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**VISIBILITIES AND INVISIBILITIES OF WONDER: A PRACTICE-LED EXPLORATION OF OPTICAL IMAGE SYSTEMS**

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## Declaration of Originality

I, Deirdre Feeney  
hereby declare that the thesis here presented is the outcome of the research project undertaken during my candidacy, that I am the sole author unless otherwise indicated, and that I have fully documented the source of ideas, references, quotations and paraphrases attributable to other authors.

A handwritten signature in black ink, consisting of the letters 'D. Feeney' written in a cursive style, followed by a large, stylized capital letter 'D' that loops back to underline the text.

01 March 2019.

Visibilities and Invisibilities of Wonder:  
A Practice-Led Exploration of  
Optical Image Systems

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# Abstract

This interdisciplinary practice-led project began with two investigations, both pivoting around the central material of glass. It explored whether glass, with its unique logistics of perception and ability to render invisible phenomena visible, could make visible an imperceptible process of slow change. It also endeavoured to understand how glass, in transporting its image-light across space and time evokes the experience of wonder. These two strands of enquiry were brought together through the research and development of my optical image systems, which serve as perceptual tools for exploring wonder and time. What initially began as an experience of observing slow changes in nature, transformed into a wider consideration of critical wonder, time and visibility. Critical sensibility became fundamental to my explorations of the materiality of wonder, but also crucial for the generation of wonder was a momentary interruption of this criticality by means of the imperceptible and immaterial transfer of light.

My hybrid devices incorporate a wide range of old and new technologies, spanning from sixteenth century optical objects of natural magic to contemporary electronics and digital fabrication processes. I relate my efforts to the work of contemporary interdisciplinary artists Adam Brown, Attila Csörgő, Julien Maire and Olafur Eliasson and discuss specific works by Jan Dibbets, Johannes Vermeer and Anthony McCall with reference to visual strategies for directing our attention to the invisible. Historians, philosophers, theorists and a sixteenth century natural magician helped establish the framework for the development of my optical systems. Giovanni Battista Della Porta, Kate Warren, Tom Gunning and Jason Leddington informed my investigations into natural magic and wonder through their various practical and theoretical approaches; and Charles-Émile Reynaud, Jonathan Crary, Hans Jonas, Paul Virilio, Henri Bergson, Mary Ann Doane and Charlie Gere contributed to the framing of my investigations into time, materiality and visibility. The projected image systems I created, *Hollow Lens*<sup>1</sup>, *Ghost in the Machine*<sup>2</sup> and *Object-Image*<sup>3</sup>, bring the visible and invisible, and material, digital and virtual into service as a means of evoking wonder and visualising time.

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<sup>1</sup> *Hollow Lens* (2017–2019), glass, steel, aluminium, LED, PCB, raspberry pi PCB, LCD, water, stepper motor, pump, plastic tubing, dimensions variable

<sup>2</sup> *Ghost in the Machine* (2017–2019), glass, steel, aluminium, 3D printed carbon fibre nylon, LED, motor, gear box, PCB, acetate, dimensions variable

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# Introduction

I have always been curious about how the material of glass, when shaped and polished in a particular way, uncannily transports an image of an object across space and time, what film theorist Dominique Païni terms ‘image-light’.<sup>4</sup> Spending many days in my studio deconstructing various projection devices, carefully extracting their lenses and light sources, I wanted to uncover how these optical systems transport their extracted image-light across space and time. Each time I held up one of the lenses in front of my studio window, the scene from outside was somehow magically projected onto the opposite wall. Depending on the lens, sometimes the image was small and inverted, but the image-light always held a wondrous intensity and luminosity that completely captivated me. I began to research and develop a series of optical image devices to explore this experience of wonder.

Wonder, the central theme in my research, is a topic that spans millennia and encompasses a vast array of fields that include art, philosophy, psychology, theology, science and magic. Before the in-depth investigations of the chapters that follow, this section maps out the specific contextual frameworks in which I explore the concept of wonder.

## Research Questions

My research is framed by two main questions. Firstly, how can interdisciplinary optical systems be developed to evoke the experience of wonder? And secondly, can time be made visibly perceptible through the material device and projected image?

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<sup>4</sup> Dominique Païni, “Should we put an end to projection?”, trans. Rosalind Krauss, *October*, 110, no. 4 (2004): 24.

## Natural Magic as a Mechanism of Wonder

Wonder has many different meanings and a dependency upon contextual and temporal points of view. The ancient Greek philosopher Socrates described wonder as the beginning of philosophy.<sup>5</sup> Aristotelian wonder grew from our lack of knowledge of how natural phenomena occur, leading us to search for their causes<sup>6</sup>. In the thirteenth century, theologian Thomas Aquinas linked *wundor*<sup>7</sup> to miracles and astonishment, which had completely hidden causes.<sup>8</sup> The wonder explored in my research begins three centuries later with the natural magic of preternatural philosopher Giovanni Battista Della Porta.

Della Porta was a key influence at the beginning of my project because he used optical objects as tools for evoking wonder. He used glass lenses to extract ‘secrets’ from nature and render them visible in the form of projected images.<sup>9</sup> For the preternatural philosophers wonder was generated when the cause of an unusual phenomenon was imperceptible to the senses.<sup>10</sup> Della Porta hid the cause of his projected images. His audience therefore did not see the glass lens, they only witnessed the spellbinding projected image-light. Historians Lorraine Daston and Katherine Park note how, for a brief moment in history, “wonder became a reflection not of ignorance but of virtuosity and connoisseurship; the product not only of great experience and erudition, but also of impeccable taste”.<sup>11</sup>

Della Porta’s wonder was generated through a system of natural magic, which selectively engaged his audience’s attention using opposite states of seen images and unseen optical objects. Like Della Porta, my research applies natural magic as a mechanism for evoking wonder in the form of the seen and unseen elements in my optical systems. Natural magic controls the direction of attention and in doing so reverses the perceptible visibility of normally visible objects and unseen natural phenomena and is still used in contemporary magic.<sup>12</sup>

The practice of natural magic emerged during the Renaissance and was used by preternatural

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<sup>5</sup> Theaetetus Plato, 155c–d, trans. Jowett. (Cited in Peter Lamont, “A Particular Kind of Wonder: The Experience of Magic Past and Present,” *Review of General Psychology*, 21, no. 1 (2017): 1; Robert C. Fuller, *Wonder: From Emotion to Spirituality*, (Carolina: University of Carolina Press, 2009), 1.

<sup>6</sup> Lorraine Daston and Katherine Park, *Wonders and the Order of Nature, 1150–1750* (Cambridge, Massachusetts: Zone Books, MIT Press, 1998, 2001), 111.

<sup>7</sup> The etymology of the word wonder comes from *wundor*, meaning “marvellous thing, miracle or object of astonishment.” (Online Etymology dictionary <http://www.etymonline.com/index.php?term=wonder> (accessed July 10, 2017)).

<sup>8</sup> Daston and Park, *Wonders and the Order of Nature*, 13.

<sup>9</sup> As Della Porta’s contemporary Marsilio Ficino described, the world was a secret web of hidden links. (Daston and Park, *Wonders and the Order of Nature*, 161.

<sup>10</sup> Daston and Park, *Wonders and the Order of Nature*, 126–132.

<sup>11</sup> Daston and Park, *Wonders and the Order of Nature*, 170.

<sup>12</sup> Smith, Wally, Frank Dignum and Liz Sonenberg, “The Construction of Impossibility: A Logic-Based Analysis of Conjuring Tricks,” *Frontiers in Psychology* 7, no. 748 (2016): 1–17.

philosophers who purposefully hid the physical causes of natural phenomena to make them appear more wondrous.<sup>13</sup> Within this preternatural practice are traces of Aristotle's *Mechanics* (848a 34–38), which proposes that machines should conceal their mechanisms to allow the miracle or *thauma* to appear more impressive.<sup>14</sup> Historian Louise George Clubb writes that during this particular period of the Renaissance:

Knowledge was not to be disseminated indiscriminately but [...] chosen to maintain epistemic secrecy while communicating to the aspiring seer the *spectacle* of nature's marvels and the manner of demonstrating them.<sup>15</sup>

In contrast, the natural magic in my research seeks to expose rather than hide the causes of what we see. By de-cloaking my optical devices, I investigate whether sensory engagement and awareness can induce a state of critical wonder, rather than the astonished wonder of Della Porta's spectacle. My system of natural magic also includes the invisible transfer of light, which as my research uncovers, is an important element of magically induced wonder.

## Critical Wonder

With the aim of superseding the sixteenth century spectacle of wonder with contemporary critical wonder, attention, sensory engagement and awareness became important tenets of my research and were explored through the material development of my optical devices. The activation of an embodied awareness also serves to evoke a critical self-awareness in the viewer. I consider critical wonder and the re-presented viewer in Chapter One with references to curator Kate Warren's concept of critical wonder<sup>16</sup>, anthropologist Ernesto de Martino's research on wonder as a mechanism for counteracting a 'crisis of presence',<sup>17</sup> and curator Daniel Birnbaum's writings on artist Olafur Eliasson's purposeful positioning of his viewer.<sup>18</sup> These varied approaches reinforce the importance of the visibility of the

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<sup>13</sup> Serguis Koderas, "The Laboratory as Stage: Giovan Battista della Porta's Experiments," *Journal of European Medieval Studies*, 3 (2014): 18.

<sup>14</sup> Koderas, "The Laboratory as Stage: Giovan Battista della Porta's Experiments," 19.

<sup>15</sup> Louise George Clubb, "Review of Laura Balbiani's 'Magia naturalis' di Giovan Battista Della Porta: Lingua, cultura e scienza in Europa all'inizio dell'età moderna," *Renaissance Quarterly*, 56, no. 1 (2003): 189. (My italics).

<sup>16</sup> Kate Warren, "Critical Wonder: Lynette Wallworth's art in the age of spectacle and socially engaged practice," *Electronic Melbourne Art Journal*, 10, (2018): 1–38.

[https://emajartjournal.files.wordpress.com/2018/03/kate-warren\\_critical-wonder-emaj10.pdf](https://emajartjournal.files.wordpress.com/2018/03/kate-warren_critical-wonder-emaj10.pdf)

<sup>17</sup> Ernesto de Martino, *Magic: A Theory from the South*, trans. Dorothy Louise Zinn (Chicago: Hau Books, 2015), 87–95.

<sup>18</sup> Daniel Birnbaum, "Daniel Birnbaum in Conversation with Olafur Eliasson," in *Olafur Eliasson* (London; New York: Phaidon Press, 2002), 8–33.

material components in my optical systems.

My research focuses not on the actual objects of historical wonder but on the mechanisms of attention used to activate sensory awareness and generate wonder. Historian Barbara Stafford, in her essay “Seizing Attention: Devices and Desires”, addresses the current trend in technologies to utilise our involuntary response mechanisms, causing a decline in conscious attention and awareness.<sup>19</sup> In response to this scarcity of critical attention Stafford emphasises the importance of valuing technologies that make us consciously aware that we are attending.<sup>20</sup> She argues that, in an age where all optical technologies are reduced to the single platform of the internet, it is important to make explicit how different experience-framing devices not only produce different kinds of information but make us think, feel, and desire differently.<sup>21</sup> The optical systems I developed explore whether the attention and awareness demanded by my curious looking devices are decisive elements in wonder.

I investigated novel scenarios generated by unusual looking devices as a mechanism for evoking wonder. Daston and Park discuss how the sixteenth century cabinets of curiosities, or *Wunderkammern*<sup>22</sup>, challenged preconceived ideas of binary opposites such as the distinction between art and nature.<sup>23</sup> A reconstructed *Wunderkammer* in a museum today will not necessarily evoke wonder. Contemporary wonder is however still linked to presenting the senses with a ‘coincidence of oppositions’,<sup>24</sup> which as I discovered through my research, continues to challenge established parameters of the seen and unseen. Binary opposites and novel juxtapositions are significant to my exploration of contemporary wonder. The research and development of my image systems deal with opposite but co-existing constructs of visible and invisible, material and digital, real and virtual, and old and new in relation to the generation of wonder.

Like a cabinet of curiosities, the framework for my research into wonder incorporates both the natural and the human-made. The purpose of my components is to heighten sensory awareness, which in turn acts as a precursor for wonder. Instead of the meticulously handcrafted objects of the *Wunderkammern* however, my components were mostly created using digital fabrication technologies. Through the natural phenomenon of the invisible transfer of light and its engagement with my carefully considered optical constructions I consequently establish a contemporary system of natural magic. The elements of

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<sup>19</sup> Barbara Stafford, “Seizing Attention: Devices and Desires,” *Art History*, 39, no. 2 (2016): 423.

<sup>20</sup> Stafford, “Seizing Attention: Devices and Desires,” 425.

<sup>21</sup> *Ibid.*

<sup>22</sup> Daston and Park, *Wonders and the Order of Nature*, 260–287.

<sup>23</sup> *Ibid.*

<sup>24</sup> Irene Brown and Christian Mieves, *Wonder in Contemporary Artistic Practice*, (New York: Routledge, Taylor & Francis Group, 2017), 1.

my optical systems are embedded into a wider systematic framework of device, image and viewer.

The material methodology of my research relates to that of artist-researchers Irene Brown and Christian Mieves as outlined in their introductory essay in *Wonder in Contemporary Artistic Practice*.<sup>25</sup> They assert that within art theoretical approaches, tools and materials are still associated with the traditional role of the artist in terms of their making techniques, but objects of wonder still have the capacity to destabilize this order.<sup>26</sup> They write, “wondrous objects not only mark the outermost limits of the natural world, but also merge existing categories of natural versus man-made”.<sup>27</sup> In light of Brown and Mieves’ argument, my investigations into the materiality of wonder apply materials and fabrication tools to create my devices, which in turn function as critical tools for generating an experience of wonder. I apply the ‘natural’ and ‘man-made’ to create the opposing elements of my interdisciplinary research.

## Optical Time

The development of my optical systems as tools for exploring wonder led to an investigation of time. The optics of the glass lens has a long association with time. In 1608 spectacle-maker Hans Lippershey placed a ten-millimetre aperture in front of his telescopic lens to reduce the optical distortions caused by the hand-formed glass. Looking into the night sky, he could see for the first time non-human worlds beyond the limited capacity of his eye.<sup>28</sup> As the glass lens optically extracted an image of an object 10,000 light years away, future time was transported into the present tense and in an instant of looking, Lippershey traversed space and time.

Without the optical device, the space between our eye and distant star is so vast it is hard to grasp, but the image formed by the lens compresses this space and renders the distant near and the invisible visible. It creates what philosopher Paul Virilio describes as a ‘logistics of perception’<sup>29</sup> and what writer Roger Shattuck terms an ‘optics of time’.<sup>30</sup> I wondered whether I could apply these concepts of perceptual logistics and optical time to the development of an optical image device. Chapter One relates how my hollow lens system explores ways of compressing time in order to make visible an

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<sup>25</sup> Brown and Mieves, *Wonder in Contemporary Artistic Practice*, 1–16.

<sup>26</sup> Brown and Mieves, *Wonder in Contemporary Artistic Practice*, 1.

<sup>27</sup> Daston and Park, *Wonders and the Order of Nature*, 13. Cited in Mieves and Brown, 1.

<sup>28</sup> Rolf Willach, “The Long Route to the Invention of the Telescope,” *Transactions of the American Philosophical Society*, 98, no. 5 (2008): 93–103.

<sup>29</sup> Paul Virilio, *The Vision Machine*, trans. Julie Rose (Bloomington: Indiana University Press, 1994), 5.

<sup>30</sup> Roger Shattuck, *Proust's binoculars: A Study of Memory, Time, and Recognition in A la recherche du temps perdu*, London: Chatto & Windus, 1964), 40–83.



imperceptible process of slow change. Chapter Two investigates ways of visualising time through the application of nineteenth century optical mechanics and a projected moving ghost. Both devices project images of time-light, that is, images of light presenting their own form of optically generated time. Time-light and its generating devices serve to create a different perception of time, not of minutes and hours but movement and light. My research explores whether time can become visible through an embodied, sensory engagement with materiality.

## The Cognition of Wonder

In addition to sensory engagement and materiality, in Chapter Three my research investigates wonder within the context of emotion and contemporary psychological theories of magic. Philosopher Jesse Prinz argues that wonder has inspired our greatest achievements in art and science, lauding it as humanity's most important emotion.<sup>31</sup> He argues that the essential sensory and cognitive components of the phenomenon contribute to a spiritual experience, which he relates to eighteenth century philosopher Adam Smith's 'bodily feeling' of wonder. My research explores the first two components of Prinz's assertion, proposing that the combination of sensory engagement with visible materiality and an unsolvable cognitive dilemma activate the emotion of wonder. Although I do not infer any kind of spirituality, I consider Smith's threshold for wonder, which at its limit must confound previous experience.

Almost 300 years after Smith's wonder, induced by confounding experience, a similar neuropsychological approach to contemporary magic has emerged, which considers the activation of working memory to check the plausibility of what occurs before our eyes.<sup>32</sup> Contemporary cognitive theories of magic became relevant to my project because I apply a system of natural magic as a mechanism for evoking wonder. The optical devices I created inadvertently explore what happens when I experience something that challenges my established belief system. My investigations take into account my experience of wonder generated through the visible and invisible elements of my optical system and cognitive theories of magic in an attempt to understand this experience.

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<sup>31</sup> Jesse Prinz, "Why Wonder is the most human of all emotions," *Aeon*, June 21, 2013. <https://aeon.co/essays/why-wonder-is-the-most-human-of-all-emotions>.

<sup>32</sup> Ben A. Parris, Gustav Kuhn, Guy A. Mizon, Abdelmalek Benattayallah and Tim L. Hodgson, "Imaging the impossible: An fMRI study of impossible causal relationships in magic tricks," *NeuroImage*, 45 (2009): 1033–1039.

## Wonder as a means of Renegotiating with the World

My research addresses the paradox of wonder, which originally emerged during the seventeenth century. Unlike the preternatural philosophers who viewed wonder as a virtuosity, their seventeenth century successors René Descartes and Francis Bacon had a less glowing opinion of the phenomenon. They viewed it merely as the spark, which ignites a quest for new knowledge and that wonder – essentially stemming from ignorance – will fade once knowledge is gained.<sup>33</sup> This negative relation between wonder and knowledge creates a paradox: if wonder initiates inquiry, then with the end of inquiry comes the end of wonder. Daston explores this quandary in her essay “Wonder and the ends of Inquiry”,<sup>34</sup> writing that “the more we know, the less we wonder”.<sup>35</sup> By purposefully creating scenarios of coincidental oppositions within my optical systems, my research process invalidates this paradox. The accumulative knowledge I gained through my project did not extinguish my experience of wonder. Instead, I found that my optical systems renew wonder through a coincidental opposition of the visible and invisible. This has made me rethink my practice from being solely concerned with material objects to one involving systems which incorporate both visible and invisible elements.

The various revelations that emerged, detailed in the chapters *Natural Magic and Wonder*, *Time and Materiality*, and *Expansion of Visibility*, showed me that wonder is a process of continuous renegotiation. Artist Tiffany Shaffran in her essay on the liminal condition of wonder writes about this reforming relationship:

...wonder becomes part of a private negotiation with the world that awakens one’s mind to unexpected possibilities. In this way, wonder is a hopeful and positive antidote to collective ennui. To experience wonder is to experience something that doesn’t fit within the personal register of experience and knowledge. It is a reflective activity that prompts re-evaluation of our understanding of the world.<sup>36</sup>

My explorations of wonder and time have shifted my artistic endeavours from a studio-glass practice to an interdisciplinary modality of research, which has led to unexpected discoveries and the development of a much broader and interconnected relationship with my surrounding world.

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<sup>33</sup> Lorraine Daston, “Wonder and the Ends of Inquiry,” <https://thepointmag.com/2014/examined-life/wonder-ends-inquiry> (accessed July 11, 2018).

<sup>34</sup> Ibid.

<sup>35</sup> Ibid. (Daston makes this comment in relation to wonder in the seventeenth century).

<sup>36</sup> Tiffany Shaffran, “Archives of Wonder: Collecting the Liminal in Contemporary Art,” in *Wonder in Contemporary Artistic Practice*, eds. Christian Mieves and Irene Brown, (New York: Routledge, 2017), 22.

# Chapters

## Chapter One – Natural Magic and Wonder

This chapter opens with the experience of witnessing slow change in the landscape, which became the starting point of my explorations into wonder and time. I describe the research and development of my optical image system, *Hollow Lens*, as a means of evoking wonder and optically compressing time in order to render visible a process of slow change. Referencing Della Porta's use of optical tools to generate wonder, I detail how my optical systems differ from those of this sixteenth century natural magician, in terms of exposed visibility and a critically engaged viewer. I argue that direct sensory engagement and awareness are crucial to an experience of wonder and that my optical system, instead of hiding its source, requires a de-cloaked device in order to direct attention to the physical cause of the change in the image. I detail how this influenced the interdisciplinary development of the device's components, which combine contemporary real-time technologies with sixteenth century water lenses. Using the water lenses like a distillation apparatus for time, allowed me to set the rate of change in the optics of the lens above the threshold for visibility and therefore draw attention to this change without effecting the process of change itself.

This chapter relates how theoretical frameworks of critical awareness, de-familiarisation, strange juxtapositions and novel scenarios enriched the material development of *Hollow Lens*. It applies ideas informed by historians Sergius Koderer, Lorraine Daston, Katherine Park and Barbara Stafford, philosophers Adam Smith, Hans Jonas, Martin Heidegger and Ernesto de Martino, and writers Kate Warren, Viktor Shklovsky and Tom Gunning. Also influential for my material investigations of wonder and natural magic were specific artworks by interdisciplinary artists Adam Brown and Olafur Eliasson. Although our interests in natural phenomena and direct sensory experience are shared, I identify how my research outputs differ in my specific application of natural magic to generate wonder.

## Chapter Two – Time and Materiality

Chapter Two explores how time can be made visible through the material device and projected image. I detail the development of my optical polygon system, *Ghost in the Machine*, which aims to re-form the perception of time and create a more human relation to time in the current digital era.

Starting with the experience of seeing a sunspot travel lightly across my kitchen wall, this chapter relates my endeavour to know time through a combination of materiality, movement and light. I describe the interdisciplinary research and development of my optical polygon system and its moving ghost, as a means of visualising an optical form of time. Referencing technology writer Charlie Gere and the real-time technologies of *Hollow Lens*, I argue how my material devices endeavour to keep our human relation with time open in the digital age.

Later sections of the chapter consider the influence of nineteenth century artist-engineer Charles-Émile Reynaud's optical mechanics on my polygon system and the importance of the theories of writers Mary Ann Doane and Tom Gunning. I explain my efforts to create an optical time dynamically generated through a rotating polygon and glass lens, and a reconstructed time-light created through translucent image frames rotating around a source of light. Works by contemporary artists Jan Dibbets and Attila Csörgő are discussed in relation to my exploration of time.

Several material and mechanical challenges to the development of *Ghost in the Machine* led to incidental findings of the importance of the perceptual gap, rotational speed and duration of my moving ghost, which are outlined in the chapter. At this stage of the project I shifted my focus from the digital image to the materially generated projected image and moved from an object-oriented to system-oriented methodology.

## Chapter Three – Expansion of Visibility

Chapter Three details the process of understanding how my optical systems continue to evoke the experience of wonder. Sensory engagement is identified as playing a key role in the generation of wonder and I investigate how attention and awareness are generated through the renewed visibility of the device.

*Hollow Lens* explored ways of optically compressing time to render visible an imperceptible process of slow change, but at this stage of the project it became clear there was more to wonder than visible materiality. This chapter takes a more theoretical approach and outlines an expanded exploration of visibility, beginning with a reversal of visibility that so often occurs between the projected image and its generating device. It takes the theoretical positions of media archaeologist Siegfried Zielinski and film theorist Dominique Païni as starting points for exploring relationships between device, image and viewer and argues for a renewed attention and ontology for the device.

In this chapter I also attend to the invisible transfer of light, prompted by the experience of seeing Johannes Vermeer's *View of Delft* (1660–1661) and my research into Johannes Kepler's early modern theory of sight and the writings of historian Svetlana Alpers. I elaborate on the development of my third major work, *Object-Image*, an optical image system which led to discovering the extent to which glass mediates an image of an object. I examine the visibility and awareness of this mediation in my systems in relation to the works of contemporary artist Julian Maire and the writings of art critic Jonathan Crary.

The most significant findings of this chapter emerge from my investigations into the cognitive psychology of magic and wonder and the light-works of contemporary artist Anthony McCall. After realising the importance of the unseen transfer of light, I argue that the continued experience of wonder in the presence of my optical devices is due to the co-existing opposites of visible device and image, and invisible transfer of light. I discuss how this realisation does not refute the importance of direct sensory engagement, attention and awareness as significant elements in the evocation of wonder – rather, it broadens my understanding of this engagement and awareness to include sensing the invisible.

## Summary

The culmination of this project was a series of three optical image systems, developed as a means of exploring wonder, time and visibility. In challenging ideas about the preconceived roles of visibility and invisibility, my research provides an insight into the role of wonder in contemporary art practice. The explorations I conducted into visual art, studio glass, optics, engineering, history, philosophy, and digital fabrication technologies were combined with research into constructs of the visible and invisible, material and digital, real and virtual. Together they led to an extended understanding and perpetuation of wonder.

# Chapter One

## Natural Magic and Wonder



Fig. 1. River Shannon, County Westmeath, Ireland, 2015.



Fig. 2. Cross Beach, County Mayo, Ireland, 2015.



*... Knowledge gained through wonder, is not the knowledge of universal law. It is not a totalising force that explains the underlying mechanisms of the world as irrefutable fact, but rather a poetic knowledge that traces a path of discovery through a narrative that connects and unifies disparate things.*

– Tiffany Shaffran<sup>37</sup>

*The artist [is] not just a fabricator of works and objects, but above all ... a guide, interpreter and creator of possible worlds.*

– Cecilia Alemani<sup>38</sup>

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<sup>37</sup> Tiffany Shaffran, “Archives of Wonder: Collecting the Liminal in Contemporary Art,” 23.

<sup>38</sup> Cecilia Alemani, *Il Mondo Magico*, (Venice: Venice Biennale, Italian Pavilion, 2017), Exhibition catalogue, 4.

## Introduction

In the recent past, I spent a prolonged period recovering from an illness. After several months being completely bed-ridden, I slowly began to emerge back into the world again. Part of my recovery was a daily walk along a river's edge, close to my home. As each day, week, month and season passed, I noticed the slow subtle changes in the landscape. The rise and fall of the river's water, a summer meadow flooded and became frozen. The horizon disappeared and as the sky mirrored itself in the ground, it created a sense of being contained inside some sort of sphere. Then came the spring thaw and as the ice melted and the water receded, it appeared as if the ground was drinking up the sky. The seam of the horizon reappeared, changing my experience of space again. Still within nature, but I was back on the surface of the world. And so the process continued (Fig. 1).

These slow changes in nature are unobservable from an 'instant' view. They incorporate the time of nature, a kind of light-time, but also my sense of time, as an observer experiencing the world. This happens too when the tide washes in and paints the mirrored sky, only to sweep it back out again, as if the beach is soaking up the sky (Fig. 2). But here the spatial mirroring has a much shorter duration, allowing us to observe the phenomena. It is visible to us. I wondered about how I could make visible the slower change of nature. How could I extract this invisible process of change, compressing time so it can be observed, but not affect the process itself?

Thinking back to the optical logistics of Lipperhey's telescopic lens<sup>39</sup> and Shattuck's 'optics of time'<sup>40</sup> rendering the faraway near and the invisible visible, I knew that glass somehow held the material key for this exploration. I wanted to investigate my idea of time-light to materially generate an optical form of time. Could glass, with its unique logistics of perception, make visible the imperceptibly slow changes in nature? I was also on a quest to understand how the material of glass, transporting its image-light across space and time, continued to cast its magical and wondrous spell. Could I use this material to generate wonder as part of my inter-disciplinary practice-led research? Before understanding how the natural properties of glass might generate a form of wonder, I needed to explore the phenomenon of wonder itself.

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<sup>39</sup> Rolf Willach, "The Long Route to the Invention of the Telescope," 90.

<sup>40</sup> Shattuck, *Proust's binoculars: a study of memory, time, and recognition in A la recherche du temps perdu*, 40–83.

Whilst investigating its historical and contemporary contexts, in the studio I started to research and develop an optical hollow lens system as a tool for evoking wonder. *Hollow Lens* is a multi-component device, which optically forms and projects a continuously changing image. It incorporates old and new technological elements such as condensing lens systems, LEDs, translucent LCD screens and composite hollow lenses, in which rising and falling levels of water are controlled by an electronic pump mechanism. When combined, these components project a slow changing image-light emerging from digitally streamed scenes on the LCDs.

This chapter outlines the research and development of my optical hollow lens system within frameworks of natural magic, projected image-light and wonder. It progresses from the already narrated experience of observing slow changes in nature, to the optical tools used by the sixteenth century natural magician Giovanni Battista Della Porta and elaborates on how and why I explicitly expose my device to generate wonder. It explores theoretical frameworks of newly encountered objects,<sup>41</sup> de-familiarisation,<sup>42</sup> and criticality<sup>43</sup> and their application as potential mechanisms for generating contemporary wonder.

This chapter details how de-cloaking my optical system captures the attention of the viewer and how this attention might subsequently contribute to the provocation of wonder. It relates how, in my attempt to extract the slow time of nature, I combine contemporary real-time technologies with a pre-modern technology of water lenses, changing the optical properties of my device and consequently the perceived moving image. I explore specific artworks of contemporary artists Adam Brown and Olafur Eliasson as contextual references for practice engaging with tropes of natural magic and wonder, uncovering shared themes and significant differences in the material sources and artistic outputs of my research and these artists.

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<sup>41</sup> Adam Smith, *The Glasgow Edition of the Works and Correspondence of Adam Smith*, Eds. D. D. Raphael, A. L. Macfie, R. H. Campbell, D. D. Raphael, and A. S. Skinner, (Oxford: Clarendon Press, 1976), 38–40; Tom Gunning, “Re-newing Old Technologies: Astonishment, Second Nature and the Unanny in Technology from the Previous Turn-of-the-Century,” in *Re-thinking Media Change – the Aesthetics of Tradition*, eds. David Thornburn and Henry Jenkins, (Cambridge Massachusetts: MIT Press, 2003), 39–46.

<sup>42</sup> Viktor Schlovsky, “Art as Technique,” in *Russian formalist criticism : four essays*, trans. Lee T. Lemon and Marion J. Reis, (Lincoln: University of Nebraska Press, 1965) 3–24.

<sup>43</sup> Kate Warren, “Critical Wonder: Lynette Wallworth’s art in the age of spectacle and socially engaged practice,” *emaj*, 10, (2018): 1–38. [https://emajartjournal.files.wordpress.com/2018/03/kate-warren\\_critical-wonder-emaj10.pdf](https://emajartjournal.files.wordpress.com/2018/03/kate-warren_critical-wonder-emaj10.pdf) (accessed November 01, 2018).

## Part One – Natural Magic

### Della Porta

Giovanni Battista Della Porta's (1535–1615) use of optical objects gave me the initial insight into how I could bring the material of glass into play as a tool for exploring wonder. Whilst thinking about the slow changes in nature, I surveyed the practice of this sixteenth century natural magician, also known as a 'professor of secrets'<sup>44</sup> and preternatural philosopher. The preternatural philosophers from the mid-sixteenth to seventeenth centuries had a particular obsession with wonder that was generated from the close observation of nature. As Daston and Park note, this emphasis on wonder marked a "unique moment in the history of European natural philosophy, unprecedented and unrepeated".<sup>45</sup> They used optical objects in the form of lenses and mirrors to see what, until then, had remained invisible to the unmediated eye.<sup>46</sup>

Of particular relevance to my research is how these optical objects served as illusionary devices to project images of the newly rendered visibilities and incite wonder. For example, Della Porta's contemporary Jean Pena placed a concave mirror inside a *camera obscura*, projecting images, which appeared to hover 'in the air'.<sup>47</sup> Della Porta himself noted how easy it was to use optical objects to create moving simulacra of animals or raise-up 'ghost-like forms', as part of his proto-cinematic performances inside a camera obscura chamber.<sup>48</sup> These simulacra and ghost-like forms were image projections created using glass lenses and light. His audience did not see the source object itself but its detached image.<sup>49</sup> This optical formation of an image, its rays of light carrying the imperceptible essence

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<sup>44</sup> Arianna Borrelli, Giora Hon, Yaakov Zik, eds. "The Optics of Giambattista Della Porta (ca. 1535–1615): A Reassessment," *New Studies in the History and Philosophical of Science and Technology*, (Netherlands: Springer International Publishing, 2017), 13.

<sup>45</sup> Daston and Park, *Wonders and the Order of Nature*, 13.

<sup>46</sup> As Della Porta's contemporary Marsilio Ficino described, the world was a secret web of hidden links. (Daston and Park, *Wonders and the Order of Nature*, 161.)

<sup>47</sup> Sven Dupré, "Inside the Camera Obscura: Kepler's Experiment and Theory of Optical Imagery," *Early Science and Medicine*, 13, no. 3, (2008): 223.

<sup>48</sup> Isabelle Pantin, "'Res Aspectabilis Cujus Forma Luminis Beneficio per Foramen Transparet' – *Simulachrum, Species, Forma, Imago*: What was Transported by Light through the Pinhole?," in *Inside the Camera Obscura – Optics and Art under the Spell of the Projected Image*, ed. Wolfgang Lefèvre, (Berlin: Max Plank Institute for the History of Science, 2007), 100; Sven Dupré, "Images in the air. Optical games, magic and imagination," *Spirits Unseen*, eds. C. Göttler and W. Neuber (Boston: BRILL, 2007), 80–87; Sergius Koderá, "Between Stage-Prop and Metaphor: Mirrors in Giovan Battista Della Porta and Giordano Bruno," *The Mirror in Medieval and Early Modern Culture: Specular Reflections*, ed. Nancy M. Frelick, (California: University California Centre Medieval Renaissance Studies, 2017), 235–256.

<sup>49</sup> Hans Jonas, "The Nobility of Sight," *Philosophy and Phenomenological Research*, 14: no. 4 (1954): 515; Joel Snyder, "Picturing Vision," *Critical Inquiry*, 6, no. 3 (1980): 502.

of an object as it refracts through the lens, created for me an appreciation of the glass lens as a kind of siphon, extracting secret invisibilities from the world and presenting them to us in perceptible form.

Also significant to my project was how Della Porta's illusionary tricks changed what is hidden to us. No longer concealed, nature's secrets are imaged and projected for all to see. What remains covert however, are the causes of how we see the wondrous image. By concealing these causes, Della Porta's lenses and mirrors become embedded into his apparatus of natural magic.

Della Porta's magical images gain even more potency through an accustomed absence of the causality of how we see our world, described by philosopher Hans Jonas as a 'causal muteness'.<sup>50</sup> In his essay on *The Nobility of Sight*, Jonas argues that whatever physical dynamic lies between light, the seeing eye and object, "the expurgation of all traces of causal activity from its presentation, is one of the major accomplishments of what we call the image-function of sight".<sup>51</sup> How we see what we see is therefore not part of our normal visual experience. Although we are sensorily blind to the causes of sight, we can still know how sight occurs. However, when we witness something new and confounding and cannot in any way grasp its cause, sensorily or cognitively, it gives the appearance of magic.

The distinctions and connections between magic, sight and visible causes became a key concern for my research. In Jonas' theory of sight, the seen object or cause is normally physically present. With the projected image however, as I have described with Della Porta's natural magic performances, the cause of the projected image-light is hidden from view. For this sixteenth century audience the cause is both unseen and unfathomable and must have generated an astonishing spectacle, in which any search for an explanation was arrested rather than activated. This is where my explorations of natural magic diverge from Della Porta's. A contemporary viewer of a projected image installation will not have the same astonished reaction to the phenomenon of the image-light being cast across the darkened space of the gallery. The contemporary viewer focusing on the image, takes for granted its 'cause' in the unseen image device. However a magical encounter with the image-light projected through the exposed optics of my device brings back into play the experience of wonder. My wonder is not one of astonishment, but critical engagement, which activates an embodied cognitive response as well as engaging the senses.

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<sup>50</sup> Jonas, "The Nobility of Sight," 515.

<sup>51</sup> Ibid.

## Critical Wonder

The particular form of wonder I investigate is an alternative critical space, where my perception is heightened and changed. Although critical engagement is not the experience of wonder itself, I propose through the development of my optical device that attention and awareness are necessary elements for contemporary wonder. In her essay on critical wonder, curator and art historian Kate Warren comments on how the artworks of Australian artist Lynette Wallworth succeed in moving beyond the normally pejoratively perceived 'spectacle', engaging her audience in critical wonder rather than passively consuming the work.<sup>52</sup> Warren writes that:

[Wallworth's] proficient use of new media technologies generates the possibility of 'critical wonder' in her audience, by activating curiosity, self-awareness and criticality via aesthetic, emotive and sensorial modes.<sup>53</sup>

The strange juxtapositions of my device aim to evoke a more critical wonder by commanding attention and challenging our preconceived notions of what is normal or possible in the world.

My focus has been to engage the viewer sensorily, cognitively and emotionally. In both the studio and physics laboratory, my optical image system was already activating a curious response in terms of its unfamiliar aesthetic and material function. At the end of the first year of the project, I also knew that each time I switched on my device to test some further development, a nuanced feeling of critical wonder arose in me as my emotions, awareness and sensing self, merged together.

Returning to Della Porta's wonder, if my interests lay in critical rather than astonished wonder, why then were these sixteenth century perceptual apparatus so influential upon my research?<sup>54</sup> It is because they were specifically made from glass and were purposefully applied to generate wonder. The intricacies of how these optical objects were applied within a context of natural magic was therefore highly significant and as I discovered towards the end of the project, some of these methods are still used today in contemporary magic. Wonder therefore was the link between the contemporary devices of my research and the optical objects of sixteenth century natural magic.

Rather than using his optical objects to advance scholarly knowledge, Della Porta was interested in using his glass tools and projected images to induce the experience of wonder in his enthralled audiences. Consequently, this "master manipulator of natural phenomena"<sup>55</sup> has been criticised for his optical

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<sup>52</sup> Warren, "Critical Wonder: Lynette Wallworth's art in the age of spectacle and socially engaged practice," 1–38.

<sup>53</sup> Warren, "Critical Wonder," 9.

<sup>54</sup> Barbara Stafford asks a similar question: "What makes this ancient perceptual apparatus not obsolete but, in fact, cognitively informative and still eye-opening?" (Barbara Stafford, "Seizing Attention: Devices and Desires," *Art History*, 39, no. 2 (2016): 425.

<sup>55</sup> Kodera, "The Laboratory as Stage," 24.

understanding of light.<sup>56</sup> He practiced just before the emergence of modern science, when the concepts of reflection and refraction were still confused.<sup>57</sup> He lived before René Descartes' *La Dioptrique* (1637) that contained the first formal reference to Snell's Law of Refraction<sup>58</sup> and he does not appear to have been familiar with Johannes Kepler's introduction of light into the optics of vision (1604) that profoundly changed our understanding of how we see the world.<sup>59</sup> It seems clear from Della Porta's practice of natural magic, however, that he had a thorough practical understanding of the emotion of wonder.

After exploring Della Porta's early technological use of glass, I was keen to apply a similar sixteenth century technical paradigm to my optical devices. Historian Sergius Kodera incorporates *techne* into Della Porta's performative approach to natural philosophy, describing it under the umbrella term of *scienza*, which he equates not to modern science, but to a pre-modern understanding of art.<sup>60</sup> Incorporating both the Latin *ars* and Greek *techne*, Kodera suggests that Della Porta's *scienza* is the combination of theory and practice.<sup>61</sup> *Scienza* became a relevant term for my research as an interdependence emerged between the technologies and theoretical frameworks of my devices functioning as works of art.

I thought about how during the sixteenth century, the divide between art and nature still lingered. Della Porta used *techne*, in the form of his optical objects to bring us closer to nature by allowing us to see it in a certain way.<sup>62</sup> Today *techne* is perhaps more associated with technical apparatus moving us further away from our own humanity, but *techne* can also inadvertently renew sensory awareness and consequently bring us closer to our own nature. I recalled the lensed scene outside my studio window

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<sup>56</sup> Dupré, "Inside the Camera Obscura," 222–238; David C. Lindberg, "Alhazen's Theory of Vision and Its Reception in the West," *Isis*, The University of Chicago Press on behalf of The History of Science Society, 58, no. 3 (1967): 333.

<sup>57</sup> Dupré, "Inside the Camera Obscura," 224.

<sup>58</sup> Fokko Jan Dijksterhuis, "Constructive Thinking: A Case for Dioptrics," *The Mindful Hand – Inquiry and invention from the late Renaissance to early industrialisation*, eds. Lissa Roberts, Simon Schaffer and Peter Dear, (Chicago: The University of Chicago Press, 2008), 59–82.

<sup>59</sup> In Johannes Kepler's *Ad Vitellionem Paralipomena* (1604), the concept of light passing through the lens of the eye to create an optical image on the retinal screen (*pictura*) was introduced for the first time. (Cited in Johannes Kepler, *Optics: Paralipomena to Witelo and Optical Part of Astronomy*, trans. William H. Donahue (Santa Fe: Green Lion Press, 2000)). However since 2014, an emphasis has been placed on the role Della Porta played in influencing Kepler. (Arianna Borelli, "Thinking with optical objects: glass spheres, lenses and refraction in Giovan Battista Della Porta's optical writings," *Journal of Early Modern Studies*, 3 (2014): 39–61; Arianna Borrelli, Giora Hon, Yaakov Zik, eds., "The Optics of Giambattista Della Porta (ca. 1535–1615): A Reassessment," 2017).

<sup>60</sup> Kodera, "The Laboratory as Stage," 16; Larry Shiner, *The Invention of Art*, (Chicago: University of Chicago Press, 2001), 11.

<sup>61</sup> Kodera, "The Laboratory as Stage," 16.

<sup>62</sup> But these objects not only helped him in his painstaking observations of nature, they served as devices with which he could generate marvels and wonder during his stage performances. (Sven Dupre, "Images in the air," 71–91).

offering me a renewed perception of the world outside (Fig. 3 and Fig. 4). It is within this more human context of *techne* that Della Porta's contribution to optics has been recently re-evaluated (2014, 2017)<sup>63</sup> and is relevant to my project. Historian Arianna Borelli describes his use of glass lenses and mirrors to extract invisible phenomena from nature<sup>64</sup> as a kind of 'thinking with objects', a description that can also be applied to my research.<sup>65</sup>

Using the material properties of glass and the physical properties of light, I began to explore new ways in which a contemporary *scienza* might give rise to a state of wonder. As curator Cecilia Alemani commented in her catalogue essay *Il Mondo Magico* (2017) "...magic is not an escape into the depths of irrationality, so much as a new way of experiencing the world".<sup>66</sup> I viewed my explorations as contemporary natural magic, attempting to extract invisibilities from our world and render them visible so that we might perceive our world in a different way.



Fig. 3. The lensed view outside my window projected onto the wall.



Fig. 4. Another image of the external world projected onto my studio wall.

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<sup>63</sup> Borelli, Hon, Zik, "The Optics of Giambattista Della Porta," (2017); Borelli, "Thinking with optical objects: glass spheres, lenses and refraction in Giovan Battista Della Porta's optical writings," (2014).

<sup>64</sup> These invisible phenomena are what Della Porta's contemporary Marsilio Ficino described as part of the "secret web of hidden links". (Daston and Park, *Wonders and the Order of Nature*, 161).

<sup>65</sup> Borelli argues that Della Porta's practice contributed significantly to the development of geometric optics. By using the then new optical artefacts of lenses and mirrors, he developed a systematic methodology of extracting and observing otherwise invisible natural phenomenon. (Borelli, "Thinking with optical objects," 39–61).

<sup>66</sup> Cecilia Alemani, *Il Mondo Magico*, 4.



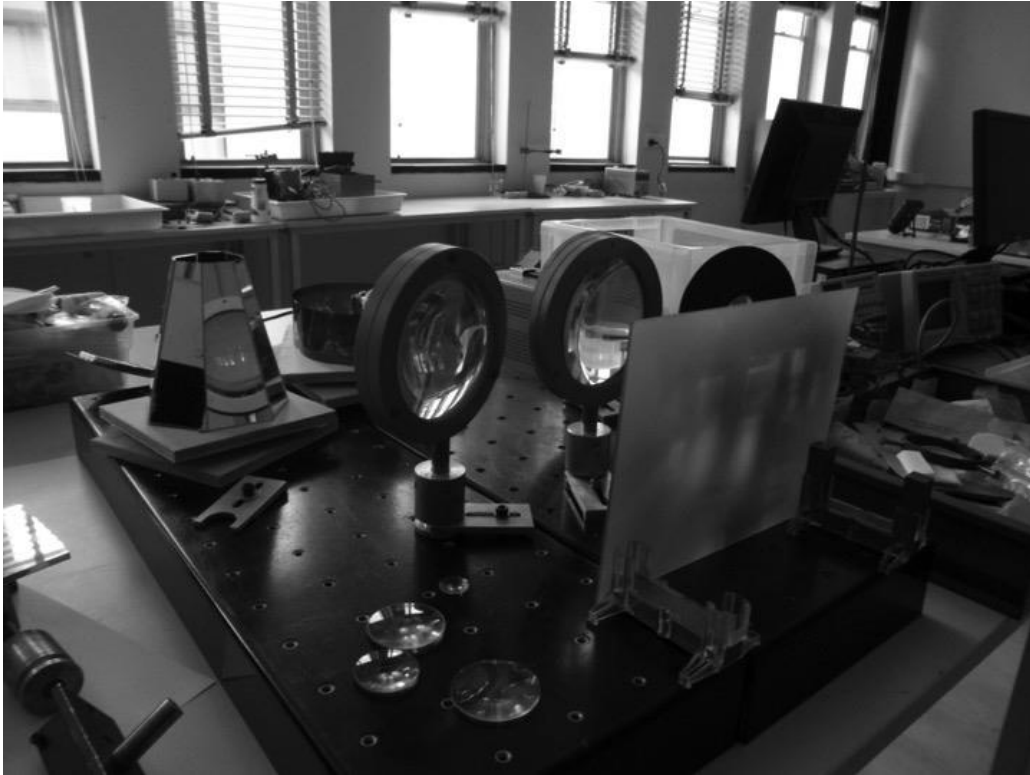


Fig. 5. Projecting an image with lenses and mirrors in the ANU Research School of Physics and Engineering laboratory.

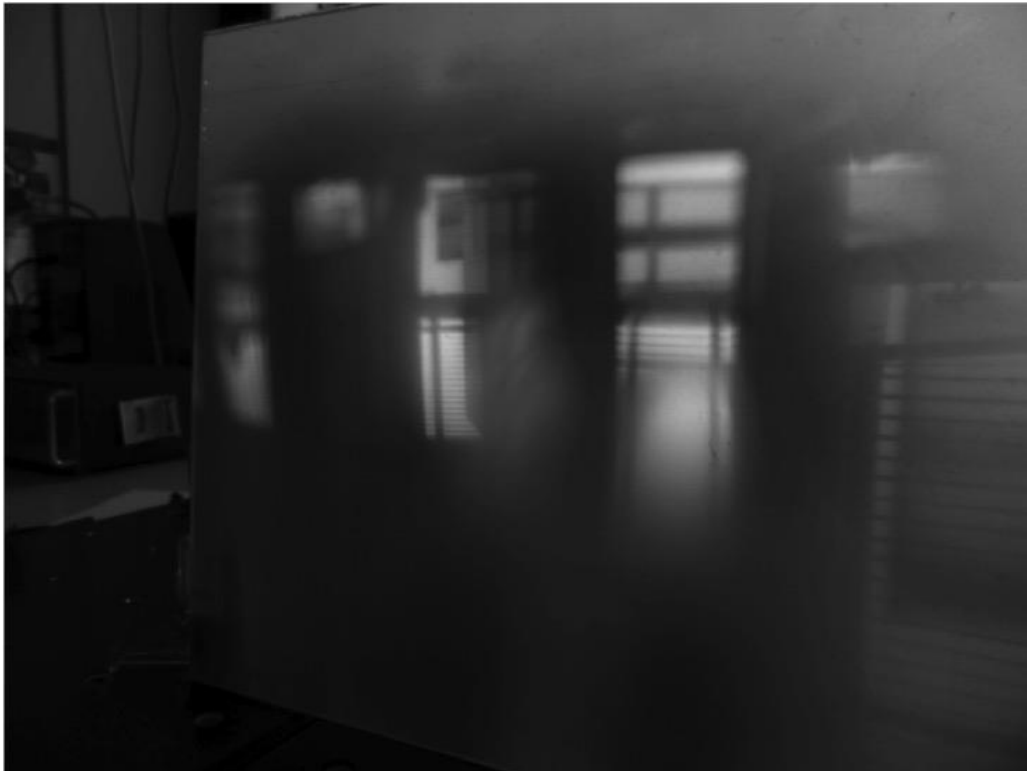


Fig. 6. An image of the space of the physics laboratory projected onto a matt glass surface.

## Material Beginnings

My material investigations into wonder, natural magic and optically compressed time inevitably began with the glass lens. In the first three months of the project, I had access to one of the ANU Physics laboratories where I found a plethora of lenses. I began to create projected composite images of the laboratory, which I found really compelling. Like the glass lenses I had played with in my studio, they allowed the space of the laboratory to picture itself (Fig. 5 and Fig. 6). It was a pocket of space within a space, a materially encoded picture of time-light, reminiscent of the analogue encoding of the landscape reflected on a painter's Claude glass.<sup>67</sup> I began to think about the composite projected image not just in terms of present space and time, but as a way of gathering images streamed across parallel spaces and time. I reflected on how my interest in collating parallel spaces and time had perhaps emerged from a life lived between Ireland and Australia, co-existing worlds that can never intersect. To compensate for the schism between these two worlds, I had over time created a realm somewhere between the two, one that is both physically present and virtually re-presented through technological means.

## Hollow Lens System

The hollow lens system explored possibilities for optically compressing space and time and rendering visible the unseen process of slow change. Developing the various technological components for this device showed me the importance of attending directly to the physical cause of the changing projected image in order to activate critical engagement and evoke wonder.

Investigating the idea of parallel space and time, I began to stream live webcam scenes using the glass screens of deconstructed tablets and set up a remote-control system to regulate the screens' images through an app on my phone (Fig. 7). The screen was translucent so I could turn it into a digital glass

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<sup>67</sup> The Claude glass is a pocket size convex mirror which has either a tinted dark surface or is made from black glass. It is usually carried in a small made-to-measure case. The reflected image on the surface of the mirror was used as a tool by landscape painters in the eighteenth century to achieve a tonal gradation of colour similar to that of the seventeenth landscape painter Claude Lorraine. ("Claude glass," Victoria and Albert Museum, accessed February 26, 2019, <http://m.vam.ac.uk/item/O78676/claude-glass-unknown/>; Arnaud Maillet, *The Claude Glass: Use and Meaning of the Black Mirror in Western Art*, trans. Jeff Fort (New York: Zone Books, 2004), 85–113).

slide and project its image, releasing it back into the physical space of the world again. Two streaming devices brought in different parallel spaces and time into my here and now.

The idea for my digital glass slide came from examining the seventeenth century optical image device of the magic lantern. In addition to a condensing and objective optical system, the magic lantern uses a hand-painted glass slide as its image-object, which refracts through its optical system and projects onto a screen. The condensing system converges the rays of the light emitted from the light source so that they enter the image object in parallel, therefore minimising loss of light. The objective lens system magnifies and focusses the projected image light. A kind of proto-data projector, it is similar to the *camera obscura* but has the important additions of the translucent glass slide and a controlled light source (Fig. 8).

I wanted to refine these initial investigations, so I began working with electronics engineer Paul Redman at the ANU Research School of Physics and Engineering (RSPE). Instead of my deconstructed tablets, we used high-resolution LCD screens traditionally applied in stereolithographic (SLA) 3D printing, giving me greater control over the screen's image (Fig. 9). When researching this part of the image system, I was faced with a technical dilemma. In contrast to the SLA screens, the original screens I had used were highly transparent but had low quality image resolution. The higher resolution SLA screens held a thin film transistor on the back of the glass, which acts as a semiconductor for each pixel of the image and therefore augments the quality of the overall image. The downside to this sharper image for the purpose of my project, was that these screens were significantly less transparent. Because I was re-purposing the technology for something other than its original design, I had to compromise between the resolution and brightness of the image and therefore the size of the projected image. In the end, I decided on a screen that had high but not optimal resolution and which consequently, being more transparent, produced a brighter but smaller projected image.

After resolving this impasse, I designed a framing mechanism for my LCDs, which allowed me to change the position of the screen as required by my optical system (Fig. 10). I deconstructed 1970s slide projectors and created a series of condensing lens systems through which I focused light from a high lumens LED through a translucent image source (Fig. 11, Fig. 12 and Fig. 13). I then tested this system with the addition of an objective glass lens to project a focused and magnified image of the Atlantic Ocean onto my studio wall.

As dusk descended on my studio in Canberra, the morning light emitted from the imaged waves of the Atlantic Ocean filled the small space. Through real-time technology and the optics of the lens, this ocean on the other side of the world was no longer contained within the digital screen. Instead it presented itself as an image-light, directly observable and wrapped around whatever surface happened

to catch hold of it in my studio. Glass in its many forms, the fibre optic cable, the LCD screens, the lenses, transported this image of light and brought the faraway ocean closer to me. I could see it, not just in my mind's eye, but re-presented before me. I knew of course that this was not the ocean itself, but its imaged form and that this real-time experience was already accessible to me by simply using a data projector.<sup>68</sup>

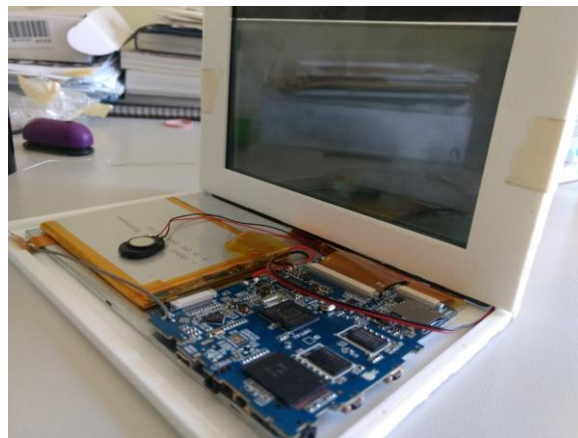


Fig. 7. Deconstructed tablet screen with printed circuit board (PCB).

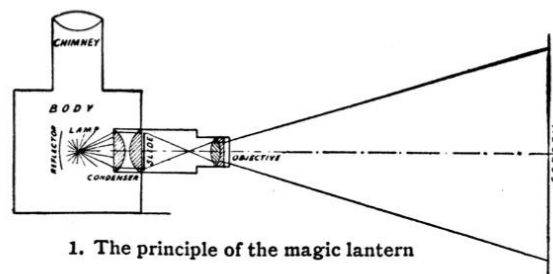


Fig. 8. Diagram detailing the optical principle of a magic lantern.

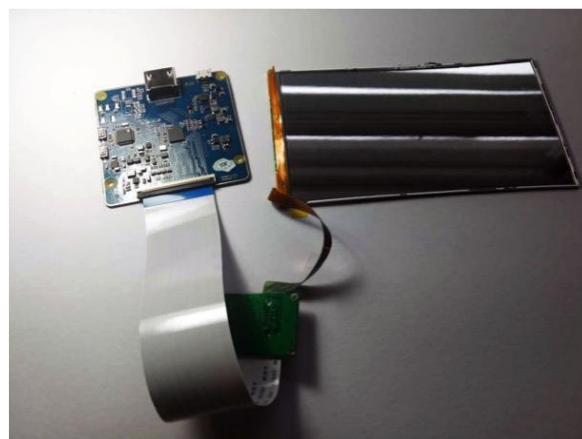


Fig. 9. High resolution LCD screen and PCB.

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<sup>68</sup> Joel Snyder, "Picturing Vision," *Critical Inquiry*, 6, no. 3 (1980): 502.

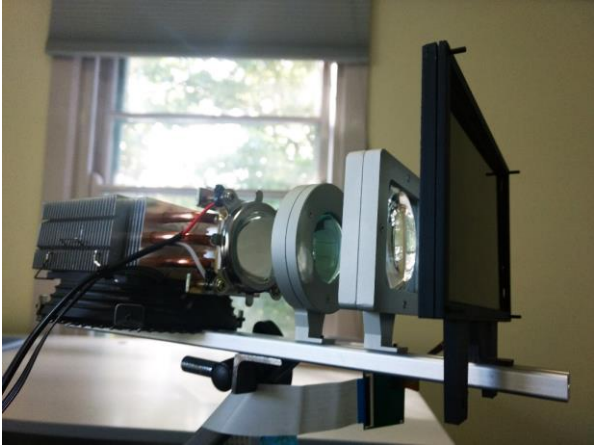


Fig. 10. Framing mechanism for the LCD screen with condensing lenses and LED.



Fig. 11. Condensing lens system – lens holders 3D modelled, milled in aluminium and anodised.

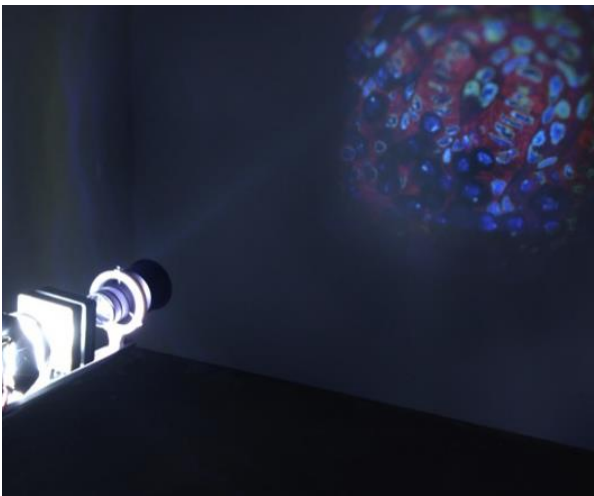


Fig. 12. Testing my system with a translucent image source.



Fig. 13. Testing my system with translucent image source of a water landscape.

Still vivid in my memory was my experience of perceiving the slow physical changes in the landscape and how, like Della Porta's close observations of nature, my direct engagement with the physical change in the landscape had been key, not just in terms of the newly rendered visibility, but in terms of the evocation of critical wonder. The imaged ocean-light appeared before me in real-time, but I knew that physical change was lacking from my optical system. From my own experience and historical investigations into wonder, it seemed to me that in order to evoke wonder, a component of physical change was necessary to directly engage the viewer's senses. This change as it physically unfolded before me would generate, not just a 'real-time' of contemporary technology, but 'real' time in terms of direct physical experience.

Throughout this exegesis I use the term 'unfold' specifically for how it relates to time and space. As I experienced through my observations of the slow changes in the landscape, although not always within our perceptual limits, space is constantly in flux. I see change as the conduit of time, unfolding itself through continuous physical movement within our surroundings.<sup>69</sup> Remembering back to the slow rising and falling of the river in the landscape, I began to think about using water to create physical and material change within my hollow lens system. I wondered if altering the rate of change of water in the optical 'landscape' of my lenses would enable my device to compress time like Lippershey's telescopic lens.

To develop my idea of creating 'real' time beyond digital technologies, one that would physically unfold within my sensory realm, I investigated hollow lenses, also known as water lenses. These were used from the sixteenth century onwards and were viewed as a 'poor man's lens', because they were less costly to ground and polish than solid lenses. When filled with water, the hollow lens refracts light to create a projected image. For contemporary context, I looked at the work of German artist Carsten Wirth who created a series of large-scale water lenses as components for a reconstruction of a seventeenth century *camera obscura* at the Max Plank Institute for the History of Science (2007)<sup>70</sup> (Fig. 14 and Fig. 15). Wirth's lenses served as a research tool for art and science historians investigating how the application of a *camera obscura* might have affected painting processes in the seventeenth century. My interest however lay in how the water lens might change our perceptual experience of the projected image.

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<sup>69</sup> Marianne Krogh Jensen, "Mapping Virtual Materiality," in *Olafur Eliasson: surroundings surrounded: essays on space and science*, ed. Peter Weibel (Graz, Austria: Neue Galerie am Landesmuseum Joanneum; Cambridge, MA: MIT Press 2001), 303.

<sup>70</sup> *Inside the Camera Obscura – Optics and Art under the Spell of the Projected Image*, ed. Wolfgang Lefèvre (Berlin: Max Planck Institute for the History of Science, 2007), 149–190.

Still at the foreground of my thinking was the slow changing landscape and how to visualise it. I speculated whether changing the water levels in the lenses would allow me to control the perceptibility of the change in the moving image. I mapped the rise and fall of the river's water with the rise and fall of two interconnected lenses (Fig. 16). Working with Redman again, we created a peristaltic pump mechanism using 3D printing and a small stepper motor, which was then connected to an Arduino printed circuit board (PCB) to control the direction and speed of the rise and fall of the water in the lenses. I modified the Arduino code to change the rate of flow and direction of the water. As the water rises in one lens the image slowly appears, whilst falling in another lens, the image slowly fades, creating a continual process of change, one that is above the threshold for visibility (Fig. 17). This visually perceptible change is also accompanied by a strange humming of the motor cycle through one direction and then changing to another. I then designed and laser-cut a transparent housing mechanism for the pump system, as it is important that the entire process be visually exposed (Fig. 18).

## Unfolding Time-light

Changing a value in the Arduino code modified the physical behaviour of the water in the lenses, consequently effecting my projected images and time-light. The rise and fall of the water in the lenses unfolded these images of light, turning my optical system into an apparatus for distilling time and space. It reminded me of Della Porta's experiments with distillation. Using streaming technologies, optical objects and light, I could distil and then extract the invisible process of change through time, yet not affect the process itself (Fig. 19).

After initially testing off-the-shelf scientific glass flasks and water in the studio, I realised that to specifically control the image projected from the digital glass slides (LCDs), a composite lens system was required. This composite glass structure would not only reinvert the image, but maintain a continuously visible image. When I used the hollow sphere alone, the image disappeared once the water level dropped below the centre line of its diameter's curvature. My aim was for the image to slowly change, not become suddenly invisible. The composite lens therefore allowed me to continuously observe the slow change in the streamed scenes that were abstracted through the water lens and projected onto the wall.





Fig. 14. Carsten Wirth. Slumped two-part plexiglass lenses. Max Plank Institute for the History of Science, Berlin, 2007.



Fig. 15. Carsten Wirth. Assembled hollow lenses with water. Max Plank Institute for the History of Science, Berlin, 2007.

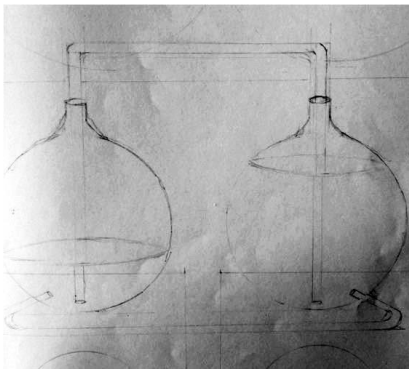


Fig. 16. Sketch of two interconnected hollow water lenses.

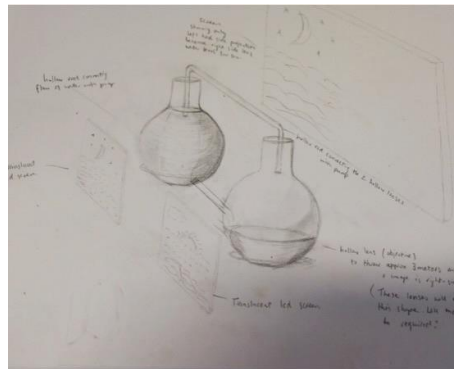


Fig. 17. Sketch of water lenses with source LCDs creating continual process of change.

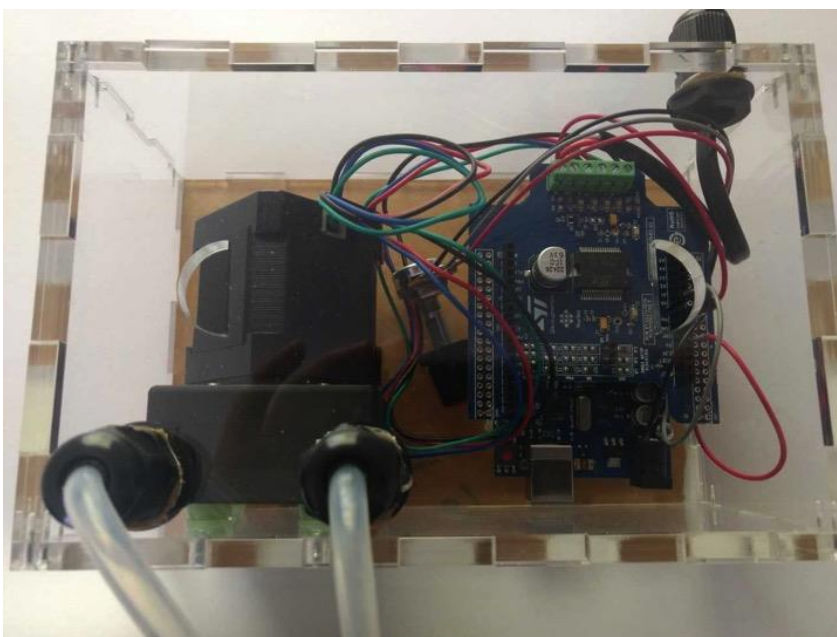


Fig. 18. Laser-cut housing for the pump mechanism.





Fig. 19. Hollow lenses with exposed pump mechanism.

I also discovered that the wall thickness of the glass flasks was too great to render the projected streamed scenes sufficiently in focus. To resolve these optical quandaries, I worked with Dr Francis Bennett, an optical physicist at the ANU Research School of Astronomy and Astrophysics. Through computational modelling we determined the specifications for my hollow lenses, which required a wall thickness of less than one millimetre and incorporated two additional doublet lenses in front of and behind each flask (Fig. 22). These composite lenses have a small diameter of fifty millimetres and to achieve a focussed image in conjunction with the water lens, meant the magnification of the projected image had to be compromised.

I was insufficiently skilled to make such thin and precise forms in glass, so I asked scientific lamp-worker Daniel Bansner to make them on his lathe using borosilicate glass (Fig. 23). Following each attempt by Bansner, I returned to the studio to test the flasks within my optical system. After several modifications of wall thickness, flask diameter and spherical form, I finally had an optical object which sufficiently magnified and focused my image. The next task was to design an adjustable armature to hold all the optical elements. I spent much time problem solving the armatures. It was important that they have an adequate range of adjustability, but it proved difficult finding hinges that could support the weight of the components. After finding and testing a suitable articulation, I laser-cut steel bases and sculptor Kensuke Todo welded the components together for both the LED armatures and those supporting the water lenses (Fig. 20 and Fig. 21).

After resolving the optical elements, what exactly was I imaging? It was a kind of process of time, a kind of parallel time of day and night. For example, as the sun sets in Canberra, it rises over the Atlantic. I gathered these two times and spaces into a single composite image of time-light.



Fig. 20. LED and lens armature.



Fig. 21. Stand for the water lenses.

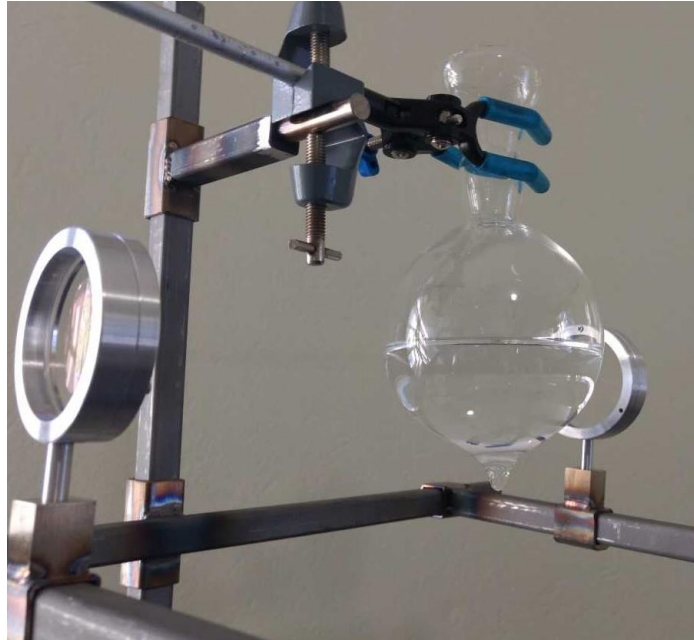


Fig. 22. Water lens test with composite lenses within milled aluminium holders.



Fig. 23. Hollow lenses being blown on a glass lathe.



## Artist as intermedia practitioner – Adam Brown

Throughout my investigations into natural magic and wonder my studio transformed into a mobile laboratory. As I was working across different disciplines at the University, I tested ideas where my associates worked. In addition to this physical dislocation of my studio, spending time in physics laboratories and engineering workshops, and understanding new materials and material process, changed how I viewed my practice. My project had become an interdisciplinary mode of artistic inquiry and was no longer wedded to a single process of making or way of looking at the world.

In conceptualising my expanded practice, the work of contemporary intermedia artist Adam Brown was helpful. His most relevant project to my research investigates the process of alchemy. *The Great Work of a Metal Lover* (2012) (Fig. 24), for which he collaborated with micro-biologist Kazem Kashefi, is based on the historical premise of alchemy. The aim of his alchemic process was to create the Philosopher's Stone, a mysterious red substance, which traditionally could transmute ordinary matter into precious silver or gold. As Brown describes it, *The Great Work* sits at the "intersection of art, science and alchemy" and re-examines the problem of transmutation through contemporary microbiological practice.<sup>71</sup> Brown created a specifically engineered ecosystem inside a chemical bioreactor, forcing specific bacteria to metabolise high concentrations of gold chloride and turn soluble gold into usable 24K gold<sup>72</sup>. He notes of *The Great Work* that, "Like alchemy, gold is imbued with secrets of the earth, origins of life and early metabolic processes".<sup>73</sup>

This alchemic process, like my optical process, extracts the invisible from nature to make it knowable in a different way. Both processes could be viewed as a kind of contemporary natural magic. Instead of using theory and mathematics, the 'secret' processes of nature become knowable through materiality. In the same abstract way, my research and Brown's work create an alternative perceptual logistics of nature. Brown's tool is the bioreactor, his materials are bacteria, gold chloride, hydrogen and carbon dioxide. My tools are the optical lens system and fibre optic cable and my materials are the landscape, water and glass. Our approaches diverge however, in relation to our source materials. Where Brown physically changes his source material, my work aspires to leave the source (slow changes in the

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<sup>71</sup> Adam Brown, "The Great Work of the Metal Lover," *Adam W. Brown: Evolution of the ISIS Conceptual Laboratory*, <http://adamwbrown.net/projects-2/the-great-work-of-the-metal-lover/> (accessed April 18, 2018).

<sup>72</sup> In the second part of Brown's artwork, he prints a series of images of the alchemic process, for which he used a scanning microscope. He then placed the gold created from the first part of his artwork, onto the specific regions of the print where a bacterial gold deposit had been identified on the scan. (<http://adamwbrown.net/projects-2/the-great-work-of-the-metal-lover/>)

<sup>73</sup> Brown, "The Great Work of the Metal Lover," <http://adamwbrown.net/projects-2/the-great-work-of-the-metal-lover/> (accessed April 18, 2018).

landscape) unaffected. Instead, as already discussed in relation to critical wonder and distilling time, I aim to change the viewer's awareness and bring attention to an unfolding time-light.

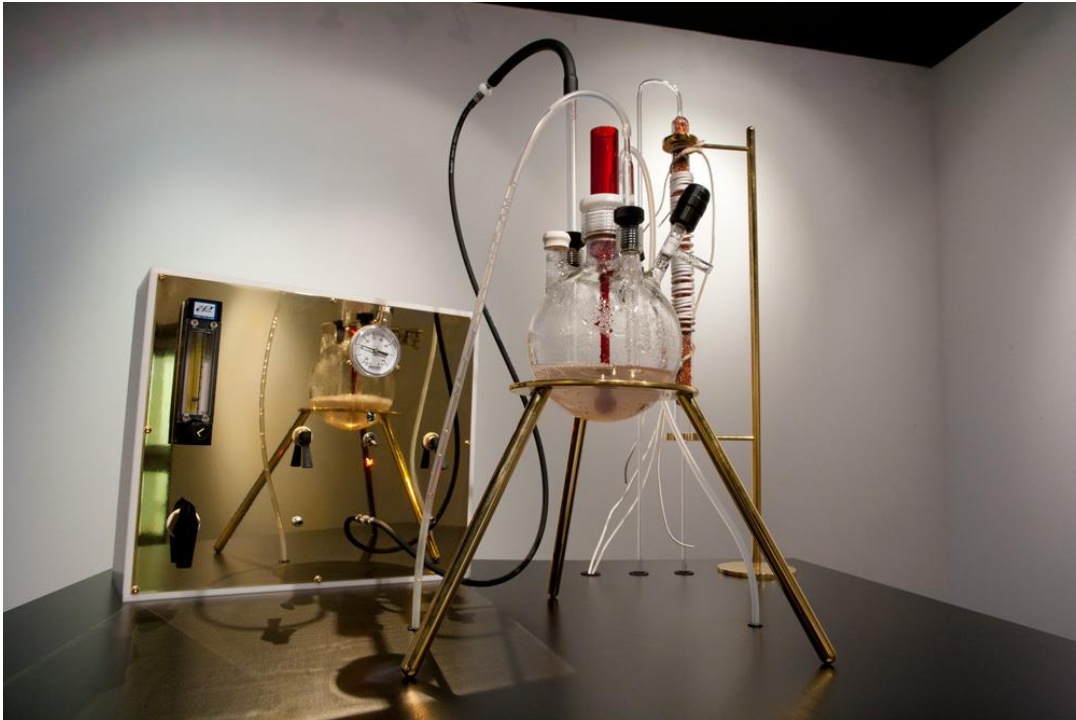


Fig. 24. Adam Brown, *The Great Work of a Metal Worker*, 2012. Michigan: Adam Brown.  
<http://adamwbrown.net/projects-2/the-great-work-of-the-metal-lover/>

## Part Two – Wonder

### Attention as a Mechanism for Generating Wonder

Although my process has been influenced by Della Porta's practice of natural magic, there is a major difference in my approach. As previously discussed, where Della Porta conceals the causes of his magic to heighten the wondrous effect, I expose them. The intention is to shift the attention of the viewer from the magnetic pull of the image to the system as a whole and investigate whether redirecting attention can induce a temporary state of wonder.

Eighteenth century philosopher Adam Smith views wonder as an experience that occurs with different levels of intensity, but that must include either a change in circumstance or an object that confounds previous experience. For Smith, the confounding new object for which there is only 'vain recollection',<sup>74</sup> excites a fleeting emotion of surprise, which in turn generates and is replaced by the feeling of wonder.

The wondrous spell of a projected image has obviously weakened since Della Porta's sixteenth century. We might not know the specific optical and technical details of its formation, but as a familiar occurrence in our everyday lives, we have become habituated to this image-light. My research explores possibilities for regenerating confounding optical image scenarios which might lead to the evocation of wonder, a process that, as Smith describes:

[occurs] when something quite new and singular is presented... [and] memory cannot, from all its stores, cast up any image that nearly resembles this strange appearance.<sup>75</sup>

This 'strange appearance' became key to the aesthetic function of my optical systems. In light of Smith's wonder generated through the new and unfamiliar, I explored the work of Russian formalist Victor Shklovsky (1893–1984) in particular his technique of *ostranenie* or de-familiarisation, in which art serves as a device of estrangement to remove everyday objects from the 'automatism of perception'.<sup>76</sup> The artistic context in which Shklovsky proposed his *ostranenie* was literary criticism and poetry and he makes no reference to wonder, however, the technique of de-familiarisation became important for my research in visual art. By changing an everyday object of an image projector into an unfamiliar looking

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<sup>74</sup> Smith, *The Glasgow Edition of the Works*, 39.

<sup>75</sup> Ibid. This was initially cited in Jesse Prinz, "How Wonder Works," *Aeon*, Aeon Media Group, 2012, <https://aeon.co/essays/why-wonder-is-the-most-human-of-all-emotions> (accessed January 10, 2017).

<sup>76</sup> Viktor Shklovsky, "Art as Device," trans. Alexandra Berlina, University of Erfurt, *Literary Studies, Poetics Today*, 36, no. 3, (2015): 152.

device with a unique aesthetic, I aimed to establish an unusual contextual scenario for the experience of seeing a projected image.

I wanted to make use of Shklovsky's technique of shifting us out of our state of inattention to the world through sensory engagement. For Shklovsky, art serves as a means of renewing our perception of the everyday by forcing us to attend directly to an unfamiliar form or context. He writes:

The purpose of art is to impart the sensation of things as they are perceived and not as they are known. The technique of art is to make objects 'unfamiliar', to make forms difficult to increase the difficulty and length of perception because the process of perception is an aesthetic end in itself and must be prolonged.<sup>77</sup>

Shklovsky's establishment of the 'unfamiliar' is similar to historian Svetlana Alpers' observation in her novella *Roof Life* (2013), where she writes:

...the way in which one's attention is heightened and sharpened by confronting things that are unfamiliar or that are made [to] appear unfamiliar by circumstance.<sup>78</sup>

A renewed strangeness enables us to regain our sensual awareness, which we have lost through habituation. Shklovsky claims that through the use of unusual vantage points, art has the ability to remove "objects from the automation of perception"<sup>79</sup> and return us to vivid sensory experience.

The strange juxtapositions of the old and new technological components of my exposed devices were starting to command attention from inquisitive physicists and engineers in the laboratories where I was developing and assembling the optical mechanism. Unlike Della Porta who revealed only his projected image to engage his audience, I was creating an unfamiliar scenario by exposing the entire system generating the image. Or at least that was my understanding at this stage of the project. Chapter Three explores how, inadvertently, I was not revealing the full cause of my projected images.

When I first began working with the physicists and electronic engineers, who helped me realise the project, they all asked the same question: "why don't you just use a data projector?" But my device relates to renewed visibility, not to the ease of using a ubiquitous machine. I wanted to shift the viewer's attention towards the machine as if it had broken down. Philosopher Martin Heidegger (1889–1976) points out how a smoothly working machine renders itself invisible, but as soon as the machine malfunctions, it suddenly becomes visibly conspicuous, allowing us to experience it in a renewed way.<sup>80</sup>

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<sup>77</sup> Viktor Shklovsky, "Art as Device," in *Theory of Prose*, trans. Benjamin Sher (Dalkey: Dalkey Archive Press, 1990), 16.

<sup>78</sup> Svetlana Alpers, *Roof Life*, (London: Yale University Press, 2013), 3.

<sup>79</sup> Shklovsky, "Art as Device", (1990), 2; Tom Gunning, "Re-newing Old Technologies: Astonishment, Second Nature and the Unanny in Technology from the Previous Turn-of-the-Century," in *Re-thinking Media Change – the Aesthetics of Tradition*, ed. David Thornburn and Henry Jenkins. (Cambridge Massachusetts: MIT Press, 2003), 40.

<sup>80</sup> Martin Heidegger, *Being and Time*, trans. John Macquarrie and Edward Robinson (Oxford: Blackwell, 1962), 406.



The aesthetic malfunction of my optical system serves to restore its visibility. By making the familiar strange, I explore whether in being presented with a sensory idiosyncrasy, the viewer might emerge from the slumber of inattention and experience wonder. As early film historian Tom Gunning notes in his essay on renewing old technologies:

Inattention can be transformed into wonder, wonder can be worn down into habit; habit can suddenly even catastrophically, transform back into the shock of recognition.<sup>81</sup>

## Artist as contemporary Natural Magician and Wonder-maker – Olafur Eliasson

Throughout my explorations into wonder, attention and de-cloaking the device, the practice of contemporary artist Olafur Eliasson was an insistent presence. I was cautious about exploring an all too obvious artist as a contextual reference, but it became impossible to ignore Eliasson's relevance, specifically in terms of contemporary natural magic.<sup>82</sup> Like Della Porta, Eliasson works with physical elements to extract invisibilities and therefore visually and materially generate a new cognitive awareness in the viewer. In addition, his practice has recently incorporated a focus on the material of glass to optically visualise these elemental properties. He explores historical but still relevant optical phenomena. In *Space resonates regardless of our presence (Monday)* (2017) (Fig. 25), he investigates what happens to light when it refracts through a Fresnel lens.<sup>83</sup>

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<sup>81</sup> Gunning, "Re-newing Old Technologies: Astonishment, Second Nature and the Uncanny in Technology from the Previous Turn-of-the-Century," 46.

<sup>82</sup> There is a long trajectory and strong contemporary current of visual artists working with exposed mechanisms, such as Marcel Duchamp's *Rotary Demisphere (Precision Optics)* (1925); László Moholy-Nagy's *Light-Space-Modulator* (1930); Jean Tinguely's *Gismo* (1960); Ian Burns' *What Might Be* (2011); Attila Csörgő's *Clock Work* (2013) and Julien Maire's *Jardin d'Hiver* (2015–17), to name but a very few.

<sup>83</sup> A Fresnel lens has a flat surface instead of a curved contour normally associated with traditional optical lenses. The Fresnel lens has a series of concentric grooves which function as refracting surfaces to optimise the gathering of light. It is named after the French physicist Augustin-Jean Fresnel (1788–1827) who, although was not the first to conceptualise the lens, made it well known by integrating it into lighthouses. (Edmund Optics, "Advantages of Fresnel Lenses," <https://www.edmundoptics.com.au/resources/application-notes/optics/advantages-of-fresnel-lenses/> (accessed February 26, 2019)).

The exposure of the mechanism in Eliasson's artworks suggests that he is aiming to establish an awareness in the viewer of how they see the visual phenomena of his installations, but he is also very strategic in his positioning of the viewer and how he directs their attention. Like Della Porta's practice of natural magic, Eliasson actively engages and selectively directs the viewer's attention. In using glass as a tool to optically extract normally unseen phenomena and make them visible in the form of projected images, Eliasson and Della Porta command the attention of an embodied viewer and consequently establish a kind of somaesthetic.<sup>84</sup> Similarly with Wallworth's work, this prompted me to ask whether it was through this embodied attending that an experience of critical wonder might arise.

Eliasson engages his viewer's senses with a material optical object in his work *Your museum primer* (2014) (Fig. 26), which is an installation of projected and refracted concentric bands of coloured light generated through a highly polished prismatic lens and LED. The lens, in the form of a ring, has a colour filter on its inner diameter and is suspended from the ceiling of a darkened gallery.<sup>85</sup> As the ring rotates, it projects circles and arcs of different coloured lights at different sizes and focal lengths that orbits the gallery walls. Like my optical devices, *Your Museum Primer* applies glass and light to make apparent a physical process that is not only constantly changing, but is also continuously mediated. The immersed viewer becomes aware that the change in their surroundings is generated through the rotating lens. As Eliasson has commented, his aim for this exhibition was to encourage viewer engagement and generate an experience of "being present with and in the world".<sup>86</sup> Likewise with my exposed optical systems, I speculate whether I can establish in the viewer a heightened sensibility and perceptual awareness of how we position ourselves in the world.

Despite shared interests in viewer awareness and sensibility in Eliasson's practice and my research, there are significant differences in how they are manifested. Where Eliasson uses glass and light to direct the attention of his viewer by visualising an optical phenomenon, my hollow lens system is not solely concerned with rendering optical phenomena visible. It additionally applies these natural phenomenon to generate time-light in the specific form of the projected moving image.

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<sup>84</sup> Somaesthetics is an emerging sub-discipline of the philosophy of aesthetics, which foregrounds the role of bodily experience in the aesthetic and was developed by the contemporary American philosopher Richard Shusterman (*Thinking through the body: Essays in somaesthetics*, (Cambridge: Cambridge University Press, 2012).

<sup>85</sup> The work was part of *The parliament of possibilities* exhibition at K20 Grabbepplatz, Kunstsammlung Nordrhein-Westfalen, Düsseldorf in 2014.

<sup>86</sup> Hollie Smith, "Olafur Eliasson: the parliament of possibilities opens at Leeum, Samsung Museum of Art," *DesignBoom*, September 29, 2016, <https://www.designboom.com/art/olafur-eliasson-the-parliament-of-possibilities-leeum-samsung-museum-of-art-09-29-2016/> (accessed April 15, 2017).



Fig. 25. Olafur Eliasson, *Space Resonates Regardless of Our Presence (Monday)*, 2017. New York: Tanya Bonakdar Gallery.  
<http://olafureliasson.net/archive/artwork/WEK110395/space-resonates-regardless-of-our-presence-monday>

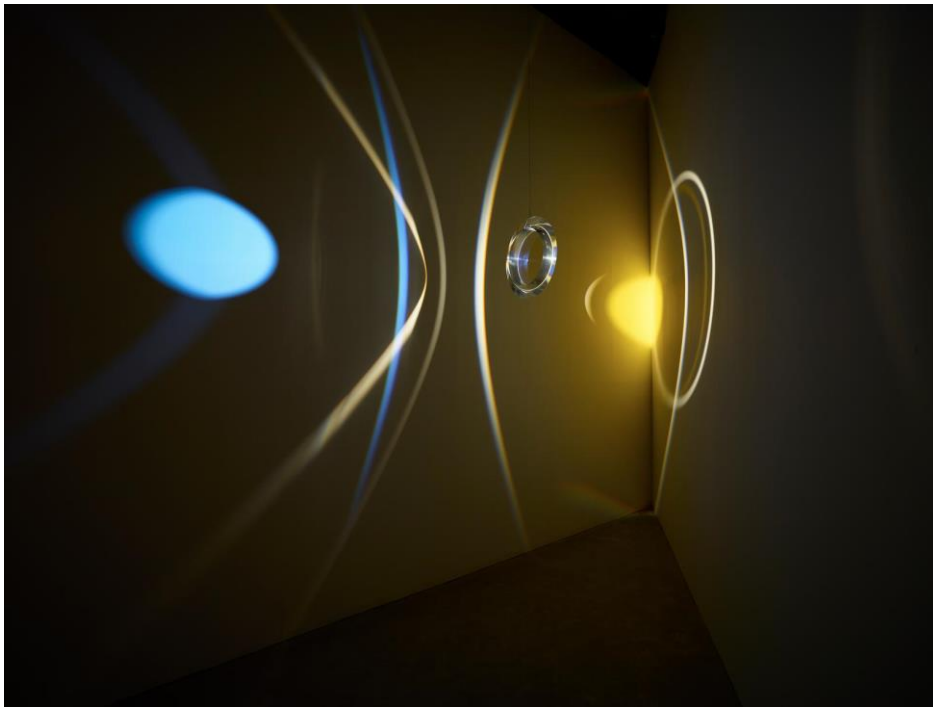


Fig. 26. Olafur Eliasson, *Your Museum Primer*, 2014. Seoul: Samsung Museum of Art.  
<http://olafureliasson.net/archive/artwork/WEK108815/your-museum-primer>

## Seeing one's own position – Re-presencing oneself in the World

I wondered if my hollow lens system could activate a blended space of the real and the representational, a kind of fictional-reality of physical device and virtual projected image. Curator Daniel Birnbaum argues that Eliasson's exposure of the device is a means of initially convincing the viewer they are participating in a completely natural experience, only to discover that what they are experiencing is "part of a machine".<sup>87</sup> For Eliasson, this discovery illustrates a kind of subliminal zone in the viewer, where "your representational and your real position merge and you see where you 'really' are, your own position".<sup>88</sup> This idea of seeing one's own position adds a self-locating function, reminding me of the early days of my research when I held up a lens in front of the physics laboratory window and saw an imaged scene of the space projected within the space itself. This lensed scene, or 'representation' of the 'real' space, created a glitch in the flow of my perceived reality of the laboratory's space. Two spaces simultaneously appeared before me, one within a perceived 'reality', the other on a two-dimensional plane. It seemed that the intrinsic ability of the glass lens to image the world, uncannily and inadvertently merges the real and the representational.

I began to regard my hollow lens device as a re-presencing mechanism. This was inspired by the writings of Italian anthropologist Ernesto de Martino (1908–1965), which I discovered during my field research at the 2017 Venice Biennale. He wrote extensively about magic, from the sixteenth to the twentieth centuries.<sup>89</sup> One of his central concepts for the enduring practice of magic relates to a crisis or loss of presence in an individual, where a person no longer feels they have the capacity to act autonomously in the world. For de Martino, natural magic was an antidote to this negative scenario, allowing an individual to regain their presence in the world.<sup>90</sup>

I reflected upon how my device might address a 'crisis of presence', related to what Jonathan Crary describes as a "social crisis of subjective disintegration" instigated by a deficiency of attention, which he argues initially emerged in the nineteenth century.<sup>91</sup> My scenarios of real and representational, of exposed physical device and virtual image, serve to re-presence the viewer through expanded attention

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<sup>87</sup> Birnbaum, "Daniel Birnbaum in Conversation with Olafur Eliasson," 10.

<sup>88</sup> Birnbaum, *Olafur Eliasson*, 11.

<sup>89</sup> De Martino's ideas were explored in the artwork *The Imitation of Christ* (2017) by contemporary artist Roberto Cuoghi. This work was part of the Italian Pavilion at the 2017 Venice Biennale.

<sup>90</sup> De Martino termed natural magic 'low ceremonial magic' (Ernesto de Martino, *A Theory from the South*, trans. Dorothy Louise Zinn, (Chicago: University of Chicago Press, 2015), 15; Fabrizio Ferrari, *Ernesto De Martino on Religion: The Crisis and the Presence*, (London: Taylor and Francis, 2014), 50.

<sup>91</sup> Jonathan Crary, *Suspensions of Perception: Attention, Spectacle and Modern Culture* (Cambridge, Massachusetts: MIT Press, 1999), 1. Crary traces the trajectory of human attention from nineteenth century modernity. Individuals began to define themselves in terms of their capacity for paying attention, resulting in a disengagement from the broader experience of the world and a narrowed focus on isolated stimuli. (Crary, *Suspensions of Perception*, 11–48).

and renewed sensory and critical awareness. These functions align with the importance Stafford places on the role of technology to facilitate cognitive awareness. As discussed in the Introduction, in an era where technology is causing a decline in voluntary attention, Stafford asserts the significance of valuing devices, which make us consciously aware that we are attending.<sup>92</sup> She writes:

In an era fond of reducing all optical technologies to a single platform (the digital internet) and most compositional systems to illusionistic virtual-reality modalities, what could be more important than exhibiting how different experience-framing devices not only produce different kinds of information but make us think, feel, and desire differently. While more and more gadgets address our involuntary response mechanisms ... I want to emphasize the value of those technologies that make us consciously aware that we are aware and fully attending.<sup>93</sup>

For Stafford therefore, striking a balance between voluntary and involuntary perception is important.<sup>94</sup> The dynamics of perception also play a critical role in how my optical system evokes wonder and makes time visible. Shifting the viewer to voluntary attending, my device can potentially shake us out of our habituated perceptual complacencies and bring about a more critical engagement with the work. The interruption to voluntary attention caused by my system allows me to *see* time and its generating device differently and subsequently, this renewed perception becomes my precursor for wonder.

## Renewable, Reversible and Controllable Cycles of Wonder

As already discussed, a cabinet of curiosities or projected image no longer necessarily evokes an experience of wonder in the contemporary viewer. What causes us to experience wonder has obviously changed since the sixteenth century, but the phenomenon still arises from encountering something new and confounding, something that forces us to reconfigure our relationship with the world. As theologian Robert Fuller has commented, wonder still “excites our ontological imagination in ways that enhance our capacity to seek deeper patterns in the universe”.<sup>95</sup>

Newness and novelty have a long association with wonder. Even before Smith’s wonder generated through new encounters, Christopher Columbus’s voyages of discoveries brought about a heightened

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<sup>92</sup> Stafford, “Seizing Attention: Devices and Desires,” 425.

<sup>93</sup> Ibid.

<sup>94</sup> Ibid.

<sup>95</sup> Robert C. Fuller, *Wonder: From Emotion to Spirituality*, 2.

sense of novelty, influencing the preternatural philosophers' rhetoric describing their wondrous discoveries of nature.<sup>96</sup> Crary writes about the expanded horizon of perceptual novelty through new forms of visual display in the nineteenth century. Of particular relevance is his observation that these novel appearances of the world were determined by the specific optical conditions of the time.<sup>97</sup> Shaffran asserts that wonder stills hold a connection to the novel, awakening one's mind to the unknown.<sup>98</sup>

Gunning, in his essay on the renewal of old technologies, breaks down the experience of wonder into a series of stages in a cycle that can be reversed and controlled.<sup>99</sup> Writing not about technology *per se*, but its novelty, he explores how the experience of wonder can be actively regenerated. Elaborating on John Onians' arc of reaction from initial astonishment to automatism<sup>100</sup>, Gunning proposes that wonder is more complex than an initially heightened emotion eventually petering out to habit.<sup>101</sup> The novel scenario of *Hollow Lens* renews the wonder of seeing a projected image. Instead of the slick plastic case of a data projector, my exposed and unusual mechanism presents not only the image-light we see before us, but how we see it. It is the exposed cause of the image that breaks the cycle of automatism and returns us to a state of critical wonder. Although *Hollow Lens* engages with technological objects and paradigms of sixteenth century wonder, it is important to note that the 'reversal' of the cycle of wonder in my research rejects any nostalgic desire to return the viewer to a time when these old technologies were new.<sup>102</sup> The renewed wonder of my optical system emerges from a strange encounter firmly positioned in the twenty-first century.

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<sup>96</sup> Daston and Park, *Wonders and the Orders of Nature*, 146–8. King Ferdinand of Spain was of the opinion that Columbus should have been known as “the Wonderer” rather than an admiral (Ibid, 147).

<sup>97</sup> Jonathan Crary, “Nineteenth Century Visual Incapacities,” in *Visual Literacy*, ed. James Elkin (New York: Routledge, 2008), 61.

<sup>98</sup> Tiffany Shaffran, “Archives of Wonder: Collecting the Liminal in Contemporary Art,” 22.

<sup>99</sup> Gunning, “Re-newing Old Technologies: Astonishment, Second Nature and the Uncanny in Technology from the Previous Turn-of-the-Century”, 40.

<sup>100</sup> John Onians is an art historian specialising in Italian Renaissance art, material cultures and the perception and cognition of art.

<sup>101</sup> Gunning, “Re-newing Old Technologies,” 43.

<sup>102</sup> Carlyn Marvin, *When Old Technologies Were New. Thinking about Electric Communication in the late 19th Century*, (Oxford: Oxford University Press, 1988).

## Concluding Remarks

My explorations of natural magic and wonder began by reflecting on how the visibility of slow changes in nature depends upon an extended phase of sequential days, weeks and seasons. I wondered whether the optical properties of glass and its ability to change our perception of time and space could make visible these otherwise imperceptible changes. As the development of my optical device progressed I realised that in addition to the glass lens, direct sensory experience of these slow changes was key and that this could not be achieved through traditional lenses and real-time technology alone. I learned that in contrast to Della Porta's hidden mechanism, exposing my device was crucial and that my contemporary form of natural magic must enact physical change within the sensory realm of the viewer.

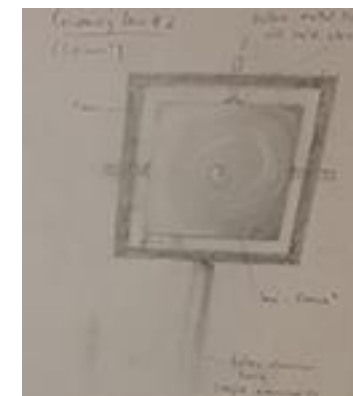
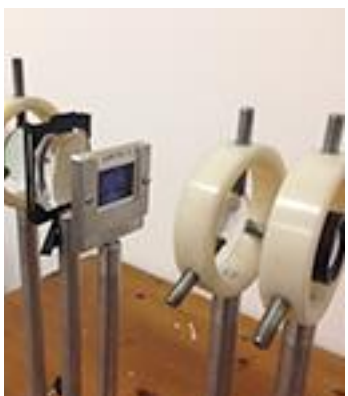
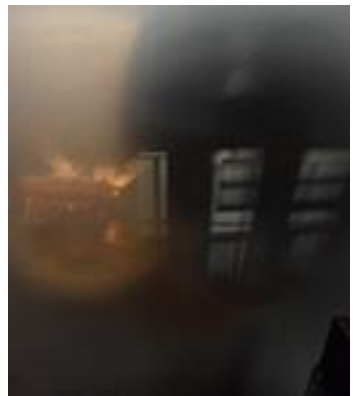
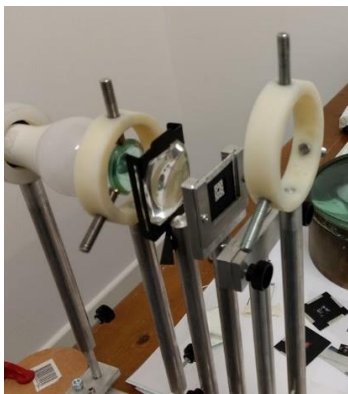
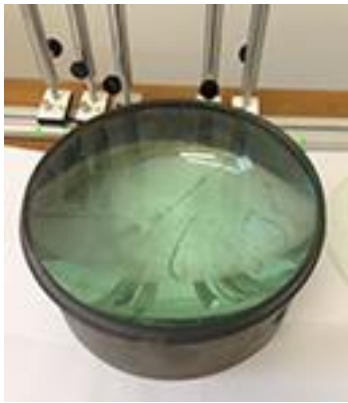
The physically changing water levels in the lenses serve a two-fold function: to project a moving image, re-presenting time and space; and to generate a post-digital 'real' time by unfolding a micro-landscape of its own. Combining digital and material processes outside my familiar world of studio glass therefore became an important development in my practice during this part of the research.

Direct sensory engagement became the link between my quest to visualise slow change and my exploration of glass as a tool to generate wonder. The aim of the strange juxtapositions and consequent aesthetic malfunction of my optical system, inspired by Heidegger's concept of the broken machine, was to command a more embodied attention and in doing so re-presence the viewer. It is this sensory interruption, created through the novel hybridity of the components of *Hollow Lens*, which potentially allows a fleeting experience of critical wonder to arise.

This renewed consideration of the projected image, its generating device and exploration of optical time, led me to the next stage of my research, where I investigated further my concept of optical time created through materiality and light.



Fig. 27. Additional process images of the research and development of *Hollow Lens*.









# Chapter Two

## Time and Materiality

*The problem with imagining media worlds that intervene, of analyzing and developing them creatively, is not so much finding an appropriate framework but rather allowing them to develop with and within time.*

– Siegfried Zielinski<sup>103</sup>

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<sup>103</sup> Siegfried Zielinski, *Deep Time of the Media, Toward and Archaeology of Hearing and Seeing by Technical Means*, trans. Gloria Custance, 270 (Cambridge Massachusetts, London: MIT Press, 2006).

## Introduction

On a sunny October afternoon when the sun was half way between autumn and winter, I sat at my kitchen table watching a circle of light move across the wall.<sup>104</sup> The quivering luminous shape reflected from a water glass, moved slowly to the right, gradually vanishing. With my gaze fixed on this moving image of light, I marvelled at how it was the earth's rotation around the sun and not the sun itself, which was creating this moving image. I pondered over the concept of time, derived from earth's orbit constantly in motion and how this continuous flux of light and shadow is transmuted into time as a form of structure and measurement, its units of minutes, hours, days and nights forever passing me by. I thought about possibilities for knowing time through the movement of an object around a source of light. Returning to my idea of time-light from Chapter One, I began to explore this rotational form of time through creating a revolving optical device and its projected moving image.

Having developed *Hollow Lens* as a means of exploring the evocation of wonder and the visibility of slow change, I now consider how to reform the perception of time and establish a more human relation to time in our current digital era.

This chapter relates how the research and development of my rotating polygon system, *Ghost in the Machine*, integrates materiality, light and movement to serve as a speculative tool for exploring time. I detail the influence of the optical mechanics of Charles-Émile Reynaud (1844–1918) on the interdisciplinary development of my rotating polygon device, and how this device relates to the dilemma of time encountered by Étienne-Jules Marey (1830–1904). Elaborating on the 'real' time generated through *Hollow Lens* and referencing media theorist Charlie Gere's concept of time within the digital era, I argue that my practice-led research keeps open our human relation with time through an embodied engagement with the 'materiality of time'.

In my considerations of optical time created through a glass lens, sequential time constructed from animation and cinematic image frames, and the time-light of my moving ghost, I reference archaeological and new media theorists such as Gunning and Doane. I detail my material investigations of durational time in relation to philosopher Henri Bergson's (1859–1941) concept of time<sup>105</sup> and show how the rotational speed of my polygon system expands or contracts the durational time of my ghost.

I uncover lost time, which has slipped through the gap between moments and remains invisible in the dark space of an irretrievable past. The perceptual gap or 'flickering image' caused by these lost

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<sup>104</sup> I was living in County Westmead in Ireland at the time.

<sup>105</sup> Henri Bergson, *Duration and Simultaneity – With Reference to Einstein's Theory*, (1922), trans. Leon Jacobson, Bobbs-Merrill Co, 1965.

moments is crucial for the legibility and visibility of my ghost. I discuss works by contemporary artists Jan Dibbets and Attila Csörgő in relation to my investigations of time, contending that where Dibbets documents moving time-light, my polygon device explores how materiality can unfold time-light through durational experience. I discover similarities between my methodology and Csörgő's meticulous interdisciplinary approach and note how, at this stage of my research, my practice has shifted from being solely object oriented to a wider systematic consideration of how objects interrelate.

## Part One – Time

### Extended Explorations of Time-light

As I observed the moving circle of autumn light on my kitchen wall, I gently tilted the glass of water back and forth on the table. Now the image light not only moved across the wall, the contents of the image also changed. The oscillation of the water in the glass caused lines of light and shadow to flicker and move within its circular form. Later in my studio I played with this idea by rotating a mirror within the path of daylight streaming through the window. The simple movement of the mirror reflected a moving image on to the wall. I then engraved two different lines onto two small pieces of mirror. By alternating the position of the mirrors, the light caught each reflective plane in turn, projecting onto the wall the appearance of a single moving line.<sup>106</sup>

The appearance of this single moving line was intriguing. My perception was merging two different lines into a unified moving image of light.<sup>107</sup> Perceptual process is also of interest to neuroscientist Alain Berthoz, who writes, "One might say that our perception and thought [...] are defined by 'lines of light', traversing and interacting with chaos".<sup>108</sup> For Berthoz, the moving line is key to how we perceive and

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<sup>106</sup> This two-framed motion reminded me of the thaumatrope, an optical toy popular in the nineteenth century. It is a small circular disk of card with a different drawing on each side. At opposite edges of the disk two lengths of string are attached. If the strings are pulled the disk rotates and the images appears to move, for example a girl on a skipping rope, where one image displays the rope over the girls head, the other image illustrates the rope below the girl's raised feet.

<sup>107</sup> I use the term perception of the moving image, rather than the illusion of the moving image, because as Tom Gunning suggests, "illusion carries a tone of denigration and distrust of perception", (Tom Gunning, "Animation and Alienation: Bergson's Critique of the Cinematographe and the Paradox of Mechanical Motion," *The Moving Image*, 14, no. 1 (2014): 3–4.

<sup>108</sup> Arkady Plotnitsky, "The Image of Thought and the Sciences of the Brain after What is Philosophy?," in *Force of the Virtual: Deleuze, Science and Philosophy*, ed. Peter Gaffney, (University of Minnesota Press, 2010), 264–5.

visually construct our spatial realities.<sup>109</sup> This simple test using mirror and light in my studio had generated a moving line with its own sense of time, but the moving line also required the engagement of my sensory and perceptual system, without which the movement would not exist.<sup>110</sup> Ironically my gaze was transfixed on the moving line of light rather than the physical motion of the fragments of mirror generating the apparent movement. At this early stage of the project I knew that the mirror would be a key material with which to develop my moving images of time-light.

Whilst reflecting upon the circle of light travelling across the kitchen wall, I came across Dutch artist Jan Dibbets' installation *All shadows that occurred to me in... are marked with tape* (1969–) (Fig. 28). In this exploration of light and time, Dibbets covers fleeting patches of sunlight on the floor and walls of an interior space with lines of masking tape. He places the tape along the edges of the sun patches, however the patches of actual light and shadow never line up with the taped lines because by the time Dibbets has laid the tape, the light has already moved position. The taped lines therefore become a kind of afterimage.<sup>111</sup>

The continuously changing light in *All shadows* related to the moving sunspot on my kitchen wall and my endeavour to visualise the slow changes in nature, for which I had developed *Hollow Lens* outlined in Chapter One. Like Dibbets, I was working with the quandary of how to make visible the slow change of time, that which is imperceptible from a single glance. Our outcomes differ significantly however. Dibbets' working process facilitated the distillation of slow time into single images, or multiple images in single frames. The resulting documented image of ever-changing light could therefore be observed by the viewer within that momentary glance. In contrast, I knew early on that my work would require an engagement with durational time. My research does not document moving time; instead it explores how materiality can re-form and unfold a different type of time, through a device that dynamically generates a moving image of light and commands the 'real' time of experience.

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<sup>109</sup> For Berthoz, perception involves an internal simulation of motion in the brain, as well as the interpretation of sensory images. "It may well be that the 'line' [...] as a movement precedes our perception and [...] simulation and that how we visually construct visual construction of all spatiality, including that of, or related to, (the image of) line itself", (Alain Berthoz, *The Brain's Sense of Movement*, trans. Giselle Weiss, (Cambridge Massachusetts: Harvard University Press, 2000), 242).

<sup>110</sup> French mathematician Bernard Teissier suggests that our perceptual systems may have evolved to create an isomorphism between the visual line and the vestibular line. (Bernard Teissier, "Protomathematics, Perception and the Meaning of Mathematical Objects," in *Images and Reasoning*, eds. Pierre Grialou, Giuseppe Longo and Mitsushiro Okada, 135–46 (Tokyo: Keio University Press, 2005).

<sup>111</sup> Sanneke Stigter, "Co-Producing Conceptual Art: A Conservator's Testimony", *Revista de História da Arte – Série W*, 4 (2015): 105.



Fig. 28. Jan Dibbets, *All shadows that occurred to me in... are marked with tape* (1969–), 10 April, 2009. Otterlo, The Netherlands: Kröller-Müller Museum. [https://www.researchgate.net/figure/Jan-Dibbets-All-shadows-detail-Masking-tape-dimensions-variable-Kroeller-Mueller\\_fig1\\_299507325](https://www.researchgate.net/figure/Jan-Dibbets-All-shadows-detail-Masking-tape-dimensions-variable-Kroeller-Mueller_fig1_299507325)



## Sensing Time

In his book *Art, Time and Technology* (2006), media theorist Charlie Gere explores how art has the potential to keep open our human relation with time in the digital age.<sup>112</sup> He concurs with Virilio's view of real time technology as having fundamentally changed our relationship with space to include "here and elsewhere at the same time",<sup>113</sup> which Virilio describes as a "no-place of teleoptical techniques".<sup>114</sup> My research into the materiality of time addresses Gere's assertion that humans now play a lesser role in the "dauntingly complex technological systems, operating at speeds beyond human control or even perception".<sup>115</sup> It seems to me that our relationship with technology has always been in flux. Crary describes how new technologies of the nineteenth century reshaped our "entire social field and the position of a human sensorium within it",<sup>116</sup> but he could just as well be describing the effect of early twenty-first century technologies, where our social and sensory engagement has changed once again.

I encountered many nineteenth and early twentieth century optical image devices during my field research halfway through this project. From Joseph Plateau's phenakistiscope (Fig. 29), to Reynaud's praxinoscope (Fig. 30) and William Dickson's kinoscope (Fig. 31),<sup>117</sup> I remembered how these early technological systems commanded that my body engage physically with them in order to witness the magic of their moving images and how unfamiliar this type of physical engagement was to me.

Whether turning the wheel of the phenakistiscope or polygon drum or peering through the eyepiece of the kinoscope, I became aware of my senses – seeing myself seeing – feeling that my physical engagement was somehow part of the mechanism generating the image. This experience motivated me to create moving material components for my devices, which activate a more embodied cognitive awareness in the viewer. Unlike the phenakistiscope or polygon, my devices do not require the physical interaction of my body to operate them, as they incorporate electronic rather than manual mechanics. However I wanted my devices to impart a more physical self-awareness in the viewer, as my engagement with the nineteenth century devices had imparted in me. With this aim in mind, I

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<sup>112</sup> Charlie Gere, *Art, Time and Technology* (Oxford, New York: Berg, 2006), 2.

<sup>113</sup> Ibid.

<sup>114</sup> Virilio writes: "Meeting at a distance, in other words, being telepresent. Here and elsewhere, *at the same time*, in this so-called 'real time' which is, however nothing but a kind of real time space, since the different events do indeed take *place*, even if that place is in the end the no-place of teleoptical techniques". (Paul Virilio, *Open Sky* (London: Verso, 1997), 10).

<sup>115</sup> Gere, "Art, Time and Technology", Bloomsbury Press, <https://www.bloomsbury.com/au/art-time-and-technology-9781845201357/> (accessed February 24, 2016).

<sup>116</sup> Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, Massachusetts: MIT Press, 1990), 149.

<sup>117</sup> These devices were cited in various museum collections, such as the Cinémathèque Française and The Musée des Arts et Métiers in Paris, France and the National Museum of Cinema in Turin, Italy.

wondered if in the context of Gere's digital age, I might reclaim the subjectivity of my senses in the presence of my material device and its optical form of time.

During my field research visiting the various optical image device collections, I became aware of the relationship between speed and visibility. Contemporary technological systems operate so quickly they are no longer within the realm of human perception and contrastingly, as described in the opening scene of Chapter One, changes in nature can occur so slowly we do not see them. Speed unwittingly became an important element in my optical devices. Through building my systems, I discovered that the rotational speed of my polygon device and the rate of the changing water levels in *Hollow Lens* were significant to the visibility of the mechanism itself, as well as the moving time-light it generates.

## Under the Influence: Reynaud and Late Nineteenth Century Optical Mechanics

I spent many weeks in the physics laboratory with various lenses and rotational devices such as a Lazy Susan, a stepper motor and turn-table to generate the moving images (Fig. 32 and Fig. 33). But each time I rotated the image strip in front of my light source to project its image-light through my objective lens system, it created a blurred, illegible image. I knew about mechanical fixes such as the Maltese Cross and beater mechanism used in projectors during the late nineteenth century, which could potentially overcome my blurring effect.<sup>118</sup> But instead of a purely mechanical solution, I was interested in resolving this problem through movement and light, in other words through optical mechanics.

I came across the concept of optical mechanics during a visit to the Cinémathèque Française in Paris during the first year of the project. There I saw artist-engineer Reynaud's late nineteenth century optical moving image devices, the praxinoscope (Fig. 34 and Fig. 35) and *Théâtre Optique* (Fig. 36 and Fig. 37). Animated characters reflected themselves off mirrored polygons, which rotated around static sources of light. Brought to life through the movement of the polygon, these images appeared like spectres, suddenly re-activated from the dormant past of the nineteenth century.

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<sup>118</sup> The Maltese Cross and beater mechanisms are gear devices that allow an object to rotate intermittently. They are used in film projectors to momentarily pause each film frame in front of the projector's objective lens.



Fig. 29. Joseph Plateau, *Phenakistiscope*, 1860. Paris: Cinémathèque Française <http://www.cinematheque.fr/fr/catalogues/appareils/collection/phenakistiscope-disque-obturbateur-et-manche-de-ap-95-1694.html>



Fig. 30. Emile Reynaud, *Praxinoscope Theatre*, 1878. Paris: Cinémathèque Française.



Fig. 31. William Kennedy Laurie Dickson, *Man using Kinetoscope*, c 1894. Science & Society Picture Library. <https://www.ssplprints.com/image/93396/man-using-an-edison-kinetoscope-c-1894>

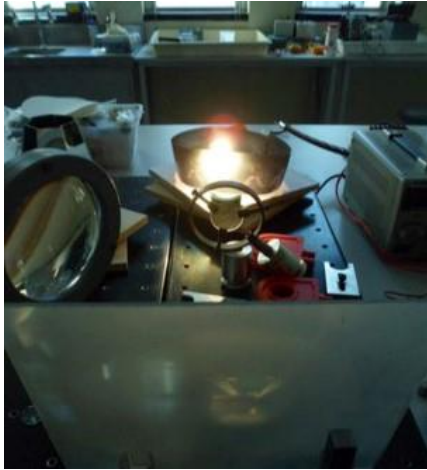


Fig. 32. Using a Lazy Susan in the physics laboratory to rotate the image frames in front of the lens to create a projected moving image.

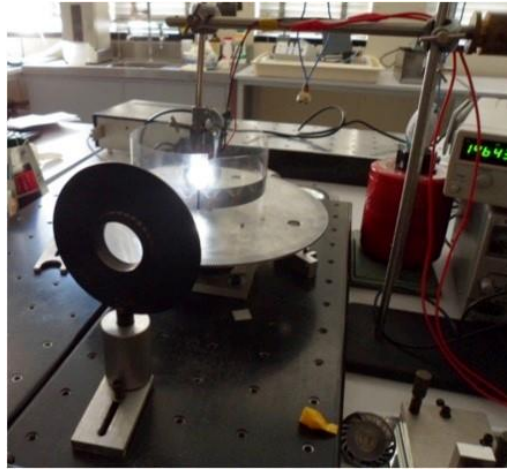


Fig. 33. Using a stepper motor to rotate the image frames intermittently.



Fig. 34. Charles-Émile Reynaud, Praxinoscope, c 1879 (detail). Paris: Cinémathèque Française.



Fig. 35. Charles-Émile Reynaud, Praxinoscope, c 1879 (detail). Paris: Cinémathèque Française.

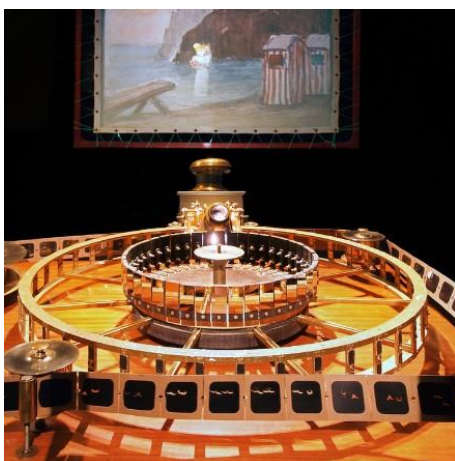


Fig. 36. Charles-Émile Reynaud, *Théâtre Optique*, 1888 (Reconstruction). Paris: Cinémathèque Française.  
<http://www.cinematheque.fr/fr/catalogues/appareils/collection/theatre-optique-reconstitution-ap-95-1724.html>



Fig. 37. A performance of *Pauvre Pierrot* as imagined by Louis Poyet, published in *La Nature* in July 1892.  
[https://en.wikipedia.org/wiki/Th%C3%A9%C3%A2tre\\_Optique#/media/File:Theatreoptique.jpg](https://en.wikipedia.org/wiki/Th%C3%A9%C3%A2tre_Optique#/media/File:Theatreoptique.jpg)

These nineteenth century devices used a similar optical mechanism to the one I had been thinking about. Instead of the earth orbiting the sun, the image carousel rotates around a static light source to generate a moving image. Like the circle of light on my kitchen wall, Reynaud's moving images appeared to create their own form of time. With my gaze transfixed on these moving characters of light, I knew that understanding the optical mechanics of Reynaud's devices would be critical to the development of my own optical system and its projected image.

The praxinoscope was a popular children's toy towards the end of the nineteenth century, which created small-scale animations.<sup>119</sup> It uses an optical mechanism of a mirrored polygon sitting inside an encircling metal drum twice its diameter. Reynaud described the polygon as a 'cage of mirrors', a series of twelve small vertical mirrors glued to each other and positioned in the centre of the drum (Fig. 34).<sup>120</sup> The polygon and the drum rotate on the same axis. Each mirrored facet of the polygon reflects a single and different image frame painted on the inside of the drum. Collectively, the images make up a frame-by-frame sequence of movement, so that when the device rotates in front of a viewer, it creates the appearance of a moving image.<sup>121</sup> Like my mirror tests detailed at the beginning of this chapter, where two separate lines appeared as a single moving line on my studio wall, perception was an integral part of Reynaud's animated image.

Reynaud later developed the praxinoscope device into a more elaborate form of the *Théâtre Optique*, which used hand-painted translucent glass slides on a rotating device allowing up to 250 image frames (Fig. 36).<sup>122</sup> He rear-projected these reflected images through an objective lens system onto a screen. For a short period he enthralled Parisian audiences at the Musée Grévin with his hand-painted animations but was soon overshadowed by the first cinematic films of the Lumière brothers.<sup>123</sup>

By applying Reynaud's optical technique of individually reflecting each image frame on to a matching mirrored plane, my moving image was no longer blurred. In contrast to the image frames, where each image presents a different stage of movement, each segment of mirror is identical. My eye and brain therefore only perceive the different stages of the moving form, they do not register the rotating mirrored plane. So whilst the mirrored plane renders the moving image legible, its reflective properties hide the mirror in plain sight.

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<sup>119</sup> Reynaud patented the name for this toy in 1877. It is derived from the Greek *praxis* meaning 'action' and scope is derived from *skopeo* meaning 'I look'. In his patent he described the praxinoscope as a device that created "the illusion of movement, with the aid of moving mirrors." (Mannoni, *The Great Art of Light and Shadow*, 367).

<sup>120</sup> Mannoni, *The Great Art of Light and Shadow*, 239.

<sup>121</sup> Like Tom Gunning, I use the term 'appearance' over 'illusion', to avoid any connotation of trickery or deceit, in the perceptions being generated by my technical devices. (Gunning, "Animation and Alienation: Bergson's Critique of the Cinematographe and the Paradox of Mechanical Motion," 2).

<sup>122</sup> Mannoni, *The Great Art of Light and Shadow*, 378.

<sup>123</sup> Mannoni, *The Great Art of Light and Shadow*, 385.

The reflective properties of the mirror became a significant element in my continued exploration of time and the projected moving image. Contemplating how the physical object of the mirrored polygon renders itself invisible through its own materiality, I knew that it would contribute to my continuing investigations of wonder and visibility, discussed in Chapter One<sup>124</sup> I was wary however of applying Reynaud's device too literally and "merely reconstituting or retro-fitting old media into new contexts"<sup>125</sup> which, as curator and critic Timothy Druckery describes, "could... only emerge as techno-retro-kitch".<sup>126</sup> As the project progressed however, I realised that although Reynaud and I were both using optical mechanics to generate our moving images of light, our rationale for using these mechanisms was very different. Reynaud's interest lay in entralling his audiences at the Musée Grévin. My concern was how to optically and mechanically generate a moving image as a means of exploring time.

## Re-Presencing Lost Time

As I rotated Reynaud's praxinoscope drum at the Cinémathèque Française, I noticed that if the rotational speed was slower than twelve frames per second, an optical 'glitch' occurred in the moving image. Spinning the drum slowly and keeping my gaze fixed on the moving character, (a young boy with a dog moving through a hoop), a faint trace from the previous image remained on the current image frame. This 'malfunction' added a ghostliness to the already somewhat spectral character.<sup>127</sup> I was intrigued by how varying the speed of the rotating mirror and its image frames caused a visual overlay of the past and the present.

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<sup>124</sup> Reynaud's praxinoscope, due to its size and function as a toy, was always potentially in full sight of the viewer. The *Théâtre Optique* however was placed behind a screen, so Reynaud's audience at the Musée Grévin did not see the device generating his *pantomimes lumineuses* (illuminated animations). When I saw a reconstructed *Théâtre Optique* being performed at the Cinémathèque Française, it was in front of the screen and therefore the mechanism was in full view of the audience.

<sup>125</sup> Timothy Druckery, in his forward to Siegfried Zielinski's *Deep Time of the Media: Towards an Archaeology of Hearing and Seeing by Technical Means*, (Cambridge, Massachusetts, London: MIT Press, 2006), IX.

<sup>126</sup> Timothy Druckery, *Deep Time of the Media*, IX.

<sup>127</sup> This is due to what is known as the phi phenomenon. The phi phenomenon is the optical illusion of perceiving a series of still images as being in continuous motion, when viewed in sufficiently rapid succession. In the case of Reynaud's praxinoscope, if the drum rotating the images and the mirrors are moved too slowly (below a speed of 12 frames per second) the eye/brain perceives the previous image frame and mirror plane, 'superimposed' on to the current image and mirror plane. Max Wertheimer defined this phenomenon in 1912. Although this postdates Reynaud's optical devices, it appears that Reynaud had an understanding of both this effect on perception as well as the persistence of vision, a phenomenon which is sometimes erroneously attributed to how we see moving images.



This overlapping of past and present called to mind Marcel Proust's epic novel *In Search of Lost Time* (1913), described by Shattuck as a quest to make us see time.<sup>128</sup> Proust, who had been influenced by his experience of optical image devices such as the magic lantern and stereoscope writes:

...it offered me as it were, all the successive pictures separating the past from the present, which I had never seen, and better yet, the relationship of the past to the present. It resembled what used to be called 'an optical view', but of the years, the view not of the moment, not of a person placed in the distorting perspective of time.<sup>129</sup>

I began to think about using my optical device to conjure a moving ghost. Like Proust's metaphorical haunting of the present by the past, Reynaud's mechanism 'optically' haunted the present as it physically rotated before my eyes. This lost time of the nineteenth century re-presented itself not just as an artefact of the Cinémathèque's archive, its structure, imagery and concept belonging to a bygone era, but as a rotating material object in the present here and now. The movement of the device dynamically generates a character with its own form of time. From this experience I wanted to re-present a character who had been lost in time by using projected moving light. I started to investigate how I could use the 'glitch' created by the slowed-down rotational speed to conjure my optical ghost.<sup>130</sup> I wondered whether I could succeed in bridging the gap between the past and the present, allowing my ghost to traverse back into the space and time of the here and now.

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<sup>128</sup> Shattuck, *Proust's Binoculars: A Study of Memory, Time and Recognition*, 46.

<sup>129</sup> Marcel Proust, *In Search of Lost Time*, Vol. III, *The Guermantes Way*, trans. Scott Moncrieff, 925 (London: Chatto and Windus, 1925).

<sup>130</sup> In his patent for the praxinoscope Reynaud wrote that "the effect is obtained by the addition of a praxinoscope and a transparent mirror arranged to reflect the image of a scene placed in front of it, while allowing the figure animated by the praxinoscope to be seen through it. This is a new application of a device already used in theatres to produce impalpable ghosts". (Cited in Mannoni, *The Great Art of Light and Shadow*, 371).

## Part Two – Materiality

### The Materiality of Optical Time

I set about producing my time-light ghost. I decided to extract optical features from both the praxinoscope and *Théâtre Optique*. I wanted to create a contemporary optical device that would reactivate some ideas of Reynaud's optical mechanics. I 3D modelled and printed a carousel to hold my forty-eight image frames (Fig. 38). The carousel's design allowed the images to be interchangeable, so I could test different series of image sequences.

After making the carousel I turned my attention to constructing the reflective polygon, which would be motor-rotated on the same axis as the carousel. In the first instance, I constructed the polygon from sheet mirror, cut to size and ground on a glass lathe, so that the pieces would sit seamlessly beside each other (Fig. 39). However, I soon realised that the prototype required a much smaller scale and that due to the form's required precision, hand-making each of the forty-eight facets was not an optimal method. So I 3D modelled and printed it to a much smaller scale (Fig. 40).

As the 3D printer builds the form layer by layer it leaves a trace of the printing line, which I then had to remove by grinding and polishing each facet by hand. When the mirrored coating was applied to the polygon it became clear however that this method was also unsuitable. The facets were unevenly polished, causing too much light scattering across the mirrored surface and consequently much of the necessary reflectiveness was lost. Another possibility was to cast the polygon in glass and then mirror this form. But I soon realised that, as was the case previously, the facets of this form required grinding and polishing by hand and therefore the necessary precision would be almost impossible to achieve. Finally a potential solution emerged during my field research in Dublin when I came across a public sculpture fabricated from polished faceted steel (Fig. 41). Its surfaces were highly reflective, throwing back fragmented images of its urban surroundings. Instead of glass, I began to think about using a highly polished metal surface. After much discussion with Neil Devlin, a machinist engineer at the RSPE, I decided to have the component milled from aluminium. Steel would have been preferable for its durability, but would be too heavy for a small motor to rotate. I modified my optical design changing the polygon from a tapered to vertical form (Fig. 42). This modification allowed Devlin to mill the forty-eight facets from a single block of aluminium (Fig. 43).



Next came the challenging task of polishing the aluminium. We had planned to use RSPE's nano-lathe, a high-spec machine, which traditionally polishes mirrors for telescopic and laser optics. Unfortunately the machine malfunctioned, forcing me to find another solution. Devlin made several attempts at polishing the surface on various lathes, but the resulting surfaces were insufficiently reflective. He then tested the diamond tool from the nano-lathe in his mill. By fly-cutting the surface of the aluminium facets, he achieved the required polish (Fig. 44 and Fig. 45).

In working through this polishing process, Devlin became an important contributor to my overall project. We began to exchange ideas about materiality and process and I began to look at my research project in a different way. I had not intended on embarking on a project which would require so many materials other than glass. I had a firm foundation in glass but these new materials required novel ways of making and thinking. This took my focus on materiality beyond the confines of studio glass, where glass is specifically crafted to make a work of art. I was now learning material methodologies that are usually in the service of science and engineering, applying them to create my works of art. My ideas and explorations no longer belonged to a single or fixed terrain.<sup>131</sup>

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<sup>131</sup> The cross-disciplinary approach of my project was facilitated by two major factors. First was the accessibility of digital technologies that allowed me to test individual elements and ideas that arose throughout the project, for example access to the Maker Space at the RSPE. This aligns with a current trend of artistic practice moving beyond the border of a single discipline and using more computer aided technologies to solve problems and materialise ideas. Additionally, carrying out this research at the ANU gave me the cross-disciplinary support required to explore and resolve many of my project's questions.

This re-discovered cross-disciplinary approach reminds me of seventeenth century natural philosophy practice. Francis Bacon, the man of 'new practical science' hoped that novel ideas would emerge from a cross-over between various practices and trades "by a connexion and transferring of the observations of one Arte, to the use of another, when the experience of several ministries shall fall under the consideration of one mans' minde". (Eugene Ferguson, *The mind's eye: Nonverbal Thought in Technology*" (1977), 830). One can see this tradition continued with Reynaud, who successfully applied interdisciplinary knowledge. Without his experience across the various fields of art, engineering, optics, industrial design and a keen interest in select technical developments of the past, he would not have developed his optical image devices. In reflecting upon my project, I have journeyed along a similar interdisciplinary path.

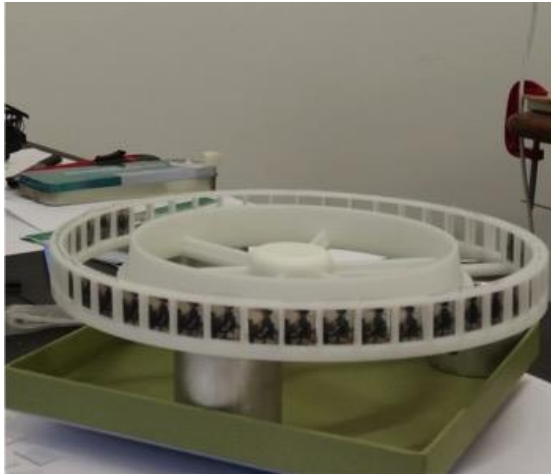


Fig. 38. 3D printed nylon carousel holding image frames, 300 x 25mm.



Fig. 39. Polygons constructed from sheet mirror, dimensions variable.

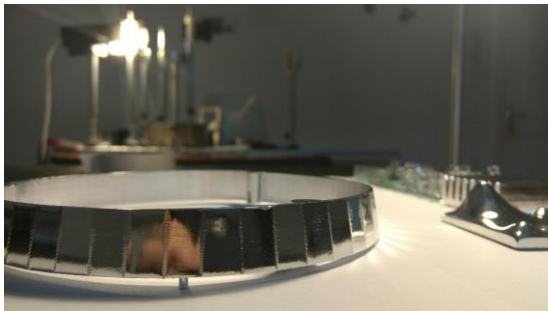


Fig. 40. 3D printed and mirror coated nylon polygon, 200 x 25mm.



Fig. 41. Robert McColgan, *Scáthán (Mirror)*, 2007, polished stainless steel. Dublin.

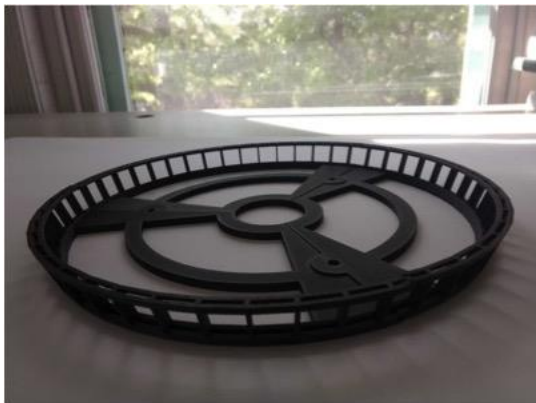


Fig. 42. 3D printed carbon fibre carousel with modified design, 300 x 25mm.



Fig. 43. Faceted polygon milled from aluminium, 200 x 28mm.

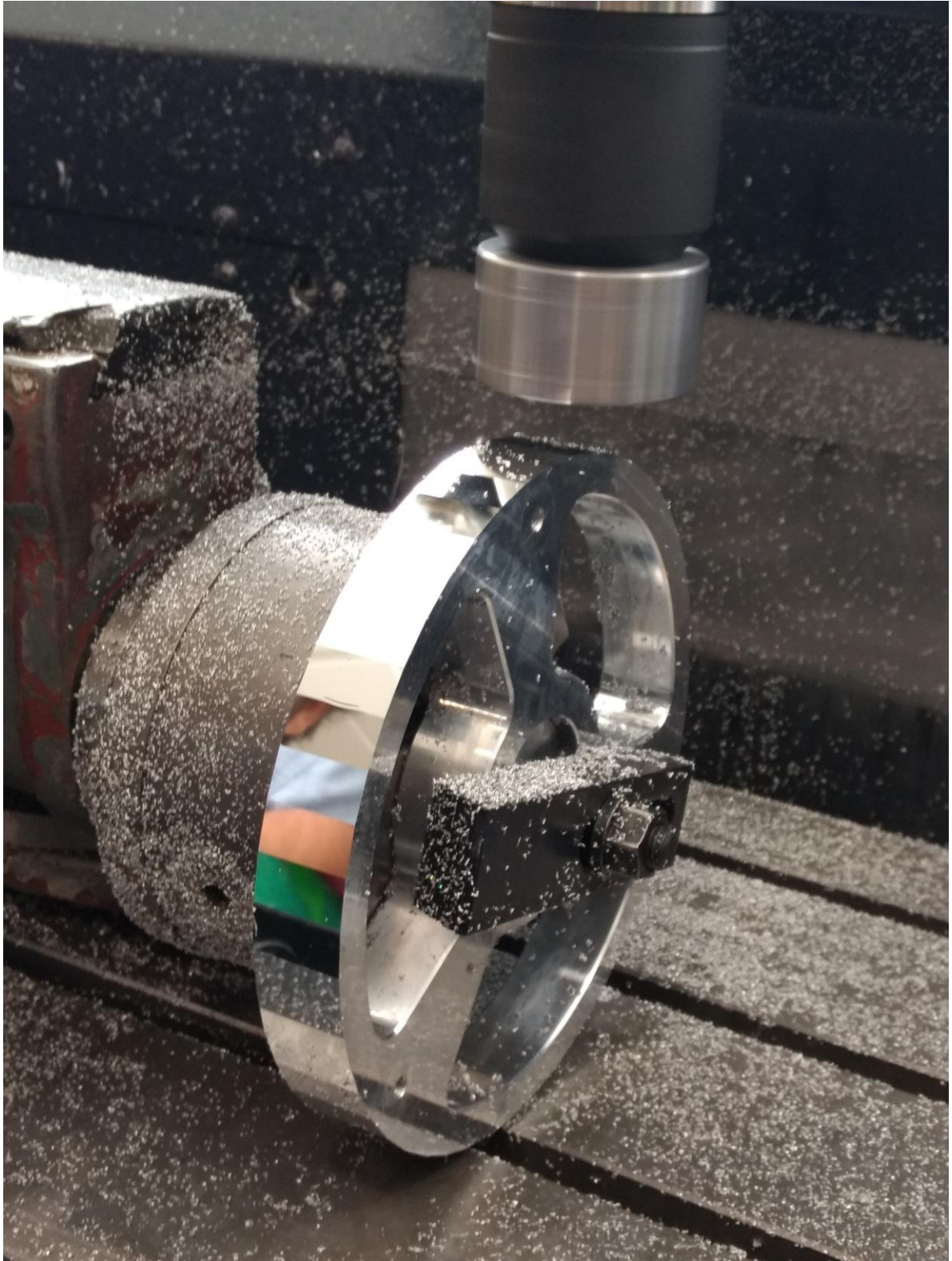


Fig. 44. Polishing the aluminium polygon – fly-cutting the surfaces using a lathe and diamond bit.



Fig. 45. Polished aluminium polygon and nylon image carousel on aluminium tripod stand.

## Nineteenth Century Lost Time

When I eventually tested the rotating polygon within my optical system, I became intrigued by how my image frames and polygon facets not only generated time-light in the here-and-now, they also reflected a specific nineteenth century consideration of time. After exploring Reynaud's praxinoscope and other nineteenth century pre-cinematic image devices, it became apparent that this particular manifestation of time is linear, segmented into units and measured. A stop-motion animator might apply this type of time to create a moving image in the same way today.

I used this concept of time to deconstruct the original moving footage of my ghost, a character from *The Magical Press* (1907), an early silent film in the Corrick Collection at the National Film and Sound Archive (NFSA) in Canberra (Fig. 46).<sup>132</sup> This short enchanting film is an example of what Gunning refers to as the 'novelty of mechanical motion', a key element of early cinema, where the movement of the image had not yet been overshadowed by narrative.<sup>133</sup> The novelty of motion waned during the twentieth century as cinema audiences became accustomed to the moving image and the speciality genre of animation became the only medium still overtly concerned with mechanical motion.<sup>134</sup> But, as Gunning comments, late in the twentieth century the novelty of mechanical motion was foregrounded once again through the emergence of 'new media'.<sup>135</sup>

Prior to this research project my practice had engaged with 'new media' by combining glass and the digitally created projected moving image. New media has of course since evolved into digital media and incorporates a wide range of accessible production and fabrication technologies. My investigations of mechanical motion introduced me to production techniques spanning digital media, fabrication technologies and electronics, as well as my familiar medium of hand-crafted glass. These scaffolds of knowledge were combined in researching and developing the material components for the optical mechanics of *Ghost in the Machine*.

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<sup>132</sup> Walter R. Booth, Dir., *The Magical Press* (1907), Charles Urban Trading Co., UK, Prod., Corrick Collection, National Film and Sound Archive, Canberra, Title no. 738957.

<sup>133</sup> Gunning, "Animation and Alienation: Bergson's Critique of the Cinematographe and the Paradox of Mechanical Motion," 3.

<sup>134</sup> Ibid.

<sup>135</sup> Ibid.





Fig. 46. Walter R. Booth, *The Magical Press*, 1907. Corrick Collection. Canberra: NFSA.

Whilst investigating the background to Reynaud's optical devices, I discovered that the praxinoscope mechanism of his *Théâtre Optique* was still in use only seven years before *The Magical Press* was made. The film clearly displays a pre-cinematic or frame-by-frame animation quality in terms of technique, narrative and aesthetic. The entire film takes place within a single scene, which opens with a young woman in late nineteenth century garb reading a newspaper. From the newspaper she tears out a silhouette of a male figure, which wondrously turns into a man. A series of comical newspaper stories then magically come to life, such as two Victorian characters emerging from an oversized teacup and a hand-painted image of the earth suddenly appearing out of the blue. These sequences have a 'cut-out' visual quality, similar to the special effects used in Georges Méliès' *A Trip to the Moon* (1902)<sup>136</sup> and are more reminiscent of pre-cinematic animation or theatre than film. Movement and time feature in the film through various iterations of grandfather clocks and an embedded clip from the Lumière Brothers' famous film of a fast approaching train.<sup>137</sup> At the end of the film the woman waves her arm as if it is a magic wand and all the conjured curiosities disappear, as pieces of newspaper disperse into the air like confetti.

When selecting this woman for my ghost I was mindful of how this character was portrayed by an actor, a person who had lived in the world performing cinematic 'magic' 110 years ago. I wanted to use my

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<sup>136</sup> Georges Méliès, *A Trip to the Moon* (1902) is a French adventure film inspired by the writings of Jules Verne. It uses both theatrical and animation style special effects to create the "artificially arranged scenes" (Elizabeth Erza, George Méliès, (Manchester: Manchester University Press, 2000), 13). It is regarded as the first film of science fiction.

<sup>137</sup> Auguste and Louis Lumière, *Arrival of a Train at La Ciotat* (1895). This early film by the Lumière brothers is associated with a story where the audience was so stirred by the train, which appeared to be moving directly towards them, they ran screaming to the back of the theatre.

optical device to bring back to life, not only the magical performance, but the person who portrayed her and who had since been lost in time, cached in the darkness of the NFSA archive. The NFSA granted me permission to use a small section of the film for my research. After importing a digitised copy into the editing software Final Cut Pro I deconstructed my ghost, dissecting her movement into equal miniscule fragments (Fig. 47). I used these fragments to reconstruct a legible sequence of movements within a series of image frames. While working on this process, I kept thinking about the lost time of my ghost. With only forty-eight frames to play with, my ghost's re-presentation would be but a spark from the past lighting up the present moment. In a few seconds she would be gone again. I thought about all the moments that would remain unfolded in the dark space of irretrievable time.



Fig. 47. Image frames for my ghost.



Fig. 48. Projected image of my flickering ghost. Figure from *The Magical Press*, used with permission of the NFSA.

The lost time I had encountered through the image frames of my ghost, was also a concern for the nineteenth century French physiologist Étienne-Jules Marey. He was interested in analysing human and animal bodies in motion but was faced with an unsolvable dilemma of visualising his findings. Using a method of chronophotography, his aim was to visually capture and represent the body during every fraction of every second as it moved through space.<sup>138</sup> Film and media theorist Doane notes that Marey's interest in time was secondary to his preoccupation with movement.<sup>139</sup> Although this might have been the case, time remained an inescapable tenet of Marey's quest and it is through his engagement with time that Marey became relevant to my research.

Marey realised that his chronophotographic technique of recording time would always create an unclosable gap. Fragmentary moments, uncaptured during the opening and closing of the camera's aperture, were lost forever as they slipped through this gap in time. His process of visualising movement and time therefore would always be discontinuous. As Doane points out, the photographic method did not improve the accuracy of Marey's earlier method of graphic inscription,<sup>140</sup> but it did produce a more legible version of the successive positions of movement through space (Fig. 49 and Fig. 50).<sup>141</sup>

My solution of applying Reynaud's rotating polygon had also come with the cost of relinquishing fragments of time. However unlike Marey, my research was concerned with producing and re-presenting time in motion, not capturing and representing it as a static image. In this way Marey's impasse was similar to Dibbets' *All Shadows* in terms of how to capture constant movement or change with a static image.

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<sup>138</sup> Chronotography is a photographic method which emerged during the mid-late nineteenth century, to capture movement frame-by-frame.

<sup>139</sup> Mary Ann Doane, *The Emergence of Cinematic Time: Modernity, Contingency, the Archive* (Cambridge, Massachusetts: Harvard University Press, 2002), 324–325.

<sup>140</sup> He attached different inscription devices to different part of the bodies of his moving subjects. These instruments which were attached to an inscription tool, then traced the movements in graph form as the subject moved through space. Marey's inscription devices are in a way an early example of data visualisation tools.

<sup>141</sup> Doane, *The Emergence of Cinematic Time: Modernity, Contingency, the Archive*, 9.



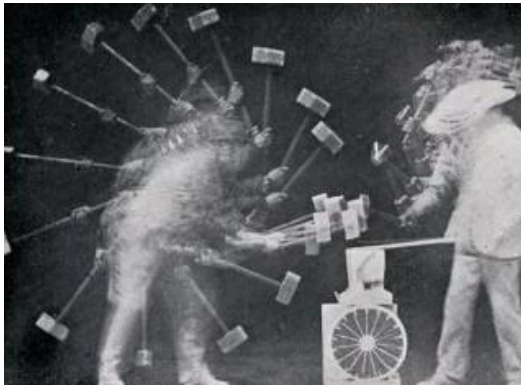


Fig. 49. Étienne-Jules Marey, *Chronophotograph*, c 1892. <http://www.graphicine.com/bodies-against-time-etienne-jules-marey/>

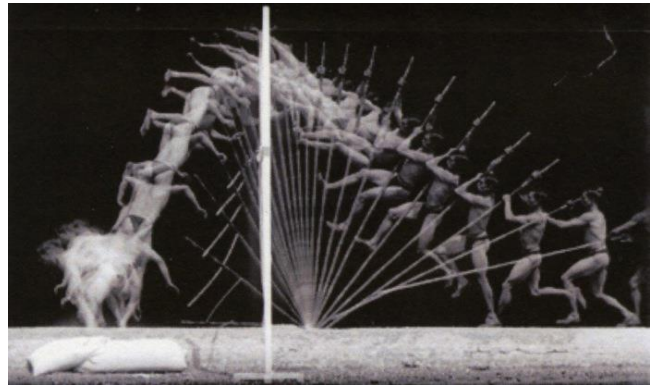


Fig. 50. Étienne-Jules Marey, *Chronophotograph*, c 1892. <http://www.graphicine.com/bodies-against-time-etienne-jules-marey/>

I too was using a series of static images to generate the appearance of my moving ghost, but my images served to generate a moving one. Using digital software I extracted forty-eight image frames from *The Magical Press*, regretfully aware that between these selected frames were lost moments in time. These gaps, which allowed me to remove the image sequence from the constraint of chronological time, influenced how I recomposed the frames. Placing the reconstructed sequence into my rotating optical system I re-presented time in a different way to minutes and hours. Like the sunspot on my kitchen wall, it was a time-light created through the re-sequenced image frames orbiting a static light source and projected through a lens, giving the appearance of a single but moving image.

Ironically the flickering movement of my ghost continues to unfold it's time-light. By means of the rotating reflective surfaces of the polygon, I perceive a constant and static background behind my foregrounded moving ghost, both of which present themselves before me through the durational time of experience. What had been an impasse for Marey, has in contrast advanced my endeavour to create a projected moving image and allow my ghost to re-enter the present. My flickering ghost from *The Magical Press*, seems to visualise the structure of time, a structure which had been formed around the negative space of the gap (Fig. 48). Is it this gap that allows her to re-enter the present from the past? It seemed that by rotating my polygon more slowly, the extended gap in optical time was creating the ghostly trace.



Fig. 51. Testing the carousel and polygon.

## Ghost in the Machine

As I continued to work on this projection device (Fig. 51), now clearly aligned with Reynaud's optical mechanics, I spent a lot of time exploring how the rotational speed of my image carousel and polygon could create a ghostly trace, similar to what I had witnessed with Reynaud's praxinoscope at the Cinémathèque Française. Unlike Reynaud's devices, I was using an electronically controlled motor, which I worked on with the help of electronics engineer Dennis Gibson from the RSPE. This motor, like the stepper motor controlling the pump in *Hollow Lens*, makes a low humming sound. When I first heard it I thought it detracted from the work, but soon realised that the sound was an integral part of the mechanism. I had initially based my calculations for rotational speed on Reynaud's devices and other early frame-by-frame animation techniques such as the phenakistoscope and zoetrope, as well as theories of persistence of vision and the phi phenomenon. However when I put all this into practice in the studio I found to my surprise that my ghost required a much slower rotational speed of about four frames per second. She was visually indicating to me to slow down time and open up a perceptual gap through which she could enter the present. It was ironic that a non-tangible moving image, lost to the

past but retrievable through my device, could dictate so much of the physical process of constructing these devices.<sup>142</sup>

After much problem solving and help from Gibson, a gear head was fitted onto a new motor shaft, allowing me to adequately slow down the rotational speed. I was then able to vary the speed of my ghost's movement with a potentiometer connected to a printed circuit board (PCB) (Fig. 52). Varying the rotational speed of my polygon and image sequences and sending this image-light from the glass frames through the objective lens, gave me the option of expanding or condensing the generated time-light. Thinking back to Lippershey's seventeenth century telescope, I too was creating an optical logistics of time. But instead of telescopic optics bringing the faraway near, my rotating optical device could expand or contract time. I began to reflect upon how this optical expansion and contraction of time relates to the idea of duration, a key element in my re-presentation of time.

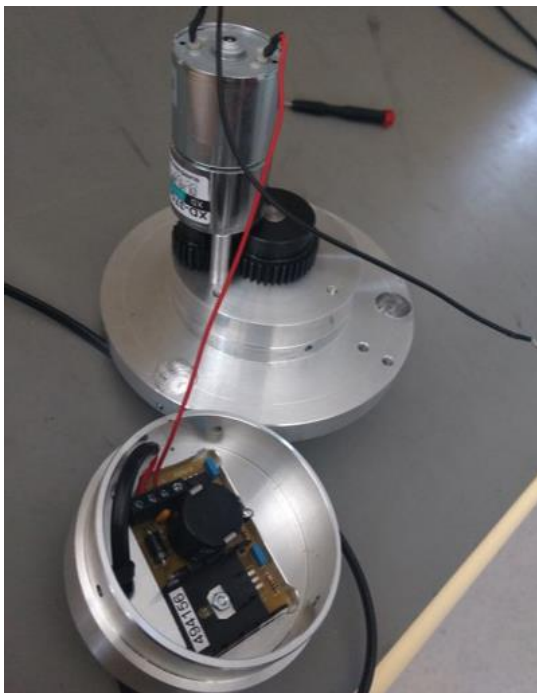


Fig. 52. Motor shaft, gear head and PCB.

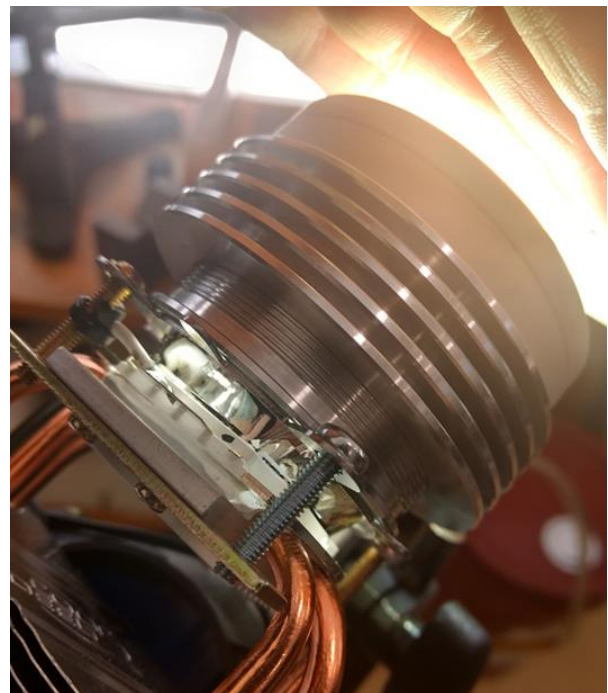


Fig. 53. Milled concentric ring on aluminium light collar which also acts as a heat sink.

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<sup>142</sup> I could have easily used a data projector to project the digitised copy of my ghost. But the material device and the re-materialisation of my image ghost through the glass frames (as well as the glass lenses), light and movement all became more inseparable as the project developed.

## Bergson's Duration and Unfolding Time through Materiality and Light

Henri Bergson's concept of duration became important in the context of the durational presence of my ghost. The French philosopher would not have approved of the optical mechanics of my rotating polygon and moving ghost light. He argued against the measurable consistency of time and was critical of mechanical motion generated through technology, including cinematic motion, which he deemed 'artificial'.<sup>143</sup> He wrote, "In order that the pictures may be animated, there must be movement somewhere, the movement does indeed exist here; it is in the apparatus".<sup>144</sup> I thought back to the initial mirror tests in my studio where I was fixated on the moving lines of light rather than the actual movement of the mirrors themselves.

'Bergsonian' motion and time would never emerge solely from the image frames and mirrored facets of my polygon device, no matter what their rotational speed. But as Gunning points out in his essay on the paradox of mechanical motion, animation depends on more than the conversion of still images into motion through technological means.<sup>145</sup> It also depends on the transformative capacity of perception, when "a melding of the human sensorium and the machine" take place,<sup>146</sup> something I had clearly already experienced with the engraved line and mirror tests described at the beginning of this chapter and the moving images of *Hollow Lens* and *Ghost in the Machine*.

What was important to my research was not an adherence to 'true' motion or the individual components (image frames, mirrored facets, electronically controlled motor) but my overall system, in which the viewer's experience played a part. My polygon device explores more than the concept of nineteenth century discontinuous time, it incorporates a type of durational time, of which Bergson might have been less scornful. The deconstructed and reconstructed time I use to create my ghost unfolds through my optical system as a reformed time of experience. And this experience takes place in the same space as my conjured ghost, who has slipped through a gap into the presence of the viewer, undoing perhaps 'the fixity of our perception' of time.<sup>147</sup>

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<sup>143</sup> Gunning, "Animation and Alienation: Bergson's Critique of the Cinematographe and the Paradox of Mechanical Motion," 4.

<sup>144</sup> Gilles Deleuze, *Cinema I: The Movement-Image* (Minneapolis: University of Minnesota Press, 1986), 22. (Cited in Gunning, "Animation and Alienation," 5).

<sup>145</sup> Gunning, "Animation and Alienation," 5.

<sup>146</sup> Ibid.

<sup>147</sup> What Gunning terms the "final effect," (Gunning, "Animation and Alienation," 5).

## From Object to System

Aiming to re-form time with my technical image devices and perceptual engagement of the viewer, philosopher Gilbert Simondon's concept of technology became relevant to my research. Simondon views technology not as an empirical instrument with which to measure the world, but as an 'ensemble', of which the device itself is only one part.<sup>148</sup> His ensemble includes how components within a device interconnect and how humans relate to the device. His concept is also concerned with how the device changes our environment and consequently our perceived surroundings.<sup>149</sup>

Similar to Gunning's melding of sensorium and machine, Simondon's technological assemblage led me to consider more than the technological device, which I had been so fixated on during my explorations of visualising time. How my device changed the perceptual experience of the viewer was also crucial. I realised that *Hollow Lens* and *Ghost in the Machine* incorporate relational speeds, each component co-determining the visibility and legibility of the device and its apparent moving image. For example, the real-time speed of the ocean scene on the LCD relates to the rate of the rise and fall of the water in the water lenses, which in turn relates to the speed of change in the projected image and my perceptual ability to see this changing image. Similar relational speeds are embedded in the polygon system. Simondon's 'ensemble' also clarified for me that my optical systems relate to more than the device, image, viewer and the relational intricacies within these systems. I realised that throughout the course of the project my interdisciplinary methodology had inadvertently developed another system, containing different but interconnected types of knowledge.

This constellation of knowledge had emerged from my constant manoeuvring between the realms of visual art, optical physics and electronic, machinist and mechanical engineering. It changed how I thought about my art practice. The words of art and technology critic Jack Burnham began to resonate with me: "We are now in a transition from object-oriented to systems-oriented culture. Here change emanates not from things but from *the way things are done*".<sup>150</sup> Although Burnham is describing a trend in American art practice forty years ago, his words illustrate how during this project, my practice transitioned from being object-based to being concerned with how objects interrelate with each other and the world. The technological, perceptual and epistemological constellation I established seemed to remove any frame or border from my project, potentially making it more challenging to 'know' its final

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<sup>148</sup> Gilbert Simondon, *On the Mode of Existence of Technical Objects*, trans. Ninian Mellamphy, (Paris: Aubier, Editions Moutaigne, 1958; Ontario: University of Western Ontario, 1980), 4–10. <http://dephasage.ocular-witness.com/pdf/SimondonGilbert.OnTheModeOfExistence.pdf> (accessed July 30, 2018).

<sup>149</sup> Ibid.

<sup>150</sup> Jack Burnham, "Real Time Systems," in *Great Western Salt Works: Essays on the Meaning of Post-Formalist Artworks*, (New York: Braziller, 1973), 16. (Cited in Gere, *Art, Time and Technology*, 124). (My italics).

outcome. Instead of a static object being known and understood, the changing interactions of the moving elements I was developing became the underlying dynamic of the project.<sup>151</sup>

## Solving Puzzles: The Optical Time of Attila Csörgő

Throughout my research I discovered the importance of fine-tuning my ideas. Although theoretically my concepts should function in the real world, I came up against continuous challenges when attempting to realise these ideas in material form. Although this was sometimes frustrating and time-consuming, I learned a wide array of solutions to problems I had not previously even contemplated. Problem solving became the way I learned how to communicate with my colleagues who were helping me to fabricate the components, in particular machinist engineer Devlin and electronics engineers Redman and Gibson. Although collaboration was not an intentional part of my overall methodology, the assistance provided by the engineers has proved invaluable, giving me insight into future possibilities for cross-disciplinary collaboration.<sup>152</sup>

In reality my components – motorised polygon, carousel, image frames, condensing and objective lenses, supporting armatures and holders – required many adjustments to function optimally and create the desired inclusive system of device, image and viewer. Sometimes an adjustment created yet another problem that had to be solved. For example, my exposed LED panels were dispersing too much light. Consequently an insufficient amount of light travelled through the condensing lens system, creating a projected image with a low level of luminosity. To resolve the issue, I worked with Sean Booth at the SoA&D Gold and Silver workshop to make some adjustable telescopic collars to contain the light.

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<sup>151</sup>Again I was reminded of Burnham who writes: “Where the object almost always has a fixed shape and boundaries, the consistency of a system may be altered in time and space, its behaviour determined both by eternal conditions and its mechanisms of control.” (Jack Burnham, “Real-Time Systems,” *Art Forum* (September, 1969): 17. (Cited in Gere, *Art, Time and Technology*, 125).

<sup>152</sup> This multi-faceted problem-solving reminded me of René Descartes’ quest in the summer of 1625 to produce a perfect parabolic lens. Frustrated by his attempts to realise his mathematical theories in material form, he enlisted the help of glassmaker Jean Ferrier and mathematician Claude Mydorge. To measure the angles of refracted light through the glass they constructed a device consisting of a glass prism and wooden visor. It was this device that provided the framework for the direct relationship between incident and refracted rays of light. It was therefore their combined effort to solve the problem of creating a parabolic lens that inadvertently contributed to the discovery of what we know today as Snell’s Law of Refraction. (Fokko Jan Dijksterhuis, “Constructive Thinking: A Case for Dioptrics,” in *The Mindful Hand – Inquiry and Invention from the Late Renaissance to Early Industrialisation*, eds. Lissa Roberts, Simon Schaffer & Peter Dear, 59–82 (Chicago: The University of Chicago Press, 2008).

All of the light generated from the LED was now travelling through the condensing lens. However this resulted in too much heat being trapped inside the collar and the lenses were at risk of cracking. I solved this problem by turning the adjustable collars into heat sinks. This additional complication taught me to consider how material solutions to problems effected my optical systems as a whole, each solution had a bearing on each interconnected component of the system. Devlin milled concentric rings on the outer cylinder of the telescopic collar so that the heat would disperse away from the lens and avoid any cracking (Fig. 53). I tested an initial milled form with a 100W LED and after several hours the collar and lens were still cool enough to touch. In this instance, the removal of material had held the answer to my predicament. I was intrigued by how conceptual and material refinement during the later stages of my project were still so intertwined and brought to mind Kodera's concept of *scienza* in Chapter One.

It was this meticulous refinement and considered engineering that initially drew me to the work of contemporary Hungarian artist Attila Csörgő. Investigating mechanisms of perception, Csörgő's practice oscillates between the realms of art, science and engineering and he applies artistic solutions to quandaries that might ordinarily belong to the world of mathematics or physics. He begins with a scientific concept but extracts it from its scientific context and re-imagines it as a work of art. Csörgő does not intentionally construct his devices to have particular visual qualities, however their required technical construction grants them an intrinsic functional aesthetic.

Like my polygon and hollow lens systems, Csörgő's devices explore interactions of light and movement to generate optical appearances of moving images. He explores how unexpected physical phenomena can "shatter the viewer's belief in apparently obvious physical laws".<sup>153</sup> His most relevant work for my research is *Clock Work* (2017) (Fig. 54), which I saw at the 2017 Venice Biennale during my field research. Csörgő describes *Clock Work* as a 'sculpture of time'.<sup>154</sup> It comprises a kinetic construction in the form of a three-dimensional infinity symbol or Möbius strip and the rotating hand of a clock, both of which are controlled by an electric motor and micro-controller. Positioned behind this construction is a parabolic reflector and halogen lamp. The reflected light from the mirror and light source casts a moving image shadow of infinite time onto the wall in front of the moving construction.

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<sup>153</sup> Mudam, "Attila Csörgő: Archimedean Point,"

<https://www.mudam.lu/en/expositions/details/exposition/attila-csoergoe/> (accessed December 4, 2016).

<sup>154</sup> You Tube, "Interview with Attila Csörgő for the exhibition Archimedean Point 09/10/2010 – 23/01/2013 at Mudam Luxembourg, Part One," <https://www.youtube.com/watch?v=iccPqW4gVaQ> (accessed December 4, 2016).





Fig. 54. Attila Csörgő, *Clock Work*, 2017. Venice: 2017 Venice Biennale.

*Clock Work* uses a physical device, which electronically, mechanically and optically generates a virtual image in real space. As I stood in the centuries-old building watching Csörgő's visualised time move by in front of me, I thought back to the circle of projected light on my kitchen wall and the continuous flux of light and shadow. Csörgő was turning everyday measured hours and minutes of 'clock' time into an abstracted form through a physical device and projected image. By rotating an object around a static source of light, he returned the idea of time to a construct originating from the earth's never-ending orbital path around the sun. As I engaged with both the device and image of *Clock Work* I thought about the time-light generated by my optical devices and wondered whether the results of my research might produce such a subtle transformation in both the visibility and perception of time.



## Material Changes

This project emerged from my fascination with the interaction of glass and light. During the early days of my research whilst working out the focal lengths of my lenses, I had used magic lantern glass slides as image sources for my optical system (Fig. 55). Their materiality captivated me. The slides, when placed in front of a light source possessed a condensed jewel-like intensity. These translucent objects seemed to hold a kind of unrealised magic. The moment I placed them within my optical system, the condensed image cast itself across the darkened room, luminous and larger than life, its magic released.<sup>155</sup> I noticed a difference between the quality of this image-light and that of a digital image being cast from a data projector. The projected image generated through the glass slide in my optical system displayed a heightened luminosity, making the digitally projected image seem dull in comparison.

Throughout the project I made various types of image objects to investigate different qualities of projected image. I created a short series of small scale slides of my moving ghost, extracted from *The Magical Press*, digitally printing the selected images as glass decals and firing them in the kiln onto microscope glass slides that I could grind and polish in the glass workshop (Fig. 56).<sup>156</sup> In a later batch of tests, I screen-printed glass powder directly onto sheets of clear glass and fired them in the kiln, carrying out numerous firings, each time varying the kiln temperature to achieve the required level of translucency (Fig. 57). When I embedded these variously formed image objects into my optical system, there were significant differences in the luminous quality of the projected image. The image-light produced by the screen-printed glass slide had greater depth and vividness of colour, something I had not previously seen with historical magic lantern slides (Fig. 58).

As I gazed at this luminous image on my studio wall, it appeared to me that the screen-printed slide was projecting something more than its own image. When I looked closely at the image-light on the wall and its object source sitting in the device, I noticed that a small portion of the light travelling through the fused powder was internally refracted within the fine layers of colour and therefore held within the image on the glass slide. When this captured light was projected as part of the image by the remaining source of light, it added volume and depth to the image. I already knew from my studio practice that when glass is polished in a particular way it behaves as a container for light. The surface finish can be controlled to allow the material to either hold or release specific amounts of light. The glass powder was

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<sup>155</sup> I had the same experience during my field research when I looked at many collections of glass slides in the various collections at the Cinémathèque Française, the Museum of Cinema in Turin, the Rijksmuseum in Amsterdam and the NFSA in Canberra.

<sup>156</sup> Even Reynaud had printed the outline of his characters onto his multiple glass slides for consistency and flow of movement, before hand-painting the details. (Mannoni, *The Great Art of Light and Shadow*, 379).

acting as a container for the light source in my optical system. Subsequently it refracted and projected this contained light in addition to and within its own image.

Through these observations in the studio, I realised that in addition to the glass lenses, the specific materiality of the image source was important. This led me to consider how I might create a projected image with the appearance of three dimensions. Chapter Three details these investigations into generating a more volumetric projected image, making use of the intrinsic ability of glass to contain light.

Although *Ghost in the Machine* uses a material image source, I was very mindful that the image source in *Hollow Lens* is digital and mediated through an LCD screen. This real-time technology allows me to stream different places of parallel time, but I did not want these spaces to be the no-place of Virilio's teleoptical techniques.<sup>157</sup> Reflecting back on Gere's suggestion of art as a way of keeping open our human relation with real-time technology, I wanted to remove the digital interface between my device and the viewer and generate a direct sensory and temporal experience of a materially formed image. It is this re-materialisation of the image, whether through the mechanics of the polygon or the changing water levels in the hollow lenses, that generates the optical time-light. No matter where the images have emerged from, here they are in the present experiential space of the viewer, creating their own form of time. It is therefore the material processes I developed throughout my project that allow the image-light to occur within the same spatial and temporal realm of the viewer.

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<sup>157</sup> Virilio, *The Vision Machine*, 5.

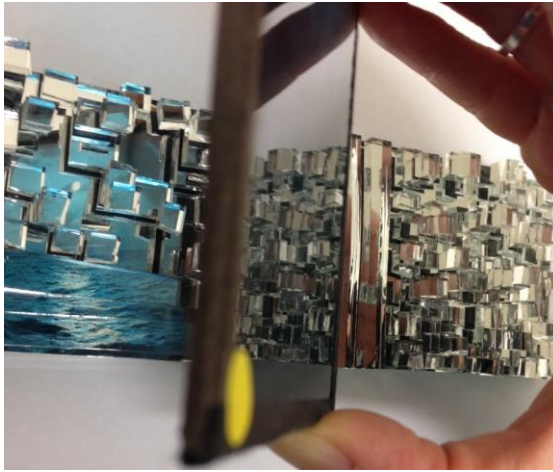


Fig. 55. Using magic lantern glass slide and constructed mirror to create distorted image.



Fig. 56. Image frame decals kiln-fired onto microscope glass slides, each 22 x 17mm.

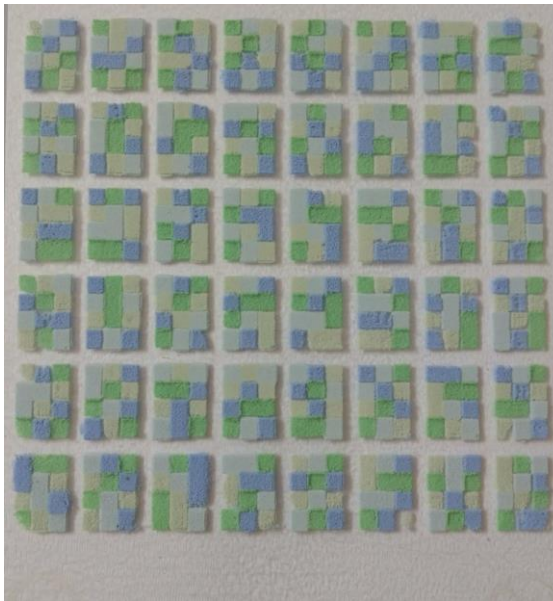


Fig. 57. Screen-printed glass powder onto clear glass and kiln-fired to a low temperature, each 22 x 17mm.

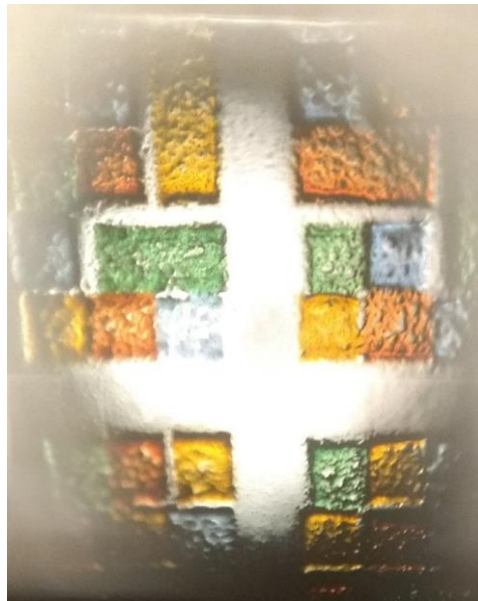


Fig. 58. Projected image from a high-fire fused glass-powder test.

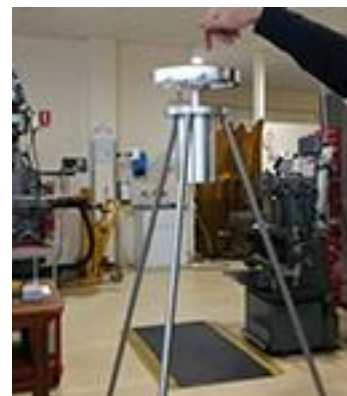
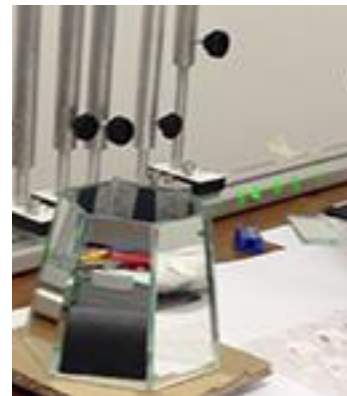
## Concluding Remarks

My exploration of time began by observing a circle of light traversing my kitchen wall, prompting me to consider time not just as minutes and hours, but as time-light generated through the earth's orbital path around the sun. *Ghost in the Machine* serves as a speculative tool for reforming time and making it visible through my material device and projected moving ghost. In the process of developing this work I found that rotational speed is important to the optical formation and durational presence of my ghost, and that the visible materiality of the polygon device activates the senses to create a more embodied experience of time. I discovered that slowing down the rotating polygon creates a perceptual gap in time and allows my ghost re-presence herself in the here and now.

My interdisciplinary investigations into the visibility of time made significant changes on my practice. My process of making expanded to include material methodologies in the sciences and engineering and transitioned from being singularly object-based to a broader concern for the systematic context within which objects interrelate. Shifting from the digital moving image to a mechanically and optically generated image facilitated a gathering of knowledge from various fields of visual art, physics, engineering, media archaeology and digital fabrication technologies.

Manoeuvring between these worlds for the purpose of my research, helped accommodate a wider consideration of wonder and visibility, which is the focus of Chapter Three.

Fig. 59. Additional process images of the research and development of *Ghost in the Machine*.



# Chapter Three

## Expansion of Invisibility





Fig. 60. Victorian domestic parlour scene of a family watching a magic lantern slide show.  
<https://magiclanternfilm.files.wordpress.com/2009/12/magiclantern-41.jpg>

*These invisible things come inside the eye – I do not say the things themselves, but their forms – through the diaphanous medium, not in reality but intentionality, almost as if through transparent glass.*

– Dante Alighieri<sup>158</sup>

*What is it like to be in a particular light?*

– Svetlana Alpers<sup>159</sup>

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<sup>158</sup> Dante Alighieri, *The Convivio of Dante Alighieri*, IX. Treatise III, 187, 1490, The Temple Classics, [https://archive.org/stream/convivioofdantea00dant/convivioofdantea00dant\\_djvu.txt](https://archive.org/stream/convivioofdantea00dant/convivioofdantea00dant_djvu.txt) (accessed February 02, 2017).

<sup>159</sup> Svetlana Alpers, “The Studio, the Laboratory and the Vexations of Art,” *Picturing Science Producing Art*, eds. Caroline A. Jones and Peter Galison, 406 (New York: Routledge, 1998).



## Introduction

The room goes dark, but not pitch black, a sense of late twilight remains. I can still see the silhouette of the black wooden box located towards the back of the room. Suddenly, an image-light appears from the front wall of the space. I turn, captivated, as that rare but familiar feeling of wonder arises and washes over me. I forget the wooden box, unaware of its sudden disappearance from view.

I am sitting in a nineteenth century domestic parlour where a family gathers, transfixed by a projected image light emanating from their collection of hand-painted mechanical glass slides (Fig. 60). For the first time I see luminous moving images magically appear in front of me. I am captivated by the movement of a girl jumping in rhythm to her skipping rope and the slow fading of daylight as the moon rises over a shimmering ocean in the clear night sky. And here I am again 200 years later, sitting in an art school lecture theatre, where a magic lantern show is being performed. Students, accustomed to the images of Instagram and Pinterest watch enthralled, as the various comical characters and solar systems come to life on the screen. As soon as the light source of the magic lantern is turned on, no further attention is paid to the peculiar looking device at the back of the room. Yet, through the darkness of the lecture theatre, it is this device that creates these moving light images – these images, which cast their spell on the young audience.<sup>160</sup>

This chapter investigates the visible materiality of the device and the immaterial transfer of light to understand the process of how my optical systems evoke wonder. It establishes a renewed visibility for my projected image devices with the function of focusing attention and generating awareness in the viewer. *Hollow Lens* and *Ghost in the Machine* explored the materiality of wonder, however at this stage of the project there seemed to be more to this phenomenon than sensory engagement and awareness initiated through the visible mechanism. Engaging with wide ranging theories from media archaeology to cognitive psychology, this chapter establishes a more analytical approach to understanding the experience of wonder and attests to how an essential combination of visible and invisible elements within my image systems give rise to wonder.

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<sup>160</sup> This magic lantern show was performed by Martyn Jolly and Elisa de Courcy for students enrolled in the SoA&D Foundation program in August 2017. This scene from 2017 is uncannily similar to a description written in 1791 by Jean-Phillippe Gui de Gentil, advisor to Queen Marie-Antoinette: “Many children gathered in a room, have their minds captured as a result of the darkness necessary for representation of the pictures which appear suddenly illuminated on a large disc, which frame the picture like a medallion. Curiosity charges their imagination, which grasps eagerly the details of the object represented.” (Comte de Paroy, *Mémoires* (Paris: Plon, 1895), 278. (Cited in Mannoni, *The Great Art of Light and Shadow*, 84).

Beginning with contexts of theoretical propositions of film theorist Păini, media archaeologist Zielinski and later in the chapter, Kepler's sixteenth century optical process of sight, it investigates relationships between image, device and viewer and proposes a new ontology for the device. It explores the reversal of visibility that takes place between the projected image and its device, and considers the significance of attending to the device as well as the image.

This chapter outlines the development of *Object-Image*, an optical system that projects 3D images using an object as its image source, rather than a traditional 2D slide, and relates the discovery of the degree to which glass mediates our perception of the image. Informed by the work of contemporary artist Maire and writer Crary, *Object-Image* explores the visibility of this mediation through my de-cloaked device and projected image.

I demonstrate how the virtual image in my systems is integrated into the design and structure of my material device and not just its projected ghostly image. In relation to Vermeer's *View of Delft*, the contemporary practices of Maire and McCall, and the writings of historian Alpers, I detail how my optical systems serve as visual strategies for drawing attention to unseen processes. Finally this chapter outlines how my research extends this strategy by embedding the invisible transfer of light into my image systems to establish a magic of inattention, which, in addition to critical attention is imperative for wonder.

## Part One – Reversal of Invisibility

### Device, Image, Viewer

Early on in my inquiry into the projected image, I came across relationships between image and device and observer and device, which did not align with my practical efforts of developing my optical devices. I sometimes noticed the device was described only in terms of either image or observer. Within the realm of film and surprisingly, media archaeology, it appeared to me that the device is not given its own ontological standing as an equally important part of the optical image system. Cinema focuses on the image, media archaeology on the perception of the mediated image. The devices, creating either the cinematic image or our ever-changing perceived image, are hidden from view. In contrast to these

hidden devices, which I had already explored in the context of Della Porta's natural magic and wonder, it was important to my research that all components of my optical devices function within clear and plain sight of the viewer.

Image-light, one of the key terms of my research, was coined by film theorist Dominique Païni in his catalogue essay for the exhibition *Projections: Les transports de l'image* (1997). Although this term has been integral to my project, Païni writes negatively about how the projected image, so dependent upon its device, is "enslaved to the mechanical apparatus that embodies it".<sup>161</sup> Media theorist Siegfried Zielinski also positions the device in relation to the image, or more specifically, in relation to the perception of the image. He explores two subfields of seventeenth century optics, still employed in contemporary image technologies: dioptrics, which uses transparent glass lenses and catoptrics, which works with reflective mirrors. Zielinski proposes that dioptrics concerns itself with the 'physics of the visible' and problems of 'looking through'. He connects this to the idea of *perspicere*,<sup>162</sup> of seeing through something, in terms of insight or understanding. Catoptrics on the other hand, he suggests, is concerned with 'looking at'. For Zielinski, LCD screens belong to the 'looking through' category, whereas all projection devices belong to the latter category of 'looking at'.<sup>163</sup>

Although Zielinski's connection of the dioptrical lens to the term *perspicere* is astute, my studio experience has shown me that it is the dioptric lens and not the catoptric mirror that is required for a projected image. Admittedly, I used computer software for the final designs of my optical systems, but for the most part, I learned about the dioptrics of projected image-light by testing various lenses in different optical configurations. I played with different polished forms of glass and witnessed how each configuration changed the image. Beginning simply with holding up an old magic lantern lens in front of my studio window, I then built composite-images in the physics laboratory, designed and constructed my condensing lens systems, and finally created my composite hollow lens system. I became increasingly captivated by my lenses and their intrinsic materiality, which shapes how they 'see' and image the world.

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<sup>161</sup> Dominique Païni, "Should we put an end to projection?," trans. Rosalind Krauss, *October* 110 (2004): 23. I have used Krauss' translation here but the original catalogue I came across during my field research at the Kandinsky Library at the Pompidou Centre in Paris: *Projections, les transports de l'image: Le Fresnoy, Studio national des arts contemporains, Novembre 1997–Janvier 1998*, Textes de Jacques Aumont, Yann Beauvais, Raymond Bellour (Paris: Hazan AFAA, Tourcoing: Le Fresnoy, studio national des arts contemporains, 1997).

<sup>162</sup> Coincidentally, this term emerged in 1570 around the same period that Della Porta was using his optical lenses to visualise the invisible world through projection.

<sup>163</sup> Zielinski writes: "...dioptrics are indebted to the idea of 'perspicere', of seeing through something, in the sense of insight or understanding; the latter, catoptrics, are more oriented toward the illusionizing potential of projection, the production of artificial reality." (Siegfried Zielinski, *Deep Time of the Media, Toward and Archaeology of Hearing and Seeing by Technical Means*, 85–86).

My research looks at lenses from the perspective of the interaction of glass and light. Zielinski's 'looking at' description of projection systems however, comes from the point of view of a media archaeologist focusing on viewer perception. Although the perceived image plays a role in my research, it encompasses a more expanded framework. Spending so much time with lenses, I began to consider another point of view – that it is the light which 'looks through' the glass lens to visualise the invisible. How we see our world is intrinsically linked to what we see in our world. I wanted this notion of 'how' to accommodate more than the viewer's perception, that is, to additionally incorporate the material device. As Crary points out, 'visionary experiences' have never been apprehended in some pure state, they are always mediated in some way by technical, material and cultural practices.<sup>164</sup> In many instances throughout my research however, I discovered that the 'material' remains ironically invisible through unawareness and inattention.

This inattention towards the device inspired me to renew its visibility. As already related, I spent much time problem solving and developing my optical devices in collaboration with physicists, electronic, mechanical and machinist engineers. But the intention was not to give my devices prominence over the image or viewer. It was to generate a system wherein all parts, device, image and viewer, are exposed and contribute in their own way to the experience. As I have already shown in Chapters One and Two, the changing optics of the water lenses make visible the process of slow change, the rotating polygon generating the moving image of my ghost has its own time-light and the viewer brings with them a sense of time and criticality. It was important that the components worked together to create a whole experience and that simultaneously, they each had their own ontology.

Zielinski's and Pardini's views illustrated how overly focused we are on the projected image *per se*, and not the system as a whole, the device-image system. This long-term trend of exclusively attending to the projected image, leads to an ironic reversal of visibility. In contrast to the purposefully hidden optical devices of Della Porta's natural magic, the contemporary projected image device – a physical object belonging to the 'real' world, corporeal and solid – is rendered invisible through exclusive attention on a virtual, transparent and ghostly image. As soon as this device is switched on, we are spellbound by its conjured image-light. Focussing solely on the image, the physical device, which creates it is rendered invisible.

My devices explore this reversal of visibility and de-cloak them so that the viewer's attention shifts solely from the image to image-system. Clearly then, my research is concerned with both the perceived image and the re-visibility of the object that creates it. As with the disappearance of the magic lantern in

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<sup>164</sup> Jonathan Crary, "Olafur Eliasson: Visionary Events," in *Olafur Eliasson*, (Kunsthalle Basel: Berlin, Muttonz: Schwabe & Co., 1997) 63; Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century*, 30.

this chapter's opening scene, my research aims, not so much to undo this reversal of visibility, but to expand it.

## Uncovering the Mechanism

Several years before this project began, I was visiting an exhibition on the magic lantern at the Cinémathèque Française<sup>165</sup> when by chance I saw Reynaud's projected animation *Autour d'une Cabine* (1895) (Fig. 63) being performed with a reconstructed version of his *Théâtre Optique* (Fig. 36). For the performance, the device was placed in front of the screen allowing me to see the mechanism generating the animation as well as the animation itself. I was instantly spellbound by the rotating mirror and hand-painted image frames, projecting their moving characters onto the screen through a system of lenses and light. This was the first time I had witnessed an exposed mechanism dynamically creating its own projected moving image. Up to that point, with the exception perhaps of the cinematic image, I had only seen pre-formed digital moving images on a screen.

Whilst investigating Reynaud's rotating polygon in Chapter Two, I discovered that he had placed his *Théâtre Optique* device behind the screen and therefore his audience at the Musée Grévin only ever saw the animated scenes of light appear before them as if by magic. Although I witnessed Reynaud's animation 120 years after its initial performance, during which time our expectation of the moving image has dramatically changed (from the praxinoscope image frames to Instagram images on our phones), seeing the mechanism significantly changed my experience of the projected image. My attention shifted from being solely on the image, to engaging with its generating device. Ironically however, even though I could see the glass lenses and mirrors of the mechanism in plain sight, therefore understanding its causal effect, I remained intrigued by how the moving image-light still appeared before me as if by magic. Curious about this enduring effect and similar to what I had now discovered with my own optical systems 'magically' projecting their image-light, I set out to explore other contemporary instances of optical devices purposefully exposed as part of the viewing experience.

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<sup>165</sup> Laurent Mannoni, curator, *Lanterne magique et film peint: 400 ans de cinéma*, (2009–2010), exhibition at the Cinémathèque Française, Paris.

## Uncloaked Device – The Works of Julien Maire

The device in my research is foregrounded with the purpose of removing it from the shadow of attention on the projected image, where it has been positioned for so long. It is in this regard that the practice of French contemporary artist Julien Maire is especially relevant. Spanning the worlds of media art and performance, Maire combines his interest in media archaeology with contemporary technologies such as 3D printing and electronics to create hybrid analogue-digital prototypes. As I was to conclude in my research, Maire is interested in the materiality of projected moving image-making. He deconstructs old technologies and adds new ones, such as stereo-lithographic 3D printing.<sup>166</sup> He develops new constellations of technologies and consequently creates projected images with a unique quality. In contrast to the overly saturated digital image, Maire “cultivates the slow process of image recuperation” and, in doing so, mixes our perception of real time with mediated vision.<sup>167</sup> His work also mindfully includes the participation of the viewer. Through his exposed reconstructions, he invites viewers to think about his devices and what they are presenting.

*Man at Work* (2014–2018) (Fig. 61) is a projected moving image installation, where Maire has created a projector and 3D printed image frames that rotate in front of an optical lens system. Each individual frame is a translucent plastic model of a man digging with a spade in a slightly different position, creating a continuous animated loop.<sup>168</sup> Reminiscent of a cinematograph’s film reel, Maire’s frames move along a vertical, as opposed to the horizontal track used in pre-cinematic devices. Each frame sequentially positions itself in front of an objective lens system to generate the appearance of movement. As Maire writes:

The audio-visual is like a soundtrack, a visual tracking shot moving in parallel to us; pictures and sounds are visual fictions that move[d] away from reality, but disrupt and influence our relation to reality.<sup>169</sup>

Maire’s visual fictions align with my experience in the laboratory and in my studio, where the images projected through the glass lens caused the real and the representational to merge and interrupt my perceived reality of space.

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<sup>166</sup> Stereo-lithography is a type of 3D printing used for creating 3D models and prototypes.

<sup>167</sup> Edwin Carels, *The productivity of the prototype: on Julien Maire’s cinema of contraptions*, Ho Ghent, University College Ghent, 2005, [https://expertise.hogent.be/en/publications/the-productivity-of-the-prototype\(15b8a4ea-fbfa-432f-bfb2-3d83fd5be785\)/export.html](https://expertise.hogent.be/en/publications/the-productivity-of-the-prototype(15b8a4ea-fbfa-432f-bfb2-3d83fd5be785)/export.html) (accessed June 3, 2018).

<sup>168</sup> *Man at Work* reminded me of the nineteenth century stereoscope and zoetrope devices. Iterations of these devices have recently returned to our visual culture, using VR and digital fabrication technologies. British artist Matt Collishaw’s *All Things Fall* (2014) and American artist Gregory Barsamian’s *Artifact* (2010) come to mind here.

<sup>169</sup> “Relief” – *Exhibition by Julien Maire*, iMAL.org, Interactive Media Art Laboratory in Brussels Centre for Digital Cultures and Technology, 2014, [http://imal.org/en/relief\\_](http://imal.org/en/relief_) (accessed June 3, 2018).

Maire uses the contemporary technology of 3D printing to generate his 'stereoscopic' images. Instead of two slightly different images coming together, as with the traditional binocular stereographic image, depth of field is created through the material relief of the 3D image source. Earlier in my project, I had experimented with projecting images using 3D printed image objects, but had put it aside until I had acquired the necessary technical skills. Exploring Maire's practice towards the end of my project inspired me to look again at the possibility of testing a 3D image object within my optical systems and pursue my discovery of how specific materialities change the projected image. I also wanted to make use of the ability of glass to hold and release light when specifically formed and polished, to create an image with the appearance of three dimensions.

With a making process similar to Marie's production of his translucent figures, I designed small-scale hollow and solid objects using 3D modelling software that could be embedded within my already established optical system (Fig. 64 and Fig. 65). The purpose of these different objects was to investigate whether objects with similar outer shapes, but different internal structures, would cause a noticeable change in the appearance of a 3D image. If the prototypes were successful, I could then make these structures in glass. I sourced translucent PLA filament for the 3D printer, which allowed me to cast a light source through the 3D printed objects (Fig. 66).<sup>170</sup> The hollow forms were more successful than the solid ones, simply because they allowed a greater amount of light to pass through. Additionally, to my surprise, when I used a nineteenth century lens originally part of a magic lantern, the resulting projected image was very different to that created by a contemporary lens which had greater magnification but smaller aperture (Fig. 67 – Fig. 72).

I found this transformation of the image really compelling, the same object could create a completely different image simply by changing its objective lens. The older lens produced a more abstract, softer image; the newer, a sharply defined image. The image projected through the contemporary lens was acutely representational of its 3D printed image source, with no detail omitted from view. In contrast, the magic lantern lens imaged its 3D image object in such a way as to turn it into something else. Rather than being representational, this image-light simply presented itself in the form of an image with no visually apparent connection to its object source. Witnessing firsthand in the studio how technical and material practice can change our perception of the image, I recollected Crary's observation relating to the constant mediation of visionary experience.<sup>171</sup> My contemporary application of *techné* was hard at

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<sup>170</sup> Polylactic Acid (PLA) is a thermoplastic polymer and bioplastic. It is derived from renewable resources such as sugar cane or cornstarch, making it a biodegradable material.

<sup>171</sup> Crary, "Olafur Eliasson: Visionary Events," 63.

work, not only heightening my sensory awareness but establishing a criticality to what I was seeing before me.

Wanting to pursue this material investigation further I used my 3D printed image objects as models to create the forms in glass. I ground and polished components of translucent glass to construct 3D objects that would fit concisely within my optical system. The projected images of these objects had much greater luminosity than those of the PLA prototypes due to the nature of the material but also because, through cold working the glass, I had much greater control over how the light both passed through and was contained within the 3D image object. After testing various configurations of image object and lens, I decided to work with two of the 3D printed forms (the projected internal space and ocean horizon) and two magic lantern lenses as these combinations were producing a more volumetric projected image (Fig. 70 and Fig. 72).

Returning again to Maries' practice, his exhibition *Mixed Memory* (2011) at the Museum of Contemporary Art Antwerp is the second project relevant to my research. Here he worked with a collection of pre- and early cinematic devices, such as the magic lantern and *camera obscura*.<sup>172</sup> Two works, *Flip Dot Mirrors* (2011) and *Random Access Memory* (2011) (Fig. 62), use a series of forty-eight mirrors driven by motors to reflect parts of particular glass slides and celluloid footage from the Museum's archive. Once again coinciding with my research, Maire establishes a dialogue between historical, outmoded media and contemporary technologies. His aim is similar to mine, in that he attempts to raise questions in the viewer about the perceived image generated through the device. As the exhibition's curator Edwin Carels commented:

[Maire's aim is] to change people's perceptions and to question the visual strategies in the digital age... by combining past and current technologies, Julien Maire does not exhibit melancholy objects, but rather reactivates them.<sup>173</sup>

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<sup>172</sup> The collection belonged to Robert Vrielynck and is now in the care of the Museum of Contemporary Art Antwerp.

<sup>173</sup> Edwin Carels, *Vrielynck Collection #1: Julien Maire – Mixed Memory*, M HKA, Museum of Contemporary Art Antwerp, 2011, (accessed June 6, 2018), <https://www.muhka.be/programme/detail/88-vrielynck-collectie-1-julien-maire-mixed-memory/artist/230-julien-maire>.





Fig. 61. Julien Maire, *Man at Work*, 2014–2018. Rotterdam: V2 Lab for the Unstable Media. <http://v2.nl/events/julien-maire-man-at-work>



Fig. 62. Julien Maire, *Random Access Memory*, 2011. Antwerp: Museum of Contemporary Art Antwerp. <https://www.muhka.be/collections/artworks/r/item/7487-random-access-memory>

I was aware of Maire's practice at the beginning of my project, but it wasn't until much later in the development of my prototypes, that I took a closer look at his work. It was unnerving to discover an approach so like my own, for example, Maire's use of forty-eight moveable mirrors bears resemblance to my forty-eight-sided mirrored polygon component in *Ghost in the Machine*. This comparability initially concerned me, but it later became apparent that the similarity emerged from the fact that we were

both looking at the same source material: pre-cinematic media archaeologies. I also realised that the likeness in our works arose more from their functional development (forty-eight frames per second and the use of mirrors in the projected moving image derived from Reynaud's praxinoscope) rather than a deliberately prescribed aesthetic.

Despite some functional overlaps there are however significant differences in the output of my research and Maire's work. These differences are manifested through the materials and ideas I explore, which give my image projection systems their own distinct aesthetic. For example, my journey back to Della Porta's sixteenth century optical natural magic and my investigation of the invisible slow change of nature substantially influence the appearance of *Hollow Lens*. Also, my work focusses more on the specifics of optics and its relation to the material of glass, probably due to my background as a maker of glass objects. It was important to me to design and fabricate each component, such as the armatures for my devices, the lens holders, the telescopic collars, so that each has its own unique presence in the overall installation, as opposed to off-the-shelf tripods and supports, which Maire chooses to use.

Exploring Maire's practice reiterated that my research was not just about developing hybrid devices which generate images of a distinct quality. Also important was how our perceptual experience of the world can be transformed through the various components of my device. By simply substituting one lens with another, the image I witnessed on my studio wall changed significantly. The specific materiality and shape of the lens through which the image light is mediated controls not only how I see, but what I see. Like Maire's projections, my images are visual fictions potentially disrupting our sense of what is real in the world.



Fig. 63. Emile Reynaud, *Autor D'une Cabine*, 1893. Image frame. Paris: Cinémathèque Française

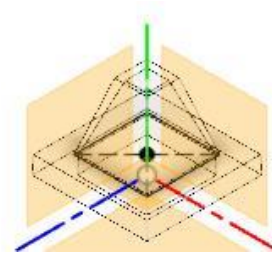


Fig. 64. 3D Model for printed hollow object.

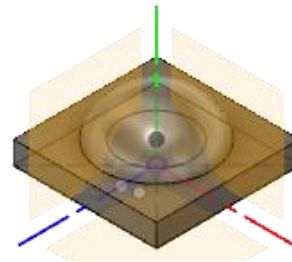


Fig. 65. 3D Model for printed solid object.

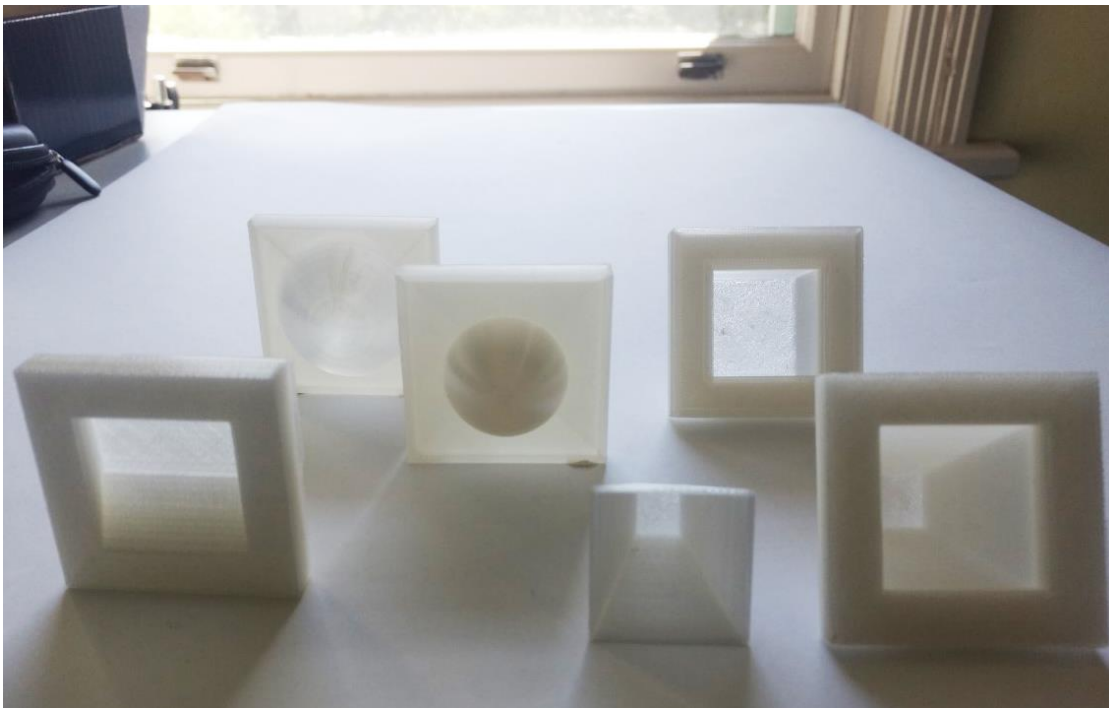


Fig. 66. Selection of printed 3D image PLA objects, each 41 x 41mm.



Fig. 67. Projected image using semi-spherical image object and contemporary lens.



Fig. 68. Projected image using semi-spherical image object and magic lantern lens.

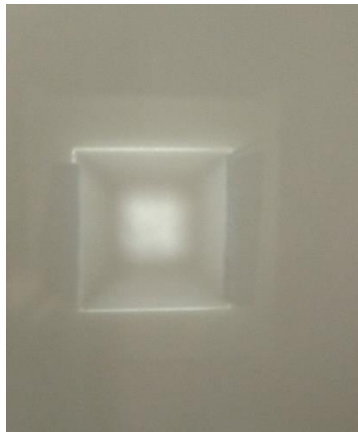


Fig. 69. Projected image using tetrahedron form and contemporary lens.



Fig. 70. Projected image using tetrahedron form and magic lantern lens.

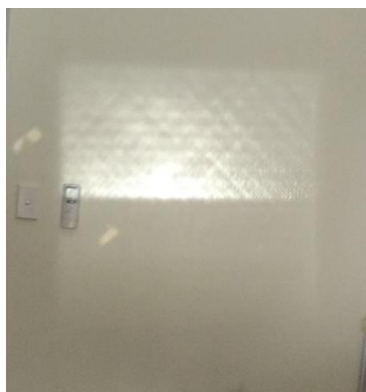


Fig. 71. Projected Image using printed 'landscape' form and contemporary lens.



Fig. 72. Projected Image using printed 'landscape' form and magic lantern lens.

## The Optical Truth and Fiction of Johannes Vermeer's *View of Delft* (1660–1661)

Whilst developing the optical devices with which to create these visual fictions and learning about ways in which materiality and perception contributed to the formation of the image, I became aware of how optical process also plays a role. As I had already discovered during my experimentation with 3D image objects, different lenses affect the transfer of light in different ways, consequently changing what I see projected on my studio wall. Remembering back to Jonas' concept of 'causal muteness' from Chapter One,<sup>174</sup> I do not witness the redirected rays of light, only their cumulative transformed image. I thought about how my entire world is optically mediated, if not through an external device then through the apparatus of my eye. Reflecting on this invisible process, I wondered whether the optical systems I developed, in which rays of light are purposefully redirected between the material device and the immaterial image, could draw attention to the constant mediation of our everyday lives.

I was starkly reminded of this notion of optical process functioning as an invisible tool when I encountered Johannes Vermeer's *View of Delft* (1660–1661) (Fig. 73) at the Mauritshuis Museum in The Hague, during my field research. Captivated by the expanded breadth of the image, the view appeared near and far at the same time. I had the impression that I was looking at this scene through an optical device containing several lenses, bringing the far away close and into focus and creating a slight concave curvature of the image on the flat plane of the canvas. It was as if I was wearing virtual reality goggles but without the effect of stereoscopic 3D depth, and instead of having to re-position my head, I could perceive it all at once. It was simultaneously real and not real, reminding me of Maire's 'parallel fictions' and my optically imaged scenes in the physics laboratory. Unable to find my own position in relation to the view before me, it shifted me from a state of perceptual complacency to an awareness of how I view my surrounding world.

My disorientating experience of *View of Delft* resonated with Alpers' observations about this painting in her book *The Art of Describing* (1983). Here she asks the reader to consider *View of Delft* not as a traced copy done with the lens of a *camera obscura*, but as a display of the notion of artifice.<sup>175</sup> For her, Vermeer's painting serves to generate awareness of how our view of the world is mediated through the optical imperfections of sight, rather than simply being an example of optical techniques applied to

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<sup>174</sup> Jonas, "The Nobility of Sight," 515.

<sup>175</sup> Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century*, (Chicago: University Of Chicago Press, 1983), 35.



produce the painted image.<sup>176</sup> If Alpers' suggestion is correct, it intrigued me how, almost 360 years after Vermeer painted this view, where contexts for our mediated view of the world have changed significantly, *View of Delft* had such a lasting effect on me. I would soon realise that the unseen optical process was key to this enduring impression.



Fig. 73. Johannes Vermeer, *View of Delft*, 1660–1661, oil on canvas, 96.5 x 115.7cm. Amsterdam: Mauritshuis Museum.

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<sup>176</sup> David Hockney, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters*, London: Thames & Hudson (2001); Michael John Gorman, "Art, Optics and History: New Light on the Hockney Thesis," *Leonardo*, 36, No. 4 (2003): 295–301.

Alpers discusses Vermeer's scene in the context of Johannes Kepler's early seventeenth century system of vision. At a time when new understanding of geometric optics was abandoning its medieval framework of phantasmata<sup>177</sup> in favour of early modern science, Kepler's theory of vision caused a tumultuous shift in our view of the world.<sup>178</sup> Incorporating the retinal image of the eye, Kepler termed this projected image on the retinal screen *pictura*. He used the *camera obscura's* projected image as an analogy to illustrate his retinal *pictura*, establishing the eye as an optical apparatus independent of a cognisant observer.<sup>179</sup> Alpers describes Kepler's *pictura* as a 'de-anthropomorphosis of vision',<sup>180</sup> writing that, "He [Kepler] stands outside and speaks of the prior world picturing itself in light and color [sic] on the eye".<sup>181</sup>

I began to think of Kepler's *pictura* in relation to the projected images being generated by my optical devices and how without the engagement of a cognisant viewer, my projected images existed in a 'prior world' of only glass and image-light. Kepler published his theory of sight when methods of empirical observation and optical tools were gaining popularity and questions were being raised about the relationship between nature, artifice and the possibility of multiple viewpoints of truth. However, once the fallible distortions of the eye and artifice were accepted, trust was once more placed in the intermediary device. Kepler trusted the device because he trusted his knowledge of the optical process of sight.<sup>182</sup> This trust was not about a represented image true to the source, but a phenomenon whose process was true. The legitimacy of the device lay in its optical process. In relation to the retinal *pictura*, Alpers describes *View of Delft* as being at the "meeting place of the world seen and the world pictured".<sup>183</sup> For Alpers, the painting is not literally an inverted retinal image, but displays a Keplerian

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<sup>177</sup> The concept of phantasmata was embedded in the medieval theory of extramission, where our visual perception functioned due to beams emitted from our eye. Phantasmata were internally imagined scenes of the encountered world, visible only to the interior of the mind's eye. One of the after effects of Kepler's new theory of sight was to render our experience of the world external and physically visible. With the inclusion of light, the internally imaged phantasmata was split two: *pictura* and *imago*. In contrast to the independently observable *pictura*, *imago* remained a product of the subjective imagination, invisible to the external physical world. (Tom Gunning, "To Scan a Ghost: The Ontology of Mediated Vision," *Grey Room*, no. 26, (2007): 104–111; Sven Dupré, "Inside the 'Camera Obscura': Kepler's Experiment and Theory of Optical Imagery," *Early Science and Medicine*, 13, no. 3 (2008): 219–244; Alan Shapiro, "Kepler, Optical Imagery, and the Camera Obscura," *Early Science and Medicine*, 13, no. 3, (2008): 217–218).

<sup>178</sup> Robert Hatch, *The Scientific Revolution Theories of Vision*, The Scientific Revolution: Theories of Vision, University of Florida, 2008, <http://users.clas.ufl.edu/ufhatch/pages/03-Sci-Rev/SCI-REV-Home/resource-ref-read/vision/08sr-vision.htm> (accessed November 20 2016); David C. Lindberg, *Theories of vision from al-Kindi to Kepler* (Chicago: University Of Chicago Press, 1976).

<sup>179</sup> Ofer Gal and Raz Chen-Morris, "Baroque Optics and the Disappearance of the Observer: From Kepler's Optics to Descartes' Doubt," *Journal of the History of Ideas*, 71, no. 2 (2010): 191–217.

<sup>180</sup> Alpers, *The Art of Describing*, 36.

<sup>181</sup> *Ibid.*

<sup>182</sup> Alpers, *The Art of Describing*, 32.

<sup>183</sup> Alpers, *The Art of Describing*, 35.

sensibility.<sup>184</sup> *View of Delft* therefore presents a retinal *pictura* lensed through the apparatus of the seeing eye. This apparatus may have imperfections, but its optical process is both timeless and true.

The Keplerian sensibility of *View of Delft* and how it presents the ‘prior world’ of a pre-cognisant retinal image,<sup>185</sup> initiated my investigation into the invisible transfer of light. In contrast to the concepts of time I had explored with my projected moving images, Kepler’s *pictura* and Vermeer’s painted view seemed to exist outside of time. My devices too would project timeless images of light in the absence of a viewer, for it is the viewer (and artist) who brings the construct of time with them. Of course Kepler’s retinal image is not the full story and a re-embodied subjectivity of the senses returned to the paradigm in the nineteenth century.<sup>186</sup> But, although my optical systems include a critically engaged twenty-first century viewer and a more embodied experience of time, it is also important that the device, a component within the overall system, has its own non-human presence.

The temporality of optical process depends therefore on how it is perceived. The same lens refracts light in the same way whether I am standing in Della Porta’s workshop in 1557 or in my own studio 460 years later. The imaged world changes of course, as does our understanding of it, but the optical process, being outside of human time, occurs in the same way. This was how *View of Delft* had such a strong effect on me so many years after its creation – Vermeer’s ‘retinal *pictura*’, created through the timeless process of the transfer of light, is independent of passing centuries. But I also remembered the moving circle of light on my kitchen wall, where the invisible transfer of light is part of the conception of time itself. Here, once human cognition is engaged, optical process is not timeless but time-ful and I had made use of this very transfer of light to explore the visibility of an optical form of time.

The necessary engagement of my devices with optical process and their ability to redirect this invisible transfer of light seemed to generate a new ontology for my devices independent of viewer perception. And while viewer perception is key, it became important that my devices have their own presence in the world. Like Alpers’ description of *View of Delft*, my systems are a meeting place of the “world seen and the world pictured”. My images and devices are ‘seen’ not only by the viewer but also by the light which ‘looks through’ the dioptric lens and they are ‘pictured’ not only by the optical redirection of light, but also by the perception of the viewer.

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<sup>184</sup> Alpers, *The Art of Describing*, 26–71.

<sup>185</sup> As Gal and Chen-Morris note, the “human observer began to slip out of optics when Kepler discussed the concept of artificial observations”. (Gal and Chen-Morris, “Baroque Optics,” 192).

<sup>186</sup> Crary, “19th Century Visual Incapacities,” 61.



## Part Two – Attending to the Invisible

In this section I begin by investigating the quandary of encountering the opposite constructs of virtual and real in the studio and develop the argument for how the experience of wonder generated through my optical image systems, is due to the co-existing opposites of my visible device and the invisible transfer of light.

### Real and Virtual: A Curious Paradox of Producing a Ghost

Paradoxically my research explores and develops physical devices to produce intangible, transparent and ghostly images.<sup>187</sup> Throughout the project, I toiled over each component of my system: from the lenses, their movable holders and variable focal lengths, to the PCBs controlling the water-flow in the hollow lenses; from streaming images on my translucent screens, to the mechanics of rotating my image carousels; and from the lumens of my LED light sources to the kiln formed image-frames. Every solution seemed to bring about another technical, mechanical or optical quandary. And all of this to produce a non-material image that is not even real. Like Gunning's paradox of materiality, which he explores in his essay on the tropes of vision and transparency, my projected images hover "between the material and the immaterial, the visible and the invisible".<sup>188</sup>

One such quandary arose whilst working on the specific optical designs of *Ghost in the Machine*. Like Reynaud's optical theatre, my system includes an additional mirrored plane. This is required to reflect the image-light into my objective lens system, which projects the image onto the screen, magnified and in focus. It took some time to figure out how and why this extra mirror changed the properties of the projected image. Up to this point I had been able to rely on physical objects (lenses and mirrors) to understand the optical properties of the materials I was using, namely glass and light. Once I placed the second mirror in my system however, the focal length and magnification changed dramatically. Instead of obtaining a magnified image, the projected image was significantly smaller than its source object.<sup>189</sup>

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<sup>187</sup> As Anne Freidberg observes: "Virtual images have a materiality and a reality, but of a different kind, a second-order materiality, liminally immaterial. The terms 'original' and 'copy' will not apply here, because the virtuality of the image does not imply direct mimesis, but a transfer – more like a metaphor – from one plane of meaning and appearance to another. (Anne Friedberg, *The Virtual Window: From Alberti to Microsoft* (Cambridge Massachusetts: MIT Press, 2006), 11.

<sup>188</sup> Tom Gunning, "To Scan a Ghost: The Ontology of Mediated Vision," *Grey Room*, no. 26, (Winter 2007): 98.

<sup>189</sup> The projected image went from being over one meter to approximately 20 millimetres wide.

No matter how many lenses and different focal lengths I tried, I could no longer achieve the necessary magnification.

To solve this problem, objects alone did not suffice. I had to understand a specific mathematical formula to grasp why the magnification of the image had decreased so much.<sup>190</sup> Unknown to me at the time in my studio, I needed to account for the virtual image reflected in the second mirror. The calculable distance (and therefore overall focal length) was not just between the two material planes of the mirrors. It also included the virtual distance of the reflected image of the first mirror on the second mirror plane (Fig. 74). This doubled the calculable distance between the mirrors. I had only been thinking of the mirror as a real and material object, forgetting that its optical function includes the virtual image. As a result, I perceived the image not at its true location where the light rays converged behind the mirror, but on its surface plane. I had omitted from my calculations what historian of science and technology Alan Shapiro describes in his essay on projected and perceived images:

The identification of the perceived and geometrical location of an image rests on the principle, or assumption, that an image is perceived in the same way as an object and that when an object sends rays to our eyes, we judge it to be in that place from which the rays actually originate, or in its true place.<sup>191</sup>

I had considered the mirror like any other material component of my devices, such as the motor or the 3D printed carousel, all of which relied on the corporeal and real. But it turned out that the mirror in my device was also dependent upon something unreal, the virtual distance of a reflected image.

This necessary combination of the virtual and the real changed my perception of the devices I was making, reminding me of Kepler's *pictura*, from which emerged the concepts of real and virtual.<sup>192</sup> My devices were made from physical materials, yet I could no longer say they were completely real. The relation between real and virtual was integral to their function and aesthetic. Not only were they producing insubstantial ghostly images, the virtual image was also embedded in their structural form.

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<sup>190</sup>  $1/f = 1/d_o + 1/d_i$  Where  $f$ =focal length of the lens;  $d_o$ = distance from object source to the lens and  $d_i$  = distance from the lens to the projected image.

<sup>191</sup> Alan E. Shapiro, "Images: Real and Virtual, Projected and Perceived, from Kepler to DeChales," in *Inside the Camera Obscura – Optics and Art under the Spell of the Projected Image*, ed. Wolfgang Lefèvre (Berlin: Max Planck Institute for the History of Science, 2007), 76.

<sup>192</sup> Shapiro, "Images: Real and Virtual," 75.

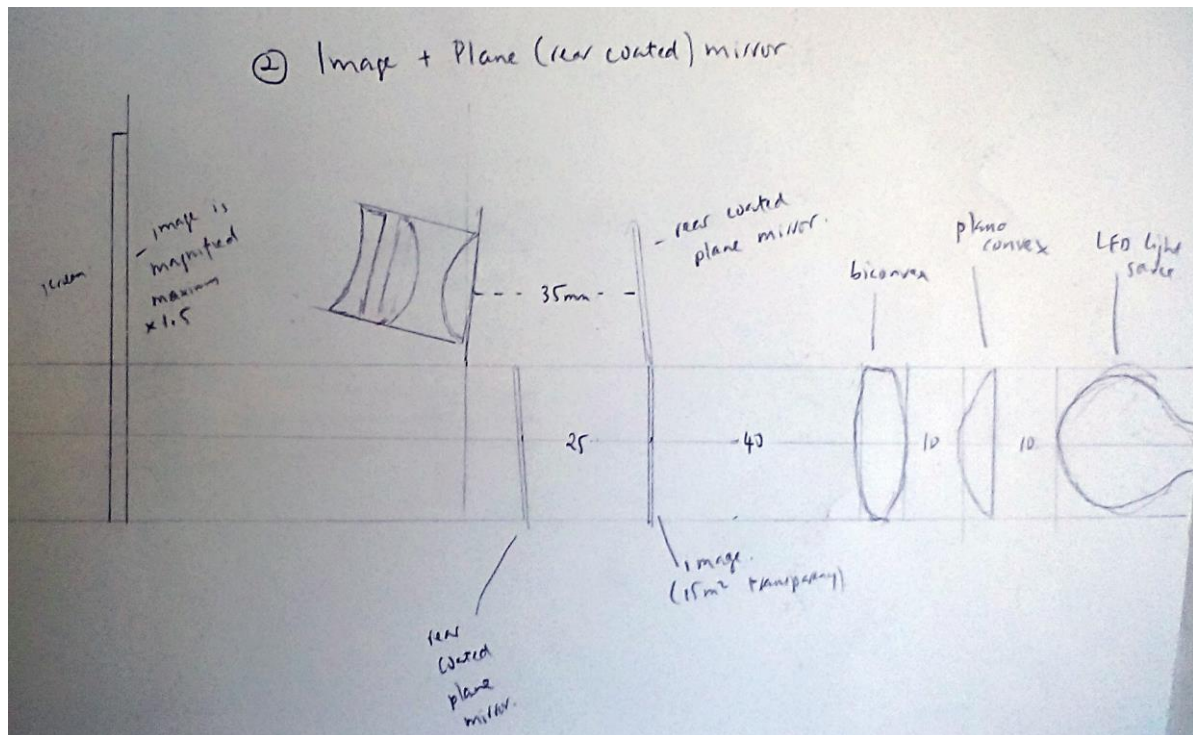


Fig. 74. Diagram detailing virtual distance of image reflected in both mirrors.

## The Magic of Inattention

As detailed in Chapters One and Two, much of this project focused on the intricacies of the physical devices and how their mechanisms would be exposed, keeping them fully visible and within the realm of the viewer's attention. But as I was to discover, focused attention on one thing can lead to blindness to another. Fixated on reversing and expanding the visibilities of the material device and immaterial image, made me unaware of a key element in the experience of wonder.

In Chapter One I elaborated on how Della Porta deliberately diverted attention away from the material lens to increase the wondrous effects of his natural magic. This technique is still used in contemporary magic. In our daily efforts to make sense of our world, we frequently make attentional and perceptual errors. But as cognitive psychologist Wally Smith points out, we discount these errors through a metacognitive awareness of the fallibility of our attentional and perceptual systems.<sup>193</sup> In magic

<sup>193</sup> Wally Smith, Frank Dignum and Liz Sonenberg, "The Construction of Impossibility: A Logic-Based Analysis of Conjuring Tricks," *Frontiers in Psychology*, no. 7 (2016): 2.

performance however, the magician crafts an attentional blind spot in the audience and it is done in plain sight, through what is called the principle of the incidental.<sup>194</sup> Here the magician directs attention to establish a perception of what is necessary to the trick's plot and what is merely incidental. To use Smith's example of sawing a person in a box in two, sawing the box in half might be framed as the important feature, whilst passing the saw from one hand to the other, the incidental element. The magician intentionally creates an attentional blindness in the audience. The audience members do not pay attention to the incidental act occurring right before their eyes, thinking it of no importance. Focussed on the box being sawn in half, they do not see the trick taking place. What they see instead is the impossible. What they see instead is magic.

Back in my studio, with my attention directed on the entire mechanism generating the projected images, I wanted to finally unravel why my optical systems continued to cast their magical spell. As I had already considered natural magic as a tool for evoking wonder, exploring contemporary theories of magic seemed a natural progression in terms of deciphering contemporary and critical wonder. By understanding magic as a mechanism for wonder, which included sensory engagement, attention and critical awareness, I could perhaps come to know why my optical systems of contemporary natural magic continued to have a wondrous effect. Already aware of the importance of optical process in relation to how we see our world, I soon learned how significant this invisible process is to wonder.

As our cognitive abilities develop and modify from childhood through adulthood, we establish a structure of causal relationships about things that happen in the world around us, such as believing what we see happen before of our eyes. Along the way, we extend our existing cognitive schemata through encounters with contradictions to these causal relationships, in other words, we learn from experience. Neuropsychologists Ben Parris and Gustav Kuhn note that throughout our lives these relationships become deeply established and "form part of an implicit belief system about what is possible and impossible in the world".<sup>195</sup> Implicit belief combined with an active *disbelief*, appear to be essential ingredients in the experience of magic.<sup>196</sup> That is, viewers of a magic performance continue to adhere to their belief system, but at the same time, they actively *disbelieve* that what they are witnessing is really happening.<sup>197</sup> To use Smith's example again of a person in a box being sawn in two, I see it happen before my eyes, yet I do not believe it is actually happening.

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<sup>194</sup> Smith, Dignum and Sonenberg, "The Construction of Impossibility," 4.

<sup>195</sup> Ben A. Parris, Gustav Kuhn, Guy A. Mizon, Abdelmalek Benattayallah and Tim L. Hodgson, "Imaging the impossible: An fMRI study of impossible causal relationships in magic tricks," *NeuroImage*, 45 (2009): 1033–1039.

<sup>196</sup> Active disbelief contrasts a 'suspension of disbelief' that occurs for example whilst watching a film at the cinema. We temporarily suspend our disbelief to engage in the imaginary and representation experience of the film.

<sup>197</sup> Jason Leddington, "The Experience of Magic," *The Journal of Aesthetics and Art Criticism*, Wiley-Blackwell American Society for Aesthetics, 74, no. 3 (2016): 253–264.

Philosopher of art, Jason Leddington suggests that ‘belief–discordant alief’, a term introduced by cognitive scientist Tamar Szabó Gendler, explains our cognitive experience of magic.<sup>198</sup> Gendler notes that in contrast to our learned beliefs, an ‘alief’ is a more primitive, representational state that is consciously or unconsciously activated by our inner self or our external environment.<sup>199</sup> When activated, an ‘alief’ creates a tension between what we believe and this more primitive representational state. We can therefore experience two contrasting mental states simultaneously.

I contemplated the concept of ‘belief-discordant alief’ in the gloaming light of my studio, where I believe only what I see happen in front of my eyes. Within my view are the LCD screens, lenses and individual image frames of glass and I witness their projected images, visualised before me. But I do not see the process of what happens in between. This does not change my belief about accepting only what I see – I still actively disbelieve in what I cannot see – but the affective behaviour of my belief is changed: the projected image-light appears before me, I do not see it happening, but somehow, there it is. The invisible process creates a space between the real and the unreal, between the two visibilities of my material device and immaterial image.

As Leddington explains, the cognitive dissonance created by the experience of magic occurs when you are “sensorily presented with an event that, despite your best efforts, resists intelligibility”.<sup>200</sup> By seeing the image and its device and only a gap in between, perhaps it is the magic of this unsolvable puzzle of two opposing mental states causing a momentary interruption in cognitive flow that allows my continued embodied emotion of wonder to arise. I recalled my very first impression of the magical ability of glass and light to extract the hidden essence of an object, making it visible in the form of a projected image and how this phenomenon had cast its wondrous spell. Contemporary magician Darwin Ortiz characterises the cognitive dissonance associated with magic as a conflict between ‘intellectual belief’ and ‘emotional belief’. He provides a humorous and elucidating nineteenth century example of Madam De Duffand, who, when asked whether she believed in ghosts, responded, “No. But I am afraid of them”.<sup>201</sup>

In my investigations into the spell cast by the projected image-light, the practice of British artist Anthony McCall was useful. In an interview for McCall’s exhibition *Solid Light Works* at The Hepworth Wakefield

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<sup>198</sup> Tamar Szabo Gendler, “Alief and Belief,” *Journal of Philosophy*, 105, (2008): 634–663.

<sup>199</sup> Gendler, cited in Leddington, “The Experience of Magic,” 256.

<sup>200</sup> Leddington, “The Experience of Magic,” 260.

<sup>201</sup> Darwin Ortiz, *Strong Magic*, (Washington DC: Ortiz Publishing, 2011), 25–26.

Gallery in 2018, he describes his early days of working with light in the 1970s, not yet realising it was an invisible material:

Perhaps the most important problem I had in the late seventies was the realisation that the work was completely invisible [...] It turned out that I had been working all along with a medium that I had been unaware of, which you would call dust. I was making work in old lofts, showing it in old lofts, which were full of dust. And so between the cigarette smoking and the dust, there was never a visibility issue. But once they were shown in museums, because the air was so clear and there was no smoking, they simply didn't exist. To fast forward, the most important thing to happen in the 1990s for me was the invention of the haze machine, which suddenly brought the works back to life.<sup>202</sup>



Fig. 75. Anthony McCall, *Line Describing a Cone*, 1973–, Melbourne: Australian Centre for the Moving Image. <https://2015.acmi.net.au/exhibitions/past-exhibitions/2007/eyes-lies-illusions/> (accessed May 30, 2018).

I remembered my experience of walking through the visualised light of McCall's *Line Describing a Cone* (1973–) (Fig. 75) at ACMI in Melbourne, as part of the *Eyes, Lies and Illusions* exhibition (2006–07). This work used a simple 16mm film projection of a beam of light, beginning as a dot and becoming a

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<sup>202</sup> Anthony McCall, "Anthony McCall: Solid Light Works," *The Hepworth Wakefield*, The Hepworth Wakefield Gallery, February 2018, <https://hepworthwakefield.org/whats-on/anthony-mccall-solid-light-works/>, (accessed May 30, 2018).

complete circle of light.<sup>203</sup> The light was projected through a fine haze, making it visible and enveloping me in a 'cone' of light within the darkened space of ACMI's gallery.

I came to realise that not everything in my optical systems was exposed, as I had previously thought. A key element in the whole process, light, remained out of sight and I would keep it so, as my secret element of inattention. Like Della Porta and Eliasson, who selectively chose what to reveal in order to heighten the wondrous affect, I choose to keep invisible the physical transfer of light. Unless I use a haze machine like McCall or install the work in a dusty space, the transfer of light remains invisible, intrinsically hiding itself. I, the artist, the natural magician, do not have to make any attempt to conceal it. Throughout my project I had attended only to the perceptively visible. Realising this, it suddenly became apparent that the invisible transfer of light was the magical key in my optical systems for generating the experience of wonder.<sup>204</sup> For so long I had focused solely on attention as a mechanism for engaging the senses and evoking a feeling of critical wonder, but it turned out that inattention, or that which remains unperceived, is just as important.

Walking around my optical devices, everything is apparently manifestly visible, but not everything is seen. Of course I see the source of the light in my optical systems, but not its transfer across the space of my studio to its projected image. I do not witness the conduit of light, redirected by the glass lens and eventually converging at an exact point to form a perceptible and focused image. There is a gap between the source and its image-light, a type of plenum, filled with an intangible invisibility of how we see our world.

Although my decision to keep the transfer of light hidden in plain sight might be viewed as adhering to the magician's principle of the incidental or contriving incidental blindness, my visible device and image serve to bring attention to this gap rather than deflect attention away from it. This critical engagement with the gap and inability to see the transfer of light, no matter how much I attend to it, momentarily confounds me and consequently evokes a sense of wonder. Therefore my experience of wonder incorporates both an active engagement with my surroundings and a fleeting moment of ambiguity in which my relationship with the world is renegotiated.<sup>205</sup> This gap does not lessen the importance of direct sensory engagement, attention and awareness as elements of wonder. Instead my optical systems hover between binary opposites of the visible and the invisible, known and unknown. The

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<sup>203</sup> Anthony McCall, "Line Describing a Cone | TateShots," *YouTube*, <https://www.youtube.com/watch?v=1-HWsxPnNNY> (accessed May 30, 2018).

<sup>204</sup> Interestingly, a haze machine makes light visible by reflecting light off the liquid droplets it creates, allowing you to see light travelling through the air that you ordinarily would not see. In a way therefore it creates a trajectory of liquid lenses across the space. Liquid lenses have recently been developed in conjunction with electrodes, allowing them to rapidly change shape and therefore alter their focal length according to the input level of voltage.

<sup>205</sup> Mievis and Brown, *Wonder in Contemporary Artistic Practice*, 2.

wonder explored in this project is the space in which real and virtual fictions of possible and impossible critically engage the viewer in their own embodied knowing, sensing what is invisible as well as visible.

## Concluding Remarks

My exploration of visibility began by observing the ironic reversal of visibility that occurs when an image is projected. The viewer's attention captivated by the image-light causes the physical object rendering the image visible, to disappear from view. This lack of attention on the device inspired me to renew its perceptibility. In the process I found that the visible device is not the only element required for the evocation of wonder and that the invisible transfer of light also plays a key role. The experience of viewing Vermeer's *View of Delft* and McCall's light works were pivotal in helping me understand the significance of invisibility in my optical systems.

Through the development of *Object-Image* I discovered the extent to which glass mediates our perception of the world. The exposure of the device generating the image in my works, seeks to make apparent these mediated visual fictions. However, informed by cognitive theories of magic, I discovered that not all is exposed in my optical system – the transfer of light is kept hidden as a magical mechanism of wonder.

The necessary gap between the seen and the unseen, material and immaterial, known and unknown, rational and illogical, together create a space in which wonder can arise. I realised that the wonder experienced through critically engaging with my systems, is not just generated by presenting my sensory perception with visibilities, it also arises from the confoundment of attending to the invisible.



# Conclusion

My project *Visibilities and Invisibilities of Wonder: A Practice-Led Exploration of Optical Image Systems* culminated in a new body of work which will be presented for examination on 12 April, 2019. The three optical image systems I developed, *Hollow Lens*, *Ghost in the Machine* and *Object-Image*, will be exhibited as an installation in the darkened space of East Space Gallery at Commonwealth Place, Canberra. *Ghost in the Machine* presents a looped projected image generated by the continuous physical rotation of a polygon optical image system. *Hollow Lens* consists of a dynamically changing optical mechanism and projects the continuous flow of a 'real' time moving image. *Object-Image* is an optical system, which incorporates 3D image objects and magic lantern lenses to project a still 3D image. It is important that the environment surrounding the works has sufficient darkness to maximise the luminosity of the projected image, whilst simultaneously allowing the physical devices to remain visually accessible to the viewer. East Space Gallery facilitates this balance of darkness and light.

This project emerged from the wondrous ability of glass to transfer an image of an object across space and time. Initially inspired by the projected image of the world outside my studio window and an experience of observing slow changes in nature, my investigations transformed into a wider practice-led consideration of wonder, time and visibility.

My research began with two questions: how can interdisciplinary optical systems be developed to evoke the experience of wonder?, and can time be made visibly perceptible through the material device and projected image? I created *Hollow Lens* and *Ghost in the Machine* as speculative tools for evoking wonder and visualising time. *Object-Image* emerged from my material investigations into how the specific form of an image source engages with light and an objective lens to mediate the projected image. In addition to the material investigations of the devices, these image systems were also informed by various theoretical considerations of natural and contemporary magic, historical and contemporary art, media archaeology, philosophy and cognitive psychology.

From the outset I realised that an interdisciplinary approach would be essential, encompassing optical physics, machinist and electronic engineering, as well as my already known medium of glass. Incorporating additional materials and methodologies gave my practice new dexterity for designing and fabricating the optical systems. Expanding the 'experimental site'<sup>206</sup> of my practice allowed my

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<sup>206</sup> Alpers, "The Studio, the Laboratory and the Vexations of Art," 403.

investigations to develop a broader relationship with the world beyond the confines of studio glass.

*Ghost in the Machine* emerged from an endeavour to know time, not through minutes and hours but movement and light. This optical system addresses the question of whether time can be made perceptibly visible through the material device and projected image. The time-light of my ghost, created by projecting the rotating image frames through the glass lens, visualises a reformed structure of time. The materiality and slow rotational speed of the device's components allow my flickering ghost to re-present herself for the viewer by slipping through a perceptual gap and creating a more embodied experience of time. The development of this system also emerged from investigating the writings of key theorists Doane, Bergson, Simondon, Crary and Gere, and explorations of artworks by Dibbets, Reynaud and Csörgő and physiologist Marey.

*Ghost in the Machine* has a raw and functional aesthetic generated by its purposefully exposed components. Despite appearances however, this system is technically refined in terms of the nuances between its electronically controlled polygon, image frames and glass optics and the process of developing this work has extended my knowledge of materiality far beyond the realm of glass. Initiating from my investigations into Reynaud's praxinoscope, the fabrication of the polygon represents a significant leap in my practice methodology and working with 3D modelling and printing also gave my practice new agility in terms of testing the individual components of the optical systems. Discovering the necessary inclusion of a virtual image within the design structure of this system has helped me rethink ways in which the projected moving image can be formed. Now that I have resolved how to create a legible moving ghost with her own form of time, I will pursue further investigations into whether a moving image can be materially generated using a single image source and multiple mirror surfaces.

*Object-Image* resulted from my material investigations of *Ghost in the Machine* and *Hollow Lens*, in addition to my explorations of media archaeology and Julien Maire's *Man at Work*. Discovering the extent to which glass changes the invisible transfer of light and hence mediates the perception of our world was a significant finding and reinforced the value of looking at the optical system as a whole, which includes device, image and viewer. Due to the limited scope and time-frame of this project, I see this finding as having further potential for exploring how the exposed optical device generates awareness of mediated vision.

*Hollow Lens* also has considerable potential and despite its technical imperfections, I consider it to be the most significant outcome of my project. It successfully merges material and theoretical research methodologies and can be described as a contemporary *scienza*. This optical system addressed my

research questions regarding both the evocation of wonder and visibility of time and has profoundly changed the way I think about my practice, particularly in relation to visible materiality.

Despite the necessary compromise I was forced to make between the translucency and resolution of the LCD screens (which resulted in a smaller projected image) other components interacting with the screens highlighted how combining digital, material and virtual elements enhanced the outcomes. Using digital code to dynamically change the optics caused a shift in how I viewed the material components of my systems. Combining physical objects with digital and electronic elements opened up new ways to dynamically and materially generate a projected moving image. Visualising an invisible process of change through the rising and falling water levels in the lenses and projected moving image, and controlling this rate of change to sit above a threshold for visibility, are important creative outcomes for how time can become visibly perceptible.

Through investigating possibilities for a new form of 'real' time in the digital age, I moved from digital to optical time, generated through physically altering the water lenses and rotating the polygon and image carousel. Clearly my project is not a rejection of the digital age as I made avid use of 'digital age' fabrication technologies, as well as moving image and optical software. But importantly, these served to realise the material components of my optical systems and, with reference to Gere, resulted in activating a more embodied and therefore human experience of time, in which I engage sensorily, cognitively and emotionally.

Critical sensibility had become fundamental to the material research from early on in the project, but through my investigations into the cognitive psychology of magic, I determined that a momentary interruption of this criticality by means of the immaterial transfer of light is also crucial for the evocation of wonder. These findings were informed by the work of key theorists Warren, Gunning, Gere, Alpers, Birnbaum and Ledington, artists Brown, Eliasson, Vermeer and McCall and the natural magician Della Porta.

The development of *Hollow Lens* led to understanding the equal importance of the visible and invisible elements of wonder. My material explorations were key to sensory engagement, attention, critical awareness and renewed visibility of the device. Considerations of McCall's light works, and sixteenth century and contemporary magic, led to the discovery that the inability to see the transport of light does not preclude attending to it. Through my practice-led research I have come to realise that the sensory evocation of wonder must include the unseen as well as the materially visible.

*Hollow Lens* provides many options for future developments in my practice. Digitally controlling the rate of change in the optics can be investigated further, particularly in relation to how the optical system might 'sense' the presence of the viewer and electronically adapt itself accordingly. Another possible

direction is to incorporate the 3D image objects into my hollow lens system in place of the LCD screens. There is much potential for the projected moving image in terms of controlling not just the optics but how its hand-made 3D image source holds and releases light.

I no longer look upon my practice as purely physical or material having realised that the structure, design and implementation of my optical systems of wonder and reformed time require multi-disciplinary elements of material and digital, real and virtual. Most significantly my research has profoundly challenged my preconceived notions of visible and invisible. No longer solely about creating glass objects, my explorations of wonder have become a new way of fathoming the world outside my studio window.

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