shift as I had moved from being a gatherer of images which directly supported the four element structure, to working more intuitively with the material gathered during the shoots. Generally, I was satisfied with the final edit and I hoped I had my achieved my aim of transmitting the textural immersive quality of pinhole imaging, capturing something extra via the evocative soundtrack. However further reflection coupled with the fact that neither the four-part structure nor the semi-abstract effect seemed to be immediately apparent to a range of audiences that had seen the work, meant that perhaps the work had fallen slightly short of these aspirations. The following extracts

from my worklogs give a flavour of the general audience reactions to *LoDI&II*'s pinhole effect, whilst further observations on audience reception are discussed in Chapter 3 Research Context I: Dialogues and Encounters.

The work looks like it was shot 'through a dirty crystal with just enough to see what is happening. The whole effect is of slightly opaque colour and this adds some mystery but I think you should enhance or boost the colour in post – I think it would be more effective! (public screening, Edgware Rd gallery show, London, Sept 2017).

Having heard that the work was arranged under the four elements and about glass, one audience member said it wasn't clear at all in the work and perhaps if it was about family and glass-making, it should include more text on screen to explain this and that each section should have a title panel. (Screening at Echo Park Film Center, Los Angeles, Nov 2018).

After much thought, I felt that *LoDI&II* was not, after all the substantive work I had envisaged but also that perhaps audience reaction per se was not the problem. I had altered the conception and direction of the work over a long period and re-worked the edit several times, including producing a shortened version with additional footage called *Lap Dissolve*, made nearly a year after finishing *LoDI&II*. This had been useful in some ways but I felt some of the impact of the images and the thread of meaning might have been lost through the whole process. In addition, as a piece of work it had occupied much of my time and it had not come together in a way that was actually complete.

Reflecting on the overall process I gradually understood that *LoDI&II* was a work-in-progress and my position shifted to acknowledging it as part of the process of experimentation and open ended. This was a big conceptual step for me and coming to terms with this meant not proceeding with any further work on it and examining what I could learn from the overall experience which might drive my practice forward. This meant I had to really examine in detail what I had learned in making *LoDI&II* and what lessons I could carry forward to the next video work. An analysis of the practice for *LoDI&II* supported the critical arguments made within Chapter 3 Research Context Pt I: Dialogues and Encounters and helped me work through what I initially regarded as a

‘failure’ and how an understanding of this helped me progress my work, altering my approach to the subsequent video works. It was in this context that *LoDI&II* was presented as part of the practice element of the thesis.

5.2.2. *Billy Goat Hill* (2018)

Fig. 26: Location shot - Billy Goat Hill, San Francisco, USA.

As part of my field trip to California in 2018, I had planned to make an urban landscape pinhole video work. This was realised in a location which gave the eventual work *Billy Goat Hill,* its name. Atop a small hill north of the centre of San Francisco, the location is notable for its views of the city set in a natural environment giving an almost 360-degree view.

What I had learned from *LoDI&II* was a conscious awareness of myself as a subjective ‘observer’, and a creative conduit and this influenced my thinking in relation to the approach for the video piece to be shot in this new location. I wanted to find a way to embody that sense of being a conduit and posited I could do this by making the using the camera in a far more dynamic way, with the camera in continuous movement. I hoped this that would be a freeing of the camera, removing the equivalence of image from the camera operator’s view to that of the camera let loose in some way and set in motion. For the shoot, I still had in mind the textural images I had captured in *LoDI&II*

and wanted somehow to expand the effect but in the context of a wide, detailed outdoor scene but in motion. It was the camerawork I proposed for *BGH* that was the most important change in this regard. If the camera in *LoDI&II* had been fairly static, generally capturing whatever light and movement happened to occur in frame (rather like a stills camera), the aim for *BGH* was to try to capture dynamically a landscape view in movement, to loosen the static element, to free up the camera and observe the effect on the image. I was also keen to determine what pinhole detail might be lost or retained and whether a sweeping camera pan would result in a juddering moving image, a common problem with conventional video cameras without a Steadicam attachment.

The weather was bright and sunny on the November day of the shoot, which provided me with the perfect conditions for capture. Again I utilised the combination of bespoke 0.35mm pinhole with EOS 600D camera, set at ISO 800, recording the ambient sound in-camera. The camera was attached to an 18 inch Unipod or camera extension pole and involved me pivoting on the spot holding the pole turning the camera through a 360 degree sweeps. The aspiration was to 'draw' lines of sight, with the camera tracing the cardinal points of the compass, to map the panorama in three dimensions. Using the camera at the end of the pole with myself holding the other end, the first shots were straightforward waist-high pans circling the whole scene. I followed these with upward arcs and lower swings of the camera rising and falling with me attempting to start and finish each shot with the camera at the same spot. Because I did not want to check these positions each time and during the shoot, I made a conscious decision not to 'live' review any of the takes with the intention of working on the edit with all the material in its raw form. For each take I continued the movement in different directions, hoping I was angling the camera in diagonal sweeps from the macro (the open sky and city views) to the micro (the close-up detail of earth and greenery). I was aiming for a fluid slightly free-form effect in which all the directions of the camera swings could be combined in the edit to appear seamless yet offer a dynamic effect.

Reviewing the footage on my return to the UK, I found that that the effect was far from the fluidity I had hoped for because of very unsteady camera movement. This was partially the result of shooting on an incline, balancing myself a small hill in hot weather conditions. My decision to let the camera roam 'free' had resulted in video footage that clearly upset spatial sense, reversing and twisting foreground to background in upside-

down scenes with skewed framing but the effect was at times too juddering and I was concerned much footage was unusable and might have to be re-stabilised in post-production.

Fig. 27: Still from *BGH*: street view

For the edit, I undertook a process of reflection and consideration of the material which revealed an important effect of pinhole video imaging, which I had not fully appreciated before. Unlike *LoDI&II*, this time the pinhole technique had been used for both wide shots and close-ups and these had captured differences of scale and the detail of soil, branches and flowers even in movement. I had done little close-up work before now with pinhole video and I was excited to see how much detail had been captured.

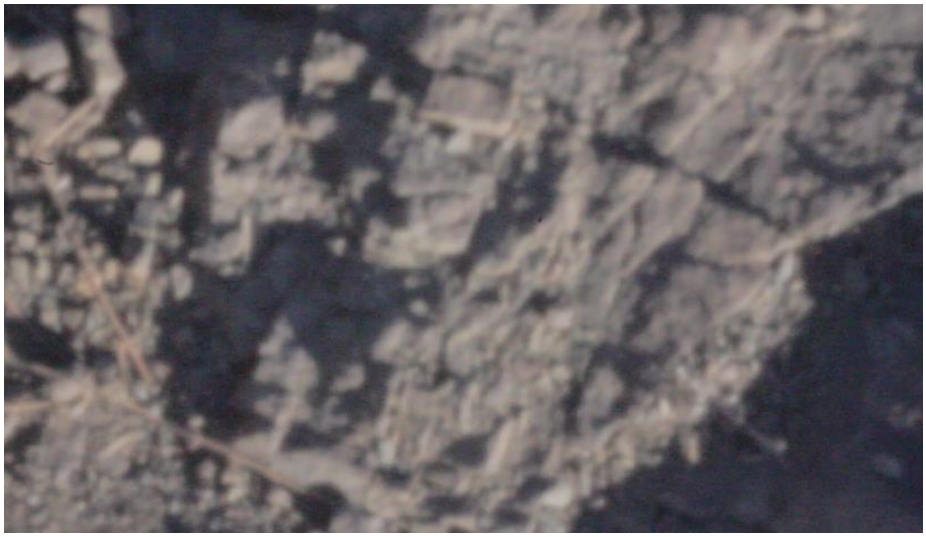


Fig. 28: BGH: close-up of soil

My initial idea was not to discard immediately some of the unstable material with judder in the image, but to use it to drive a new way to assemble the edit. The lop-sided viewpoint of the shots and the dizzying camera movement suggested a kind of geometric approach using the skewed horizon lines to fit it all together. So using printed stills of selected frames of the footage, I assembled a storyboard, a visual representation of the planned shoot, one which would aid decisions on where to cut or dissolve. The first concept was to follow horizon lines from sequence to sequence and to be led by the movement (including the judder) in the images. I felt this might play to the disruptive quality of the movement whilst providing a visual anchor in the horizon line. However, the first edited version proved confusing as the 'judder' was disorientating and visually distracting. For the next and what would be the final edit, I kept the skewed horizons and twisted camera angles but decided to take a different approach. I removed some of the footage I deemed too unstable and divided and arranged the remaining material into groupings under these main motifs: Ground, Sky, Peak (the distant view) Street (buildings and roads) and Feet (traces of myself as maker). For the final edit, some sections were woven together smoothly whilst with others I allowed the speed and direction of camera movement to disrupt scale and spatial perception, underlining the overall effect by adding some duplicated and/or reversed shots. For this work in relation to sound, I stayed as close as possible to the atmospheric sound captured on-site, such as low flying aircraft, police sirens and the background hiss of traffic mingled with birdsong, footsteps and barking dogs. I felt this more in keeping than adding a designed soundtrack.

If I was the subjective observer on *LoDI&II*, I became the active component on *BGH* where movement was key in my role as camera operator. I understood later that this reminded me of Jennifer Nightingale's approach as an embodied moving camera operator in her work in *Pinhole No 1* (as discussed in the Dialogues section of Chapter 3: Research Context Pt I). In addition, the spatial disorientation achieved in *BGH* recalled the albeit more controlled camera work of artist Tony Hill's 16mm film, *Downside Up* (1985) in which the camera is affixed to a 360-degree armature, which swings vertically through an arc of outdoor space. Hill's exploration of camera and body motion have long been the main focus of this films. In his one-minute television film *Holding the Viewer* (1993), Hill also used a camera on an extension pole but pointed directly towards an actor holding and moving the other end of the pole. While *Holding the Viewer* relates most directly to *BGH* in extending its hand-held camera method of capture, the difference for me was the intention to free the camera - to remove the equivalence of image view with the camera operator's eye or view. The camera motion achieved using myself as the central pivot in *BGH* allowed me to loosely determine the speed and dynamic directions of camera movement whilst somewhat relinquishing control of exactly what images would be captured.

What had started as a kind of free 'mapping of a panorama' in movement and in three dimensions, resulted in a short video work which particularly revealed pinhole's versatility in capturing minute detail and texture in an outdoor scene. The camera movement offered a baffling point of view, of perception of scale and space on screen. The macro to micro views with fast and slow panning shots captured the sensation of a continuous turning view within a landscape, de-stabilising the conventional relationship between the viewer and screen. In its final form as a five-minute piece to be looped for display (continuing the effect of panorama and circularity of movement), *BGH* felt a more considered piece because I had worked painstakingly through all the material to deliberately open out the pinhole effect in a more responsive manner.

Billy Goat Hill has not at time of writing been screened to an audience hence the absence of any responses or feedback.

5.2.3. *Mouthpiece* (2019)

The primacy of natural light for clearest pinhole video images had been established in the tests and demonstrated in *LoDI&II* and *BGH*. However, I was aware that there were new developments in film lighting which might eventually offer some equivalence in luminosity and I wanted to make a further video piece with the best artificial lighting I could access.

In terms of subject matter, my previous work and indeed all the pinhole videos have been notable for featuring no human element and being set in external environments: cityscapes or landscapes. For this third piece, I wanted to work with the human face and capture expression in moving image portraits and to utilise some movie lighting possibilities in a studio setting. Thus, *Mouthpiece* developed as a means to see the effect of artificial light on pinhole video capture and to compare this with lensed capture under the same conditions. In this context I felt my omission of human portrayal could start to be addressed. My aspiration was that this would be a further addition to a body of work on pinhole video, hopefully providing evidence of its versatility and signposting this aspect to other practitioners.

Thinking through ideas of portraiture, I started to conceive of the formal photographic portrait as essentially only transmitting a tiny part of the person's character, captured at one moment forever. I wondered what more might be captured via moving image if the individuals were speaking to camera and what their faces might reveal over a longer period than the 'snap' of the shutter. Might moving image reveal how they behave or unconsciously present themselves when videoed? I decided I wanted this to be a more conceptual piece than the previous videos, one which could draw on the quality of pinhole to perhaps capture other aspects of the individuals. I had an aim to introduce pinhole for moving portrait capture which might prompt its use further afield. The worklog notes for *Mouthpiece* below describe how the concept arose and my thoughts regarding the planning for the shoot.

Notes from the pre- and post- production worklog (Mar-June 2019) – edited for clarity.

'Mouthpiece' is a video portrait work which accompanies my other pinhole works in the genres of 'visual essay', 'Light of Day I & II' (2017/18), of 'landscape' 'Billy Goat Hill' (2018/19) and as follow up to the 'still life' theme of my very first pinhole video Aperture (2014). With 'Mouthpiece' the intention is to create a format which features a set of moving image portraits which can showcase the aesthetic qualities of pinhole versus lensed capture within a single screen work and capture in new form some particularities of the human subjects.

'We tell ourselves stories in order to live'. Writer and critic, Joan Didion.

Concept: Each of us recounts stories of what we have experienced, and we can often embellish or exaggerate to create a kind of public narrative to either avoid revelations or to offer a better/different version of ourselves. It is generally accepted that these different versions of personal stories are often 'tailored' to the situation and to whom we are speaking, and often to an idea of how we wish our words to be received. This is as often as not unconsciously done and there is the tricky issue of our memories whether consistent or not, play a part. My suggestion is that we create alternative fictions or versions of our lives and these become embedded as part of the fabric of our personalities, this despite the notion of being true to oneself being still held as both valid and possible.

The idea for a video work arose from a number of sources: a dream I had of random mouths speaking to me via huge TV screens, listening to a 3-part radio programme on Radio 4, 'The Tyranny of Story' and a screenwriter's primer on the basics of storytelling. These all occurred at around the same time and I decided to follow them as signs and consider how the ideas therein were related. The radio programme offered different view points including from neurologist and author, Oliver Sachs that, 'each of us constructs and lives a narrative, this narrative is us - our identity' and from psychologist, Jerry Bruno that, 'the self is a perpetual rewritten story and in the end we become the autobiographical narratives by which we tell about our lives'. The underlying idea is that we are storied animals and that the purpose of our personal stories or accounts of experiences is in essence a way of explaining other people's behaviour in relation to

ourselves. Added to these assertions was the reading of a 2014 screenwriter's manual, 'Into the Woods' by John Yorke of the BBC Writers' Academy. He offers descriptions of the typologies and archetypes common to all story-telling, and argues that story structure is hardwired into human perception and that all stories are essentially alike because they reflect the way in which we make sense of the world. Although Yorke's work was not a directly influence on the proposed video work it has generated ideas around presentation of self in portraiture as a type: hero, lover, fighter, pioneer and victim, thinking on types prompts thought for further video portrait work.

If the still photo portrait essentially transmits a tiny part of the person's story/ history captured in a moment forever, one might perhaps capture more of 'them', including facial expression, posture and shape in the moving image form rather than in a still. I conjectured that a work in moving image with a spoken element might reveal some new traits of those portrayed and that it might question the conventions of traditional photo portraiture. Further I wanted to expand to the type of portraiture by utilising the qualities of lens-less video technique: soft focus, wide angle and muted colour in contrast with lensed images effectively combining the two forms of capture within one overall suite of portraits.

The concept was to shoot a straight-to-camera shot of a head and shoulders with two side views: profile left and profile right, to be assembled in triptych style. I knew that this was already a trope within photo portraiture particularly the police 'mugshot' photograph and as applied historically to criminal typologies and was at first wary that this form might also obliquely reference the ideas of eugenics present in early colonial photography. I hoped that I could avoid these references by shooting in colour with a High Definition video camera with careful framing. I was also aware of the visual link of the stare-straight-to-camera technique of classic still photographers such as Walker Evans (1903-1975) and documentary photographer August Sander (1876-1964) in his Typologies series, where the subjects look straight out directly at the viewer – almost life-size and eye to eye. I wanted to emulate this direct style as a way to communicate to the participants that in some way the portrait is your mirror, it's you. As for the idea of a triptych or 3 views combined in one image, I was influenced by examples of classical painting which combine portrait views in one canvas for example, in Lorenzo Lotto's

Portrait of a Goldsmith (1535) on the left below *and Van Dyke's triple portrait of Charles I (1635)* on the right.

Triple view portrait paintings

I felt that utilising this triple view in the video one would add an extra dimension both literal and figurative to the portraits, given that most faces are not symmetrical and that profiles vary as well. This is borne out by a commonly accepted norm of having a 'best side' for film, indeed I have noted that photographic portrayals often have a left side bias. I knew of this bias but it has even been demonstrated in various scientific trials as I found out when reading an article by A. Lindell in an online article in 'Frontiers in Psychology' from 2017.

My choice of tight shots: centre, left and right profile with some close up on the mouth, nose, chin would I hoped, emphasise the movement of the mouth and draw attention to the enunciation of a particular phrase, a literal one around the idea of story-telling which each participant is speaking straight to camera. The same camera would be a standard set up giving 3 views, the shots alternating with the pinhole aperture and the lensed attached to the camera. The combination of the two forms of capture would aim to contrast and draw attention to how speaking to camera might affect behaviour: facial expressions such as raised eyebrows, licking or puckering of lips, showing teeth breaking into a smile, a smirk or the nerves at being in front of camera. The participants: up to 12 people known to me who are selected from friends, fellow artists, musicians, actors and a family member plus myself as one of the participants. They would be given instructions to firstly deliver a particular phrase in a neutral way and encouraged to give

expression and emphasis on any repeats of the phrase as they felt. The phrase chosen is 'Everyone is telling A Story' because it carries a double meaning in this context: each time we recount something it is form of story and the phrase repeated as part of a portrait piece also becomes itself a type of story. I envisaged that the participants might unknowingly use the phrase as a kind of conversation in which they are telling themselves that 'they are telling a story'.

Mar/April 2019 - the shoot

We undertook 2 separate shoot sessions with a simple set-up of 12 participants captured in lensed and unlensed footage: 7 women and 5 men of mixed ages, ethnicities (I wanted a range of types within my friendship circle with no intention to offer a full diversity range). The video was shot in an interior under artificial lighting and at 4K for best resolution in order to combat possible light issues with the pinhole aperture. The subjects were in brightly-lit sitting set against a greenscreen – to allow the possibility of laying in a background in post-production.

For the shoot I developed a framework to shoot unlensed images and combine them with those shot in lensed footage. Using the same camera under the same artificial lighting conditions, I posited that the same format of distance from subject, same poses, identical background and using a repeated spoken text, might provide a format for a comparison between the two forms of capture. As I am not very experienced in studio set-ups, for this shoot I used a professional camera operator who provided the Sony A6500 4k camera and lighting. The concept was a straight to camera head and shoulders 'mugshot' of short duration followed by the same set up but in profile left and profile right. The camera was set up close to each seated subject (as below) to be able to concentrate on the mouth and lower face when using either the pinhole aperture or lens.

Fig. 29: *Mouthpiece* - set-up

We used a 0.35mm pinhole with a Sony A6500 4K camera which has a much higher ISO range than previous cameras I have used. For the lensed shots the same camera was used with its Canon 24-105 2.8 lens set at ISO1000. Lighting used was an Aputure Movie Light Kit on full power, backed by a powerful studio light panel, all lights were set to daylight (5600k). The front and side profiles were shot first in pinhole and then exactly the same shot with a lens, with each person repeating the same phrase, 'Everyone Is Telling A Story' several times.

Worklog - issues for the *Mouthpiece* edit - May 2018*.*

- *Slightly different framing from lensed (close-up) to unlensed (wide) shots within frames mean might each sequence might not neatly be matched up.*
- *Too many variables using 12 people: 36 shots lensed + 36 shots pinhole = 72 shots to edit. The solution might be to reduce number of participants or remove footage of participants who didn't respond well to the instructions and situation? I might try using pairs of participants at a time to experiment with possible combinations creating a dialogue between them – however this might not work across the triptych structure.*

For *Mouthpiece* I knew I had to organise the edit to make it both manageable and expressive of the contrasting footage but I also wanted to carry through some aspects

learned in *BGH* by structuring a formal plan for the work, to create a working but flexible guide for the edit. I decided to use a storyboard again, printing off hard copy stills from the video footage so I could arrange them in different configurations. This proved to be a much quicker method for the fixed, controlled shots in *Mouthpiece* than it had with *BGH* as each individual was shot in exactly the same set up. I tried many combinations using the stills but kept referring back to the actual moving capture to check on nuances, timings and common visual factors. Thus in the case of *Mouthpiece*, the storyboard method became embedded in the practice as indispensable for both assessing the visuals post-shoot and for driving the edit to complete the work.

After trying various permutations, the first result was a reduction in the number of subjects from twelve to eight and I decided to unite the front, side left and side right views by presenting all the shots in triptych form on one screen. This turned out to be a little problematic as framing differences were noticeable because the pinhole capture gives a much wider view than the tight lensed framing.

Fig. 30: Storyboard image strips used for *Mouthpiece* edit.

The issues are reflected in this comment from the pre-edit worklog for *Mouthpiece*:

June - the assembly for the storyboard feels like a really difficult puzzle, but at the moment what I want is for the video to give the impression of dialogues between each person shown lensed versus unlensed – in the triptych the two side views must face inward to the frontal view. Perhaps using the phrase as a speech and response, like a 'conversation' will determine the order and I could possibly use silence and freeze-frame to cut where necessary to imply listening.

The key to the final edit was the use of the same repeated phrase, "Everyone Is Telling A Story", which served as a thread through the images with the words used to anchor the edits from face to face. The repetition of the lines aimed to focus attention on the how the facial expressions might change when enunciating each time. In the finished work, the viewer is presented simultaneously with alternating lensed and unlensed views, which aim to highlight facial mannerisms and head, mouth and eye movement set against the bright backdrop, its vivid greenscreen colour noticeable throughout. The contrast in the colour saturation of the green from unlensed image to lensed image is marked: in pinhole this green is rendered rather murky, with an almost underwater quality with the faces shown in grainy wide shot, almost lurking at a distance, whilst the lensed green 'pops' out brightly with faces framed mid close-up, clear and bright. When compared with pinhole, the lensed green appears almost clinical in detail. Originally, I utilised the greenscreen background to allow the option of 'dropping in' another background or image in post-production, but I found that despite the different saturations the green operated as a cohesive field of background colour for the triptych format.

Fig. 31: Screenshot end sequence *Mouthpiece*

At the time of thesis submission, *Mouthpiece* had only been viewed by the participants themselves and some colleagues. Below are two responses, lightly edited for clarity and received as email or noted verbatim with permission given to include the comments as anonymised. They shed some light on its reception and whether the effect of contrasting the two forms was understood in the context of the content. In March 2020, these comments were emailed by a colleague who is also an artist:

> I do feel that the pinhole images have an effect of distancing me in time and place, making those seem more of a story of 'fiction' or 'art'. The sharper images make me think I believe them more; they have a documentary feel - is this because maybe that's what I am conditioned to when I watch talking heads on TV - that I expect or respond this way to a higher res image? I'm not sure. The alternating between the types of image, pinhole or no-pinhole, seems random and it bothers me. At the end I want more time to look at the final grid of 9 faces as that section goes too quickly. I want more time. My desire to review, to 'be quiet' with them is quite strong. I want to rest with them a while in the silence they leave me with. I want to think about their combined story. I want to look at the difference between the pinhole and 'the other' (2020, personal correspondence, 27 March).

There were some useful points raised here, that for this viewer that the pinhole images offered a sense of distance, of being in the past and that they appeared more as a story or like part of an art piece, while the lensed images felt more believable, 'real' as in a documentary. An important comment was this viewer wanted to 'rest' with the faces and consider the participants' 'combined story'. This was part of the reaction I had hoped for in contrasting the two types of footage but they indicate that perhaps the contrasting sequences should be on screen for longer to allow the viewer to gaze more on the respective image effects and differences. Another colleague and academic commented on surprise at first seeing the profile and then frontal image of some of the participants and particularly noted for one of them 'the difference between the strength and cragginess of his face compared with the quiet of his voice' (2020, telephone conversation, 5 February). This person guessed that I had used pinholes but found those sections chunkily pixellated and difficult to view on screen. The differences were noted of the two green backgrounds, one lensed and one pinhole as more affecting to the image, and this person saw the digital green as harsh, as symbolic of digital data as in early computer screen design while the soft pinhole green was seen as painterly and more relaxing to look at.

The first work *LoDI&II* aimed to capture pinhole's impressionistic and atmospheric effect achieved in ambient light. This was enhanced by adding a bespoke soundtrack to *LoDI&II* and although an incomplete piece, it generated insights which informed the next stage of development for the concept and the practice in *BGH*. This second video, which I consider a more complete work, revealed pinhole's versatility in capturing minute detail and texture in motion, and how this aspect supported a video landscape in panoramic form. My approach for *Mouthpiece* was formal and less intuitive than the previous works and in the process it meant a departure from my original idea of creating three genre works. I realised *Mouthpiece* was less an obvious portrait work and more a model for a conceptual artwork. The importance of *Mouthpiece* however, was that my practice altered as result of an approach which the use of the storyboard as a method to reflect, adjust and select different configurations. This was perhaps an echo of my previous practice of collage and photo-montage but as method for visualising, it will figure in my practice for my future video work. The storyboard method along with keeping the worklogs as part of the practice have been transformative in externalising what I have

learned through the process of making and reflecting and how insight has generated new practices.

To conclude, the tests and the practice elements represented a body of work which demonstrate what was learned in the practice of making the pinhole apertures themselves, testing these with different cameras under varying light conditions and how these lessons were applied as my grasp of the possibilities grew. The three practice element works demonstrated the potential for video produced by the pinhole method in a range of forms: an impressionistic essay, an immersive free-form work and in a conceptual portraiture piece the last of which is I believe, one of the first digital examples of the combination of pinhole footage and lensed footage within one complete work. The works provide a firm and exciting basis for continued development in my own video work and are offered as examples for other practitioners to consider when developing their own pinhole video practice.

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Chapter 6: Conclusion

This Practice as Research thesis is the first investigation into pinhole technology combined with digital moving image, undertaken by an artist whose practice combines art with technology. The thesis established through reflective practice pinhole's currency and importance as an artistic medium for moving image practices and its potential as a practical and creative technique for artist-practitioners. The thesis was a combination of a written thesis, which positioned pinhole video imaging in relation to the camera obscura, pinhole photography and cinematography and to current advances in scientific imaging, and the practice element, which comprised three original pinhole digital moving image works. Two principal research questions drove the inquiry:
What is the creative potential of pinhole video capture and in what ways might the pinhole video technique be related to the moving image work produced by advanced forms of image capture?

The first involved an investigation to test the technical boundaries and aesthetic possibilities of the pinhole aperture united with video cameras. Taking into account the characteristics of pinhole imaging with its infinite depth of field, wide angle, soft focus and rectilinearity, the investigation explored pinhole video's anomalies, advantages and drawbacks during the experimentation phase and this evolved, through reflection and iteration, into a working method for successful capture. The research delineated the necessary equipment, materials and mechanics for a pinhole video camera set-up, particularly the crucial size of the pinhole aperture and the impact of camera model utilised: its light capability, ISO range and relative flange distance. Guidance on seasonal, ambient and location conditions for pinhole video offered an understanding of the central importance of natural light for successful capture. The research additionally signaled the potential of newer more powerful artificial light sources which could be utilised for pinhole video work. This investigation thus forms a model for other practitioners to conduct their own experimentation and to consider how the pinhole video technique could be used in the content of their work.

The practice was central to providing new knowledge through detailing a method for pinhole videography and the three video artworks were evidence of what was learned in

the experimental phase and exemplified the aesthetic quality of the medium. The works aimed to bring close attention to the specificity of the pinhole aesthetic, centred on its 'raw' light quality achieved with little or no post processing. The quality of soft focus, and pixelated texture of these works prompted an awareness of the similarities with the sensuous image as presented in theories of haptic visuality, which explore the relationship between the haptic and the optic as embodied and material. The idea of gazing at and grazing over the moving image is just one example of its multisensory approach to image-making and was one of the audience responses I hoped for in the presentation of my pinhole works. The image generated in pinhole video also aligns with materialist film practices which aim to foreground the effect of the projected image and challenge the viewer to look at and through the screen. Thus, pinhole video capture was positioned alongside these approaches as part of tradition of critical aesthetics in moving image.

This research enquiry makes a contribution to practice-based research by offering an account of the theoretical positions of Media Archaeology (MA) and Remediation and their relevance to the enquiry. The thesis advances a new position which proposes the *re-purposing* of media as alternative term to describe the process of technological change. A discussion of MA covered its main theoretical positions with the emphasis on its view of the material culture of media technologies, particularly as presented through the study of obsolescent media devices and failed technologies. An understanding of how the materiality of media contains culturally and socially assigned codes and how these exert a presence in new media, enabled closer reflection on the implications of the video apparatus being developed in the inquiry. This meant the lens-less video camera was situated in relation to its forerunner the original camera obscura. It was considered in relation to the latter's cultural impact and reception in the past, its effect on the subjectivity of the viewer and its subsequent abandonment. A useful discussion of these aspects formed part of a re-examination of older forms of lens-less capture in relation to the pinhole video camera apparatus.

As regards remediation theory, which has some parallels with MA, the thesis explored a consideration of remediation's equation of immediacy and hyperimmediacy being combined as a theory of remediation in representation. Remediation's proposition is that all media constantly interact with other media by reproducing and replacing and making

other changes in form. However, the thesis argues that as a hybrid apparatus the pinhole video camera does not necessarily fit the model of replacement of one medium of representation by another or offer the erasure of the artifice of the image which is meant to occur in remediation. Reflection on theories of remediation and whether they could apply to my pinhole video camera as a medium resulted in the development of the idea of the re-purposing of media apparatus, in this case that of the conventional photographic camera.

The reasons are elaborated in two important points. First, in the re-purposing of the video camera with no lens, its light capture is fundamentally altered and it follows that this affects the image differently from a camera with a lens. In a pinhole video camera, the image is initially generated through ‘raw’ light entering the pinhole aperture and it is ‘unmediated’ by a lens. Even when this light is recorded as data on the digital sensor it could also be regarded as ‘raw’ and ‘unmediated’ until it is sampled and computationally reconstructed as an image in post-production. Second, as the pinhole image capture occurs within one assemblage, there is no replacement of one medium of capture by another. To conclude here, in offering an account that uses Media Archaeology (MA) and remediation as a background to the inquiry, the thesis offers the notion of re-purposing of media as alternative way to understand the process of technological change. This has produced a methodology which is I believe to be relevant to other practitioners in media art.

The second research question in this inquiry concentrated on the ways the pinhole video technique might relate to the work produced by new forms of image capture. An overview was offered of related advances in scientific lens-less imaging particularly new types of device that are challenging the conventional apparatus of capture. This established some common factors between technologies in the scientific arena and pinhole videography.

The thesis supported the idea that image capture as a whole is being transformed by two crucial factors: it no longer necessarily involves or is dependent on the lens, and that the device we term a ‘camera’ is undergoing a rapid transformation as the new technologies expand our ability to capture new aspects of light. Although coming from different directions, the central proposition is that for artists and scientific imaging

developers it is an exploration of raw light that unites both practices. The underlies the push in the development of imaging devices to capture light in all its behaviours and that this is the common factor in the efforts of artist-practitioners and technical imaging developers.

In this context a discussion was offered as to the relevance of pinhole video technology in relation to the field of Lightfield technology. This was felt to be of specific relevance because, as a technology, Lightfield is notable for its capacity to capture all the light rays in any given scene. The parallels are demonstrated by the fact that in Lightfield the image yields its abundance of ‘raw’ light as huge amounts of data, which permits a vast range of imaging possibilities post-capture. This resonates with pinhole videography as its light capture is also ‘raw’ although in this case it is unmediated by a lens and similarly its data form allows practitioners to work directly and creatively with pinhole’s particular qualities in the post-capture process.

The pinhole video inquiry produced a set of parameters and general rules for image capture and this generated reflection on current commercial applications of lens-less technology. Research revealed lens-less image capture in the field of astronomy to capture distant light from ‘dark’ stars and black holes, and pinhole cameras used in nuclear physics precisely because a lens absorbs rather than projects high energy rays while a pinhole can produce an image. These and other lens-less applications such as surveillance are subject to the similar parameters and rules which pertain for pinhole video – the availability and degree of light source, the ambient conditions for capture and the relative size of the aperture. These observations underpinned the relevance of situating the project within the field of scientific and commercial lens-less imaging.

It is my hope that via the combination of practice element and written thesis, the impact of removing the lens for capture is made clear and that the contribution to new knowledge and insight is shown in several ways. First, by providing the very first practical investigation into the parameters and capabilities of pinhole video capture, a method is offered for other digital practitioners to learn from and to apply as a technique. Second, that the artistic and creative potential of the technique evidenced in the video works demonstrates its potential as a new and original medium for moving image. Third, as regards the relevance of the field of science to this artistic practice, the thesis makes

a contribution to knowledge by asserting that dependence on the single lens has shifted, resulting in a transformation of the essential apparatus of the camera, and that the endeavours of both fields share an impulse to capture light in ways that expand human perception to go beyond the conventional boundaries of vision. These factors I assert, unite the efforts of artistic and scientific fields alike and that the thesis has contributed to knowledge by opening up a dialogue between them, which allows both sides to talk to each other and in so doing find common ground and mutual appreciation of the relevance to each others' fields.

Future developments

The project's technical insights and the practice embodied in the video works have established that video capture with a pinhole is a both an innovative technology and a medium with artistic potential. The study has further strengthened my belief in pinhole video's capacity for growth and for its recognition as a serious medium, as an exciting basis for continued development by other practitioners. In my continuing art practice, the results of the study will be progressed with the expansion of *Light of Day I & II* as a post-doctoral project. The existing version will become a more reflective and personal video essay, expanded with new pinhole video material, archival and family still photography, graphics and sound. The development of this work is the focus for my post-doctoral activity and funding will be sought to aid its completion. To that end, I have secured an agreement to screen the eventual completed work at the Fabbrica Del Vedere (The Vision Factory) in Venice, a private art space that contains an extensive archive of pre-cinema artefacts and documents and imagery related to early avant-garde cinema.

More broadly, my hope is that this research will be taken up by practitioners both in artistic, scientific and commercial spheres who are actively exploring new ways to creatively capture light and moving image. This could mean that what is exciting about a dialogue between the two fields is that a real art/science collaboration could result in a new aesthetic for moving image capture.

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Key practitioner websites/links:

Zoe Beloff. http://www.zoebeloff.com/

Thomas Comerford. http://www.thomascomerford.net

Paul DeMarinis. https://pauldemarinis.org/

Christopher Harris. https://clas.uiowa.edu/cinematic-arts/people/christopher-harris

Tony Hill. *Downside Up* (1985) extract: https://www.youtube.com/watch?v=I-mAqEaQMXM) and *Holding the Viewer* (1993) https://vimeo.com/201314571

Jason Joseffer. http://www.jasonjoseffer.com

Mary Kelly. http://www.marykellyartist.com

William Kentridge. https://vimeo.com/user88124692

Malcolm LeGrice. https://www.malcolmlegrice.com/

Jennifer Nightingale. http://www.aru.ac.uk/people/jennifer-nightingale

Joost Rekveld. http://www.joostrekveld.net/

Robert Schaller. https://www.robertschaller.org/film/

Vicky Smith. http://www.beefbristol.org/staff/vicky-smith/

Appendices:

Appendix 1: Light of Day I & II

Notes May/June 2017

These notes chart the first steps in research for a proposed lens-less video work set in Venice which relates to unexpected connections I have found to glass production and to my Venetian family history. They are edited for clarity from worklog entries.

Conception: A video about glass made without glass.

Aim: to gather pinhole video footage as part of a visual essay on the glass-making process which is associated with Murano in Venice. To incorporate images related to my Venetian family's Murano roots and to capture within this, the city's quality of sunlight and its darkness, its reflections from water, the role of glass – the ever-present elements that are fundamental to the experience of Venice itself.

Composition of glass

On the composition of glass: the alkali of early Syrian and Egyptian glass was sodium carbonate, extracted from the ashes of plants, including seashore plants which thrive in high salt environments. So in glass-making there are direct links to the sea via sand and the salt. The molecular structure of glass as molten sand cools, goes through a complete transformation and gains an entirely different inner structure. So it never quite sets into a solid, it becomes a kind of frozen liquid or a material that scientists term an 'amorphous solid'. It is like a cross between a solid and a liquid with a part crystalline structure of a solid and part molecular randomness of a liquid. One can think of it as a kind of mid-state therefore between a solid and a liquid.

Glass and Venice

My thoughts are that the notion of an 'amorphous solid' as mentioned above which occurs in the formation of glass could be kind of an analogy for the city of maritime

Venice itself - as a collection of solid stone buildings floating on the canals, and balanced with the symmetry of their liquid reflections. As Peter Ackroyd puts it, 'Glass is material sea. It is sea made solid, its translucence captured and held immobile'. (2010: p.38). Also from Ackroyd, 'Glass is translucent, weightless, it is not a dense material but a medium for colour and light. Glass has no content. It is all surface, infolded in crests and waves, where the outer is also the inner' (2010: p.40).

Venice has been a centre for glass production since the 1200s, and colourless and coloured glass is still created on the island of Murano. In Mediaeval times Murano artisans made glassware, lamps, artificial gems and items from rock crystal particularly 'eye cylinders' which could be set on the head (Toso, 2000: p.40) The surface of these was slightly convex and with the invention of frames around 1290 led to spectacles, although there is some dispute over whether the Venetians 'invented' the first use of bi-vision glasses as opposed to magnifying glasses. Murano artisans also produced some of the first lenses for Galileo's telescopes and binoculars in 1610. The making of spectacle lenses, magnifying glasses and hourglasses alongside glassware and plate glass mirrors continued in Murano well into the industrialised 1900s.

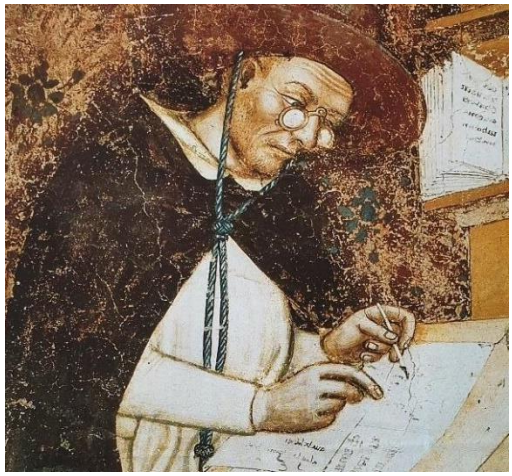


Fig:32: Early Italian mediaeval painting (1320s) of first bi-vision glasses

In a direct link to my pinhole research, I discovered that in 1658 a Venetian, Daniele Barbaro was one of the first known people to utilise a lens in conjunction with a camera obscura (Smith,1985: p.12) to sharpen and upend the image.

Fig.33: *Early Sunglasses- Venetian (1790)*

Another example of early use of lenses also appears in Venice in this example from 1790, a first pair of sunglasses held at London's College of Optometrists. I also found this Murano glass sculpture of an eye in the collection at the museum providing another serendipitous link!

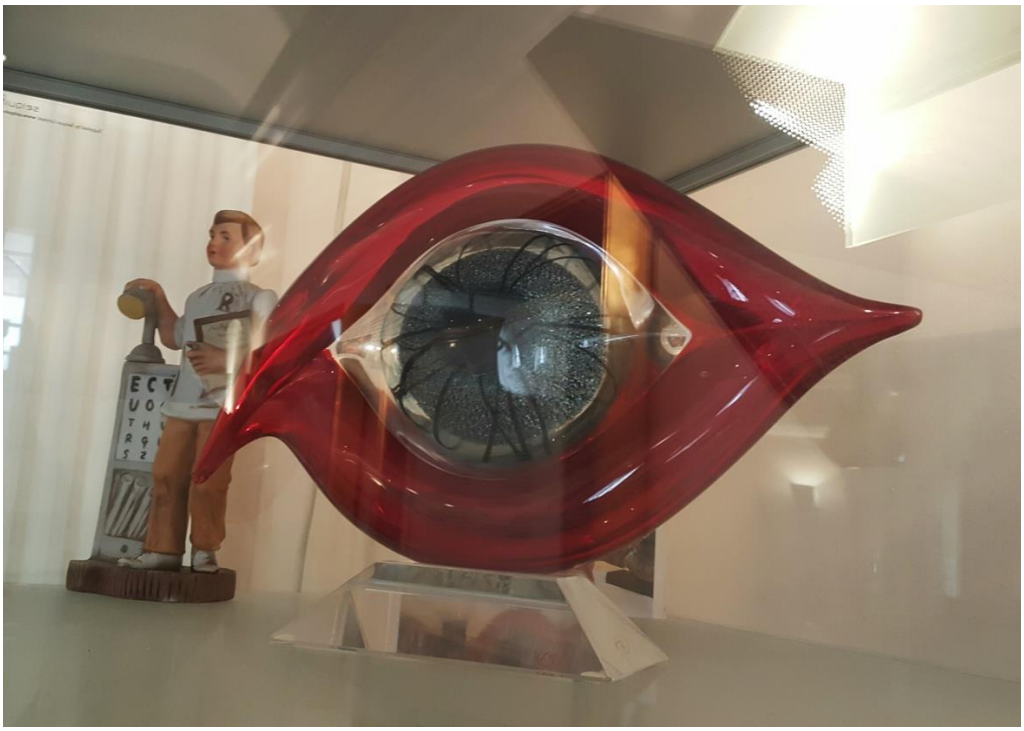
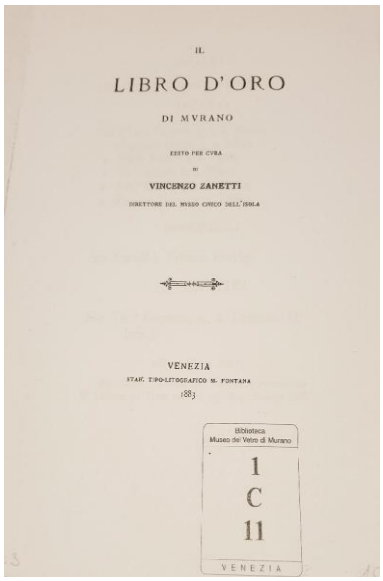


Fig.34*: Murano Glass. Eye Sculpture at the College of Optometrists Museum*.

Family connections

My grandfather, great uncle and great grandfather were glassworkers in Murano. Their family name of Dorigo, I am told by a relative, was recorded as 'vetraio' (glassworker) even as far back as 1260. Family coats of arms were given at that time by the Doge of Venice to a select group of artisans in Murano and apparently the Dorigo emblem exists on a mural in one of the great halls of the Ducal Palace. However, I have only been able to trace the family back directly to 1690 in the record of the Libro D'Oro (The Golden Book) at the Museo del Vetro (Murano's Glass Museum) where the family coat of arms (the stema) also appears in a frieze in the grand upper salon of the museum.



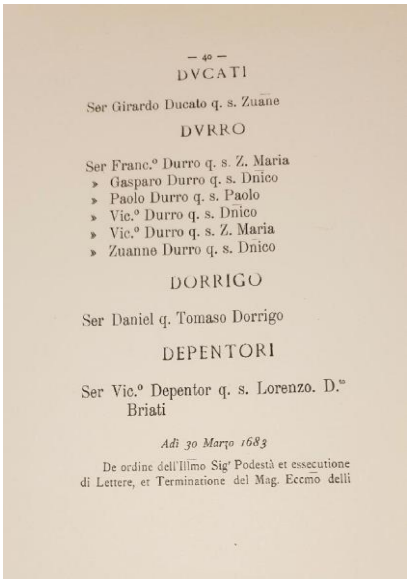


Fig.35: *Dorigo Coat of Arms* Fig 36-37: *Entries in the 1605 Golden Book, register of glassmaker family status conferred by the Doge of Venice.*

In the 1600s the most important Murano glassblower families were allocated a minted coin called an osella. It was coined annually until the fall of the republic. This currency was used on Murano only. On the osella, the Murano rooster emblem appears with the snake in its beak alongside the coats of arms of the most important Murano glassmaker families. I have a reproduction Osella coin from 1767 that shows the Dorigo crest on one side as shown below.

Fig.38:*The Osella coin*

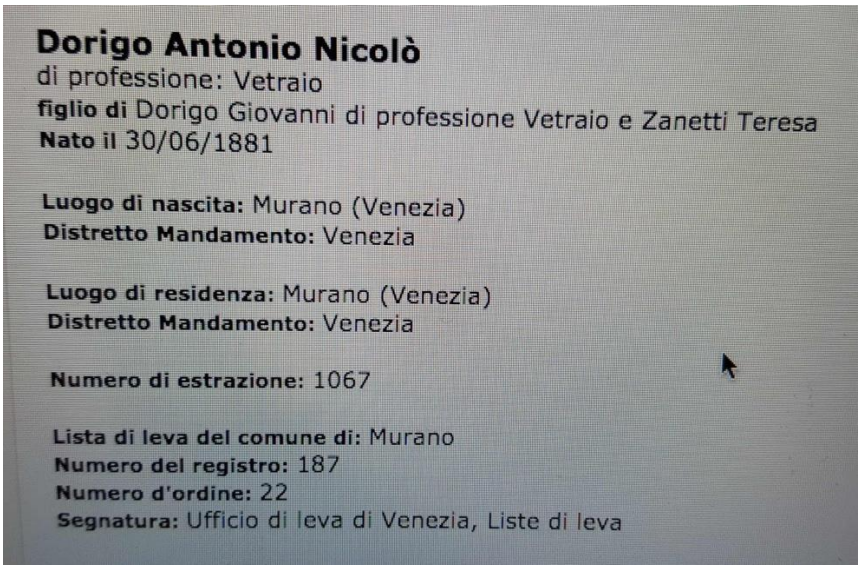


Fig. 39: *Dorigo entry in Libro D'oro, online version*

Through research at the Murano Glass Museum, I discovered records of the Dorigo family and a further connection to my antecedents in that the Museum was founded by Abate Zanetti in 1861. My great grandmother Teresa was also a Zanetti (seen in this 1896 photo at below left).

Fig 40: *My grandfather Umberto, his mother Teresa, father Giovanni, brother Antonio and unnamed sister*.

Fig.41: *The Dorigo family palazzo on Murano (1780) still there and unoccupied.*

On one of my trips I took a visit to BAUM University of Venice to consult genealogy books to trace more about the Dorigo heraldic shield but couldn't find any further evidence of how and when exactly the status was given. This will need more research and a visit to the Ducal Palace to see the room decorated with a mural of all the Venetian Coats of Arms.

On further connection, my name.

My name is Lucietta (diminutive of Lucia), not a common name even in Italy. Lucia is from the Latin LUX – feminine word for light. LUX is also the name in Physics for a unit of illumination. It is part of the etymology of elucidate and indeed illumination.
The **lux** (symbol: **lx**) is a unit of illuminance. In Photometry, which measures intensity of light, lux is used to measure light that hits or passes through a surface as perceived by the human eye. I also discovered that Santa Lucia is the patron saint of vision and that her mummified body is located in San Geremia Church near Santa Lucia railway station in Venice. On one trip in 2017, I visited the church and saw that even now there persists quite a cult around her image. There are many stories about how she lost her eyes notably that the Roman Governor of Syracuse, ordered Lucia to prove her devotion to the empire by burning a sacrifice to the emperor. She refused and was sentenced to be raped as punishment. Other narratives suggest her eyes were gouged out in torture by the Romans or as a self-mutilation to stop the attentions of men.

Fig.42: *Painting of S. Lucia undated.*

Figs 43-45 *Devotional images of S. Lucia*

Fig.43: *S. Lucia Eyes Devotional Brooch*

Fig. 44

Fig. 45

In keeping with the Latin derivation of her name Lux, she is often depicted as a bringer of light. S Lucia pilgrims to this day visit S Geremia, Venice and wear the ‘eyes’ brooch shown above.

Fig.46: *Mummified corpse of the martyr S Lucia with silver death mask in S Geremia Church*.

Observations on the importance of Venice's Light

The ambient light of Venice has always been as important as its form and space. The special quality of Venice's light through water is the unifying element which creates the city's extra dimension compared with other port cities. The sunlight on water bounces upwards and outwards, multiplying in intensity. For this reason, classical Venetian painters naturally captured the city's very special luminosity, as have in later decades have numerous cinematographers. An example of Venetian light in painting is Tintoretto's use of paint in a Venetian tradition of illumination as an optical effect as well as offering a kind of transcendent vision.

The reflections of canal waters and from the lagoon appear to make the buildings float or blend into the water. So Venetian buildings seem to have reflections as foundations and the surfaces of the city appear ephemeral under the ever-changing ambient light. The same effect can be seen inside the buildings, where polished marble floors, large mirrors and glass and crystal chandeliers in the interiors also add to effect of echo a city hovering between the solid and the liquid. There is also a long tradition of the use of glass mosaics inside the Basilica di S Marco where the tesserae reflect and refract window light. As the sunlight from the windows fluctuates, different parts of the mosaic glitter and can even absorb dull light.

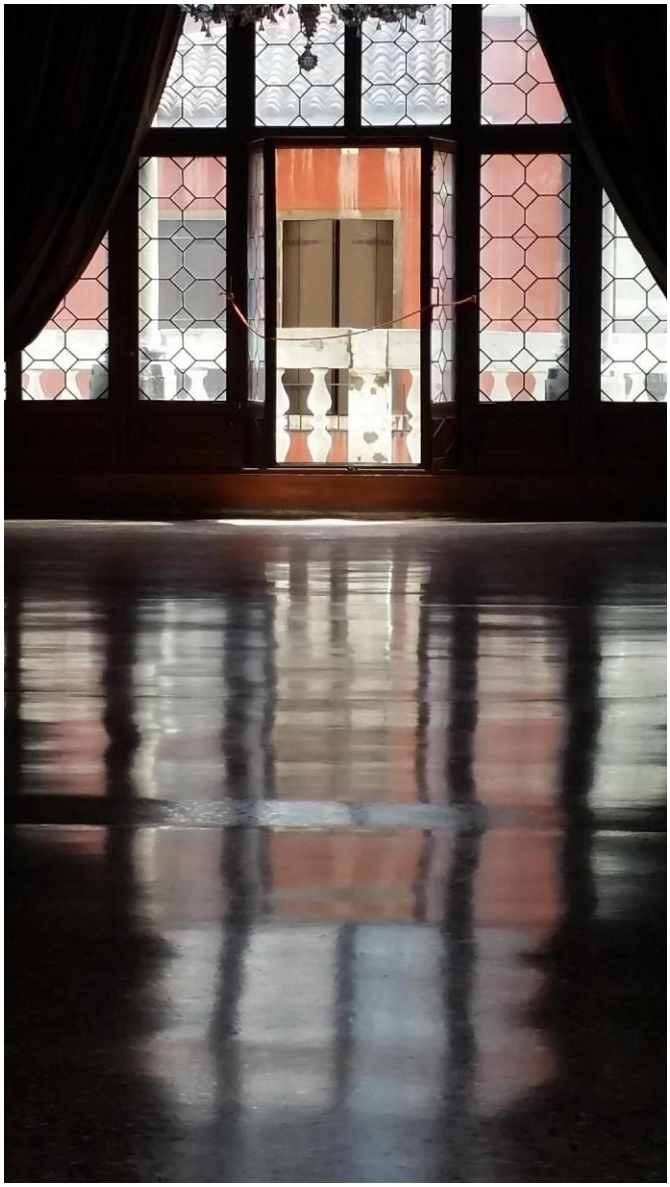


Fig. 47*: Piano Nobile (upper salon) at Palazzo Mocenigo, Venice*

This quotation from Joseph Brodsky in his essay on Venice draws attention to the visual sensation of the city, ‘This is the city of the eye; your other faculties play second fiddle’ (p.27) and he says ‘the eye, our only raw fish-like internal organ indeed swims here: it darts, flaps, oscillates, dives, rolls up’ (p.28) and ‘After a while …..the body starts to regard itself as as merely the eye’s carrier, as a kind of submarine to its now dilating, now squinting periscope’ (p.25). The interplay between light and water seems to alter one’s perceptions as noted by Peter Ackroyd, ‘The surface of Venice is constantly morphing, so making images of Venice is like being a restorer, peeling off the layers to find the picture after picture underneath. Venice is inexhaustible because the shifting and shimmering light, the reflection and the movement of water keep changing its

face' (p.40). In Summer, the sunlight appreciated by artists and film makers alike, is amplified by the water and multiplied repeatedly, while shadow is a very defined almost starkly black. I have particularly noticed this when walking down long high alleys (the calle) which are are dark and cool, only for my eyes to be dazzled by a brilliantly hot and bright square which opens out at one end. It occurs to me this effect has a kind of parallel with the aperture and the camera obscura – the dark chamber which transposes light.

All these links: light in the derivation of my name; Saint Lucy as Patron saint of vision who lies in a Venice church; my antecedent glass-maker family in Murano; the lenses of Galileo in Venice for binoculars; the first uses of a lens with a camera obscura by a Venetian, the early camera obscura use by Venetian painters; the fact that lenses and mirrors are still the components for photographic capture all were felt as signs I should create a lens-less video on the subject of Venice which would visually reference some of these links. In addition, because the pinhole aperture offers a level of imperfection, I believed I could produce a textured video work to counter the classic photographic view of Venice (one can barely take a bad photograph) or its alternative the garish tourist picture postcard, subverting these with pinhole's softness and texture. Thinking about how to pull various visual elements together I created a matrix to guide the concept. This was based around the four classical elements which seem very present in the Venetian environment and are key in the production of glass:

Element	**Visual**	**Research area**
Earth	Textures of Sand, Silica, Rock Crystal	History of Murano glass and lenses
Air	The blowing of glass, human breath blowing life into glass	Venetian family history: glass-maker antecedents
Fire	Light, colour, heat waves of furnace, the sun	Pinhole capture under various light sources
Water	Reflective surfaces, water cooling of wooden glass-working tools, Water ebb, flow	Venice's relationship with the Lagoon and canals

Production notes - guide for images wanted and sites for the shoots – to support the visual elements in the matrix:

Earth: the colours of sand on the beaches, to contrast with the powdered pigments that glass blowers use to colour glass (as below), sandblasted or crumbling plaster walls in the city. Location: Lido di Venezia beaches, Murano and Canareggio alleys.

Fig.48: *Colour glass pigments*

Air: the breath of the glass blower which makes the liquid glass into a form, wind blowing through the city in ephemeral ways – washing lines, flags flapping and moving shadows. Location: Guarnieri Furnace, Murano, S Chiara Furnace, Murano, S Giovanni e Paolo Square in the Canareggio area on main island.

Fig.49: *Guarnieri Furnace, Venice*

Fire: the heat and gas light of the furnace itself, the colours of molten glass, bright sun reflected on water. Location: Guarnieri Furnace, S Chiara Furnace, Murano.

Figs 50-51: Guarnieri Furnace, Venice

Water: the reflections on the hulls of boats, the movement and the changing colours of water, ripples and sunlight on water, tides and water turbulence from motor boats Location: Murano canals, S Giorgio Island and the Lagoon near the Lido.

Fig.52: *Boat hull reflection, Venice*

Final thoughts – how to combine the family images with the pinhole impressionistic capture of the city? A different kind of essay work perhaps a longer piece which is more creative than a documentary style with voice-over (of relatives talking) and a new soundtrack. Or a shorter piece which could offer offer a group of quintessential and powerful vignettes to act as visual of haikus of the city – more like a visual poem with sound or voice over?

Appendix 2: Commentary: Christopher Harris pinhole work

Interview extracts and commentary

Sunshine State (Extended Forecast) colour, 16mm 8 min) is a pinhole film set in Florida, a lyrical video work which has been described as a film about the cosmic consequences of the sun's collapse. The Rotterdam International Film Festival in 2007 described it thus, 'Somewhere in a quiet outer suburb of the Milky Way galaxy, we live our lives in the pleasant warmth of our middle-of-the-road star, the Sun. Slowly but surely we will reach the point when there will be one last perfect sunny day. The sun will swell up, scorch the earth and finally consume it'.

The following are selected extracts from an interview via email correspondence with Christopher Harris from April 2019. These were not included as part of the discussion in Chapter 3: Practitioner Dialogues. My questions and reactions are extrapolated from the interview worklog, which I felt important to include although not directly related to the inquiry.

Autobiographical elements

LW: To what degree does *Sunshine State* fit with the two Florida films you have referred to in various presentations? Is it autobiographical as it features a young girl, her sun yellow chalk drawing, her billowing dress and the spinning wind toy?

CH: The film, like the other Florida films, were films that depending on my being based in Florida. They are a response to living in Florida that would never have been made had I not lived in Florida at the time. I never wanted to live in the suburbs and it was my first time living there and the quiet of that kind of life left me to reflect on the transience of whatever peace and quiet, even contentment and happiness that I unexpectedly felt. My emphasis was on the transience. The Florida films allow me to sift through life in Florida which, because of my roots in the Midwest, I found to be somewhat alienating. The young girl in the film is my child and I wanted to document her (as a character) during a specific time in a specific place as again, I was very aware of the transience of life. My emphasis was on the transience.

On audience reaction to the pinhole medium

LW: What kind of audience reaction did the work receive from first screenings and to what degree do you think the quality of the pinhole image affected viewers, if at all?

CH: That's hard to say because I didn't do as many Q&As at screenings for the film as I've done for other films. I can say that the film screened well in Europe and won a couple of awards. The jury at the Hamburg International Short Film Festival recognized the film with a special mention and I was pleased with the jury statement: "The biggest story ever told through a pinhole". FYI, I believe that there may be some response to the film in a forthcoming book called 'Experimental Filmmaking and the Motion Picture Camera'.

Importance of soundtrack

LW: Can you outline how the voice over track came about? It sounds like radio reports and space communication sounds and appears to be authoritative like a scientific extract or was that the intention and it was scripted?

CH: The voice over is all found or appropriated from existing sources and none of it was scripted by me or staged for the film. The weather forecast comes from local television broadcasts and the radio static is just regular radio transmissions but my understanding is that radio signals go on forever so that every radio broadcast is out there in space traveling forever (I don't know if that is factually correct but that's what I was thinking about).

My notes: Harris's soundtrack successfully undermines the idyllic imagery particularly with these words on the soundtrack when a voice says 'And as we take a look outside, boy, what a bright sunshine over Daytona Beach and other parts of Central Florida, but how long are we going to see that sun?" This echoes the idea of the Sun's possible collapse. I am increasingly interested in how soundtracks affect image and I often shoot mute for my video work so that I can add sound after the fact: this can be a designed soundtrack not so much to re-write the image but as in *LoDI&II* to enhance the visual experience and add spatial quality. The soundtracks in *LoDI&II* are often tangentially related to diegetic sound for example a mix of the bell tolls or the chug of a boat but they

are intended to add aural texture and evoke atmosphere. The use of designed sound is starting to be much more considered in video art and there are now more collaborations with sound artists. This aspect has been a new development for my practice but an important one.

On making *Sunshine State*

LW: What are your thoughts when you look now at the piece?

CH: I mostly remember the experience of making the film. Mostly I remember how I shot it over a very hot summer and how my young daughter was such a trooper working in the heat. I had a lot of trouble framing one shot in particular because the parallax viewfinder on the Bell and Howell 70-DR camera I used made framing of close shots difficult.

My note: The DSLR cameras and the other models I used have digital viewfinders and are parallax-free so the scene framed does not perceptibly differ from the scene the sensor records. The difficulty for framing of shots with pinhole video is that one needs strong contrast in the scene to be able to establish the frame for a shot and this can then be thrown out when light levels fluctuate.

Commentary

As an outsider/European the title of the video alone conjures a sort of idyllic perpetual holiday environment, the daily presence of heat and bright sunlight. The Sun and implicitly sunlight, are echoed in its title referencing Florida's name as the 'Sunshine State'.

Interpreting this pinhole film as created in a 'state of sunshine' my thoughts were immediately that using pinhole for this work was perhaps an unconscious acknowledgement of the powerful effect of the sun so necessary for this form of capture. The fact that a pinhole camera needs large amounts of light to register image makes it an ideal medium for Harris by materially evidencing the sunlight of Florida, and through its aesthetic lending the film a tactile impressionistic quality to the notion of an 'ideal' suburban life. Furthermore, in the pinhole capture for *Sunshine State* there are also

echoes of the conditions which were necessary for early movie-making cinema, with bright sunlit exteriors and the limited movement of a single fixed camera.

I interpret *Sunshine State* as having a special resonance now in the current context of global warming where we are no longer protected by the sun but threatened by its effect due to human abuse of the environment. The piece lyrically underscores human concerns about the effect of our Sun with an authoritative voiceover (as described above) indicating that we are under considerable threat. Suburban Florida here is shown as beautiful under the sun but possibly threatened by its heat and light with the suggestion from the portentous voiceover that the sun might cease altogether and all life will be destroyed.

In particular, this idea of cosmological damage through the Sun's collapse is envisioned through the main overhead sequence of a colourful beach balls floating on the pool surface with one ball perhaps representing our planet Earth, set within Space, perhaps represented by the intense blue water of the pool. The larger ball appears as though caught in the grid lines of the pool floor, while a second ball (another planet?) floats nearby. The darker shadows of both balls on the pool floor add a further meaning to the voiceover's reference to the death of the Sun and by extension its satellite, Earth. Finally, although the voice over intones that 'all matter will be engulfed in a fireball' one might interpret a small glimmer of hope in the form of the lifesaver ring which appears later floating almost still on the pool surface while its shadow floats slowly off screen. Harris emphasised in his comments that it is part of his vision to film quotidian objects and mundane situations which can evoke ideas of planets and galaxies – the macro to micro. In *Sunshine State* as well as the pool and ball images, he extends this idea with shots of the little girl's spinning, twirling dress and the spiralling wind toy which perhaps further evoke the idea of the universe as a spiral with our Sun at its centre.

Despite the voiceover and soundtrack which Harris intends as a re-write of the idyllic images, the film displays a deft lightness of touch, allowing Harris to lyrically suggest the fleeting moment through the pinhole aesthetic which serves to emphasise the temporality of the scene.

Harris’s final email response to the comments above. (April 2019):

All of these comments are completely in line with my thinking at the time of making the film or at the very least welcome observations. In particular, the emphasis on objects that evoke planets and galaxies.

Glossary

Camera obscura - the effect of a natural optical phenomenon that occurs when the light from scene passes through a small aperture or pinhole in a wall or screen and appears as a projected image on a surface opposite that wall/screen. This term is also used for the device or the housing which carries the aperture.

Compressive Sensing consists of a Liquid Crystal Display (LCD) panel that acts as an array of apertures that each allow light to pass through and a single sensor capable of detecting light in three colours. Each aperture in the LCD array acts individually to allow light to pass through when either open or closed. Creating an image starts with the sensor recording the light from the scene that has passed through a first random array of apertures. It then records the light from a different random array and then another and so on. Each of these 'snapshots' is then correlated because they record the same scene in a slightly different way. The process of compressive sensing analyses the data, looking for the correlations which it then uses to recreate the image.

Computational capture comprises a set of imaging techniques that combine data acquisition and data processing to create the image of an object or scene through indirect means to yield enhanced resolution for 3D reconstruction. This form of imaging surpasses the physical limitations of optical systems and eliminates the necessity for optical elements such as the lens. Computational imaging technique often draws on compressive sensing techniques, where the angular field of the object is being reconstructed. Other techniques are related to the field of computational capture such as digital holography.

Lens-less - a generic term to describe images captured through the action of light in a camera or device which does not use a lens.

Materialist film can be loosely defined as a form which deals with the devices and materials that create the film in order to demystify the film process. The aim is to be non-illusionist and to produce certain relations between what the camera is showing and the way the image is presented.

Moving image - motion image capture via any medium, analogue or digital.

Pinhole - a small aperture through which light passes to offer a projected, reversed and inverted image (left to right and upside down view). I also use this to indicate the image produced by the aperture.

Plenoptics or *Lightfield* is the scientific term for visual capture achieved by the light field or the intensity of light emanating from a scene, and the direction of all the light rays are traveling in space. It contrasts with a conventional camera which records only light intensity. The Lightfield camera uses an array of micro-lenses placed in front of an otherwise conventional image sensor to sense intensify, colour and directional information. The characteristic of this type of camera image is that point of focus and depth of field can be radically altered by software. This technology is currently in use primarily in cinematography and simulated screen applications such as *VR* (see below) and is reported to be in rapid development for use over a number of platforms.

Volumetric capture is a technique used to capture footage in three dimensions for viewing in a virtual or mixed reality headset. It uses photogrammetry which is the science of making measurements from photographs, via scans of real world objects or scenes outputting these in the form of 3D models. It is different from the technology used in 3D movies today. For example, when a person is recorded with volumetric capture, the body is fully scanned and reproduced, with all details and all sides recorded. It creates a digital copy of the person. Volumetric capture is developing quickly and is a component in immersive environments using *Virtual Reality* (VR), a simulated screen and headset experience that can be similar to or completely different from the real world.

<u>Cameras utilised in production phases</u>:

The Blackmagic URSA was one of the world's first high end digital film cameras. It is an EF Mount 4K Camera with a Super 35 sensor, a global shutter and a built-in 10-inch monitor. It is reputed to be useful for low light levels but has a limited ISO range of 100-800. The model I used for the test is now discontinued.

Canon 600D is a Digital Single Lens Reflex (DSLR) camera which shoots 2K HD Video and has an ISO range of 100 - 6400.

Canon 5D is a full-frame DSLR. It has an ISO range of 100 - 1600.

The Sony 2K FS7 is a smaller, handheld form of Sony's line of digital cinema cameras. It uses the Super 35 Camera system to capture Ultra High Definition video using a Super 35mm-sized sensor for cinematic imagery. It has an extended ISO range of 100 - 3200.

The Sony Alpha A6500 camera features a 24-megapixel APS-C CMOS sensor, records 4K video. It has an ISO range of 100 - 25600.