My journey into the sensations of sight

By

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Abstract:

Electronic media technology provides artists with tools for exploring interactivity. New immersive media sensations can result from the interactions between viewers and electronic artwork. This thesis is a record of my personal creative journey, including the ideas and the resulting interactive artworks that have unfolded on a voyage towards expressing sensations of sight. There are two interactive and immersive new media artworks that were developed as a part of this creative exploration. "*Zeugen*" uses thirty-two human-cast robotic faces and a face tracking system to track the movements of viewers in a gallery space. "*Mind Mirror*" is an electronic artwork that uses stereoscopic and stroboscopic audiovisual phenomenon (intermittent photic-stimulation) to cause the viewer's mind to create involuntarily visual hallucinations. The result is an experiential event propelling the viewer into a state of visual euphoria. My creative process (methodology) is presented in the form of a personal narrative outlining the practical motivations that have guided my work and I situate the work within a historical and theoretical discourse.

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List of Abbreviations

ECU: Emily Carr University

LED: Light Emitting Diode

RGB LED: Red Greed and Blue Light Emitting Diode

SLM: Sound and Light Machine

CNC: Computer Numerically Controlled

PVA: Polyvinyl Acetate

POV: Persistence of Vision

I/O: Input and or Output

I/Os: Inputs and or Outputs

RS485: Regulated Standard 485 (network)

V: Volt

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Introduction

I have always been fascinated with my mind. I can use my mind to imagine fantastical worlds, but what fascinates me the most is how I make meaning of the world I see around me. I have made art from the time I was a child and I have enjoyed the self-expressive potential that art has always afforded me. The artworks I make have a personal meaning for me; yet when I release them into the world, a personal meaning is ascribed to my work by anyone who sees it. I have always wondered about the exact nature of the meaning mechanism of vision. I have frequently asked the question: how do we make meaning of what we see? My creative journey is essentially an intellectual exploration of the experience of seeing.

When I first arrived at Emily Carr University of Art + Design (ECU), I thought of seeing as a linear process. I have since become aware that vision consists of a series of interwoven relationships between seeing, being seen and, in some ways, the unseen. I have learned that these relationships all contribute to my visual sensations. I have therefore expanded my inquiry to include a more holistic notion of vision. In this thesis, I invite you on my journey of expressive inquiry into 'seeing' and 'being seen'.

This thesis is a record of my personal journey, including the ideas and the resulting artworks that have unfolded on my voyage towards expressing the sensations of sight. I begin by briefly describing my creative experiments: two interactive and immersive new media artworks that address seeing and being seen. The ideas that I briefly address are the physicality of seeing, the meaning-making machinery of the mind, the brain/mind paradigm, exploring the mind using art, the sense of being stared at, and self-reflexivity. I situate my thesis research and artwork within a historical and theoretical discourse. Key artists that have influenced my practice include Daniel Rozin, David Rokeby, Marie Sester, Golan Levin, Bridget Riley, Tony Conrad, Robert Baldwin, Brion Gysin, and Mitch Altman. I contextualize my artwork and list my contributions to a new media art practice lineage. Finally, I share my creative process (methodology) in the form of a personal narrative outlining the practical motivations that have guided my work.

A brief description of the artwork

In order to contextualize my thesis artwork, I must first present a brief description of their physical form and function. In later sections, I elaborate on the technical details of both artworks. The ideas about 'seeing' and 'being seen' that I explore in later sections have a direct relationship to my creative journey. During this journey, there were some ideas and concepts that influenced the decisions I made when building my artwork. In turn, the artworks informed the ideas and concepts as they began to take form. Nowhere in this discussion do I make presumptions about the viewers' experience of the works. Instead, I provide a personal perspective about the forms, meanings, and experiences that the artworks offer.

Figure 1: *Morgan Rauscher, "Zeugen", 2010 (collage of images)*

Zeugen

"*Zeugen*" consists of thirty-two human-cast robotic faces and a face tracking system, which together follow the movements of viewers in a gallery space. When a viewer approaches the work, the artificial eye lids suddenly open to reveal a grid of thirty-two watching pairs of eyes. The viewer has access to the front (face side) of the work where the faces are installed, and the back (tech side) of the work where the technology driving the robotic faces is exposed. I consider both the tech side and the face side to be important visual elements. The polished presentation of the face side's 'plastic' surfaces is contrasted with the high-tech, kinetic, and complex presentation of the tech side.

At first glance, the faces look uniform because I used a casting process that removes most recognizable features which contribute to race, age, and even gender. Upon closer inspection, the viewer may realize that the faces have unique features. Their individual characteristics give them different 'personalities'; these features include eye colour, face shape, motion gestures made by the robotic eyes etc.

Interactivity on the face side is driven by the tech side of the work, which consists of mechatronic elements. Thirty-two individual robotic contraptions, microcontrollers, and a computer are exposed. On the computer screen, the viewer can see a video stream taken from the front of the work, and a 'face tracking box' that frames the faces of viewers interacting on the face side of the work.

"*Zeugen*" has one primary technical function: the work uses face tracking software to locate and follow faces so that the robotic eyes make 'eye contact' with the viewer. If the viewer's face is recognizable to the face tracking software, then all of the robotic eyes will follow their movements. "*Zeugen*" can track multiple faces, meaning that several participants can interact with the work at the same time. If a viewer moves from side to side quickly, then the eyes instantly find the viewer's new position and move to re-establish eye contact in a sudden sweeping movement.

The role of the participant in "*Zeugen*" is twofold: the viewer is meant to look at the work, while also being 'seen' by the work. When the viewer is looking at the tech side of the work,

their interactivity role is absent. The work is only responsive to people standing on the face side. On the tech side, the viewer becomes the 'examiner' without any expectations of interactivity.

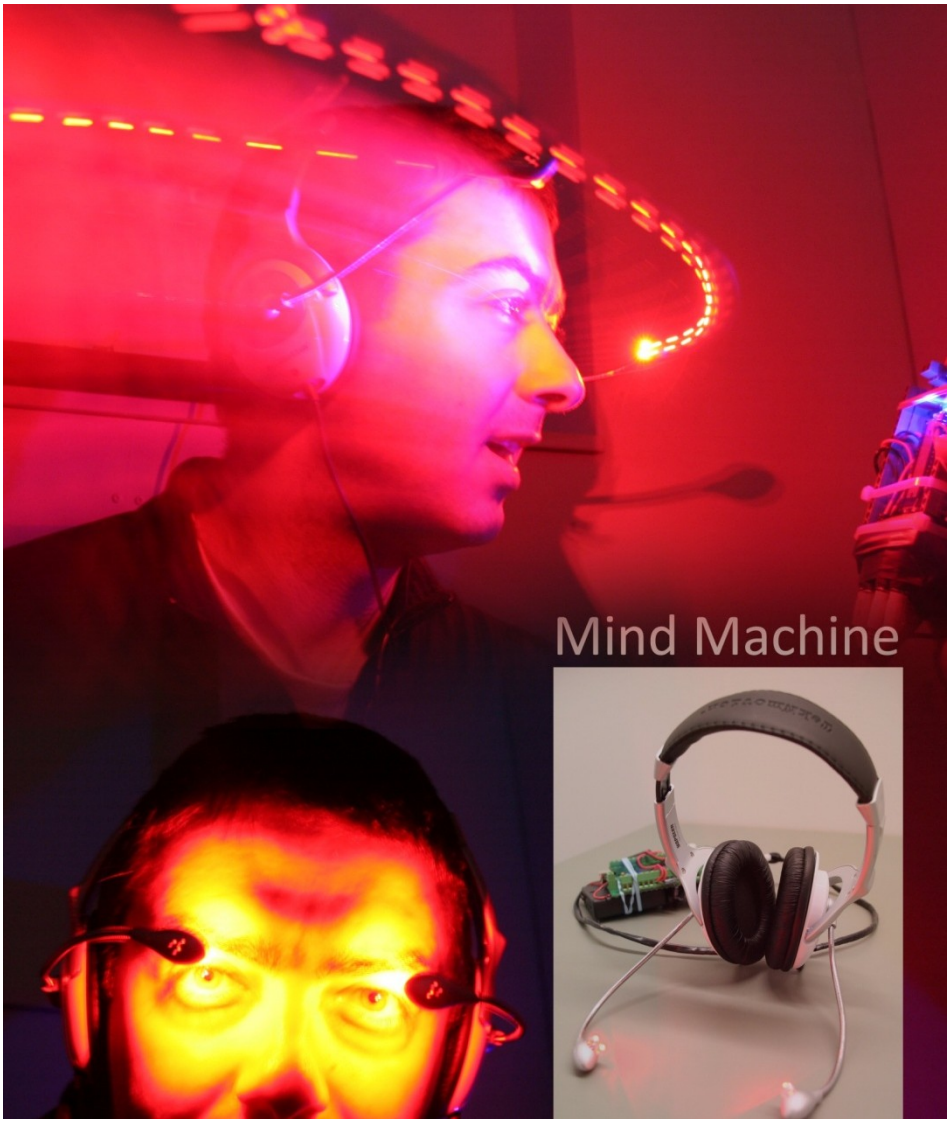

Figure 2: *Morgan Rauscher, "Mind Machine", 2009 (collage of images)*

Mind Mirror

"*Mind Mirror*" is a creative electronics new media artwork that uses stereoscopic and stroboscopic audiovisual effects to cause the viewer's mind to create involuntary hallucinations. The result is an experiential event, propelling the viewer into a state of visual euphoria. "*Mind Mirror*" takes the form of a pair of headphones. Both the left and right speakers have malleable wire extensions with two bright lights on the tips. These 'light wires' can be adjusted to vary the distance between the lights and the viewer's eyes. The closer the lights are to the eyes, the more intense the visual effect. If the lights are further away from the eyes, near the side of the head, the viewer has an augmented hallucinatory experience.

The visual illusions caused by "*Mind Mirror*" are a result of the flashing lights that generate "photic-stimulations of alpha brain waves using flashing lights" (Robert Baldwin, 1972, p.147-149) and "binaural beat frequencies at the speakers" (Altman, 2007, p.88-100). The sound and light on the left side pulse at a different frequency than the sound and light on the right side. The difference in sound and light frequencies causes the brain to express particular brain wave frequencies. The specific frequency range I am working with is the alpha range, which is expressed by the brain while a person is in a "dreamy, receptive and passive" (Altman, 2007, p.88-100) mental state.

Ideological Context

Physicality of seeing

In the beginning of my creative investigation into the physicality of seeing, I encountered both historical and contemporary theories about the nature of sight. For any inquiry into vision, the most obvious starting point is the eye. Investigations into human vision have been conducted as far back as Greco-Roman times: "many classical writers (including Euclid and Claudius Ptolemy) conceived of vision in terms of rays emanating from the eye, so that vision could be understood as ... touch." (Yellott, 2004) This classical perspective resonates with my own perspective on vision: I also believe that vision is completely interwoven with my ability to project meaning on what I see. Many centuries after the work of Euclid and Ptolemy, "Kepler realized that light

entering the eye through the pupil behaved like light entering camera obscura and he pushed the theory of the retinal image in 1604" (Sheldrake, 2003, p.245). We now know that the eye is an advanced biomechanical sensory organ that is able to detect light and send coded signals to the brain. I suggest, however, that scientific knowledge has not fully accounted for the precise meaning-making elements in the mind.

Throughout my research, it became apparent to me that the connection between the biology of sight and the psychology of seeing is ill-defined. In particular, it remains to be characterized how the bioelectrical signals in the brain are converted into conscious meaning in the mind. The point where light is interpreted after being translated by the eye (Boahen, 2008) into bioelectrical thought signals in the brain (Hine, 2008) is where I begin my creative investigations into seeing. I suggest that the biophysical apparatus of vision does not fully account for the perceptual sensations of sight. "Vision involves a two way process, an inward movement of light and an outward projection of images [...] The inward movement of light is familiar enough. Light moves from the book through ... your eyes ... From the point of view of the standard theory, there is no reason that you should be conscious at all." (Sheldrake, 2003, p.245) I believe that my conscious visual reality does not rely on physically seeing alone. In fact, I am able to imagine something, dream and even hallucinate within the deep recesses of my mind without the use of my eyes at all.

I use art and technology to help me understand my perceptive experiences. My work is an inquiry into the intersection of the visual and mental meaning-making mechanisms. I would suggest that the interpretation of subjective perception eludes traditional scientific understanding. From a purely biological point of view, my 'visual reality' is thought to be a physical connection of light, eyes and the brain, yet I know that I interpret the world when I *perceive* it. As a consequence, I examine the complex, iterative process of seeing and interpreting by exploring new ways of 'visualizing' and thereby 'understanding' my dynamic visual perception.

The meaning making machinery of the mind

“Why am I here? [...] I have to figure out some way of explaining that to myself.” (Burnett, 2008-2009) It is my very connection to reality that is at stake. I use my eyes to see the world and make sense of what I see. If I can understand what I see, I can begin to form my personal reality. It follows that if I cannot make sense of what I see, my visual reality begins to break down. “The neurotic turns away from reality because he finds either the whole or parts of it unreadable.” (Freud, 2005) On the other hand, when I see a visual anomaly (illusion or sensation that only exists in my mind), it can manifest in many forms, including confusion, disorientation, and even delight. I hypothesize that I can use the fluid visual space of undefined meaning to help me explore the fluid space of the mind.

I naturally want to ‘define’ the things that I see. In order for me to digest what I see, I must make meaning of the complex experiences that my visual apparatus is undergoing. When I recognize something that I see, I am using a mental mechanism to generate meaning. However, the exact nature of the meaning-making mechanism is not fully understood in scientific terms. For example, in the case of abstract paintings, I can sometimes define what I see as raw emotions or some kind of unexplained experience. Nevertheless, I still get a ‘sense’ of what I am looking at. I need to make ‘sense’ of what I see in order to ‘see’ anything at all.

Each person undergoes a unique conscious experience whereby they interpret the world around them in a personal way. It may be impossible for anyone to develop a unified theory about how human beings make meaning because each person has a unique way of projecting meaning. This can be illustrated by the following example; if I were to ask two observers of “*La trahison des images*” (The Treachery of Images) (Magritte, 1928–1929) to identify the ‘mood’ of the pipe in the painting, one observer might say that it is a ‘sad’ pipe and another might say that it is a ‘relaxed’ pipe. In both cases, the observers have a real experience of assigning meaning to the pipe, but the event is not that simple. The meanings that unfold in the minds of both observers are not exclusively based on a series of words or visual cues that already exist in their memories. They both look at the pipe and probably agree that what they are seeing is a

'pipe', but they certainly do not see the same thing. Furthermore, the 'signifier' (pipe) is a combination of several pre-existing images, descriptions and memories in their mind. However, these discrete 'signifiers' are not the only elements required to achieve a moment of signification. It is more likely that a new event unfolds in the mind with each viewing experience and that there are no discrete moments of meaning making, but rather a whole cycle, all at once, of understanding.

I do not build my artwork under the assumption that meaning has discrete definitions or even discrete moments of definition. "*Mind Mirror*" does not present a visual in the traditional sense. Instead, it is entirely up to the viewer to rationalize, define, and formulate meanings for the phantom visual sensations they experience. The visuals cannot be described in terms of discrete, signified things. However, there are similarities in the verbal accounts that viewers give after using the 'machine'. Some viewers describe seeing lines, shapes or patterns, recalling basic elements of visual content. Other viewers describe seeing objects, and even account narratives as the visual sensation unfolds. Thus, there is no unified description of the things the viewers see. I focus purely on the captivating sensation of vision, and this is fundamental to my visual experimentation.

On my creative journey, I am continually confronted by a very serious question that I think all artists ask themselves: does my art *mean* anything to anyone else? Rather than being concerned with answering this question by communicating a specific message in my art, I am more concerned with delivering a 'perceptual prosthetic' experience. By this I mean that my artwork does not necessarily communicate specific political, historical or cultural messages, but rather assist the viewer in experiencing a visual event. In these visual events, I am attempting to imbue on the viewer a new layer of conscious sensation that they can take with them and use in every subsequent visual experience. If the viewer can learn something about the way they make meaning of what they see in an intuitive sensory event, then they can carry that understanding forward to all future visual experiences.

Unlike the phantom visual sensations of "*Mind Mirror*", "*Zeugen*" offers the viewer a more clearly 'defined' visual in the form of thirty-two faces. I centralize the visual experience: the

viewer is familiar with the sculptural manifestation of a human face. The motion-tracking movements of the robotic eyes generate fluidity in visual interpretation, leading to an experiential interaction that is completely personalized to each viewer. The artwork responds physically to the movements of the viewer, thereby transforming its 'image' and continuously redefining its 'meaning'. As with "*Mind Mirror*", "*Zeugen*" highlights the visual experience over the physically visible object.

In "How Images Think" (Burnett, 2004, p.253), Burnett offers insight into the human capacity to attribute meaning while iteratively engaging with transforming visual environments. In the chapter "Foundations of Virtual Images" (Burnett, 2004, p.253), Burnett describes "images in terms of the spaces they occupy and the time of interaction with viewers" (Burnett, 2004, p.253). In particular, he elaborates on the Federation Square project in Melbourne, Australia. "One of the walls on the site acts as a screen for a continuously changing succession of light forms" (Burnett, 2004, p.253) and "the light form is driven by a series of robotic mirrors" (Burnett, 2004, p.253). The dynamically changing display Burnett describes is analogous to my own artwork, which involves unique and transformative visual experiences. My works certainly hold "meanings that are not solely located either in images or viewers but in a set of relations created by the context of interaction" (Burnett, 2004, p.253). In fact, it is this very 'interaction' that my artwork exemplifies.

The brain/mind paradigm

The complexity of the mind as a meaning making apparatus cannot be reduced to the functions of the brain alone. The brain is a mass of biological matter that computes information using bioelectrical signals that come from the sensory organs. In contrast, the mind is an interpretative, dynamic and expressive 'space,' which currently lacks a unified physical or conceptual description. In order to explore the brain-mind paradigm in a work of art, I develop artwork for the purpose of questioning rather than answering. I do not attempt to make rational connections, nor do I attempt to build any kind of theory resolving the current debate about the brain and mind. Rather, I feel it is my responsibility as an artist to consistently question the intellectual status quo.

"Is our scientific understanding of fundamental principles already more or less complete? Have all the big questions been answered?" (Sheldrake, 2003, p.245) "Philosophical, psychological and neural theories" (Rose, 2006, p.452) attempting to explain how my conscious mind works have left me with more questions than answers. Nevertheless, I believe that the intersection between the brain and the mind is critical to understanding my interpretation of the visual world. It is for this reason that I examine the fundamental elements involved in the experience of seeing. I also believe that the signifier 'mind' is problematic because it is merely another name for what might have previously been called the 'heart' or the 'soul'. That being said, I use the term 'mind' in the context of this paper.

"To many people, science is seen as a source of certainty, a box full of answers that can be trotted out when dealing with life's many questions. Most working scientists, however, see their subject in a very different light: as a method for navigating effectively in an uncertain world." (Cohen, 1997, p.309) Currently, the interpretation of my subjective perception eludes traditional scientific understanding. It is important to recognize that there exists a significant knowledge deficit in the area of the perceptive apparatus and human consciousness. Phenomena like "telepathy and the sense of being stared at are currently unexplained in scientific terms" (Sheldrake, 2003, p.245).

Although I do not approach my research with a scientific viewpoint, I have tried to become familiar with current neuropsychological theories in my interdisciplinary research. I consider there to be some contradiction in contemporary neuroscience and psychology regarding the precise function of the mind. There are essentially two competing ideas. The first idea is that meaning is bioelectrically manufactured by complex interwoven neurological operations in particular cortexes in the brain. From this viewpoint, our visual perception is almost entirely assigned to the visual cortex. The second idea is that we can no longer operate under the assumption that there is a unified cartographic mapping of the brain into discrete components. In support of this idea, there have been many cases of physically damaged brains where the 'area' of the brain responsible for processing and making meaning or memory has been traumatized beyond the point of recovery. Despite this damage, the brain is able to re-

establish normal function by somehow redistributing cognitive processes to undamaged parts of the brain. It is important at this point that I reiterate that I am not making scientific claims regarding the problems or solutions to the brain/mind paradigm. I simply acknowledge that a tremendous amount of work has been done and needs to be done in order to reach a tangible understanding of how the complex relationships between the brain and the mind work.

My artwork addresses the brain-mind paradigm by stimulating the senses into immersive media sensation 'events' that potentially affect the conscious experience. My artwork exploits mental/visual sensations that are meant to affect the viewer's conscious mind. I am convinced that I may be able to enhance my perceptive capacity at the level of the mind and inversely affect the potential of the brain. I see these artworks as analogous to visual aids, such as telescopes and microscopes, which are intended to enhance biological vision.

Exploring the mind using art

"Art is somewhat like the mind. It is a vehicle out of which from nothing comes so much." (Burnett, 2008-2009) The functional similarities between the creative arts and the mind make art an ideal candidate for the study of the mind. Art exists at the point where artifact and meaning coexist. However, one must ask if the scope of art or science is capable of this exploration independently, or if some partnership between art and science is a more likely solution. My research and subsequent artwork exists somewhere at the intersection of art and science, as I believe they both relate to my practice.

Rescher explains that; "if nature were not rulish in exhibiting manifold regularities – if it were pervasively 'unruly' (say, because its laws changed rapidly and randomly) – then anything approaching a scientific study of the world would clearly be impossible." (Rescher, 2005, p.46) Following this line of reasoning, I see how it has been difficult for biological science to explain the visual mind. My subjective perception changes rapidly and seemingly without a quantifiable order. A similar 'disorder' is induced with "*Mind Mirror*" because the visual hallucinations of patterns, lights, shapes and even feelings are dynamic, uncertain and 'unruly'. Thus, it is sensible to consider the use of the creative arts to excogitate theories about the dynamic

conscious visual mind. “Art then, is an increase of life, a sort of competition of surprises that stimulate my consciousness and keep me from becoming somnolent” (Whiten, 1941, p.40).

There are several reasons why I think that art is an important tool to investigate the visual mind. First, art takes a flexible approach to any kind of investigation and this allows me to follow a holistic creative journey. Second, my artistic training has endowed me with an inherent understanding of human perception. When making works of art I am always conscious of the ‘perceptive potential’ of my intended audience. Third, “an artist is multidisciplinary by nature” (Burnett, 2008-2009) and this allows for ‘cross-inter-multi-disciplinary’ collaborative research styles that are certainly required when attempting any sort of inquiry into a subject as complex as the mind. Fourth, I am always making creative ‘experiments’. However, I do not equate my art practice to scientific research – but rather, I recognize they are both scholarly endeavors. Finally, many artists throughout history have studied human perception and shown that art can recognize important elements required for investigating sight.

The sense of being stared at

I have focused thus far on notions of seeing and interpreting the seen: being seen is the other experience of sight. What is the sensation of being seen? Lacan describes the event as “the sensation of another’s gaze upon oneself” (Ragland-Sullivan, 1986, p.343), which occurs when I am being watched. “*Zeugen*” attempts to evoke the sensation of being seen as one of the visual affects of the piece.

“Jean-Paul Sartre described the phenomenology of apprehension of others, pitching his argument around the fundamental phenomenon he called the gaze ... of Sartre's insight, Lacan stresses that the analyst should not confuse the gaze with the fact that people see with their eyes ... in human relations the sensation of another's gaze upon one is sufficient to cause individuals to make themselves an object for that gaze.” (Ragland-Sullivan, 1986, p.343) Thus, being seen by others is a sensation that transcends the biological mechanism of seeing and the psychological result is the ‘sense’ of being seen. Sheldrake appropriately renames Lacan’s

“sensation of another’s gaze upon oneself” (Ragland-Sullivan, 1986, p.343) as “the sense of being stared at” (Sheldrake, 2003, p.384).

Sheldrake maintains that the sense of being stared at is a naturally occurring phenomenon. “It may be deeply rooted in our animal nature, and widespread in the animal kingdom.” (Sheldrake, 2005, p.10-31) Studies of the sense of being stared at cannot be limited to an objective, quantifiable analysis because it involves the fluid sensation of sight. The sense of being stared at is therefore currently being researched using predominantly subjective approaches. Despite these limitations, the analysis that has been conducted by researchers such as Sheldrake is sufficiently compelling to support the existence of this ‘sense’.

Sheldrake's wide range of experiments provides sufficient evidence to account for the existence of an experience that is felt by people who are being watched. He points out that “the sense of being stared at is well known to many police officers, surveillance personnel and soldiers ... Most were convinced of the reality of this sense, and told stories about times when people they were watching seemed to know they were being observed, however well the observers were hidden.” (Sheldrake, 2003, p.384) “*Zeugen*” is an artificially rendered ‘experience’ that has the potential of manufacturing the sense of being stared at. Many observers of “*Zeugen*” have described a feeling of being watched by the work. However, the work does not exclusively evoke the experience of being stared at and can facilitate many other sensations. It may seem counterintuitive that an artwork can generate the sense of being stared at, as the faces and eyes in “*Zeugen*” are entirely artificial. One might expect that the sense of being stared at relies on a person-to-person interaction. However, the accounts of viewers of “*Zeugen*” suggest that the sense of being stared at may be a self-reflexive ‘event’ and perhaps even self-induced.

A self-reflexive experience can be generated by a visual event using a mirror. Self-reflexivity, as exhibited by the mirror event, requires a combination of both seeing and being seen by oneself.

Self-reflexivity

Thus far, I have explored the ideas of seeing, making meaning, and being seen. Together, these ideas form fundamental notions influencing my art practice. The point of intersection uniting these concepts is self-reflexivity. Understanding the essence of 'reflection' and the many forms it takes allows me to understand the conscious experience of self-reflexivity. "*Zeugen*" uses a two-way mirror and "*Mind Mirror*" metaphorically reflects the viewer's mental events. In both cases, I am interested in working with the viewer to reach another layer of awareness through what I call 'hyper-conscious reflexivity'. My metaphorical and physical vehicle of choice for this 'reflection' is therefore, of course, a *mirror*. Ultimately, I wish to achieve a reflection of the mind back onto itself and to do so I rely on certain principles of 'reflection' discussed in this section.

Mirrors

Mirrors have the power to uncover the very nature of my being because they confirm my existence by reflecting an image of me enacting my 'self'. The concept of self-reflection is built on the notion that "the world and logic reflect each other systematically; and the reflection is what we mean by ontology" and "an ontology is an abstract structure inverted to account for the world" (Feibleman, 1958, p.228). In other words, my physical reflection is an abstracted logical reasoning of my reflected image. However, my physical reflection is not necessarily an indication of my existence as my reflection can take on both the role of reflector and reflected or perceiver and perceived. This dichotomy of duality is exhibited by "*Zeugen*" when the perceiver and the perceived are represented by the inverse relationships of seeing and being seen. When the faces of "*Zeugen*" are visible, there is little to no reflection from the two-way mirror. Therefore, the viewer does not see a reflection of themselves, but rather the faces looking at them. When the lights illuminating the faces are turned off, the viewer is presented with a direct reflection of themselves. The artwork and the viewer are both potential witnesses of the same event that is the 'vision' that exists between them.

It is critical here to understand certain aspects of the mirror. First, the mirror is a developmental experience in which I become aware of the physical image of myself and this

affects the way I perceive myself from that moment on. Using my newly-discovered mirror image, I achieve a new 'total capacity' of self-awareness that enhances my state of consciousness. I gain the ability to think about myself in ways that are only possible after seeing my physical reflection in a mirror. Second, I continue to have a relationship with my visually reflected self-image on a continuing basis. In the very same way, "*Zeugen*" facilitates an experiential event that becomes a part of the conscious structure of the viewer. A visual event reflecting an image of the viewer and the sensation of being watched evolves into a phenomenological conscious development. "*Mind Mirror*" works in the same cyclical fashion, although the reflexive event is only seen in the mind of the viewer and there are no 'physical' mirrors involved.

The self-contained reflective mental experience of looking into a glass mirror locks my eyes and my perception in a cycle of 'hyper-reality'. The reason why a mirror's reflection is different from simply 'reflecting' on oneself in the mind is that a mirror is a visual anchor for the mind to rest on. My artwork is a physical artifact that produces visual sensations acting as gateways that anchor the viewer in the experience of self-contemplation.

A reflection can help facilitate understanding of the thinking experience. The event is entirely interpersonal and that is why it results in a state of self-awareness taking the form of the 'other self' capable of looking back and even 'talking' back. In this way, a reflection is dynamic and cyclically interactive but the artwork is an anchor holding the reflective experience in place. "*Zeugen*" takes this point one step further in that the physical reflection of the viewer is only available to the viewer while the lights that illuminate the faces are off. Once the faces behind the two-way mirror are illuminated, the mirror 'dissolves' to expose the faces to the viewer, while simultaneously hiding the viewer's physical reflection. During these events, the reflection experience oscillates between an event and a memory of the event. The reflexive event is therefore simultaneously physical, mental, visual and virtual.

The commonplace 'bathroom mirror' made of reflective metal-coated glass is easy for me to comprehend because I have integrated the technology into my daily life. However, I rarely stop to think about how a glass mirror's reflection is not perfect. Without natural sunlight on a perfectly flat and reflective surface, I get a distorted image of myself. A mirror's reflected image

is also inverted with respect to my 'real' image. In fact, a point of reflection is not possible without presenting the opposing image, which is a distortion inherent in the 'reflection'. The dimension of my self-reasoning seems amplified in the space between the two opposing images of the real and the virtually-reflected 'real' that is inverted and reversed.

"The mirror's property of reversing that which it reflects suggests a parallel universe on its other side ... as with Carroll's Alice who passed through the looking glass into another world" (Werness, 1999, p.4 and 114). The mirror here is not seen as a reflection of the 'true' self or in this case a reflection of one story as a 'true' mirror image, but rather the mirror is exposed for its distortion and inverted duality. The themes, storyline, and events are inverted and therefore distorted to represent the 'other' as opposite.

With this example, I can see the potential for the "*Mind Mirror*" to reflect back a distorted image of the conceptual mental 'self'. Conversely, the commonplace mirror is a vehicle for achieving an 'accurate' physical image of the self. It must be recognized that while I seek clarification from a 'mirror image', the inverted and opposite image is not a perfect clone of my self-image. I hypothesize that the mental coequal affect of reflection that is induced by the "*Mind Mirror*" also has a significant level of inversion distortion. Nonetheless, it is a vehicle for connecting the visual and virtual world of seeing that is reciprocated by the mind's eye.

In order to accurately reflect the mind back onto itself in "*Mind Mirror*", I had to assess the point where there is enough detail in the 'reflection' that the mind would be capable of inducing a state of self-recognizable reflection. This was done by learning about and adopting the appropriate stroboscopic and stereoscopic frequencies of oscillating LED light and sound. Devices that cause these effects are generally called sound and light machines (SLM). The differential required to coax the mind into the alpha wave range was most appropriate for my purposes. The beta range, above the alpha range, causes an alert state of hyper-active response that is not conducive to contemplative mental states. The theta and delta ranges, well below the alpha range, cause the viewer to become drowsy, which is also problematic. The alpha range is the optimal range because the viewer is able to undergo the state of visual hallucination with a balanced degree of relaxation and alertness, optimal for moments of self-contemplation.

Type	Band	Frequency used in SLM	Associated States
Delta waves	½Hz to 4Hz	2.2Hz	deep unconscious, intuition and insight
Theta waves	4Hz to 8Hz	6.0Hz	subconscious, creativity, deep relaxation
Alpha waves	8Hz to 13Hz	11.1Hz	spacey and dreamy, receptive and passive
Beta waves	13Hz to 30Hz	14.4Hz	conscious thought, external focus

Table 1: *Brain Wave Frequencies and Associated Mental States (Altman, 2007, p.88)*

Mirrors are symbolic references to many important concepts. My ability to rationalize the complex concept of a mirror lies in the symbolism signified by sight. Seeing "takes precedence over the other senses in most world cultures" (Werness, 1999, p.4 and 114). This allows for the visual arts to make special use of the mirror as a symbol referencing the multidimensionality of the human perceptive experience. Diego Velazquez's oil on canvas painting entitled "Las Meninas" (Velazquez, 1656) uses the mirror in the background to expose the concept of reflection as a window of access into the symbolism that is inherent in the reflection. First, he is painting his 'self' portrait. He is also painting a reflected subject being painted in his painting (the king and queen and the observer or arguably the painting in the painting) (Werness, 1999, p.4 and 114). Finally, he is painting the vehicle of the reflection itself in the form of the mirror in the background. These three representations of the observer, the reflected and the source of reflection (the mirror) encompass the critical elements required for understanding the perceived cycle of reflection. Foucault reads Velazquez at the beginning of his text, "The Order of Things" (Foucault, 1970, p.3-16) as portraying a paradoxical relationship between reality and representation (Ashley, 2008). Foucault identifies different reflection relationships in the painting than what I have described here, but essentially demonstrates an identical notion "because they are all representations of a point of reality outside of the painting" (Ashley, 2008). The signifiers referenced as external to the painting signify reflection and are constantly shifting and transforming the sensation of reflection. This internalized manifestation of the meaning making paradox is manifested visually by the "*Mind Mirror*" as the viewer experiences visual sensations, which are constantly in motion and never still for the defining.

In addition to Velazquez, contemporary artists, such as Dan Graham and Jeff Koons, have incorporated mirrors and reflective surfaces directly into their work as a way of engaging the viewer in the reflexive experience.

Reflection

RE-flections: "the Latin particle re-, which corresponds to the English 'again' and 'against', properly denotes a turning back (upon oneself or itself) or an opposition" (Gasche, 1986, p.348). A reflection is therefore manifested in 'simulacrum,' defined by Plato as a copy of a copy or a double of a double; which itself signifies an original (Gasche, 1986, p.348). However, this cycle of a reflective continuum is whole and moving at the same time, and that is what facilitates the reflection sensation. Stipulating an 'originator' of the reflection is problematic. The mirror image and the viewer's body are being reflected simultaneously against one another to produce a moment of recognition. In the same way, when a viewer interacts with "*Zeugen*", they recognize their physical image and they are able to simultaneously contemplate their image as seen by others. Reflection as a form of 'doubling' can also be described in terms of difference (Gasche, 1986, p.348) but in either case "duplicity . . . logically proceeds the philosophical opposition of the simple and the derivative double" (Gasche, 1986, p.348). This "infinite duplicity" (Gasche, 1986, p.348) continuously cycling may account for the sensation of momentary reflexivity that occurs and recedes as I fade in and out of the self-reflective experience. The sensations generated by "*Zeugen*" are analogous to "changing relationships moving from recognition to uncanny effects of abstraction and to the disappearance of recognition" (Turim, 1980, p.143). Most importantly, these descriptions of the reflective sensations transition me from the stagnant perspective of oppositions to a continuum of interwoven relationships required to generate a self-reflexive experience for viewers of both "*Zeugen*" and the "*Mind Mirror*". Understanding my reflection in terms of a dynamic event can allow me to recognize the uncanny feeling I experience during the reflection sensation.

I am continuously becoming the image of myself when I look in the mirror. The changes that occur are reflected back to me in real time. The mirror not only shows the minute changes in my appearance as I comb my hair, but the dynamic perception of my 'self-image' that is

changing in my mind throughout my entire life. What distinguishes a representation from a reflection? A reflection is distinct because it happens in real time and changes as I do. The dynamic principle of 'reflection' in a mirror is contrasted with a static 'representation' as found in a photograph. A portrait (photograph) is a representation of the self, but it is trapped in a single moment of time. The photograph does not update to unfold the experience of simultaneously perceiving and being perceived. A photographic representation is locked in a reflected moment in the past from the moment it is captured. However, I may still contemplate my 'self' by viewing a photograph. The difference is that I cannot achieve the heightened state of dynamic self-awareness that a mirror offers as both the physical and mental image of my 'self' unfolds. My work uses interactivity to dynamically engage the viewer and build immersive experiences that change to adapt to the viewer's actions in order to maintain a reflexive experience. "*Zeugen*" literally moves with the viewer, watching and tracking the viewer's movements. In both "*Zeugen*" and "*Mind Mirror*", each viewing experience is completely customized to the viewer. "*Mind Mirror*" virtually shifts towards the viewer's visual interpretation as a natural result of the hallucinatory event. In this regard, the "*Mind Mirror*" is an interactive, autodidactic synesthesia 'event'.

Commonplace mirrors seem to force me into the reality of my physical reflection. I can contemplate my very existence by referencing the 'other' person in the mirror. In a mirror, my perception is contained by the image of my physical body. Because it is hard to completely identify with the sensation of simultaneity in the reflection, I tend to ignore or deny this 'other' sensation. This ultimately results in my inability to realize my full 'hyper-conscious' perceptive potential. Therefore, the act of being reflected must involve new ways of thinking about my state of self-reflexive awareness. It is quite obvious that the purpose of a mirror is indeed to provide a reflection, but reducing my understanding of the 'reflection sensation' to the visual image denies me the simultaneity of "that thinking feeling" (McMahon, 2001, p.3-8). "*Mind Mirror*" forces a meeting with the self in a hypnotic-like visual field that lies somewhere between what I see and what I think I see. The liminal space that results is a new space for such a self-reflexive event.

The commonplace mirror offers a physical reflection of the 'virtual self,' as represented by the 'person in the mirror'. This interactive event of perceiving one's 'virtual self' is analogous to

Murphie's descriptions of virtual reality, in which there is "more complexity than a simple relation between an object and subject" and "by virtue of its self-reflexivity, acts out its own becoming" (Murphie, 2001, p.197). In this way, a mirror drives a state of self-awareness as a mental mechanism where my mind can identify with the self as it continuously changes. My artworks therefore have the power to reflect not only my physical appearance but my dynamic conscious perception of that appearance simultaneously in a single, yet constantly changing, conscious moment.

Awareness

Inherent in the 'self' is the desire to 'Scito te ipsum' (Latin, translated as "know thyself"). My propensity for self-centered reflection can easily translate to an infatuation with the self. Steven Z. Levine's story of Monet's journey "From Self-Infatuation to Self-Reflection" (Levine, 1994, p.15-24) uncovers the motivation inherent in Monet's art, but the art is of course a reflection of the artist's need and the need in all of us to know ourselves. The transformation from the need to know to the knowing of the 'self' is facilitated by reflection. Thus, the need for one to know oneself and the reflection of said self requires a transformation from a self-centered view to a self-actualized perspective of the 'self'. This moment of self-realization requires that I step away from myself to look inward, and this moment can be thought of as a transcendence of space and time.

The moment of self-reflection I am describing cannot be traditionally perceived as representational but rather virtual and yet meaningful. It is not in the initial physical or subsequent mental reflection, but in "the secondary reflective relation" that "introduces a certain separation or transcendence within the self, and finally permits the range of self-consciousness" (Brockelman, 1985, p.83). When I look in a mirror, my reflection is in fact occurring, but I am not in the mirror, nor am I the object being reflected in the mirror. Rather, I am somewhere in between or even outside of these two spaces in a 'virtual space' of self-reflection. This self-awareness experience can therefore be described as circling around the sensation of feeling my 'self' in the moment. This sensation is analogous to, but not exactly the same as, a virtual reality representation of myself. Murphie describes the Deleuzian

'integrality' as allowing "for a notion of perception based upon difference and change rather than upon identity and stasis" (Murphie, 2001, p.197). Perception of the 'self' without stagnation (caused by traditionally-held relationships of equal opposites) is achieved by the dynamic relationship between the reflected and the reflection in a mirror (Foucault, 1967). By reflecting one thought (utopia) with another (heterotopia), he is able to provide a looped window of access into understanding the 'other' (heterotopias). In the same way, if I reflect on the accessible physical reflection of myself, I may gain access through the metaphor of a mirror to my less understood mental 'self' in such a way as to open a window into the current moment of my consciousness that happens somewhere in between 'here' and 'there'. This is further explored with the "*Mind Mirror*", which instead of reflecting light is actually capable of reflecting consciousness.

Analogous to the sensation of self-reflection and the metaphor of reflection in a glass mirror are the requirements for 'reflections' of consciousness that I have built into my "*Mind Mirror*." I suspect that, just as with glass mirrors, a heightened state of awareness enhancing the thinking experience is manifested. Part of the problem of expanding my self-awareness apparatus is that I am used to grounding my perceptive experience in traditional linear reasoning. However, "when the ground rises to the surface, the human face decomposes in this mirror in which both determinations and the indeterminate combine in a single determination which 'makes' the difference" (Deleuze, 1994, p.28). Achieving awareness of the thinking sensation described by Melissa McMahon as "waiting for the movement to stop and reflect itself back to itself" (McMahon, 2001, p.3-8) requires that the present conscious experience is overturned, thereby impressing upon the mind a state of transmutation.

To understand how my thoughts work and to perceive my thinking experience I find myself outside of myself looking in. Building and engaging with "*Zeugen*" and the "*Mind Mirror*" has allowed me to come closer to understanding my conscious experience and achieving another layer of awareness through 'hyper-conscious' reflexivity.

Creative Journey

The following section will situate my thesis artwork within a historical discourse and contextualize my work within the new media art lineage. First, I will describe the historical context of the works and then share my creative process of art practice, beginning with "*Zeugen*".

***Zeugen*: Historical Context and Contributions**

Marcel Duchamp's "*Rotary Demisphere* (Precision Optics)" (1925) was "an early example of 'interactive art' […] the viewer becomes an active participant in the art ... required to turn on the optical machine and stand one meter away" (Rush, 1999, p.224). I do not fully agree with this definition of interactive art, which simply requires participation. Instead, I feel that interaction and interactivity are a result of a reciprocity of actions. My view is best illustrated by a simple example: a ping-pong game. If I simply respond to the ping-pong ball by returning it to the other side of the net, then I am not acting so much as I am reacting to the physical principles of the game. If, however, I place a spin on the ball so as to thwart my opponent's attempt at volleying the ball back to me, then I am engaging in interactive game play. Therefore, interactivity requires a cycle of action whereby both (or all) participants actively contribute as opposed to merely respond to the experience. Artists now use microcontrollers and sensors when building interactive electronic projects. These technological advances allow new media artists to receive inputs, calculate processes, and control outputs (all of the basic components required for interactivity). The resulting interactive artworks use the principles of electricity that Duchamp experimented with, with an added layer of interaction.

Daniel Rozin's "Wooden Mirror" (Rozin, 1999) is a creative electronic artwork that explores the mind and reflexivity. The "Wooden Mirror" (Rozin, 1999) is made up of small wood chip 'pixels' and reflects light in such a way as to display a 'wooden mirror' image of the observer. Just like a glass mirror, the 'wooden mirror' changes with the viewers' movements, but reflects a pixilated image. In order to successfully reflect a recognizable form that also induces 'super-conscious'

'hyper-real' self-recognition, it is critical to include the critical elements required to generate this reflection at a high enough 'resolution'. There are many similarities between "*Zeugen*" and the "Wooden Mirror" (Rozin, 1999). Both works capture video surveillance images and process video image data, then transmit the data to display an interactive servo-controlled visual experience. However, "*Zeugen*" reflects both the literal image of the viewer and presents artificial 'observers' that, when taken together, create the necessary layers of simultaneity required for the reflexive experience.

Like "*Zeugen*", David Rokeby's "Watch" (Rokeby, 1995) also uses surveillance technology. However, he establishes a dialogue surrounding the power and domination-driven viewing practice of surveillance. The work consists of a surveillance camera filming the exterior public space of the Holly Solomon Gallery in New York City. It shows the video feed on a display inside of the privileged space of the art gallery. The work is more of a reflection (contemplation or consideration) of surveillance rather than a reflexive moment replicating 'the sense of being stared at' or representing seeing and being seen. The audience is not aware that they or others are being surveiled until after the fact, and do not directly interact with the work in real time. "Watch" was intended by Rokeby to become an "artificial perception system" using surveillance technology. However, and quite obviously, the 'loaded' implications of the work make the discourse of power politics and surveillance unavoidable. Surveillance technology is the vehicle for a strictly power-driven observation as it is unidirectional and in many cases completely clandestine and subversive. In surveillance technology, "an arms race between agents supporting and opposing unobservable surveillance techniques has been unfolding for at least two decades." (Parsons, 2009) It is within this race that Rokeby makes critical works of art assessing the vehicle and implications of unidirectional surveillance. In contrast, the viewers of "*Zeugen*" can see and be seen by the work, but the work is always in plain view. There is no element of clandestine observation; viewers on both the tech side and the face side of the work can always see each other and the technology that drives the work is open to examination.

"Watched and Measured" (Rokeby, 2000) is a commission for The Science Museum in London, England. "Watched and Measured" (Rokeby, 2000) is a direct example of invasive video

surveillance systems as the system identifies human presence and draws an outline around the heads of people walking into the Wellcome wing of the museum. Whereas Rokeby's "Watch" (Rokeby, 1995) began a critical discourse of surveillance, "Watched and Measured" (Rokeby, 2000) expanded the discourse and drew closer to the 'sense of being stared at' by directly demonstrating the capacity for machine vision to identify humans in video footage. "Watched and Measured" (Rokeby, 2000) does not generate a completely embodied and self-reflexive moment of awareness to elicit the 'sense of being stared at'. The viewer is only made aware of the fact that they were under surveillance after the fact and not in a single, personalized reflexive moment. That is to say, Rokeby's work deals more directly with surveillance than reflexivity.

Marie Sester's "Access" (Sester, 2006) is an interactive new media artwork that was installed at the ZKM Center for Art and Media in Karlsruhe, Germany late in 2006. The artwork allows online users to "track anonymous individuals in public places, by pursuing them with a robotic spotlight" (Sester, 2006). Sester's project uses a spotlight to evoke thoughts of prison camps and detention facilities. The audience of the gallery is put under the careful watch of people using the artwork online in remote locations. Questions of remote control and the distant observer are contained in a raw and visceral event (that is, in real-time). The artwork is controlled by people, but mediated by technology. The 'observer' is not directly looking at the subject in the gallery space and so the sensation of 'being seen' is muted by technological mediation and the unpredictability of the online human observer. During studies of the sensation of being stared at "most people … being stared at say they have turned around and looked straight at the person staring at them." (Sheldrake, 2005, p.10-31) In the case of Sester's "Access," viewers cannot face the 'observer' because they would be looking into a blindingly bright light on the ceiling. Once again, a power dynamic is in place, disrupting the pure and embodied experience of 'being stared at.' Instead, the works of both Sester and Rokeby focus my attention predominantly on surveillance. However, "Access" does provide me with another key element that is essential to replicating 'the sense of being stared at': real-time tactile interaction.

Golan Levin's "Eyecode" (Levin, 2007) is another new media investigation of seeing and being seen. "Eyecode" (Levin, 2007) "is an interactive installation whose display is wholly constructed from its own history of being viewed. By means of a hidden camera, the system records and replays brief video clips of its viewers' eyes. … The unnerving result is a typographic tapestry of recursive observation." (Levin, 2007) Levin uses a matrix of eyes and adds the essential element of interactivity. One difference between "*Zeugen*" and "Eyecode" (Levin, 2007) is that "*Zeugen*" uses physical objects and "Eyecode" (Levin, 2007) mediates the visual experience by presenting the eyes on a computer monitor. Another difference is that the eyes in "*Zeugen*" track the movements of the viewer, whereas the eyes in "Eyecode" (Levin, 2007) replay the movements of the viewers' eyes. Both works are interactive new media explorations into the gestures of the gaze and both works explore sensations of sight.

Levin expands his exploration to include 'being seen' with the work "Opto-isolator" (Levin & Baltus, 2007). The "Opto-isolator" (Levin & Baltus, 2007) "presents a solitary mechatronic blinking eye, at human scale, which responds to the gaze of visitors with a variety of psychosocial eye-contact behaviors" (Levin & Baltus, 2007). This work exhibits most of the parameters that I have discussed for replicating 'the sense of being stared at'. The "Opto-isolator" has an eye and interactively tracks the motions of a viewer. However, this work lacks two key elements that I feel are necessary for a completely immersive and self-reflexive sensation of 'being seen'. First, the work does not have a sufficient anthropomorphic signifier (other than the eye) to indicate the signified 'other' (person). The eye is installed in a black box and not a recognizable face. Second, there is only one eye, meaning that the dominant 'observer' in this 'visual exchange' is the viewer in the gallery space as they are equipped with two eyes. The eye could belong to an animal but if that were the case, the animal would be one that is mythical because "there are no animal species with just one eye." (McDonnell, 2009, p.4) "*Zeugen*" overcomes these challenges by installing the eyes in a very large grid of human cast faces.

"*Zeugen*" is a contribution to new media movements in expressing experiences of seeing and being seen. "*Zeugen*" contributs to both the visual arts arena and new media technology developments. I have shown "*Zeugen*" at the Emily Carr University of Art + Design Concourse

Gallery. I have also shown the work at the Surrey Art Gallery opening for "Interactive Futures 09: Stereo" Conference (a conference directed by Maria Lantin and Julie Andreyev). Recently, I have also been invited to submit "*Zeugen*" and participate in the internationally recognized Prix Ars Electronica competition (2010) under the interactive art category.

Zeugen: Creative process (methodology)

Nikola Tesla is a source of tremendous inspiration for me. He writes: "When I get an idea I start at once building it up in my imagination. I change the construction, make improvements and operate the device in my mind." (Tesla, 2007, p.19) Tesla's creative process is analogous to my own methodology of making, though, unlike Tesla, I cannot "rapidly develop and perfect a conception without touching anything". (Tesla, 2007, p.19) I don't take extensive notes, build scale maquettes or make sketches when planning my work. I simply ponder over the ideas one at a time, formulating the total picture conception of my work. I then build the individual components one at a time. Of course, I encounter many problems once I begin building, such as availability or physical limitations of materials, damaged or poorly manufactured parts, lack of time, and financial constraints. Nevertheless, I establish a sort of confidence to proceed by fully forming certain ideas in my mind, leaving other parts of the plan open to variation once I begin the process of building. This section deals with the trials and challenges encountered in the development of "*Zeugen*": it is a record of my creative journey. I will not be sharing all of the details of my experimentation, which are well beyond the scope of this paper. Instead, I will focus on the anthropomorphic, interactive and technical elements that I was most concerned with when making "*Zeugen*".

I began with running a singular eye experiment in order to test my theory of using a spring as a universal joint. The experiment worked, and I simulated an event where the eye tracked my movements. However, a singular eye does not offer the anthropomorphic qualities I was seeking (for reasons previously discussed). I then began mounting the eyes in pairs to simulate the movement of a pair of eyes. At this point, I was already convinced that the eyes would have to be placed in a face. Before I cast all thirty-two faces, I experimented with a wide range of casting materials including silicon rubber, fiberglass, latex, and mold-making styrofoam. I was

most concerned with casting the faces in such a way as to maintain human elements, but somehow minimize stereotypically-ascribed identifiers of race, gender, and age.

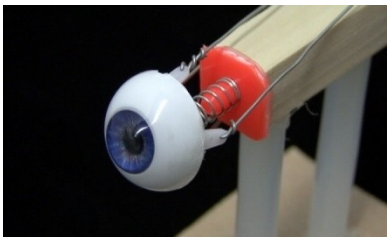

Figure 3: *Morgan Rauscher, "Zeugen", 2009 (process image: single eye test)*

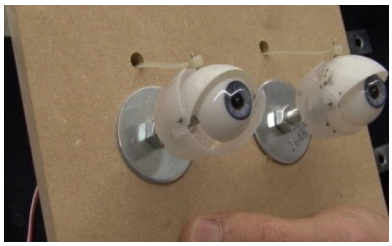

Figure 4: *Morgan Rauscher, "Zeugen", 2009 (process image: two robotic eyes test)*

Figure 5: *Morgan Rauscher, "Zeugen", 2009 (process image: materials tests)*

The face casting process was quite challenging. My first consideration was examining the individual facial features. In particular, what facial features (other than the eyes) are important to anthropomorphosis of the face, yet do not require interactions? There are expectations of the mouth to speak or make facial gestures such as smiling. There are less, yet existing, expectations of the ears to listen. Because of these expectations, I omitted the ears and the mouth from the face casts. The nose, however, seems to evoke the least amount of expectation for interaction in the viewer. The nose is also the visual feature linking the eyes together, as it rests perfectly between them. Taken together, the eyes and nose are a powerful anthropomorphic visual.

The face-casting process involved several steps. The first step was finding and casting many volunteer models. I built a special face-casting contraption that acted like a mask and could easily be used repeatedly. I used an alginate and water mold-making solution that is suited for body casting; this material maintains a high degree of detail and is hypo-allergenic. It should be noted that the working time of alginate is relatively short because the mold becomes dry. There is a narrow window of about an hour to obtain the plaster master-mold once the alginate casts is poured. A considerable amount of fine crafting of the molds was also necessary.

Figure 6: *Morgan Rauscher, "Zeugen", 2009 (process image: face casting mask)*

Figure 7: *Morgan Rauscher, "Zeugen", 2009 (process image: alginate body casting)*

Figure 8: *Morgan Rauscher, "Zeugen", 2009 (process image: plaster mold rough)*

Figure 9: *Morgan Rauscher, "Zeugen", 2009 (process image: plaster mold refining)*

Next, I sealed the plaster master-mold with a thin coat of finish to protect the surface detail and prevent chipping of the plaster surface. The master-molds were then ready for vacuum casting. I used polyethylene sheets as the vacuum casting material in order to produce a 'backup' negative of the mold. An interesting limitation of the material that I found was that I could not vacuum cast more than a few faces in a row before the actual plaster positive would heat up. Because I had to cast nearly a hundred vacuum forms in order to get the best possible result, this problem became a serious time consideration. As "*Zeugen*" evolved, I began using polystyrene materials in order to get a stronger surface and visual feel to the work. Conveniently, polystyrene melts under considerably lower temperatures and this reduced the heat problems enough that the expansion, melting and miscasting effects became negligible.

Figure 10: *Morgan Rauscher, "Zeugen", 2009 (process image: sealing plaster mold)*

Figure 11: *Morgan Rauscher, "Zeugen", 2009 (process image: vacuum forming)*

The thin vacuum formed faceplates were remarkable. Very minute skin details were visible by shining a light behind the polyethylene faceplate. With light shining at the front of the face plate, the result was a milky, shiny surface.

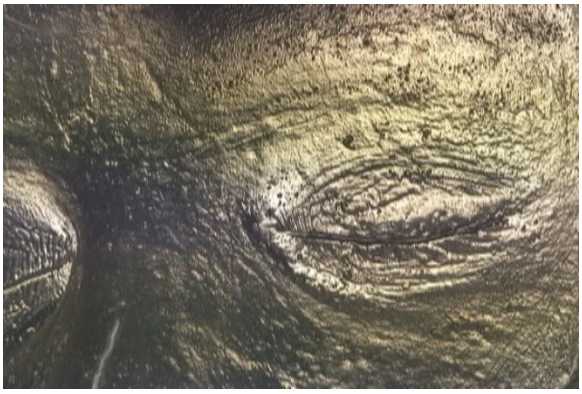

Figure 12: *Morgan Rauscher, "Zeugen", 2009 (process image: polyethylene detail)*

Figure 13: *Morgan Rauscher, "Zeugen", 2009 (process image: polyethylene detail)*

I knew there had to be more than one face or the identity of the singular face would become a central theme of the work. The question was: how many faces? I suspected that two faces would focus the critical discourse around the work to the specific relationship between the two faces. In my mind's eye, I could see the work as occupying my whole mind when I thought about it. I therefore decided to cast as many faces as required to occupy most of my visual plane. Now, when I stand at the appropriate distance from the work looking straight at it, my whole visual field is filled with glowing faces looking back at me. I also began using tri-colour (red, green, and blue) frequency-modulated light emitting diodes (RGB LED) to experiment with lighting effects.

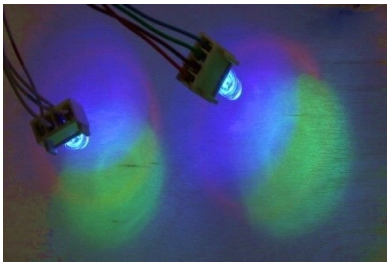

Figure 14: *Morgan Rauscher, "Zeugen", 2009 (process image: RGB LED test)*

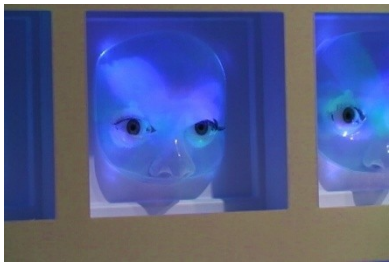

Figure 15: *Rauscher, "Zeugen", 2009 (process image: face lighting test)*

Figure 16: *Morgan Rauscher, "Zeugen", 2009 (process image: grid of faces)*

The faces were installed into a four by eight grid. I used a computer numerically controlled (CNC) milling router to cut the frame, with the assistance of the CNC technician Steven Hall. The highly polished and perfectly cut acrylic surfaces and plywood sub-frame resulted from the use of the CNC machine. I was also able to save time during the construction phase relative to constructing the frame 'by hand'.

Figure 17: *Morgan Rauscher, "Zeugen", 2009 (process image: CNC machining detail)*

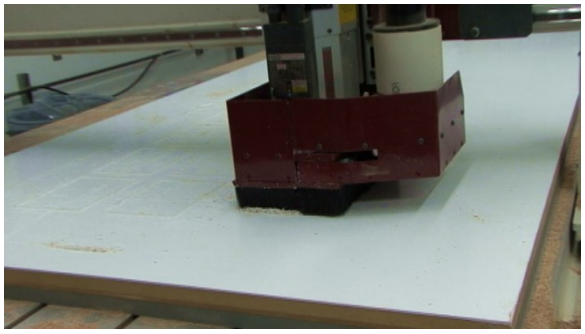

Figure 18: *Morgan Rauscher, "Zeugen", 2009 (process image: CNC machining detail)*

The frame was designed so that the planks could be assembled into a grid using interlocking joints. In early versions, the wooden frame and acrylic face plate were white. Later, I decided to maintain the natural color of the plywood and a black acrylic face plate for aesthetic reasons.

Figure 19: *Morgan Rauscher, "Zeugen", 2009 (process image: frame construction)*

Figure 20: *Morgan Rauscher, "Zeugen", 2009 (process image: frame detailing)*

After assembling and finishing the sub-frame and acrylic surfaces, as well as casting and forming all of the face plates, I began to research methods of face-recognition and tracking. I found a desktop webcam that could track human faces. My idea was to use the webcam and hardware to physically control my own custom hardware, and therefore move the servos that control the movements of the eyes. This approach had several limitations. First, with a standard desktop face tracking webcam, it is only possible to track one face. Second, the hardware found in almost all devices is 'closed-box,' meaning that it cannot be custom-programmed. Thus, it is not possible to program 'personality'-based robotic eye gestures or movements with these systems.

Figure 21: *Morgan Rauscher, "Zeugen", 2009 (process image: motion-tracking desk top webcam)*

Despite hardware limitations, I pushed forward to complete the first version of "*Zeugen*." I wanted to identify any other limitations that would require reworking. In order to control the thirty-two faces in the first version of "*Zeugen*," I had to find a way to control six servos per face. There were two servos controlling the upwards and downwards movements of the eyes, two servos controlling the left to right movements of the eyes, and two servos controlling the eye lids. I also needed to control four RGB LED's per face. I was familiar with microcontrollers such as Arduino, but I was also aware that my project requirements extended well beyond the power of an Arduino microcontroller. At the time, the most powerful Arduino microcontroller could only control fifty-four output devices, while I needed to control a total of three hundred and twenty devices. In order to develop the project, I collaborated with electrical engineer Randy Glenn to design a new microcontroller called Displayduino (see Appendix 1 for details). An extensive amount of computer software and hardware programming was encountered as I made my first attempt to build thirty-two motion tracking human cast faces.

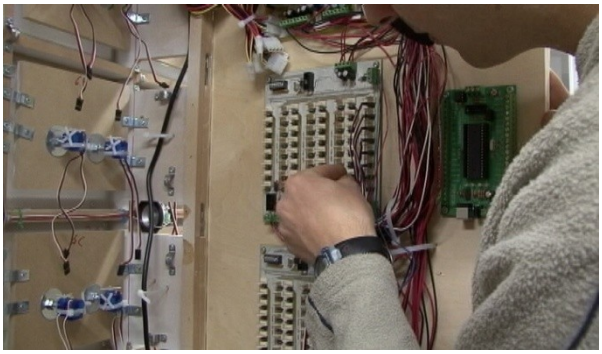

Figure 22: *Morgan Rauscher, "Zeugen", 2009 (process image: original custom electronics)*

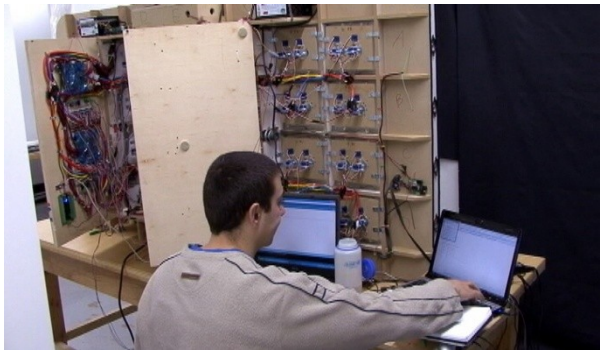

Figure 23: *Morgan Rauscher, "Zeugen", 2009 (process image: programming custom electronics)*

I showed the first version of "*Zeugen*" at "Not That Grad Show" in the Concourse Gallery at Emily Carr University of Art + Design in 2009. I was disappointed with the results for two reasons. First, many of the servos controlling the work failed the night before the show. They simply could not take the stress loads that were required to move the eyes. Second, the motion tracking system was not fully operational and relied on a single webcam.

Figure 24: *Morgan Rauscher, "Zeugen", 2009 (at ECU 'Not that grad show')*

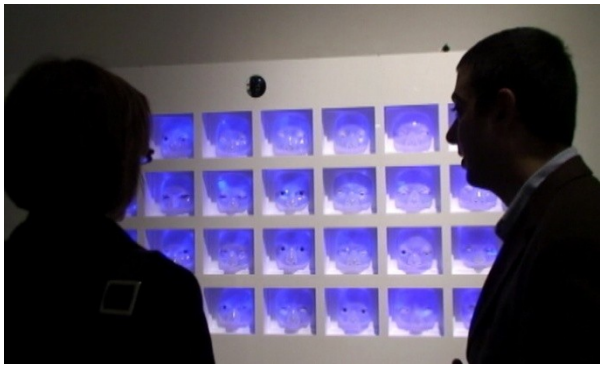

Figure 25: *Morgan Rauscher, "Zeugen", 2009 (at ECU 'Not that grad show')*

To address these limitations, I went back to the drawing board. I began by redesigning the mechanical contraption that controlled the movements of the eyes. In the first version I used a universal spring joint. I decided to design a new system utilizing the mechanical tools of LEGO®. I was able to dramatically reduce the amount of servos required for each face from six to three and I was able to reduce the torque required to move the servos by around ninety percent.

Figure 26: *Morgan Rauscher, "Zeugen", 2010 (LEGO® adaptations)*

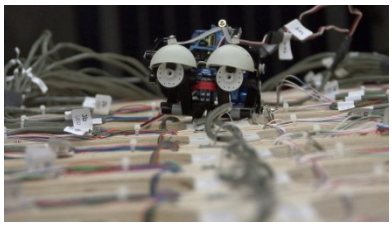

Figure 27: *Morgan Rauscher, "Zeugen", 2010 (LEGO® adaptations)*

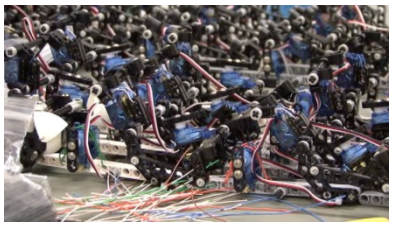

Figure 28: *Morgan Rauscher, "Zeugen", 2010 (LEGO® adaptations)*

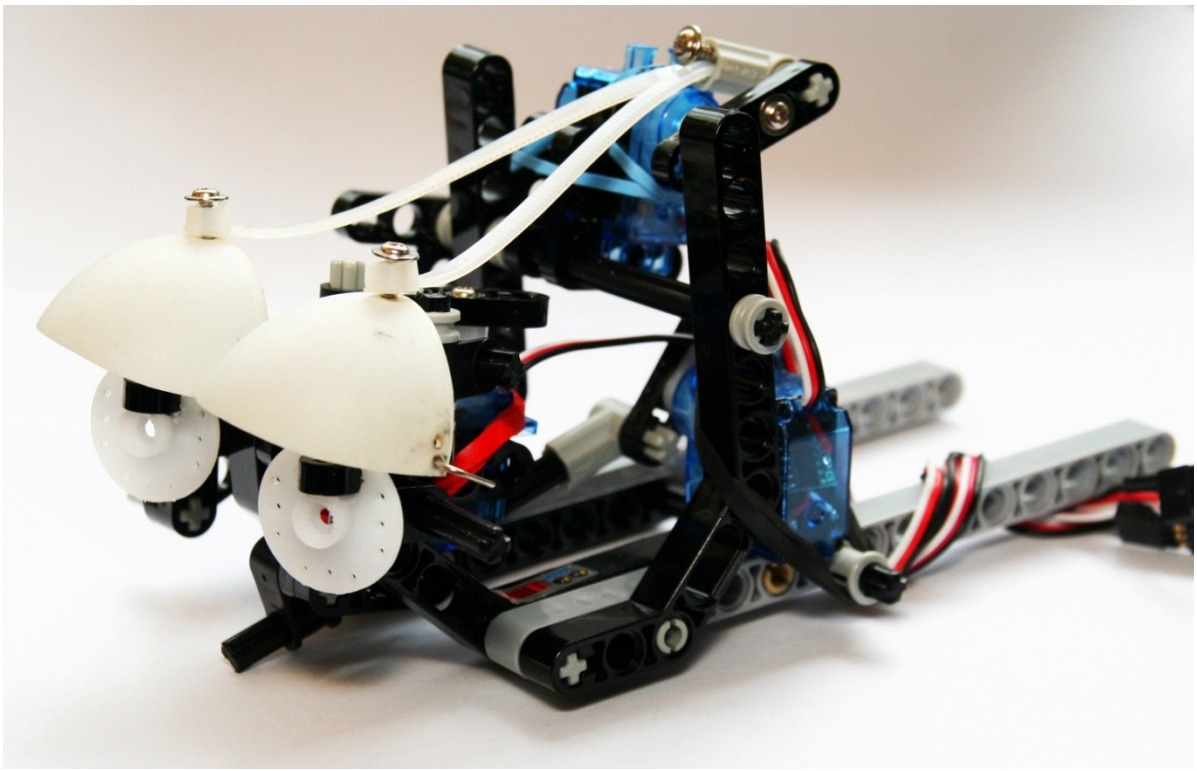

Figure 29: *Morgan Rauscher, "Zeugen", 2010 (LEGO® adaptations)*

At "Not that grad show", I noticed that viewers were trying to see the mechatronic elements on the reverse side of the work. This observation led me to redesign the work such that it could be viewed from both sides. The idea of technological transparency became central to my work: it is important for me to share with my viewers both a visual experience and the technology that makes the experience possible.

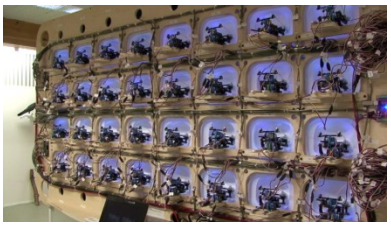

Figure 30: Morgan Rauscher, "Zeugen", 2010 (new robotics)

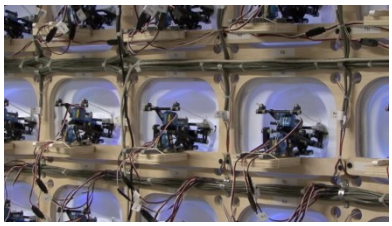

Figure 31: Morgan Rauscher, "Zeugen", 2010 (new robotics detail)

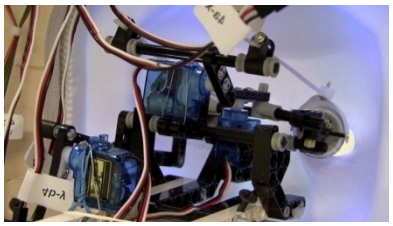

Figure 32: Morgan Rauscher, "Zeugen", 2010 (new robotics detail)

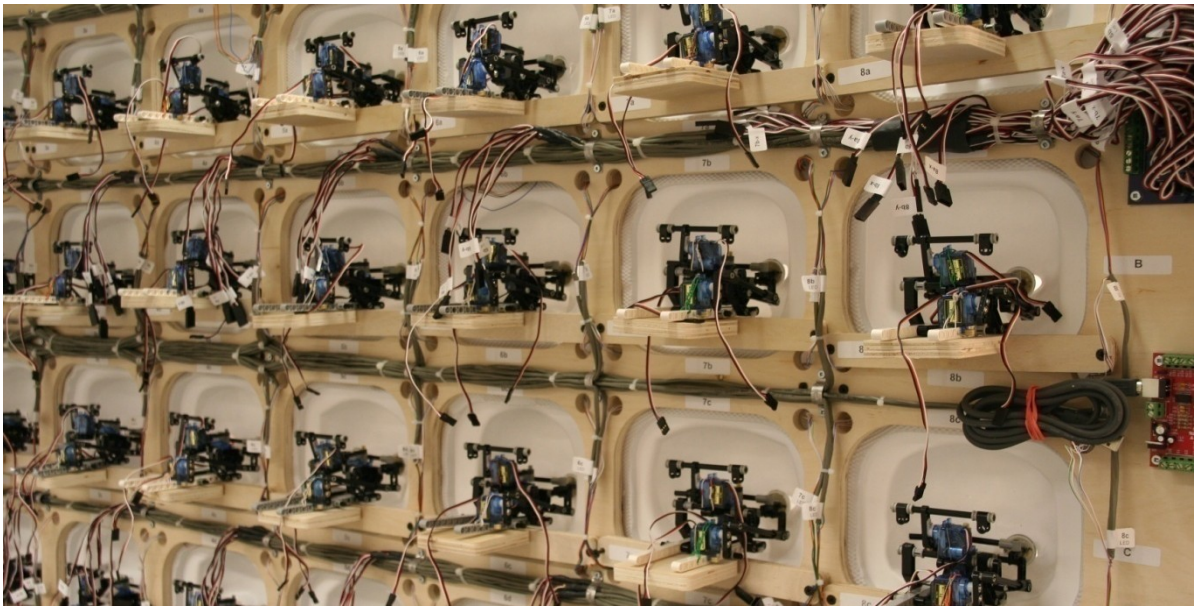

Figure 33: *Morgan Rauscher, "Zeugen", 2010 (new robotics from tech side of work – detail)*

I programmed my own face recognition and face tracking software to eliminate the limitations inherent in a single face tracking webcam. In order to accomplish this, I had to learn how to program in C++ to take advantage of the Open Frameworks open source libraries.

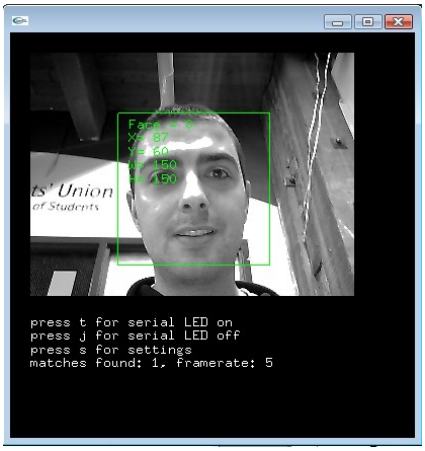

Figure 34: *: Morgan Rauscher, "Zeugen", 2010 (face tracking program)*

Figure 35: *Morgan Rauscher, "Zeugen", 2010 (face tracking program in operation on "Zeugen")*

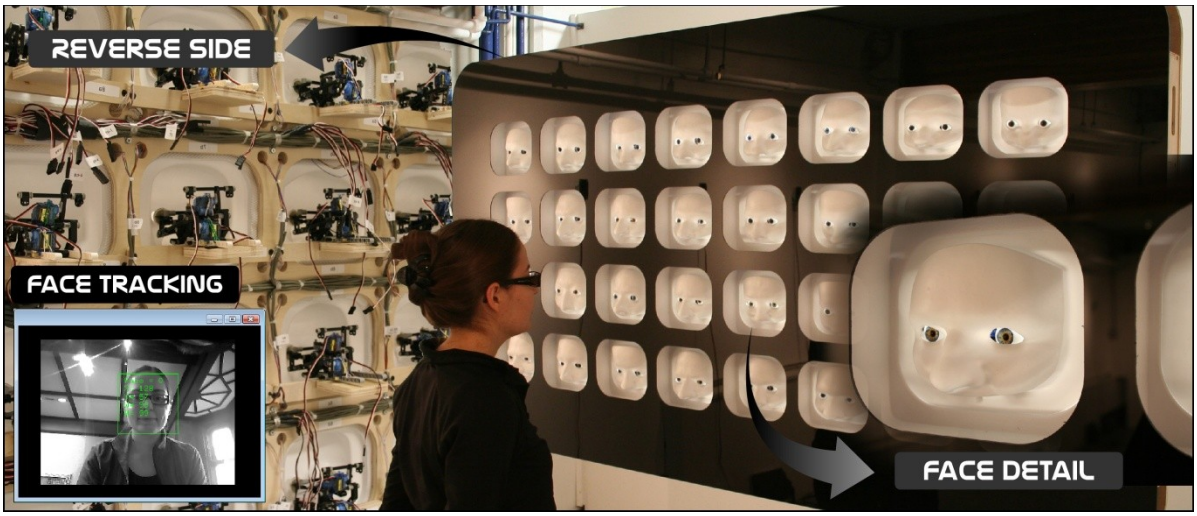

Figure 36: *Morgan Rauscher, "Zeugen", 2010 (descriptive collage of the functions of "Zeugen")*

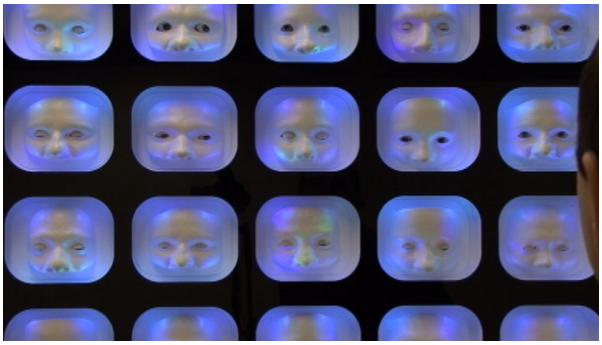

Figure 37: *Morgan Rauscher, "Zeugen", 2010 (new faces detail)*

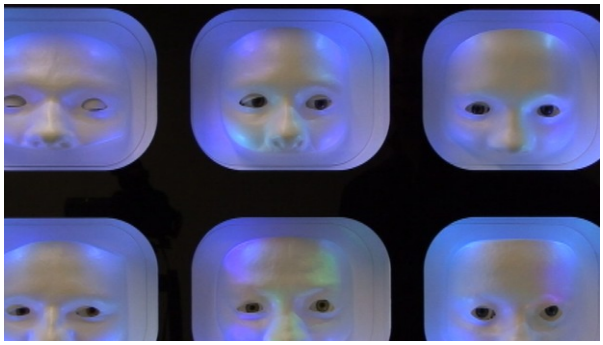

Figure 38: *Morgan Rauscher, "Zeugen", 2010 (new faces detail)*

As a testament to the success of my vision of the work and the form it took, I showed the second version of "*Zeugen*" at "E-Mixer" in the Surrey Art Gallery (Interactive Futures '09). The work was well-received by the international attendees of the conference.

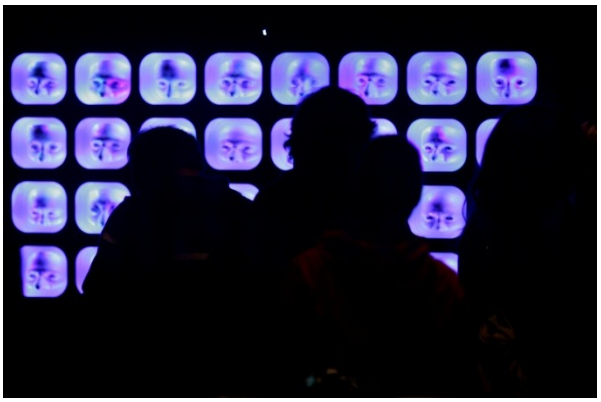

Figure 39: *Morgan Rauscher, "Zeugen", 2009 ('E-Mixer', Surrey Art Gallery [Interactive Futures '09], Surrey BC)*

Figure 40: *Morgan Rauscher, "Zeugen", 2009 ('E-Mixer', Surrey Art Gallery [Interactive Futures '09], Surrey BC)*

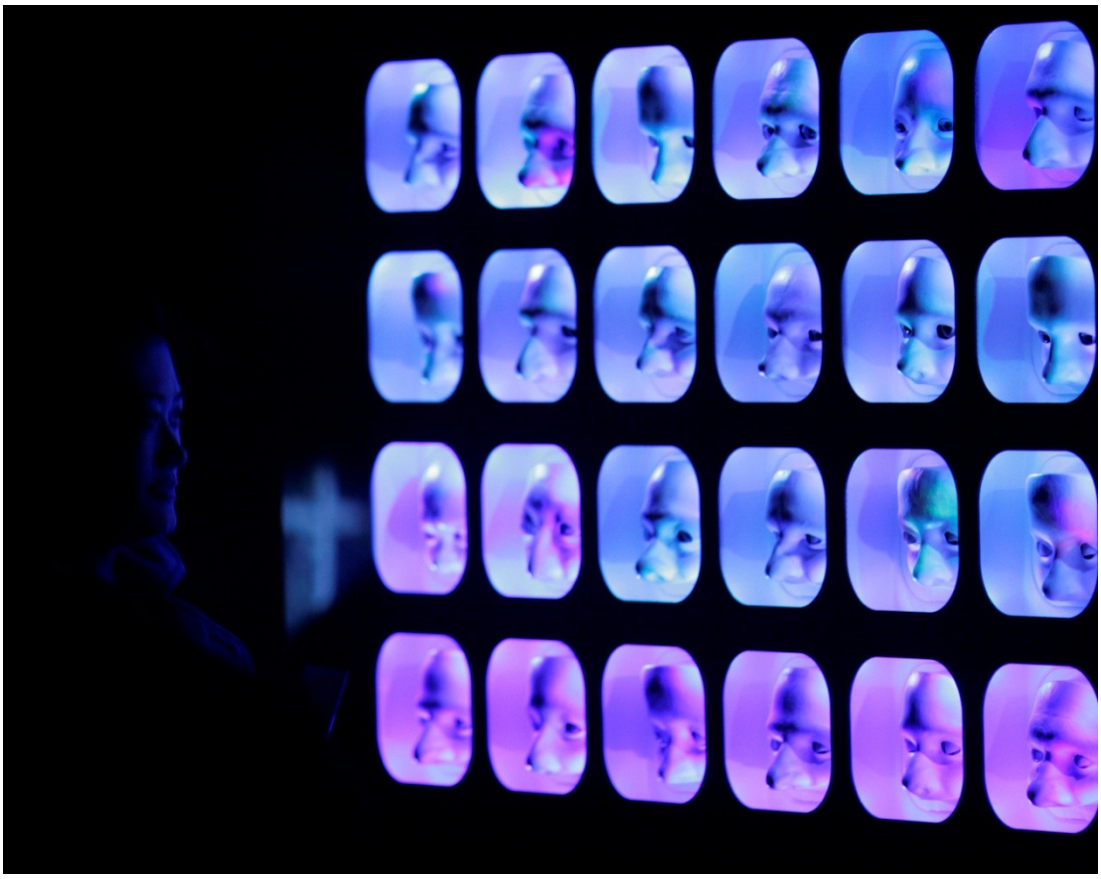

Figure 41: *Morgan Rauscher, "Zeugen", 2009 ('E-Mixer', Surrey Art Gallery [Interactive Futures '09], Surrey BC)*

Mind Mirror: Historical Context and Contributions

There have been several artists and artistic movements that have played with visual illusions and effects. I will briefly mention a few artists that have made works with similarities to "*Mind Mirror*". Each example I provide will include a work of art that explores visual phenomena related to my own interest.

Bridget Riley is well known for her work in Op Art. Her work "Cataract 3" (PVA on canvas) (Riley, 1967) causes a quasi-hallucinatory experience. The viewer is propelled into a state of illusion in which the wave forms in the work not only take on a three-dimensional appearance, but also appear to be oscillating. "Cataract 3" (Riley, 1967) utilizes optical phenomena that engage the viewer in a hyper-conscious moment. "*Mind Mirror*" is analogous to many of the Op Art works in that it generates a visual effect that can only be explained in terms of an 'event' of the mind.

It forces a separation between the brain and mind and it locks my vision in a 'hyper-real' conscious moment.

Tony Conrad, an early figure of the structural and experimental film movements, made the film "The Flicker" (Conrad, 1965). This film consists of a flickering white screen. A stroboscopic visual effect occurs at irregular intervals. Each viewer sees the film as generated by their mind's eye in a unique visual experience. However, the flickers of light in the film are not controlled. That is to say, they are not designed to achieve a specific oscillation rate and subsequent brain wave spectrum. Just as with "The Flicker" (Conrad, 1965), "*Mind Mirror*" induces stroboscopic effects. However, "*Mind Mirror*" is unique in that it is a controlled device, producing photic stimulation of alpha brain waves, thereby producing visual illusions in the mind of the viewer.

Brion Gysin was the first artist to use stroboscopic stimulation in a work of art. Together with technician Ian Sommerville, he created the "Dreammachine" (Gysin, 1961). The machine works best when the viewer has their eyes closed and faces the "Dreammachine" (Gysin, 1961). A fantastical array of hallucinatory events, including narratives, were reported by the many viewers of the work. Gysin advertised the "Dreammachine" (Gysin, 1961) as a 'drugless high' and suggested that it could one day replace the television. The "Mind Mirror" also produces visual delights, but my attempt at achieving a state of 'hyper-real' conscious reflexivity differs from Gysin's attempt at achieving a drugless high, which he claimed allowed the mind to traverse space-time.

Another contemporary artist, Kurt Hentschlager, developed the work "FEED" (Hentschlager, 2005-06). "FEED" utilizes fog and pulse lighting to immerse a group of viewers in an experience of visual disruption. The pulsating lights cause a similar visual effect as that of Gysin's "Dreammachine". Rather than being generated by an artifact, Hentschlager's "FEED" is a more encompassing, embodied experience. The viewer is disoriented because they are unable to distinguish the physical space of the gallery. However, Hentschlager does not use a stereoscopic technique, as the entire room and the fog within are illuminated at once with each flash of light. The "Dreammachine" and my "Mind Mirror" both use stroboscopic visual effects to stimulate the left and right eyes independent of each other. This technique allows for the

activation of particular brain wave frequencies, as demonstrated in the scientific research of Robert Baldwin.

Robert Baldwin took an academically-grounded approach exploring the stroboscopic photic-stimulation of the brain. (R. Baldwin, 1972, p.147-149) He outlined the schematics for a device entitled “Kinetic Light #1”, including circuit diagrams and correlating electroencephalographic data. He was able to document many effects of the stroboscopic lights on the mind of his participants. Due in part to Baldwin’s research is our current understanding of the specific mental states that correlate with the brain wave patterns.

I personally became very interested in sound and light machines when I discovered a “do-it-yourself” brain machine kit on the Make magazine website. Mitch Altman gives a tutorial about how to make your own sound and light machine using a mini-POV circuit. (Altman, 2007, p.88-100) My contribution to sound and light machine development is an augmented experience sound and light machine. The viewer is able to see both the visual dreamscape generated by photic-stimulations and at the same time is able to see the space around them. The lights do not obstruct the viewer’s vision as with traditionally designed sound and light machines. Therefore, the visual hallucination becomes an augmented hallucinatory visual experience.

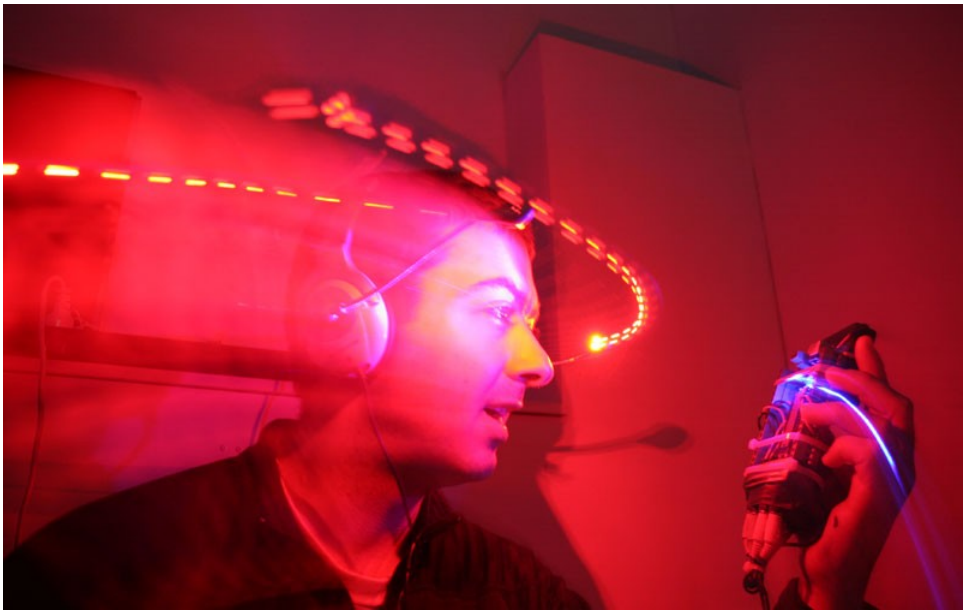

Figure 42: *Morgan Rauscher, “Mind Mirror”, 2010 (in operation)*

Mind Mirror: Creative process (methodology)

My first experience with sound and light machines was when I built the "do-it-yourself" kit that I purchased online. The kit consists of a handful of LEDs and a mini-POV (persistence of vision) microcontroller. I built the kit, which involves positioning one LED in front of each eye. The oscillation differential between the flickering LEDs generates the necessary stroboscopic visual effect. The mini-POV microcontroller also hooks up to a pair of headphones to generate stereoscopic sound. The pulsations of sound oscillate at the same frequency differential as the LED lights.

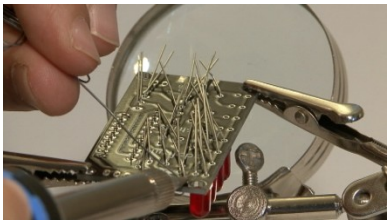

Figure 43: *Morgan Rauscher, "Mind Mirror", 2010 (process image: Mini-POV circuit assembly)*

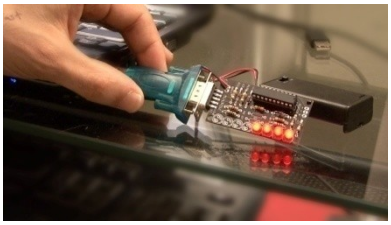

Figure 44: *Morgan Rauscher, "Mind Mirror", 2010 (process image: Mini-POV hardware programming)*

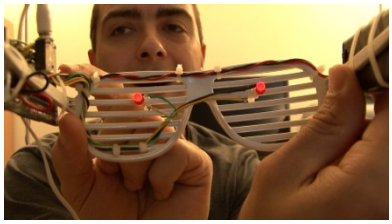

Figure 45: *Morgan Rauscher, "Mind Mirror", 2010 (process image: Mini-POV glasses project testing)*

My first adaptation to the "do-it-yourself" sound and light machine was to install the LEDs in translucent frames. As a result, I could experience the photic-stimulations with my eyes open. I had developed a vehicle for augmented visual stroboscopic hallucinations.

Figure 46: *Morgan Rauscher, "Mind Mirror", 2010 (process image: "Mind Mirror" assembly)*

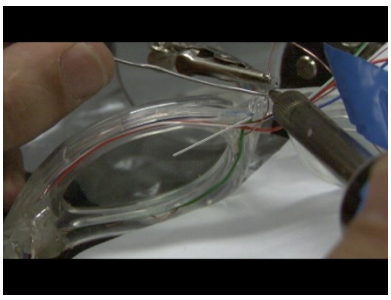

Figure 47: *Morgan Rauscher, "Mind Mirror", 2010 (process image: circuit building)*

Figure 48: *Morgan Rauscher, "Mind Mirror", 2010 (process image: testing)*

Figure 49: *Morgan Rauscher, "Mind Glasses", 2010 (at the Café for Contemporary Art in North Vancouver, BC, during 'Live Common Ground')*

I then showed "*Mind Mirror*" at both the Café for Contemporary Art in North Vancouver and the Concourse Gallery at ECU. I learned from the viewers of "*Mind Mirror*" that the device was cumbersome. There was also a problem in the size of the glasses. In order to accommodate the broadest possible spectrum of users, and allow for variation in the experience, I re-designed the "*Mind Mirror*" to have flexible wire extensions outfitted with LED lights.

Figure 50: *Morgan Rauscher, "Mind Mirror", 2010*

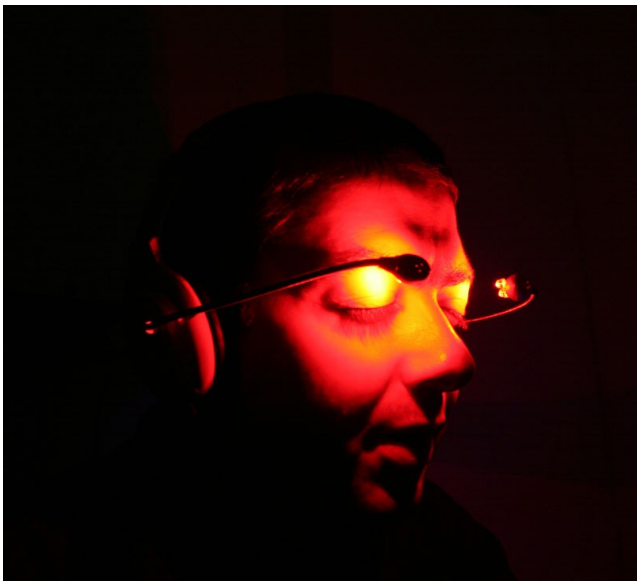

Figure 51: *Morgan Rauscher, "Mind Mirror", 2010*

Conclusions

I have learned a great deal on this creative journey towards understanding vision. I have learned that there are many more questions than answers and that the sensations of sight have enormous potential in new media visual art practice. Seeing is not a linear, mechanical event with a well-defined beginning at the eyes and the complete meaning of what I see somewhere in my brain. Seeing and being seen are part of the same continuous and flowing experience.

I have learned that seeing and being seen reach a junction at reflexivity. I have also learned that the eyes are merely a gateway to sensations of the mind. Using perceptual prosthetics such as "*Zeugen*" and "*Mind Mirror*", I have learned about myself in a way that cannot be easily described.

I now understand that by using stereoscopic and stroboscopic audiovisual media, an undefined event unfolds in the mind. However, I envision a time when we are able to understand these relationships from a more detailed perspective allowing me to have more control over the visual sensation. I foresee a time when we can transmit information from mind to mind, not in the form of text or images, or even ideas, but in pure, unadulterated sensation.

Bibliography / References Cited

Altman, M. (2007). Sound & Light Machine Firmware Documentation. *MAKE Magazine, 10,* 88-100.

Arduino. (2009). from http://www.arduino.cc/

Ashley, D. (2008). Las Meninas. Retrieved November 15, 2009, from http://uwacadweb.uwyo.edu/Ashleywy/las_meninas.htm

Baldwin, R. (1972). Kinetic Art: On Producing Illusions by Photic-Stimulation of Alpha Brain Waves with Flashing Lights. *Leonardo (Pergamon Press), 5*(2), 147-149.

Baldwin, R. (1972). On Producing Illusions by Photic-Stimulation of Alpha Brain Waves with Flashing Lights. *Leonardo, 5*(2), 147-149.

Boahen, K. (Writer) (2008). Making a computer that works like the brain. In TEDTalks (Producer), *TED*. USA: TED.

Brockelman, P. (1985). *Time and Self: Phenomenological Explorations*. New York: The Crossroad Publishing Company.

Burnett, R. (2004). *How Images Think*. Cambridge, Massachusetts: The MIT Press.

Burnett, R. (2008-2009). Dr. Ron Burnett in Thesis Meetings with Morgan Rauscher. Vancouver Morgan Rauscher.

Cohen, I. S. a. J. (1997). *Fragments or Reality: The evolution of the curious mind*. Cambridge: Cambridge University Press.

Conrad, T. (Writer) (1965). The Flicker. United States.

Deleuze, G. (1994). *Difference and Repetition* (P. Patton, Trans.). New York: Columbia University Press.

Feibleman, J. K. (1958). *Inside the Great Mirror*. The Hague (Netherlands): Martinus Nijhoff.

Foucault, M. (1967). Des Espace Autres. France.

Foucault, M. (1970). *The Order of Things: An Archaeology of the Human Sciences*. New York: Vintage Books.

Freud, S. (2005). *The Unconscious* (G. Frankland, Trans. 106 ed.). London: Penguin Books.

Gasche, R. (1986). *The Tain of the Mirror: Derrida and the Philosophy of Reflection*. Cambridge, Massachusetts and London, England: Harvard University Press.

Gysin, B. (Artist). (1961). *Dreammachine*

Hentschlager, K. (Artist). (2005-06). *FEED*

Hine, E. M. a. R. (Ed.) (2008) A Dictionary of Biology (6 ed., Vols. Oxford Reference Online). Oxford: Oxford University Press.

Levin, G., & Baltus, G. (Artist). (2007). *Opto-Isolator*

Levine, S. Z. (1994). From Self-Infatuation to Self-Reflection. In *Monet, Narcissus, and Self-Reflection* (pp. 15-24). Chicago and London: The University of Chicago Press.

Magritte, R. (Artist). (1928–1929). *La trahison des images (The Treachery of Images)*

Murphie, A. (2001). Putting the Virtual Back into VR In B. Massumi (Ed.), *A Shock to Thought: Expressions After Deleuze and Guattari* (pp. 197). London: Routledge.

Parsons, C. (2009). Code-Bodies and Algorithmic Voyeurism. Retrieved December 1, 2009, from http://www.christopher-parsons.com/Academic/Code_Bodies_and_Algorithmic_Voyeurism(for_web).pdf

Ragland-Sullivan, E. (1986). *Jacques Lacan and the philosophy of psychoanalysis*. Kent: Croom Helm Ltd.

Rescher, N. (2005). *Cognitive Harmony: The role of systemic harmony in the constitution of knowledge*. Pittsburgh The University of Pittsburgh Press.

Riley, B. (Artist). (1967). *Cataract 3* [PVA on canvas].

Rokeby, D. (Artist). (1995). *Watch*

Rokeby, D. (Artist). (2000). *Watched and Measured*

Rose, D. (2006). *Consciousness: Philosophical, Psychological and Neural Theories*. New York: Oxford University Press.
Rozin, D. (Artist). (1999). *The Wooden Mirror*
Rush, M. (1999). *New Media in Late 20th Century Art*. London: Thames and Hudson.
Sester, M. (Artist). (2006). *Access*
Sheldrake, R. (2003). *The Sense of Being Stared At: and Other Aspects of the Extended Mind*. New York, NY: Crown Publishers.
Sheldrake, R. (2005). The Sense of Being Stared At - Part 1: Is it Real or Illusory? . *Journal of Consciousness Studies, 12*(6), 10-31.
Tesla, N. (2007). *My Inventions: The Autobiography of Nikola Tesla*: Cosimo, Inc.
Turim, M. (1980). The Place of Visual Illutions. In T. d. L. a. S. Heath (Ed.), *The Cinematic Apparatus* (pp. 143). New York: St. Martin's Press.
Velazquez, D. (Artist). (1656). *Las Meninas*
Werness, H. B. (1999). *The Symbolism of Mirrors In Art From Ancient Times To The Present*. Lewiston - Queenston - Lampeter: The Edwin Mellen Press.
Whiten, T. (1941). *Tim Whiten: messages from the light*. Toronto: The Koffler Gallery.
Yellott, J. (2004). Jack Yellott's Dates: Visual Science Before 1600. Retrieved October 12, 2010, from http://www.cogsci.uci.edu/vision/yellott_1600.html

Appendix 1: MondoMatrix

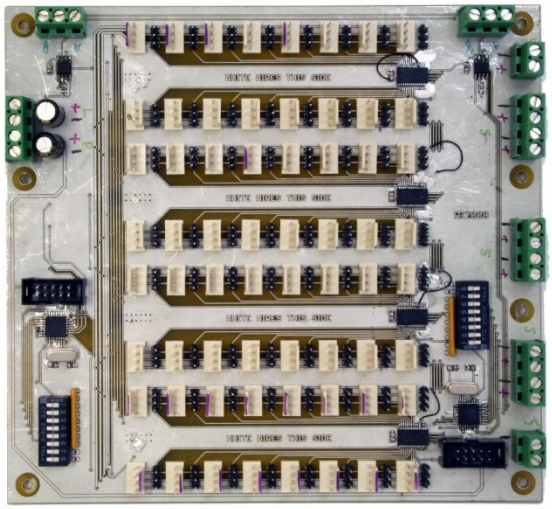

Figure 52: *Morgan Rauscher, "Zeugen", 2009 (front side of custom electronics PCB)*

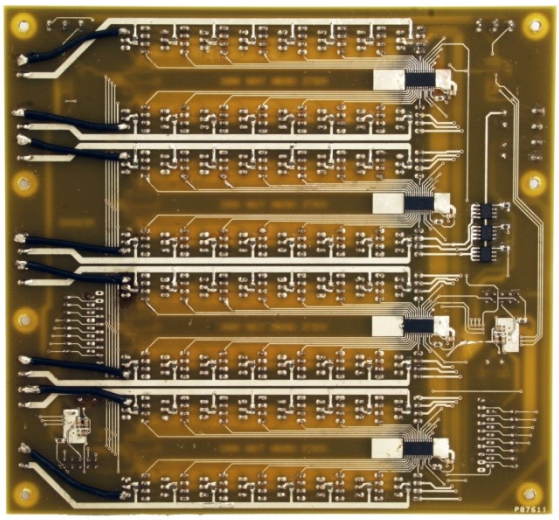

Figure 53: *Morgan Rauscher, "Zeugen", 2009 (back side of custom electronics PCB)*

Creative electronics are an essential tool for interactivity in the contemporary arts. They allow artists to use inputs (sensors, switches, etc.) and outputs (lights, motors, etc.) to make art that moves, illuminates, and interacts. The combination of creative electronics and computers makes advanced interactive art projects possible. A wide range of artists and designers use interactive electronics to develop wearable computing, creative displays, and immersive media installations. However, there are limitations in available creative electronics hardware that restrict the potential of the available software. The bottleneck in the creative electronics industry is currently due to hardware limitations. New interactive electronic artists and artwork are constantly emerging and new tools must be developed to support the sustained growth of the creative electronics community.

One of the most popular microcontroller and programming environments for artists is Arduino. "Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments" (Arduino, 2009). Arduino is widely adopted by creative electronics artists. It can also be interfaced with a computer for even more powerful

programming options. However, limitations in the Arduino hardware prevent Arduino projects from reaching larger scales.

The main limitation of Arduino is that it can only control a small number of elements. The basic Arduino board, the Duemilanove, can control fourteen digital input and output (I/O) pins and six analog I/O pins. Arduino had already recognized these limitations and has been expanding the Arduino hardware. For example, Arduino released the Arduino Mega with fifty-four digital I/O pins and sixteen analog pins to provide more options for Arduino users. These Arduino expansions were made possible by the increased capacity of the microcontroller (chip) that Arduino uses. Even if the Atmel ATmega chips were to improve dramatically there would still be an essential limitation in the number of possible I/O pins from the Arduino hardware device. Thus, the Arduino cannot provide the scalability and control required to realize my designs.

With this problem in mind, in partnership with Randy Glenn (founder of Surreality Labs in Toronto), I co-creatively developed a new microcontroller that radically expands the Arduino platform. The project began in the summer of 2009, and the goal was to utilize the power and flexibility of the Arduino Programming Language but expand the Arduino hardware platform. The project was given the name 'Displayduino' to commemorate the project's focus on interactive 'visual' and installation art (also acknowledging Arduino with 'duino'). The challenge was to produce a microcontroller that can utilize the already popular Arduino but increase the control that the Arduino hardware provides.

The Displayduino is available to the international community of electronic artists online under the GPL Open Source license. A technical contributions blog, extensive information, and community support website can be found at http://www.mondomatrix.com. In addition to Displayduino, we have developed 'daughter' or 'sub' boards for controlling servo motors, LED lights, and any other electronic device operating from 0 to 12 volts. These boards can be 'daisy chained' or networked (via RS485). In pursuit of my own creative electronics projects and as an extension to my thesis research, Displayduino is a tool that artists can use to develop similar creative experiments.

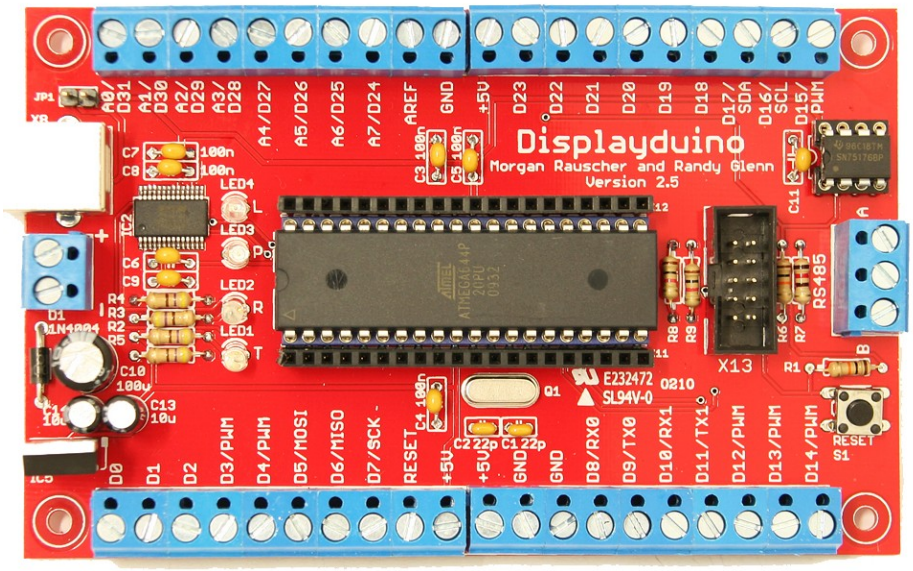

Figure 54: *Morgan Rauscher and Randy Glenn, "Displayduino", 2009*

The Displayduino microcontroller connected to an array of expansion boards can control thousands of LEDs, servos, and other electronics devices. The Displayduino project expands the Arduino output capacity from under 100 connections to thousands. Additionally, because the Displayduino technology is modular, individual projects can expand or only use the thirty-one digital and seven analog I/Os pins that come standard on the Displayduino controller. If the artist wants a larger project, they simply need to add more Displayduino expansion boards. The most notable achievement of the Displayduino project is the power of modular expansion to the current Arduino platform. This gives creative electronics artists the power to scale their projects up or down using only one Displayduino microcontroller and the already popular Arduino Programming Language.

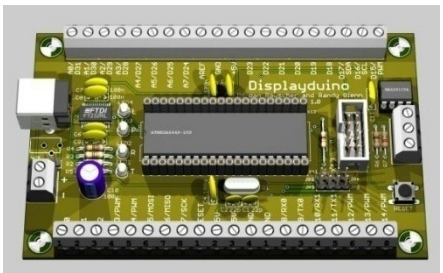

Figure 55: *Morgan Rauscher and Randy Glenn, "Displayduinon", 2009 (3D rendering)*

Figure 56: *Morgan Rauscher and Randy Glenn, "ServoMatrix", 2009 (3D rendering)*

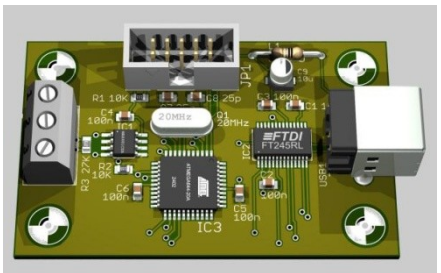

Figure 57: *Morgan Rauscher, "Displayduinon", 2009 (USB to RS485 3D test rendering)*

A lengthy design process was encountered at various stages in the development of Displayduino. Several virtual prototypes were generated to determine the feasibility and functionality of the new controller. In addition to designing the Displayduino microcontroller, three expansion boards were designed and built. Displayduino expansion boards use information that is send over the RS485 network to facilitate modular project expansions. The Displayduino expansion boards designed were ServoMatrix, LEDMatrix, and PowerMatrix.

Displayduino controllers and expansion boards also come with screw terminals allowing for the re-use of the boards in several projects, thereby limiting soldering and facilitating rapid prototyping applications.

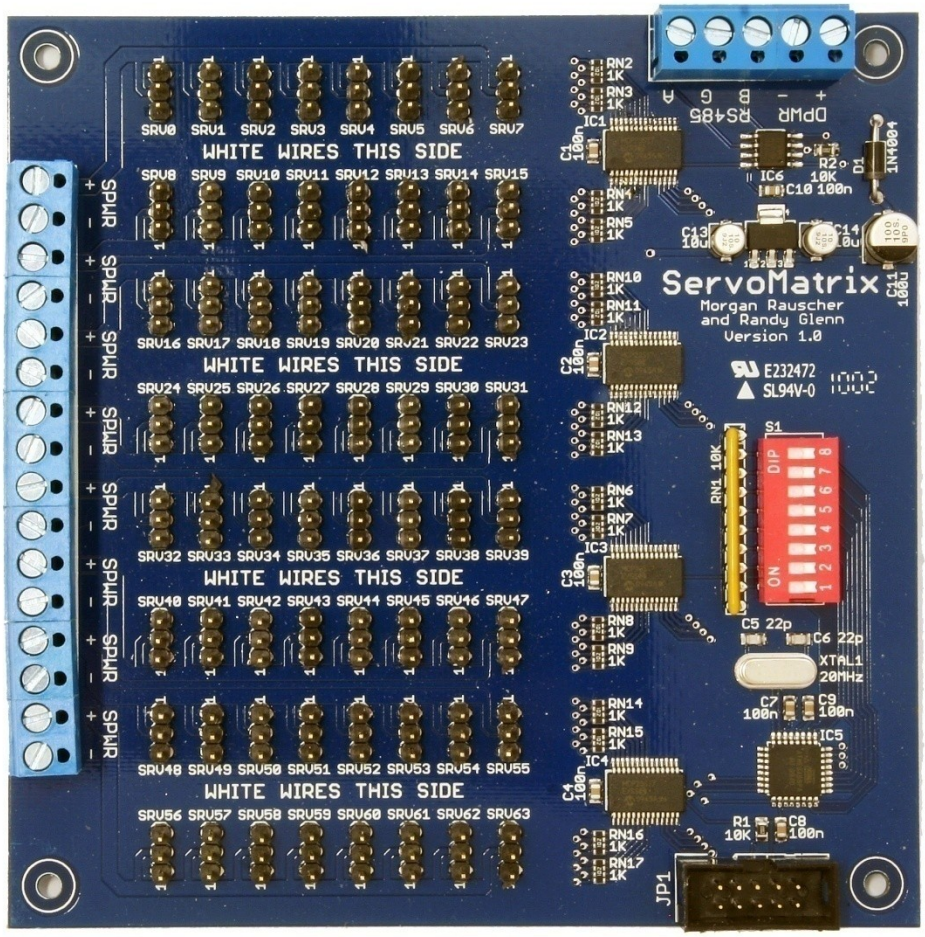

Figure 58: *Morgan Rauscher and Randy Glenn, "ServoMatrix", 2009*

ServoMatrix is a Displayduino expansion board that can independently control sixty-four servos. The servos and ServoMatrix are powered by two different sources, which allows for separate power supplies to the board and to the servos. The benefits of this design approach are power

safety, component protection, and versatility. Each row of eight servos can be independently powered. The result is that each ServoMatrix expansion board can have eight different types of servos running at the same time. If a given project requires multiple ServoMatrix boards, the Displayduino controller can manage up to 64 boards in a row. Therefore, one Displayduino microcontroller can manage thousands of servos. Using multiple Displayduino controllers and software array techniques, this number is only limited by the amount of electrical power that is available. In contrast to the Displayduino hardware, using current Arduino hardware, only a small number of servos can be safely operated.

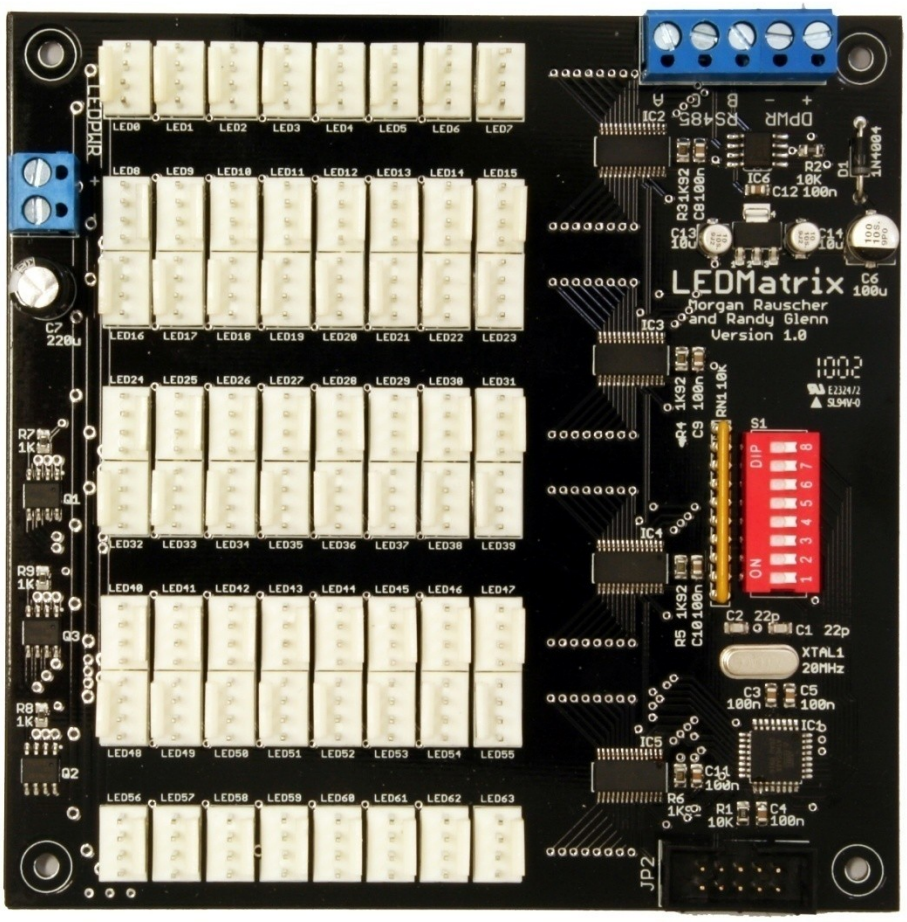

Figure 59: *Morgan Rauscher and Randy Glenn, "LEDMatrix", 2009*

LEDMatrix is another Displayduino expansion board that was developed in the summer of 2009. LEDMatrix can control sixty-four tri-color frequency modulated light emitting diodes (LEDs). LEDMatrix controls red, green and blue (RGB) LEDs and can create full color effects and displays. Just as with the ServoMatrix, LEDMatrix has separate power ports for the LEDs and the LEDMatrix controller. This design element protects both the LEDMatrix board and the LEDs

from power surges and short circuits. Large full color pixels can be outputted from the LEDMatrix to create scalable color displays and objects. The LEDMatrix was specifically designed to assist artists and designers creating projects using full color LED effects.

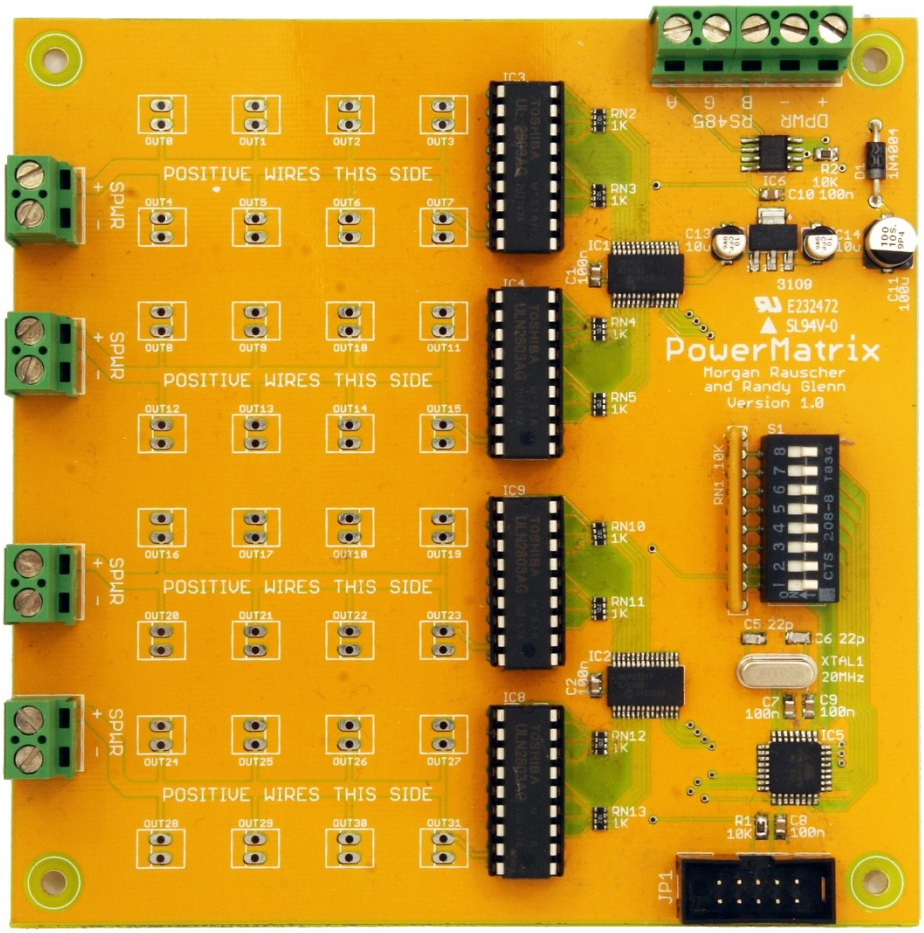

Figure 60: *Morgan Rauscher and Randy Glenn, "PowerMatrix", 2009*

The PowerMatrix was the third expansion board designed (2009). The board is capable of controlling 32 'power ports' that can deliver a range of voltage. The controller is able to control any 32 electrical devices that use a range of 0 to 12 V of power. The PowerMatrix truly embodies the goal of the Displayduino project because it expands the Arduino hardware technology to electronic devices of all kinds (of a potentially unlimited number).

There is no question that Arduino is one the most successful creative electronics platforms currently in use. In order to specifically cater to the art and design community and expand on the success of Arduino, Displayduino was born. It is the long term goal of the Displayduino

project to continue to provide expandability to the Arduino platform and offer new avenues of creative electronics exploration.