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Stretched Skulls: Anamorphic Games and the *memento mortem mortis*

Stephanie Boluk <stboluk_at_vassar_dot_edu>, Vassar College
Patrick LeMieux <patrick_dot_lemieux_at_duke_dot_edu>, Duke University

Abstract

From Hans Holbein's *The Ambassadors* to Robert Lazzarini's *skulls*, anamorphic artworks explore the tension between mathematical models of vision and an embodied experience of space. After reviewing the ways in which anamorphosis has been deployed as a philosophical tool for investigating digital media in terms of human phenomenology, specifically through the criticism of Espen Aarseth and Mark Hansen, this paper analyzes how contemporary videogames like Sony's *Echochrome* series, *levelHead* by Julian Oliver, and Mark ten Bosch's forthcoming *Miegakure* technically, aesthetically, and conceptually explore anamorphic techniques. While *The Ambassadors* is famous for its anamorphically skewed skull, a classic *memento mori*, we propose that the anamorphic effects of videogames can be more accurately described as a *memento mortem mortis*: not reminders of human mortality, but of a nonhuman the death of death. By foregrounding the impossibility of ever fully resolving the human experience of computational space, the *memento mortem mortis* in these "anamorphic games" gestures toward experiential domains altogether indifferent to human phenomenology to create allegories of the beyond.

Introduction

The Myth of Mimesis

Figure 1. *The Origin of Painting: Dibutades Tracing the Portrait of a Shepherd* (1785), by Jean-Baptiste Regnault.

In *Naturalis Historia* (c. AD 77-79), Pliny the Elder recounts two myths of mimesis. In one, the daughter of the Corinthian sculptor Butades, saddened by the imminent departure of her lover, traces the outline of his shadow as it is cast on a wall (see Figure 1) [Pliny, Bk 35, Ch 43]. Inspired by this image, Butades presses clay over the drawing to sculpt a relief

portrait based on the silhouette. This myth, which binds drawing and sculpting, does not celebrate the originality or expressivity of the artist's hand but instead focuses on the possibility of an indexical relationship between light, sight, and representation: an ancient camera activated by the hand of Butades' daughter. Elsewhere in his *Naturalis Historia*, Pliny recites another well-known myth featuring the painters Zeuxis and Parrhasius who compete to determine the most talented artist [Pliny, Bk 35, Ch 43]. In the story, Zeuxis paints grapes that look so natural birds fly down to peck at them, but Parrhasius wins the competition by painting curtains that deceive even Zeuxis who attempts to draw them aside to reveal his competitor's artwork. Like the crows clamoring for figurative fruit, Zeuxis had been tricked by Parrhasius' *trompe l'oeil*. The desire for mimetic representation has fueled the invention of perspectival technologies from Butades' lovelorn daughter tracing shadows on a wall to Renaissance-era drawing machines tracing light through panes of glass to contemporary ray tracing, an algorithm for rendering photorealistic computer graphics (see Figure 2). What unites these mathematical methods of simulating light is their obligatory and often unexamined process of reducing the human body to a cycloptic camera lens, an abstract optic perfectly positioned to decode perspectival data.

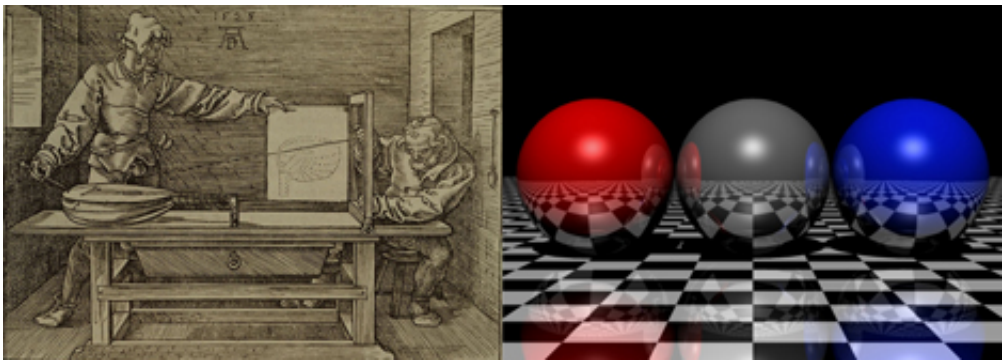

Figure 2. *Man Drawing a Lute* (1525) by Albrecht Dürer and a typical example of ray tracing

But imagine if the sun had begun to set on Butades' daughter, transforming her lover's silhouette into a monstrous grotesque? Or if Zeuxis had approached Parrhasius' painted curtains from an oblique angle, disrupting the two-dimensional illusion of depth? What if Albrecht Dürer's glass "veil" had been bumped askew or the algorithms responsible for rendering computer-generated imagery were not calibrated properly? Do these subtle shifts in view or vantage point radically alter the human perception of perspectival images or is optical distortion actually a precondition for mimetic representation? Pliny's myths of mimesis remain myths because they continue to express the desire for a technological correlate to human sight — a technology capable of rendering a painted, projected, or backlit screen into a transparent, immaterial, or immediate window.[1] The fantasy of immediacy stubbornly ignores both the material support of an image and the embodied response of a viewer, reinforcing the notion of a lossless transmission between an abstract set of Cartesian coordinates and an equally abstract Cartesian mind. In contrast, this essay treats anamorphosis as the rule governing vision rather than the exception to "normal" sight. We argue that there is no central, authoritative, or natural way of seeing despite the way optical technologies simulate the effects of light on the human eye. Even after the centuries-long construction of the modern viewing subject, the most naturalistic representational technologies still suppress a strange supplement. Whether one is examining early painting or traversing the polygonal environments of a virtual world, an anamorphic remainder looms in the interstices between technics, optics, and human perception. 2

The possibilities and problems of perspectival rendering have been inherited by the computer graphics industry, a field of research whose design goals and business models are deeply wedded to the history of mimetic technologies. Despite the fact that there are only a finite number of unique polygons, pixels, and processes perceptible to the human eye, the videogame industry, for example, continues to invest in higher and higher visual fidelity. As graphics guru and co-founder of id Software John Carmack noted at the 2011 Electronic Entertainment Expo (E3), rendering technologies are "converging at the limits of our biological systems" [McCormick 2011]. With graphics approaching the threshold of human perception, an increasing number of computer games are beginning to experiment with alternative spatial, temporal, and optical regimes indigenous to digital environments. Much like the restrained naturalism of Renaissance 3

perspectival rendering led to a more self-conscious and reflexive Mannerist period of visual art, so have the nascent discourses surrounding computer generated imagery and videogaming begun to internalize and amplify the codes of perspective to produce what we call “anamorphic games.” Anamorphic games overtly dramatize the relationship between sight and simulation, vision and virtual reality and begin to rethink what it means to play with perspective.

4 This paper begins with a review of how anamorphosis has been treated as a philosophical tool for exploring the relationship between phenomenology and technology. From Hans Holbein the Younger’s *The Ambassadors* (1533) to Robert Lazzarini’s *skulls* (2001), anamorphic artworks mediate the tension between mathematical models of vision that reduce sight to a single, abstract locus and more fully embodied modes of perception. This tension is made patent in the 3D modeling and real-time graphic processing of computers. Extending the arguments of media theorists Espen Aarseth and Mark Hansen, we analyze how anamorphosis functions in contemporary videogames. Games like Sony’s *Echochrome* series (2008-10), *levelHead* (2007) by Julian Oliver, and Mark ten Bosch’s *Miegakure* (forthcoming) feature anamorphic techniques that mark the dissonant registers of time and space produced between human biology and digital media. By perturbing vision in order to problematize the relation between body and code, anamorphic games produce what we call the memento mortem mortis: a reminder of the limits of human phenomenology and a tacit acknowledgment of the desire to think the unthinkable and play in the spaces that exceed the boundaries of perception.

Memento Mortem Mortis

5 Anamorphosis is a perspectival rendering technique popularized during the Renaissance that results in a strangely stretched, but geometrically viable image. When attempting to “decode” the distortions applied to a given anamorphic artwork, an onlooker must either assume an oblique viewing angle in relation to a foreshortened image or reflect a catoptrically warped image through a corresponding conic or cylindrical mirror. In 1927, Erwin Panofsky famously characterized traditional perspective as a “symbolic form” loaded with the Western ontology of the stable, fixed, and unified Cartesian subject [Panofsky 1996]. Anamorphosis, on the other hand, is regarded as a marginal visual technique, a *trompe l’oeil* that operates according to a different cultural logic, covertly applying pressure to the universality of classical perspective and all its ideological assumptions. But imagine if these assumptions were somehow reversed. Does not perspectival rendering, despite its cultural ubiquity and long history of perceptual conditioning, also require decoding? Is it even possible to see a perfect, perspectival image without minor distortions of eye, angle, and atmosphere intervening? Though ease of rendering and conventions of human sight privilege this particular, historically contingent instance of mimesis, what if every perspectival image is actually anamorphic? What if anamorphosis was not only considered a means of encoding secrets in images, but was itself the secret that lies at the heart of all images?

6 Traditionally, perspectival rendering assumes that the position of the viewer is directly in front of and oriented toward the “picture plane,” a geometric field that typically coincides with the material surface of an image. Conflating the picture plane with the angle and dimension of a canvas, for example, allows geometric projections representing light vectors to intersect with an unambiguous, material support (i.e., the surface of a canvas). This conflation of mathematics and materiality removes the need for difficult, higher level modeling and simplifies the rendering process considerably. The geometry of anamorphic images, however, requires nonstandard viewing angles by intentionally foreshortening the picture plane and decoupling it from the physical geometry of the painting, panel, page, or screen. As an experimental and unconventional technique that produces coded, mannered, and seemingly non-natural imagery, anamorphosis is often regarded as a curiosity, an occasional virtuosic supplement to the catalogue of classical perspective throughout the history of art. But if one acknowledges the fact that any historical coincidence of the imaginary picture plane and the material surface of a painting is merely one particular case within a much larger field of possibility, anamorphosis can be re-thought as the rule, rather than the exception to perspectival image-making.

7 From the covers of book jackets to the commercials on television to first-person videogames, contemporary visual culture is dominated by perspectival modes of representation. It is easy to forget that mimetic images, no matter how naturalistic, require a cognitive leap in order to “resolve” the relationship between a mathematical system of rendering and embodied vision. By explicitly denying the “correct” viewing position in front of a canvas, anamorphosis forecloses the possibility of ever resolving the human gaze to the geometric parameters of an image. Anamorphic technique

foregrounds the biological complexity of binocular vision, the angle of approach, height of the viewer, surface deformations in a medium, and even the atmosphere through which light passes. These anamorphic conditions undergird human perception and demonstrate that classical perspective — what has been culturally coded as natural — remains a constructed, mathematical method of simulating light rather than a practical model of sight. Despite the popular desire for transparent, immediate experiences of media, traditional perspective is impossible to fully realize for viewer and painter alike. Whether standing in front of a painting or grasping a controller, embodied vision is not properly perspectival but *actually anamorphic*, constantly modulated by haptic encounters with the material environment.

8 The quintessential example of anamorphosis is Hans Holbein's *The Ambassadors*, a large and meticulously rendered oil painting featuring a strange, anamorphic "smear" across the bottom of the otherwise typical portrait of two sixteenth-century European diplomats (see Figure 3). The men stand costumed and well lit in a carefully proportioned, perspectival space, each with an elbow resting on the foreshortened table. The painting displays a menagerie of symbolic details denoting worldly opulence including fine clothing and foreign textiles, a lute with a book of open sheet music, two globes, and various instruments for navigation and cartography: instruments of rationalism that will help provide the "correct" perspective for mapping the New World. Yet, if the viewer examines the painting from an unorthodox position below and to the right of the standard viewing angle, the smear congeals into a grinning skull: a subliminal *memento mori* hidden in plain sight.[2]

Figure 3. Hans Holbein's *The Ambassadors* and a detail of the "resolved" anamorphic skull.

9 While the inclusion of subtle reminders of mortality like skulls, time pieces, wilting flowers, or rotting fruit were common among portraits and still lifes produced in medieval and Renaissance Europe, Holbein's *memento mori* is particularly unsettling given its uncanny manifestation through the technique of anamorphic foreshortening.[3] The anamorphic skull is powerful not because it looks like a skull, but precisely because it does *not* look like a skull. Consider the possibility that this "not-skull" might reveal nothing to the viewer but paint. A sixteenth century audience, for example, might have missed the skull entirely, only subliminally apprehending a death's-head upon one last, over-the-shoulder glance from the bottom of a stairwell or threshold of an exit. Though it has the potential to trick the eye, this smear of abject materiality exists within its own ontological (and more specifically mathematical) register and casts an anamorphic doubt back into the previously-perspectival world of the two diplomats. Working with the established cultural tradition of the *memento mori*, the artist summons notions of death's alterity as a metaphor for the ultimate strangeness of both the materiality of paint and the mathematics of perspective. This fleeting glimpse of a death's head reminds the viewer not of their eventual expiration, but of the (perhaps more unsettling) fact that there exist objects and affects that exceed not only perspectival rendering but human experience all together. The anamorphic skull suggests a world of nonhuman technics that not only lies beyond the limitations of the human body, but is also completely disinterested in the affairs of man and the vagaries of life and death.

10 In this respect, it may be more accurate to use the term *memento mortem mortis* than *memento mori*. The *memento*

mortem mortis transforms the human-centered “remembrance of death” into the nonhuman “remembrance of the death of death” — the realization that one day even death will die and despite the impossibility of ever experiencing a world devoid of life, the *memento mortem mortis* invites the viewer to speculate on the radically attenuated phenomenology and starkly materialist conditions of such a world. Where the *memento mori* mobilizes representations of death to challenge human vanity, the *memento mortem mortis* extends this critique beyond morbid anthropocentrisms by summoning not the representations of human death, but the nonhuman processes of technical objects. The result is not the humbling acknowledgement of some thanatological equalizer between all human life, but a call toward philosophical speculation. In this way, the painterly materiality of the anamorphic skull exposes a notion of cosmic indifference that is vaster, more alien, and more terrifying than the anthropocentric concerns of life and death represented through a *memento mori*. Throughout the history of painting, the skull, like other depictions of human detritus, has been used to signal human mortality. By stretching these skeletal remains across a separate, foreshortened picture plane that refuses to cohere with the geometry of the painted scene, the *memento mori* opens up the yawning abyss of the *memento mortem mortis*.

11 This paper proposes anamorphosis — and those technologies that directly frame their nonhuman components in relation to human phenomenology — as one example of a *memento mortem mortis*. In anamorphic images, the subject and object never completely resolve for one another, and there remains an incommensurable gap as reflected in Holbein’s painting. In this sense, the human and the skull can never see eye to eye, and *The Ambassadors* functions as an allegory for de-anthropomorphized materiality in the idiom of early-modern painting. Hubert Damisch has argued that mathematical perspective was the dominant mode of image-making in the twentieth century (far more than in previous eras prior to the development of mechanical forms of image inscription such as photography, film, and video [Damisch 1995, 28]). Yet these chemical, mechanical, and digital forms of perspectival rendering can still each be regarded as different cases of anamorphosis. All images are anamorphic in so far as they apply the rules of perspectival projection to an ontologically arbitrary and anthropocentric picture plane. The coincidence of the picture plane and material surface of the image is popular because of the convenience of calculating only one projection, rather than the multiple abstractions necessary for anamorphic rendering. Despite the fact that all paintings could be considered anamorphic under this definition, only some, like *The Ambassadors*, form a *memento mortem mortis* by explicitly questioning the necessary relation between the human body, an image’s material support, and the abstract geometries of the perspectival picture plane.

Part 1: Anamorphosis and Media Theory

Ergodic Resolution

12 For theorists such as Espen Aarseth and Mark Hansen, anamorphosis functions as a paradigm for understanding digital media. Whereas Aarseth appropriates anamorphosis to examine what he calls “ergodic literature” and operates from the common assumption that anamorphic images necessarily posit a privileged perspective from which to faithfully reconstruct an image, Hansen embraces anamorphic technique as a model for those aspects of digital media that fail to visually resolve and produce bodily discomfort because of the formal incongruity between inhabitable, haptic space and digital media. We will begin by problematizing Aarseth’s theory of ergodic literature through a close reading of *skulls*, a “digital born” sculpture by Robert Lazzarini in the tradition of *The Ambassadors*. *Skulls* is featured in Hansen’s writing on the “digital any-space-whatever,” a term he uses to describe the embodied, proprioceptive sensation produced in response to the disjunct ontological registers of digital media. The affective apprehension of the digital any-space-whatever parallels the speculative gesture of the *memento mortem mortis*. After gaining an understanding of the anamorphic qualities of digital media, this essay turns toward three anamorphic videogames in order to explore the phenomenological and technological character of human (and nonhuman) play.

13 Espen Aarseth’s *Cybertext: Perspectives on Ergodic Literature* is a highly influential work of media criticism and an early entry into the nascent field of game studies. Taking examples from print, computer games, hypertext fiction, and electronic literature, Aarseth builds a working theory of “ergodic literature,” his term for literary works whose completion requires “nontrivial effort” on the part of the reader [Aarseth 1997, 1–2]. By nontrivial effort, Aarseth means the kinetic as well as intellectual labor performed by a reader or player that specifically influences the outcome of a given text or

game. Ergodic literature is distinct from most standard forms of writing because it requires meaningful effort above and beyond, for example, turning pages or flipping to the end of a book to read the final chapter. If we consider Aarseth's model in relation to Holbein's skull, a viewer's self-conscious act of bending low to the ground in order to match the oblique angle of anamorphic distortion meets the requirements of ergodic, nontrivial labor. The active engagement required in any attempt to decode or decrypt anamorphic images is what leads Aarseth to make an analogy between early modern techniques of anamorphosis and certain forms of interactive media.

14 In the concluding chapter of *Cybertext*, Aarseth defines anamorphosis as a "solvable enigma" [Aarseth 1997, 181]. For Aarseth, the key quality of anamorphosis is the moment of revelation produced when the distortion of the warped image is resolved through the viewer's effort to locate the vantage point from which classical perspective is restored. The passage from what he terms "aporia" to "epiphany" characterizes anamorphic painting with ergodic literature [Aarseth 1997]. With this in mind, Aarseth interprets the text-based games and interactive fiction of the late seventies and early eighties such as Will Crowther and Don Woods' *Colossal Cave Adventure* (1975–76) and Infocom's *Zork* trilogy (1980–84) as models of an anamorphic textuality in which the player must work in order for the mystery to be revealed.

15 But not all ergodic texts provide puzzles with seemingly concrete answers and Aarseth invents a second category he terms "metamorphosis" in which mastery and resolution are refused (e.g., Michael Joyce's *Afternoon: A Story* [1987]). We argue, however, that there is no need for a second category in which to reroute those texts which appear to not have singular interpretations, linear causality, or solvable enigmas waiting at the ready. As suggested in the previous section on the *memento mortem mortis*, rather than reifying a specific subject position in front of a painting, image, or artifact, the concept of anamorphosis radically critiques all subject positions as tenuous and fraught. Even if there is a viewing angle in which an image becomes more legible, there remains no one "correct" angle and any resolution the viewer might feel should be met with some skepticism. The anamorphic skull in *The Ambassadors* (1553) is not a *memento mori* in the sense that it reminds the viewer of her mortality as she catches a glimpse of the skull through the corner of her eye, but is actually a *memento mortem mortis* because it calls into question the very concept of a fixed subject and resolved object. Rather than simply serving as a reminder of some distant, future bereft of human life, the *memento mortem mortis* demonstrates that experience itself is already composed from nonhuman assemblages imbricated within a vast network of relations never entirely legible to conscious experience.

The Digital Any-Space-Whatever

16 In *New Philosophy for New Media* (2004), it is the failure of anamorphic images to be easily assimilated by the human body that Mark Hansen finds relevant to digital forms. Robert Lazzarini's sculptural installation *skulls*, exhibited at the Whitney Museum of American Art's 2000 show *BitStreams*, serves as Hansen's central case study on the issue (see Figure 4). Like Holbein and other artists using anamorphic techniques, Lazzarini's artwork engages with the limits of human perception, systems of perspectival projection, and the tension produced between these two orders. Instead of projecting smears of paint across picture planes, Lazzarini builds smeared sculptures that stretch in three-dimensions and challenge the viewer to reconcile vision and proprioception. Where anamorphic images are rendered onto a foreshortened picture plane, Lazzarini's sculptural process involves applying two-dimensional perspectival effects directly to the geometry of three-dimensional haptic objects.

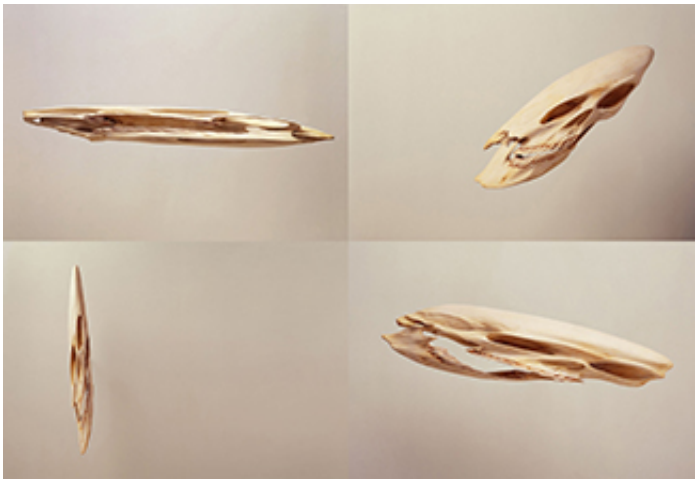

Figure 4. A photograph of Robert Lazzarini's *skulls*.

17 Lazzarini's digital development process begins by laser scanning a household object, instrument, or weapon to generate an editable polygonal mesh. The points, lines, and planes of these abstract geometries are then mathematically bent, warped, shifted, and distorted before being rapid prototyped. The 3D prototypes serve as templates for sculpting the now-deformed objects, often from the same materials that constitute the original object (e.g., the stretched *skulls* is carved by hand from bone resin). Though this process remains relatively consistent throughout his catalogue of sculptures, Lazzarini's subject matter is selected specifically to enhance the cognitive dissonance created between the physical materiality of his anamorphic sculptures and their perceptual effects [Hansen 2006, 199]. Ranging from skulls to violins, hammers, teacups, telephones, telephone booths, chairs, knives, revolvers, and brass knuckles, these handheld objects and weapons share one thing in common aside from their anamorphic effects: an ergonomic reference to the human body. It is only through this remarkable conflict between optic and haptic that Lazzarini's sculptures become tools from another digital dimension, hammers with ungraspable handles.[4]

18 Among this selection of digitally disfigured tools, *skulls* stands apart. These sculptures do not share the same status as the broken, Heideggerian hammer that reveals its nonhuman character only when it ceases to function for a human operator's intended use. Instead, *skulls*, like *The Ambassadors* before it, conceals a *memento mortem mortis* that frames nonhuman fields of experience within the register of human utility. The horizon of unthinkability represented in skulls serves as a means to philosophical inquiry. The unthinkable itself becomes a technology — an important (and fully operational) philosophical tool for speculation. The optical instability of Lazzarini's sculptures draws attention to this speculative horizon as a means of re-inscribing it within the sphere of human perception. Thus, there is a certain irony to the fact that skulls maintains a kind of functionality despite its anamorphic distortions. The fact that viewers cannot fix their gaze on a stable optical regime only intensifies the skulls' role as a *memento mortem mortis*. Technically, *skulls* does what it is *supposed* to do — it enables philosophical, aesthetic, and contemplative work.

19 Mark Hansen identifies *skulls* as an emblematic object that expresses the embodied as well as the profoundly alienating condition of digital media in *New Philosophy for New Media*. Lazzarini's *skulls* shifts focus away from the ergonomic, hand-held common objects to the forms of the body itself. Looming in life-scale and carved in bone (yet digitally modeled), *skulls* renders one of the most visually recognizable parts of human anatomy strange and uncanny and is the means through which Hansen describes the incommensurable ontology of a computer. In a chapter titled "The Affective Topology of New Media," Hansen argues that Lazzarini's adaptation of the anamorphic skull from Holbein's *Ambassadors* is "exemplary of digital media art" [Hansen 2006, 202]. Lazzarini's sculptures exist physically within three-dimensional space and yet, no matter what angle the distorted objects are viewed from, they fail to visually resolve in a satisfying way. Their hollow eyes refuse to stare back. If an observer closed her eyes and held Lazzarini's stretched skulls, the contours might resolve to the haptic touch, but as Hansen writes, *skulls* " 'makes sense' visually — only within the weird logic and topology of the computer" [Hansen 2006, 202]. Lazzarini offers an optical distortion designed to disrupt, rather than pacify, the senses. The sculptures, according to Hansen, produce a bodily experience of

what he terms the “digital any-space-whatever” (digital ASW), a proprioceptive sense akin to nausea, vertigo, or ilinx as the body fails to orient itself [Caillois 2001, 12]. Hansen writes that in the face of *skulls* “you feel the space around you begin to ripple, to bubble, to infold…and you notice an odd tensing in your gut, as if your viscera were itself trying to adjust to this warped space” [Hansen 2006, 198–9].

20 Hansen’s term for this unsettling bodily awareness, the digital ASW, is based on Gilles Deleuze’s cinematic “any-space-whatever” (ASW) discussed in *Cinema 1: The Movement-Image* [Deleuze 1986, 109]. The cinematic ASW is an attempt to describe the empty, dislocated spaces of post-war cinema and distinguish them from the Hollywood logic of pre-war film. What is highlighted in both Deleuze’s and Hansen’s version of the ASW is not the visual perception of this space, but the effects produced on the body. The key difference between the digital ASW and Deleuze’s theory is that “because it must be forged out of contact with a radically inhuman realm, the digital ASW lacks an originary contact with the space of human activity” [Hansen 2006, 204]. As such, the digital ASW emerges within the body when the viewer comes in contact with the nonhuman logic and incommensurable perspectives of computational space. According to Hansen, “[w]hat *skulls* affords is, consequently, not a direct apprehension of an alien space that *is* digital, but a bodily apprehension of just how radically alien the formal field of the computer is” [Hansen 2006, 205] (emphasis in original). In this sense the *memento mortem mortis* and the digital ASW go hand in hand. In an artwork like *skulls*, which is as psychologically unsettling as it is proprioceptively disruptive, experiential strangeness quickly transforms into existential thinking when confronted not with mortal remains, but with the irresolvable remainder of the *memento mortem mortis*. Though Hansen’s concept begins as an embodied, affective apprehension, the digital ASW gestates within the same inclement ontological spaces conceptualized by the *memento mortem mortis*.

21 Following Hansen’s argument, videogames, like all digital media, are built upon formal fields only interpretable by computers. The rapid speed of bits being flipped, the immense scale and mind-numbing repetition of data processing, and even the mechanical flow of electrons can never be visually represented to human experience. Instead, the *memento mortem mortis* relies on the incongruity between computational and biological forms of space and time that manifest as an embodied and affective response in the human (i.e., Hansen’s digital ASW) to allegorize these invisible processes. Most game designers, however, attempt to mitigate these processes. While a work like *skulls* emphasizes the failure of the viewer to grasp these forever skewed and uncanny objects, most mainstream videogames do not generally make a practice of cultivating sensory discomfort.[5] The games we examine in this essay intentionally play within the dissonant registers produced between biological and computational systems. They produce ludic metaphors of the *memento mortem mortis* to model an engagement with the concept of an unthinkable computational wilderness. Yet, despite their experimentation with alternative haptic and visual regimes, even these games resist pushing the implications of their design to its limits. Rather than forcing the player to stare an inassimilable digital landscape in the face, they offer a fantasy of mastery through the successful completion of goal-oriented tasks and suggest that the body can be acclimated to their eccentric spaces. Flight simulators were developed to combat airsickness, and it is with a similar logic that “anamorphic games” invite players to test-drive the digital ASW, to make it safe and naturalize the body to the “incredible strangeness,” “odd tensing[s],” and “weird sensation[s]” of the *memento mortem mortis* [Hansen 2006, 198–9].

Part 2: Anamorphic Games

Introduction to Anamorphic Games

22 Although thousands of years have passed since Butades’ sculpted silhouette and Zeuxis’ painted grapes, the desire for mimesis remains one of the guiding principles of the videogame industry. W.J.T. Mitchell’s *Reconfigured Eye: Visual Truth in the Post-Photographic Era* (2001), for example, opens with Pliny’s “birth of painting” and draws a genealogical line from early optical experiments such as Dürer’s glass “veil” to contemporary digital imaging technologies like ray tracing. Mainstream videogame development participates in this logic, constantly propelled forward by fantasies of “realistic,” immersive imagery and dematerialized interfaces. As Robert F. Nideffer pithily summarizes:

> Improved lighting, increasingly accurate physics models, and more believable artificial intelligence (AI) are seen as the next frontier for game engines by many in the industry. For anyone who

> attends meetings like the Game Developers Conference (GDC), the Electronic Entertainment Expo (E3), or SIGGRAPH, it quickly becomes apparent that these concerns are voiced almost exclusively from the desire to enhance the game world's realism. [Nideffer 2007, 215–16]

23 Realism, in this case, refers to the ability to accurately represent mimetic details like high-resolution, photographic textures and believable camera and character animation. In addition to privileging graphic spectacle, the videogame industry relies on Hollywood's narrative conventions, which frequently take precedence over aesthetic experimentation and the development of novel game mechanics. Thus it is not realism or naturalism, but, more precisely, a *filmic* realism that defines the aesthetic and narrative sensibilities of many recent commercial games.[6]

24 Amidst the production of *Final Fantasy XIV*s and the annual *Madden NFL*, however, a transformation has begun to occur. The increased power of home computers, availability of open-source game engines, and prevalence of digital distribution services has catalyzed the development of smaller-scale projects like maphacks and modified engines, social and networked games, augmented and alternate realities, and mobile and web applications. The diffusion of the modes of production, the accessibility of design technologies, number of digital distribution platforms, and the formation of a broader audience has permitted experimental game designers to challenge the representational hegemony of traditional genres to develop alternative forms of artgames, antigames, countergames, overgames, notgames, and metagames.

25 The "anamorphic games" discussed in this essay manipulate time, space, and physics in ways that not only draw attention to the formal logics of the computer, but also attempt to highlight a player's embodied interaction with graphic technologies. The human body is affectively tuned to negotiate physics and the flow of time and space. Whether deftly crouching to avoid a low overhang or unconsciously sidestepping some four-dimensional form, proprioceptive capacity is largely reflexive. But what happens to these embodied actions when encountering a hybridized space, a mixture of the actual and the virtual that contrasts embodied space-time by deploying anamorphic algorithms? What if a body were required to negotiate two- and three-dimensional spaces simultaneously as with Sony's *Echochrome* software? Can muscles remember the extra-dimensional abstractions overlaying Julian Oliver's *levelHead*? And is it possible to render four-dimensional sight as Mark ten Bosch's *Miegakure* claims? The games mentioned here offer the player simulations of a poetic physics, or what Bill Seaman has termed "e-phany physics" or "the code-based authoring of an artificial physics which is consistent within the virtual space, yet does not adhere to the laws of actual physics" [Seaman 2000, 41]. So what happens to the body when those internalized dynamics are re-written within poetic simulations? The following videogames create interfaces to allegorize a space beyond the limits of human perception and attempt to hubristically resolve the gulf between technological abstraction and phenomenological action.

Echochrome: Anamorphic Architecture and Shadow Play

26 When the first generation of home videogame consoles supporting 3D graphic processing was introduced in the mid-nineties, the development of 2D, sprite-based games was temporarily arrested.[7] In the flush of fascination with these strange polygonal spaces, the efforts of software engineers and game designers alike were redirected from painting with pixels to domesticating and naturalizing 3D environments for mainstream consumption.[8] In recent years, there has been a renaissance of 2D platforming games. The flatness of the screen and depiction of 2D space is no longer a technological constraint, but a creative tool, a game design element that can be placed in conjunction with 3D spaces to create metagames which use graphics processing and computer rendering as their main technological platforms and design constraints. One series of games that structures its gameplay around the perspectival play of both two- and three-dimensional spaces is Sony's *Echo* franchise which includes *Echochrome* (2008), *Echoshift* (2009), and *Echochrome II* (2010).

27 *Echochrome* is produced by Sony's Japan Studio and Game Yarouze for the PlayStation Portable (PSP) and PlayStation 3 (PS3). In the game, the player is presented with a minimal, immaculately white space featuring a centralized, floating object composed of stairs, walkways, ramps, and ramparts reminiscent of M.C. Escher's impossible spaces and paradoxical architectures (see Figure 5). By twisting the joystick, *Echochrome*'s hovering levels begin to rotate and, unlike a hand-drawn optical illusion, actually reconstitute their perspectival conditions in real time. All the

while, a solitary figure wanders back and forth, footsteps clacking in empty space. The lone resident of these “endless walkways” (the rough translation of *Echochrome*’s Japanese title, *Mugen Kairō*) is a textureless mannequin who autonomously strolls up and down the crisply contoured, isometric expanses. Both the oblique reference to Escher's artwork and the mannequin (an object traditionally used for rendering perspectival figures) are fitting considering that the game’s main mechanic involves rotating anamorphic architectures in ways that paradoxically play with the dichotomy between screen and space.

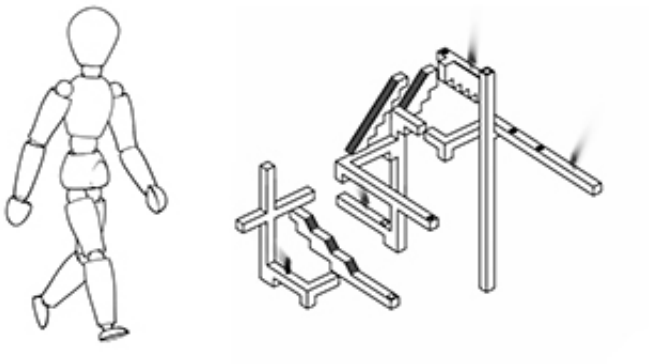

Figure 5. Images of *Echochrome*'s mannequin and level design.

In *Echochrome*, there are five main rules governing the mannequin's movements: 28

> (1) When two separate pathways appear to be touching, they are. (2) If one pathway appears to be above another, it is. (3) When the gap between two pathways is blocked from view and the pathways appear to be connected, they are. (4) When a hole is blocked from view, it does not exist. (5) When the mannequin jumps, it will land on whatever appears beneath it. [Sony 2008]

These five laws of perspective define the relationship between two- and three- dimensions within the game-space.[9][9] By inverting the order of perspectival rendering, the pictorial logic of the screen is given precedence over the mimetic representation of space. What you see is literally what you get. 29

Echochrome recalls Holbein’s *The Ambassadors* in the way it mixes traditional perspective with anamorphic effects. By placing both two- and three-dimensional space in conversation with each other, the game conflates the dual logic of flat “screen” and deep “window,” two metaphors Anne Friedberg contrasts in *The Virtual Window: From Alberti to Microsoft* (2006). Friedberg argues that although perspective has been the historically dominant form of visuality, computers have dramatically transformed how space is culturally perceived and organized. She examines the graphic user interface of computer desktops and the way they are composed of multiple, overlapping windows, conflicting light sources, and purely abstract drop shadows. Although Leon Battista Alberti famously described classical perspective as a “window” onto another world, Friedberg demonstrates how computer software companies have appropriated similar rhetoric for describing the non-perspectival, non-linear incongruities and contradictions of computer operating systems. In this sense, Microsoft Windows has become a window as the artificial tropes and interface metaphors of these operating systems have been naturalized as yet another form of realism.[10] 30

Echochrome stands out as a particularly intriguing example of alternative spatial organization because it knowingly plays with the tension between pictorial and sculptural space. As the player rotates the central object in three-dimensions, real-time graphic processes render an illusion of depth with the screen or monitor serving as virtual window. Near and far, broad and deep, *Echochrome*’s rotating spaces appear to behave rationally, like a revolving showroom car or a piece of electronics on a turntable. But when the motion stops, the collisions and connections of the Escher-esque architecture are ultimately determined according to the logic of the suspended two-dimensional image. The “window” into another realm flattens into an opaque screen.[11] 31

Adjusting *Echochrome*'s perspective not only transforms the player's view, but the structure of the architecture itself. The spatial dimensions and composition of the object do not remain fixed in an absolute space. Instead, the in-game architecture is reconstituted depending on the angle from which it is viewed. Yet, in the tradition of Espen Aarseth's concept of ergodic literature, this is perspectival rendering structured within the idiom of anamorphic play and operating according to fixed points of resolution. If the player rotates the architecture correctly, or, more precisely, manipulates the in-game camera, the puzzle will be solved and the secret revealed. Discovering the solution to these levels, cracking their spatial code, promotes a reductive model of anamorphosis — one that equates embodied vision with an absolute, mathematical result produced by a virtual camera. In this sense, *Echochrome* differs from a work like *skulls* in which there is no chance of ever decoding the painterly smear into perspectival representation. The game's ludic logic acts as an interface through which the player finds herself able to assume a naïve position of control and mastery of those perspectives that would otherwise be hopelessly irresolvable. Through *Echochrome*'s eccentric camera, the human eye is simulated as a one-dimensional point in space, perfect for projecting and reflecting ray-traced light. 32

While *Echochrome* creates a world built around the intersections of two- and three-dimensional space, its sequel, *Echochrome II*, adds the play of light and shadow to its predecessor's uniquely hybrid perspective of multi-dimensional objects. Once again, what you see is what you get. The mannequin's silhouette, referred to as "the cast," must traverse visual puzzles through the player's anamorphic manipulations of light. In *Echochrome II*, the cast does not walk along the physical objects, but along the shadowy, two-dimensional projections that fall in the wake of floating blocks, stairs, and steps (see Figure 6). 33

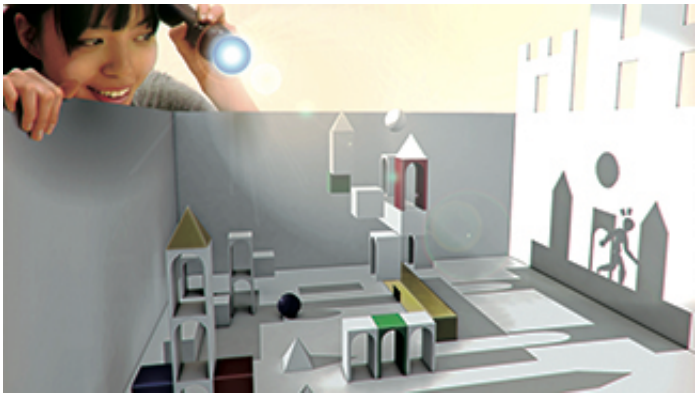

Figure 6. An *Echochrome II* advertisement featuring interactive illumination.

Like its predecessor, *Echochrome II* was developed by Sony's Japan Studio and made for PS3, but it requires the PlayStation Move, a motion-sensing hand controller spatially tracked by the PS Eye, Sony's interactive, infrared camera.[12] The Move controller is topped by a glowing sphere that flickers and changes colors when the wand is active, emitting infrared light for the PS Eye. This motion-tracking technology inverts the relationship between controller and camera popularized by the Nintendo Wii, which emits two infrared points of light from a stationary bar set near the screen and tracked by a camera within the Wii Remote (see Figure 7). In *Echochrome II*, this light-tracking technology is used to position the in-game light source which, when cast on the floating objects, produces virtual shadows in real time based on the player's bodily gestures. These motions translate into the screen's perspectival space surprisingly well as the player shines the Move controller on their television like a digitized flashlight. Rays are traced from the tip of the wand at the precise angle of incidence — rays which pierce the screen to connect out-of-game light sources to in-game objects and architectures. 34

Figure 7. A comparison of Sony's PlayStation Move and Nintendo's Wii Remote.

35 The shadows produced by the Move evoke the flickering lamp flame from Pliny's account of Butades' daughter, but rather than assume a visual symmetry between silhouette and object (the way in which this myth has been traditionally depicted in various paintings), the game reveals the dissonance and distortions that prevail in the world of shadows.[13] In *Echochrome II*, the player can adjust the light source in order to form a kind of anamorphic shadow play. If a player positions the controller at a particular angle, in the same way a viewer might position her body in relation to *The Ambassadors*, the game will reveal hidden, albeit banal, images (e.g., a smiling face, a snake, etc) simultaneously converting previously insurmountable obstacles into more conventional 2D platforms for the player-controlled "cast" to hop, skip, and jump across (see Figure 8). Just as Butades used the shadow traced by his daughter to cast a relief portrait, *Echochome II* conflates silhouette and sculpture to model not earthen effigies but polygonal pathways. These digital-born projections not only operate according to the pictorial logic of two-dimensional shadow play, but are assigned an autonomous physics and materiality distinct from the original objects. The glowing orb simulates a cycloptic eyeball, projecting unique perspectives as the player learns how to alter the angle of the light source in order to play along with the fantasy of mastery over distorted, anamorphic images.

36 Both *Echochrome* and *Echochrome II* produce spatial effects that are unique to the logic of the computer, but they depart from the *memento mortem mortis* by generating puzzles as a "solvable enigmas." Both games encourage the player to participate in a fantasy of mastery by simulating of anamorphic effects within a deterministic game-space. Whereas anamorphic painting requires a player's body to physically adjust in relation to the object, these videogames produce anamorphic encounters through in-game camera rotation. *Echochrome* doesn't actually require a bodily perception of space, but uses perspectival rendering in a way that mimics anamorphosis. Similarly, *Echochrome 2* simulates a perspectival "eye" as a single point in space through using Sony's Move. In this sense, players only see the shadow play of *Echochrome 2* second hand. Rather than activating perspective through vision, they render the gaze of a cycloptic eye, adjusting the Move controller in order to project perspectival imagery onto the screen. Though the *Echochrome* games require haptic input, the mathematical transformations depicted in each polygonal space do not engage an expanded field of affective, bodily experience and instead work to reinforce the hegemony of vision through a user-friendly design. The visual distortions are framed in such a way that any sense of a radical encounter with the *memento mortem mortis* is as repressed as it is with conventionally perspectival renderings.

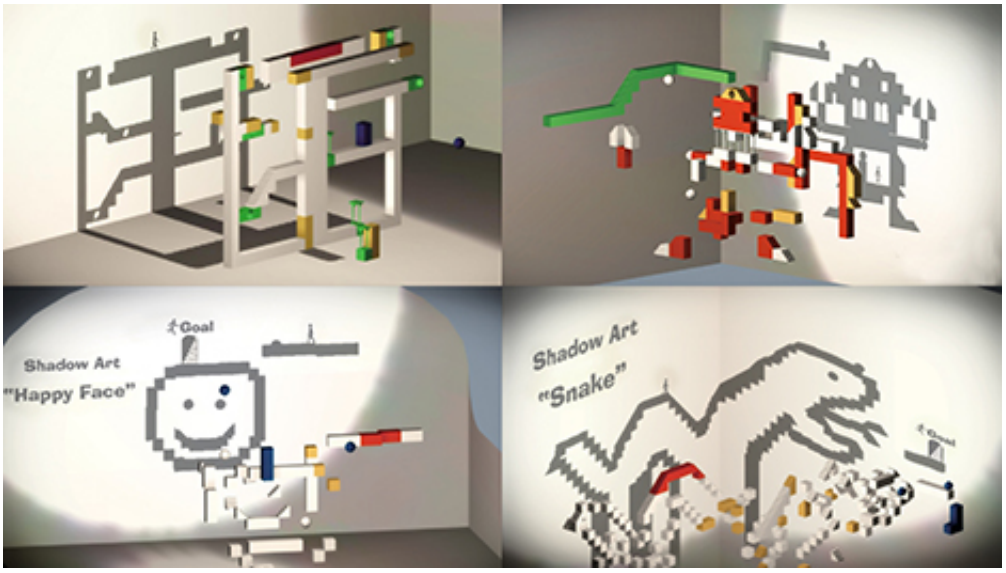

Figure 8. Anamorphic shadows in *Echochrome II*.

levelHead: A Multi-Dimensional Memory Palace

Echochrome II is designed to function with (and market) a specific commercial remote: Sony's PlayStation Move. The most recent generation of console controllers, inspired by the success of Nintendo's unconventional Wii Remote, challenged the joystick-button and mouse-keyboard input combinations that have served as the industry standard in human-computer interface design. New hardware like the Wiimote, Move, and Microsoft's Kinect are beginning to expand players' attention beyond their two thumbs by incorporating motion tracking and gesture recognition. Despite explicitly reframing input in terms of the body, these technologies fall under the category of "natural user interfaces" or NUIs that rhetorically reinforce a conventional understanding of immersivity and interaction in which the body is rendered invisible and vision is transformed into a mathematical abstraction. Amidst this technological turn toward the natural, independent artist Julian Oliver has designed a game and control scheme that does not take standard forms of interaction for granted. 37

In 2007, Oliver created *levelHead*, an interactive installation exhibited in museums and galleries as well as on home computers (see Figure 9). *LevelHead* combines color-coded and patterned cubes with custom, open-source software and a webcam to motion track and replace the six unique "quick response" or QR codes of each cube with three-dimensional, interactive architecture. The result is a large, real-time video projection that displays the player's hands interfacing with the virtualized cubes, each facet filled with internal geometries. The cubes serve as both screens and joysticks, and, as with *Echochrome* and *Echochrome II,* the player's physical gestures and positioning change the perspectival viewport to propel a small, white, humanoid silhouette through a six-sided interior space. This unassuming avatar, like the minimally-designed "cast" featured in the *Echochrome* series, follows the path of least resistance based on the angle at which a user holds each cube. By tilting the cube-controllers, the player indirectly steers the small silhouette that behaves like an automaton or dummy, a lost soul wandering aimlessly through shifting architecture. The cubes work in sequence, each containing six three-dimensional rooms overlaid within the same physical space for a total of eighteen rooms. By tracking objects and actions instead of interfacing with standardized controller input and by projecting the results back on that which is being sampled, Oliver's augmented reality game extends the perspectival space of the screen to the physical environment and vice versa. 38

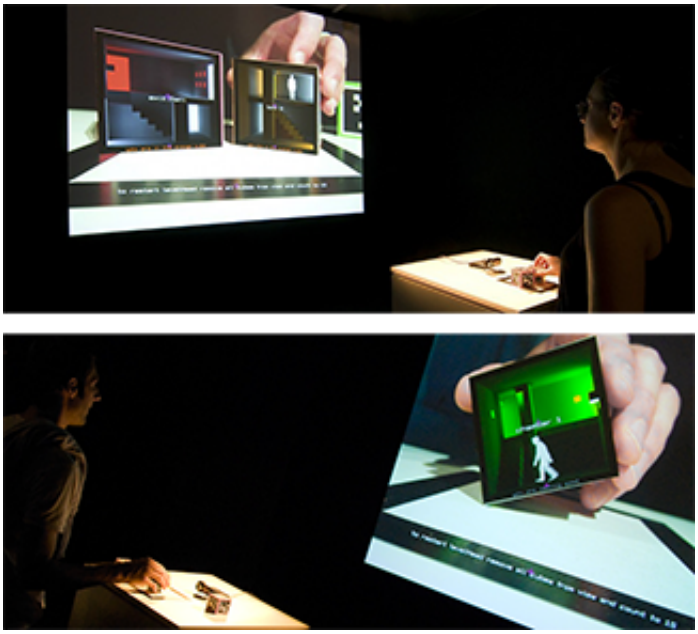

Figure 9. Installation of *levelHead* with cube-controllers, camera, and projection.

LevelHead presents the inside of the cube as if it were a shadowbox, but when the player adjusts any QR-encoded face captured by the camera, an entirely different space appears. The challenge of *levelHead* is to imagine six simultaneous rooms within the geometry of the box in hand. This difficulty, as Oliver has written, is complicated when one must remember the spatial organization of six discrete geometries despite the fact that they are not simultaneously present or interconnected in a way that is physically possible. The logic of the cube's architecture, therefore, must be constructed out of a different set of haptic cues, engaging with the wrist and hand rather than the screen and eye: 39

The tangible interface aspect becomes integral to the function of recall...[A]s the cube is turned by the hands in search of correctly adjoining rooms muscle-memory is engaged and, as such, aids the memory as a felt memory of patterns of turns: "that room is two turns to the left when this room is upside down" [Oliver 2009]. 40

Although Oliver offers a walkthrough on YouTube, he notes that the game is "very difficult" and, given the two-minute time limit to finish each puzzle, it is doubtful many have fully toured what he calls "the apartment" [Oliver 2009]. Thus, for the vast majority of players, engagement with *levelHead* comes closer to producing an experience of Hansen's digital ASW and engaging the *memento mortem mortis* than *Echochrome*. The cube-controller each player holds inevitably transforms into a kind of virtual skull, a reminder of an anamorphic discrepancy between eye-hand coordination and camera-computer calculation. 41

When grasping the "level heads," hands and wrists quickly organize each cube into a coherent program that does not necessarily comply with what the eyes see. As Oliver points out, the body grounds the player's frame of reference, yet she grapples with a space removed from standard forms of orientation. There is a palpable disconnect between what the player feels holding the solid cube and what she sees projected. The incommensurability between haptic and optical feedback recalls *skulls*. Were a viewer to close her eyes and place her hands on the sculptures, the digital-born objects would resolve to the touch, yet the visual distortions throw off the viewer's equilibrium to produce the feeling of a digital ASW. *LevelHead* makes a game out of negotiating haptic orientation with a visual and cognitive disorientation and dramatizes what Andy Clark and David J. Chalmers characterize as "the externalization of thought" [Clark 1998, 8]. 42

In "The Extended Mind," Clark and Chalmers cite a 1994 study by David Kirsh and Paul Maglio in which participants were asked to play the game *Tetris* (1985). Data was collected in three ways: (1) the unobtrusive sampling of real-time keystroke data as advanced, intermediate, and novice gamers played *Tetris*, (2) tachistoscopic tests of the same subjects performing mental rotation tasks related to *Tetris*, and (3) an "expert system" called *Robotetris* built as a machine control for the experiment [Kirsh 1994, 518]. After comparing the results of these three groups, Kirsh and 43

Maglio discovered that when enabled by environmental as well as bodily support, the human operators were far more efficient. Using a controller, participants performed the operation in 300 milliseconds (200 milliseconds to press a button, then 100 milliseconds for the screen to refresh) while it took around 1000 milliseconds for the same result to be achieved mentally (measured with standard tachistoscopic tests). For Clark and Chalmers, this study empirically demonstrates how cognition exceeds not only the mind, but the hand as well — consciousness co-developing in concert with body and environment.

44 While Kirsh and Maglio explain how prosthetic technology transforms cognition using the example of *Tetris*, the videogame itself was designed with a model of vision independent of haptic engagement. For most videogames, the screen is treated as invisible or transparent and gamers assume the pixels and polygons are accurate representations of the game-space. Conversely, the ability to recall space in *levelHead* is overtly dependent on both the body and a series of external apparatuses precisely due to the fact that the architecture produced in the game *cannot* be visualized accurately in three-dimensional space. As Oliver emphasizes in an artist statement, the muscle memory of the hand is indispensable for successful navigation of the game's paradoxes. While seasoned players of almost any videogame are acutely aware of the operation and indispensability of muscle memory, most game design still relies on a model of autonomous visual memory (i.e., observing a visual space enables the player to form an abstract mental model). This is one of the unique aspects of *levelHead* which does not take hand, body, or cube-controller for granted or treat them as merely instruments for executing orders. Oliver's game is built around the assumption that all the interactions within this cybernetic system are a necessary pre-condition for comprehending and traversing the environment.

45 The *Tetris* study erodes the Cartesian model of mind-body dualism, demonstrating a distributed model of cognition that puts pressure on the question of where the body stops and the rest of the world begins. Ironically, this example of situated cognition is constructed around a cognitive aporia. The incommensurable gulf between the processes of a computer and the embodied engagement of the human is also necessary for the cybernetic system to function: the hyphen in human-computer interaction signifying this chasm. Thus, Oliver's "level heads" tilt and twist into versions of the smeared skull, challenging the player to peer into an irresolvable and paradoxical architecture. Clutching this existential object, a clear *memento mortem mortis*, the player glimpses into a space beyond human thought, beyond the debates of "to be or not to be" into a dimension where these questions are rendered insignificant.

46 Beyond the simulated cameras and on-screen architecture of *Echochrome*, *levelHead* extends anamorphic distortion to the embodied space of the human viewer. By creating a mathematical projection in which six interconnected rooms co-exist within the same three-dimensional space, *levelHead* inverts the standard notion of projection and plays with a kind of fourth-dimensional logic. In the virtual space of the screen, these three-dimensional rooms exist within the same cube, overlapping each other. Although only one room is visible, the player can imagine the cube functioning like a tesseract or hypercube. The player must imagine six three-dimensional cubes contained within the cube she holds in her hand, although only one set of three-dimensional coordinates is observable at any time. These rooms simulate a fourth-dimensional space. This conceptual abstraction functions as a rhetorical device that stands in for the player's encounter with the alien and inaccessible ontology of the everyday technological objects with which we surround ourselves. Anamorphosis becomes a means to aestheticize this encounter with what Ian Bogost has called the "alien phenomenology" of the computer (a concept we discuss further below) [Bogost 2012].

Miegakure: A Garden of Many Forking Dimensions

47 While *levelHead*'s disorienting architecture implies a fourth-dimensional space and marshals the *memento mortem mortis* to allegorize this potential, Marc ten Bosch's *Miegakure: A Garden in Four Dimensions* (in development) directly incorporates four-dimensional theory into its game design philosophy. Both *Echochrome* and *levelHead* experiment with perspectival systems in which the laws of two- and three-dimensional perspective overlap with each other. *Miegakure*, on the other hand, adds one more spatial register in order to attempt to create a four-dimensional puzzle platformer (see Figure 10). Although visualizing the fourth dimension stretches the very limits of human perception, it is relatively simple to represent mathematically. It is a space where the abstractions of math and physics discourse freely and the human body may be able to affectively register interdimensional shifts subconciously, but perspectival vision is more or less left in the dark. For this reason, the fourth dimension has been a curiosity for artists wishing to critique the ocularcentrism of

classical perspective and Cartesian space. In her work on fourth-dimensional theories of twentieth-century art, Linda Dalrymple Henderson writes that “the fourth dimension was a concern common to artists in nearly every major modern movement” because it “encouraged artists to depart from visual reality and to reject completely the one-point perspective system that for centuries had portrayed the world as three-dimensional” [Henderson 1984, 205]. Though many visual artists throughout the twentieth century have dabbled in four-dimensional theory, from multi-point and non-perspectival Cubist renderings to Surrealist explorations of scientific theories like the non-Euclidian spatial geometries of Henri Poincaré, ten Bosch takes his inspiration from Edwin Abbot Abbot’s *Flatland: A Romance of Many Dimensions* (1884), a nineteenth-century novel narrating a square’s journey through one-, two-, three-, and eventually four-dimensional space.

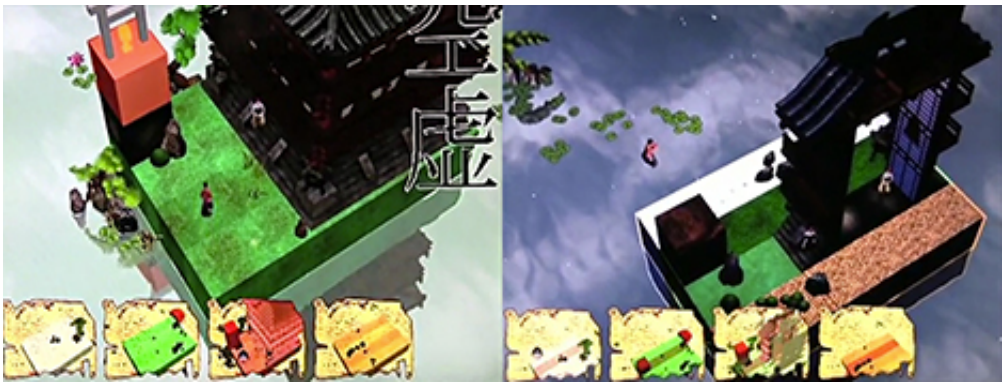

Figure 10. Screenshots from Mark ten Bosch’s forthcoming *Miegakure*

48 Faced with the paradox of representing the non-representable, ten Bosch’s strategy is to create a game-space in which each three-dimensional coordinate contains not three, but four points of information. As written on his website, “at the press of a button one of the dimensions is exchanged with the fourth dimension, allowing for four-dimensional movement” [ten Bosch 2011]. Thus, a block situated within a three-dimensional grid will appear to magically “smear” across the screen by substituting a given coordinate for a hidden fourth point in another space. Mathematically, one can make n-dimensional objects by simply adding more and more coordinates alongside the traditional designations for width, height, and depth. What exists as a computational abstraction cannot be visually modeled on the two-dimensional screen but the process of substituting alternate sets of data symbolizes the traversal between four spatial dimensions.

49 Marc ten Bosch does not treat this relationship between gameplay and fourth-dimensional physics merely as a form of symbolic substitution. He hubristically proposes that *Miegakure* grants access to the fourth dimension, allowing players to “experience it first-hand, using trial and error, as opposed to being told about it” and promotes a fantasy of mastery, colonization, and control over four-dimensional space [ten Bosch 2011]. Despite his ambitious claims, the deeper significance that will ultimately be gained from the game is not a “first-hand” knowledge of the fourth dimension, but its computational processes. And it is in this respect that *Miegakure*’s fantasy of traversing the fourth dimension becomes a metaphor for traversing the microtemporal repetitions and vast spatial scale of informatic systems. The gameplay of *Miegakure* recalls Hansen’s claim about the way in which the anamorphic space of *skulls* stands in for the “weird logic and topology of the computer” [Hansen 2006, 202].

50 In *Gaming: Essays on Algorithmic Culture* (2006), Alexander Galloway persuasively argues that videogames are “allegories of control”; they are cultural objects which rhetorically present themselves as sources of interactivity and agency, yet in doing so conceal the “protocological network of continuous informatic control” under which individuals now live [Galloway 2006, 106]. Computer games ultimately subsume the player within a strict system of rules that allegorize contemporary informatic culture at large. One might further add that videogames function not only as allegories of control, but as allegories of the beyond. And this is the logic of the *memento mortem mortis*. By presenting a set of computational processes as rules for organizing play, videogames invite players to discover the limits and affordances of a given game-space and along the way produce reminders of the death of death. To play a game is to test a nonhuman system, to uncover (and be uncovered by) the codes that will produce both experiential dissonances

like the digital ASW while opening fields for philosophical speculations. In this way, play is co-developed through a mutual enterprise of "becoming computational." In *Miegakure*, the fourth-dimensional exercises depicted in the game's diegesis and its computational dynamics are interlinked. In this way, *Miegakure* establishes a tidy homology between the fourth spatial dimension and the internal workings of a computer by placing them within the same experiential register: at the limits of human perception. By attempting to colonize computational space through the insertion of a human agency, *Miegakure* adopts the ambitious premise that the formal topology of computational space can be manipulated, controlled, and conquered absolutely (when, as Galloway observes, videogames in fact excel at accomplishing the opposite) [Galloway 2006, 106]. Ten Bosch's game delights in the telic fantasy of extending the human agency into spaces and places where it does not belong.

51 The gap between what is possible to represent in mathematics and what is sensible within human phenomenology is the inspiration for Quentin Meillassoux's concept of "the great outdoors" in *After Finitude* (2008). Rather than thinking of the great outdoors in the tradition of Caspar David Friedrich and those works of art which situate the human subject amongst the overwhelming sublimity of nature, Meillassoux uses the expression to refer to a universe that persists beyond the horizon of human correlation writing "[t]his is the enigma which we must confront: mathematics' ability to discourse about the great outdoors; to discourse about a past where both humanity and life are absent" [Meillassoux 2008, 26]. "Miegakure," ten Bosch clarifies, is Japanese for "hide and reveal" and refers to a specific gardening technique used in Japan [ten Bosch 2011]. The game is set within a Japanese Zen garden, evoking a space of contemplation and relaxation as the player ponders mathematical abstractions and inter-dimensional ontologies. Like Mark Z. Danielewski's *House of Leaves*, *Miegakure*'s four-dimensional gardening techniques conjure a space that is paradoxically larger on the "inside" than the outside. The objects in the garden interweave with one another and expand through multiple dimensions. The gardening metaphor is particularly apt because a garden not only represents a space of contemplation, but one of control and the domestication of nature. Ten Bosch's game can be read as an attempt to domesticate a computational wilderness, to seize the great outdoors, and till the land such that it falls back under the purview of human experience and agency. By creating a morphology between anamorphic techniques and the great outdoors, *Miegakure* pushes anamorphic games into the next speculative dimension by procedurally rendering an allegory of the beyond.

Conclusion

Alien Phenomenology and the Entelechy of the Weird

52 The fascination with a computational wilderness, the great outdoors of digital space, is what games scholar and designer Ian Bogost has developed into a philosophy he calls *alien phenomenology.* Synthesizing the recent proliferation of ideas falling under the category of Speculative Realism, and specifically engaging with Graham Harman's version of Object-Oriented Ontology, Bogost's *Alien Phenomenology* (2012) embraces the alien nature of quotidian material objects. He passionately describes how the material world of objects and things has been de-privileged in the face of the *sturm und drang* of human drama. According to Bogost:

> If we take seriously [Graham Harman's] idea that all objects recede interminably into themselves, then human perception becomes just one among many ways that objects might relate. To put things at the center of a new metaphysics also requires us to admit that they do not exist just for us [Bogost 2012].

53 These concealed and re-distributed relations underwrite Bogost's construction of an alien phenomenology. He declares that "[t]he true alien recedes interminably. It is not hidden in the darkness of the outer cosmos nor in the deep sea shelf, but in plain sight, everywhere, in everything" [Bogost 2012]. This insight opens the question of how the behavior of humans is transformed as a result of this reconfigured relation to objects. The answer Bogost offers is *wonder*: "[d]espite all the science fictional claims to the contrary, the alien is different. One does not ask the alien, 'Do you come in peace?' but rather, 'What am I to you?' The posture one takes before the alien is that of curiosity, of wonder" [Bogost 2012]. Bogost attempts to reinscribe a sense of respect for the mysteries of quotidian objects — for the alien that does not arrive from a galaxy far, far away but is part of our everyday lives. The "alien is everywhere" and perhaps this is

most deeply felt when attending to what peers back from the remote space of a computer [Bogost 2012].

54 Bogost's response to this call of the wild is to practice wonder, but this is by no means the only answer philosophers have posited. On the other hand, is not horror the obverse of wonder? Horror comes closer to the feeling Hansen describes as the digital ASW and what Eugene Thacker articulates in his recent book, *After Life* (2010). In *After Life*, Thacker explores the philosophical concept of life and living. Also informed by the recent explosion of speculative philosophies which redirect philosophical inquiry away from the human towards "a politics of life in terms of the nonhuman or the unhuman," Thacker turns to the fantasy writing of H.P. Lovecraft to find creative models for thinking that which exists beyond thought [Thacker 2010, 5]. Lovecraft, he argues, "presents the possibility of a logic of life, though an inaccessible logic, one that is absolutely inaccessible to the human, the natural, the earthly, an 'entelechy of the weird' " [Thacker 2010, 23]. What Thacker identifies as "weird" in Lovecraft's writing, is the same speculation at work in the anamorphic gameplay of videogames that attempt to test or allegorize the limits of human experience. While Lovecraft attempts to name the unnamable, these games convey the sense of *playing the unplayable*. As Thacker writes, "the weird is the discovery of an unhuman limit to thought, that is nevertheless foundational for thought. The life that is weird is the life according to the logic of an inaccessible rift, a life 'out of space and time,' and life of 'extra-dimensional biologies' " [Thacker 2010, 23].

55 Whether using terms like "weird," "eccentric," "alien," or "anamorphic," these ideas attempt to resituate the place of the human within a more complex cosmology of objects (Levi Bryant's term for this is "flat ontology" and Bogost revises this slightly with his theory of "tiny ontologies") [Bryant 2010] [Bogost 2012]. The strange spaces navigated in videogames like *Echochrome*, *levelHead,* and *Miegakure* allegorize the incomprehensibility of a computer; they create expressive systems that point to the profoundly alien nature of the technological objects that are such an integral and often ignored aspect of contemporary culture. Yet, despite the ubiquity and embeddedness of computers within the economic, social, and even biological strata of everyday life (at least on one side of the digital divide), the games examined here perform the friction produced as a result of the irreconcilable alterity that defines technological objects. As a way of assuaging the anxiety of discovering one lives on an alien planet, games like *Echochrome*, *levelHead*, and *Miegakure* present defamiliarized spaces and propose that the abyss that separates humanity from the mysterious black box of technology is, in fact, navigable. In these games, the computer is not so much a Lovecraftian monster, but a kind of riddle or enigma, troubling but potentially solvable. The fundamental paradox of these "anamorphic games" is that they ultimately subsume alternate worlds into a playable world. They present imagery and gameplay referencing the "great outdoors" but packaged specifically for the human player. Their controls fit into the palms of human hands and their screens cast wavelengths of light within the spectrum of human vision. In this respect, and based on the fundamentals of game design, the videogames presented in this essay actively resist what could be called a kind of speculative gaming. The *memento mortem mortis* is still only a reminder that tentatively motions toward a nonhuman heart at the center of all material media. Like Holbein's *The Ambassadors* and Lazarrini's *skulls*, these anamorphic games deploy a *memento mortem mortis* to create metaphors for a computational wilderness, reminding their users of both their experiential limitations and the limitations of technological understanding.

56 If one were tasked to develop a game completely indifferent to an end user, what would this speculative game look like? Would it participate in a mutual withdrawal of both player and game, or would it place both game and player at incommensurable odds with one another? In much the same way the anamorphic lens can be said to neither reflect nor refract light, but rather trap the gaze, the speculative game would serve as a black hole. Speculative games cannot have a user, they cannot be used or even be thought by the player. The software discussed in this paper challenges the viewer, not to perceive the imperceptible or conquer otherworldly domains, but to simply begin speculating on the possibilities of such dimensions of existence. The result is that these are not so much speculative games, as they are games of speculation.

Notes

[1] In Jay David Bolter and Richard Grusin's *Remediation* (1999), the concept of "immediacy" is treated as a powerful fantasy bound in a complex relationship with "hypermediacy." Immediacy is the desire for a completely transparent mode of communication through an interface that renders itself invisible to the user while hypermediacy draws attention to the multiple and interconnected layers of mediation at work in an

object. As Bolter and Grusin write, “[o]ur culture wants both to multiply its media and to erase all traces of mediation: ideally, it wants to erase its media in the very act of multiplying them” [Bolter 1999, 5]. This paradoxical “double logic” has dominated popular imagination throughout the history of Western art and continues to inform the development of image-making technologies from painting, photography, and film to computer graphics, interface design, and virtual reality. The desire for immediacy is expressed by the privileging of linear perspective which Bolter and Grusin argue “is still regarded as having some claim to being natural...Meanwhile computer graphics experts, computer users, and the vast audiences for popular film and television continue to assume that unmediated presentation is the ultimate goal of visual representation and to believe that technological progress toward that goal is being made. When interactivity is combined with automaticity and the five-hundred-year-old perspective method, the result is one account of mediation that millions of viewers today find compelling” [Bolter 1999, 30].

[2] It has been suggested that the *The Ambassadors* was originally hung at the top of a staircase and that glimpses of the skull could be caught upon approaching the painting from the bottom left. Turning around upon descending the staircase would also reveal a concealed skull.

[3] Jacques Lacan writes in the *Four Fundamental Concepts of Psychoanalysis* (1973) that the anamorphic distortion gives access to “a dimension that has nothing to do with vision as such — something symbolic of the function of the lack” [Lacan 1998, 88]. Read psychoanalytically, Holbein’s anamorphic skull is a “trap for the gaze” into which the subject disappears. Lacan ultimately concludes his chapter not by distinguishing anamorphosis from traditional perspective, but by arguing that it demonstrates what is implicit in all image production (and by extension the concept of a stable Cartesian subject): “In any picture, it is precisely in seeking the gaze in each of its points that you will see it disappear” [Lacan 1998, 89].

[4] In *Tool-Being: Heidegger and the Metaphysics of Objects*, Graham Harman re-imagines Martin Heidegger's philosophy of objects and the distinction between “readiness-to-hand” and “presence-at-hand.” The concept of “readiness-to-hand” is generally used to refer to the way in which objects are not seen in themselves, but only in terms of their relationship and utility to humans. Thus, the cup is not understood as an object in itself, but defined instead based on its ability to hold liquid. When a cup breaks and becomes “presence-at-hand,” an encounter with the pure presence of the cup as a being in itself can then occur. The ontology of objects is defined in terms of and against their relevance human users. Harman resists the reduction of objects to human phenomenology and proposes that “the famous tool-analysis holds good for all entities, no matter how useful or useless they might be. Beings themselves are caught up in a continual exchange between presence-at-hand and readiness-to-hand” [Harman 2002, 4]. According to Harman, Heidegger’s thinking implicitly contains a far more radical ontology of objects than has been previously assumed. He builds an “object-oriented ontology” around the idea that objects have a kind of secret life in which they “withdraw from human view into a dark subterranean reality that never becomes present to practical action any more than it does to theoretical awareness” [Harman 2002, 1].

[5] While a novice player may find the side-scrolling environments of a game like *Super Mario Bros.* (1985) uncanny and baffling, the goal of Shigeru Miyamoto and Nintendo’s developers has always been to create worlds in which the spatial and temporal mechanics can be quickly apprehended and then taken for granted in order to engage in other, more digestible operations. For example, two-dimensional spatializations such as moving left to right (as one might read English or advance forward in the first quadrant of a Cartesian grid) or climbing from bottom to top were exploited by and reinforced in early arcade games and influenced Nintendo’s original titles. However, in *The Legend Of Zelda* (1986), it is only custom and visual literacy that prevents a player from thinking that the player’s avatar, Link, is not floating through a 2D space, a gravityless version of *Super Mario Bros*. In *Legend of Zelda*, rather than assuming the perspective of a side-scrolling cross section, the horizontal and vertical axes correspond to the cardinal directions of an orthographic, bird’s-eye view map. Link’s movement is multi-directional, a significant feat at the time allowing him to walk North, South, East, and West rather than forward, backward, up, and down. While there is nothing *necessarily* intuitive or natural about this spatial mapping, the game was designed to mitigate the strangeness of navigating this artificial world rather than draw attention to its eccentricities.

In *The Legend of Zelda* (1986), there are two in-game locations that explicitly defy Cartesian cartography: the Lost Woods and the Lost Hills. When traveling through these single-screen mazes, Link finds himself endlessly looping, temporarily arrested by a classic gaming trope. Like *Asteroids* (1979) and *Pacman* (1980), if the player’s avatar crosses the edge of the screen, it appears immediately on the opposite side as if teleported instantly from one side of the level to the other. This looping effect is initially counterintuitive because of the morphology of the flat, two-dimensional screen but becomes more and more comfortable as player’s adjust their spatial expectations to the particularities of each game-space. The mazes in *The Legend of Zelda* are relatively straightforward to program. A series of conditional “if” statements dictate which sequence of directions lead Link out of each repeating landscape. Yet, the mathematical certainty and programmatic simplicity of the Lost Woods and Lost Hills generates complex and sometimes paradoxical topologies. Were a player to attempt to map the twists and turns traversed while rambling through the woods or hills, she would find the geometry of each maze does not cohere with the map of Hyrule. In this case, procedural and haptic logics defining the game-space do not render coherent visual schema. Whether the player realizes it or not, each looping space maps not to the flattened grid on which the rest of Hyrule is mapped, but instead to the topology of a three-dimensional torus.

[6] The emergence and celebration of the “cut-scene” in the late nineties is perhaps the most egregious way in which games have attempted to translate filmic storytelling into videogame narratives. A survey of the most anticipated games shown at this year’s E3 confirms that Nideffer’s observations remain relevant as mainstream games are dominated by Hollywood-style visual and narrative logic. The showpieces are comprised of games like *Mass Effect 3* (2012), *Modern Warfare 3* (2011), *Battlefield 3* (2011), *Uncharted 3* (2011), and *Far Cry 3* (2012), which tempt players with the promise of the richest and most filmically immersive graphics on the market. The ubiquity of the series, as seen in the overwhelming number of game franchises, further demonstrates the conservative conditions under which mainstream games operate. There is generally less stigma attached to videogame sequels when compared to other media as both programmers and gamers alike seem to have a higher tolerance for seriality and repetition. The computational processes driving most games (and software at large) can be easily expanded, modified, and resold — there is always a substantial amount of exchange and appropriation in games at the level of code. Moreover, a game’s narrative is frequently regarded as peripheral to enjoyment of the software compared with modifications of gameplay. As a result, commercial studios are more reluctant to take million-dollar risks on untested intellectual property than simply revise an already-vetted formula when there is less pressure from the market to do so.

[7] This generation included notable systems like the Sega Saturn (1994), the Sony PlayStation (1994), and the Nintendo 64 (1996) which ran at least 32-bit graphic processors in order to render the real-time polygonal meshes that make up the perspectival spaces of 3D games.

[8] Nintendo’s transition from 2D to 3D games demonstrates the challenges of adjusting to these new spaces. Remembering the difficult launch of *Super Mario 64* (1996), a release title for the Nintendo 64, Shigeru Miyamato remarked in a conversation with Nintendo’s CEO Satoru Iwata that the reason why 3D action games were unpopular was because of how common it was for “people to get motion sickness” and that it was “easy to get lost in the playing field” [Iwata 2011]. Hansen likens the feeling of the digital ASW to motion sickness and, in the case of videogames, this is precisely the medical condition a significant number of uninitiated players experienced upon first exposure to 3D graphics. Despite dramatic advancements in graphic processing technologies and the growth of audiences desiring to play in 3D virtual worlds, the difficulty of acclimatizing players to these spaces remains. Even today, particularly amongst Japanese consumers, Nintendo's 2D titles consistently out-sell its 3D counterparts. Both *Super Mario Galaxy* (2007) and *New Super Mario Bros.* (2006), for example, were released around the same time and both were critically acclaimed; yet the side-scrolling platforming game sold two and a half times more copies than *Super Mario Galaxy*. *Super Mario Galaxy* was one of the first games to incorporate eccentric gravity and spherical levels into its design. In his interview with Miyamoto, Iwata comments, “[A]t the time, I did not fully understand its benefits. I knew right away that visually [*Super Mario Galaxy*] would look great. But its true value was beyond what could be seen with the eyes, it was something that I hadn’t realized” [Iwata 2011]. Both Miyamoto's remark on motion sickness and Iwata’s observation on the way in which the effects of spherical space transcend visuality indicate an awareness of how the body functions while playing these games. The visual is only a small part in a much more comprehensive bodily engagement with digital space.

[9] In the world of *Echochrome*, the three-dimensional architecture reinforces the logic of the two-dimensional screen like Nintendo's 2007 release of *Super Paper Mario* (2007) for the Nintendo Wii, Kuju Entertainment's Zoë Mode development studio's 2007 release of *Crush* (2007) for the PSP, Polytron Corporation’s premier XBLA title, *Fez* (2012), and DigiPen Institute of Technology's eagerly awaited student game, *Perspective* (forthcoming).

[10] Terry Harpold also makes this observation in *Ex-foliations: Reading Machines and the Upgrade Path* (2009) when he examines the default desktop wallpaper of Windows XP known as the “Bliss Screen,” a vista composed of rolling grass and blue sky. Noting the uncanny connection between this pastoral imagery and Freud’s description of an alpine meadow in his 1899 essay “Screen Memories,” Harpold analyzes the advertising surrounding the release of the OS. One television commercial sets Madonna’s “Ray of Light” against images of euphoric Microsoft users “diving” through the screen in order to soar through (indistinguishable) physical and virtual spaces to the amazement of those looking on who have yet to test the GUI for themselves. The rhetoric of unmediated immersion and of a deep perspective, which the advertisement deploys in order to present the computer screen as a perspectival “window,” renders invisible the complex and contradictory non-linear visual organization that truly comprises the Windows GUI [Harpold 2009, 238–41].

[11] *The Ambassadors* also illustrates the tension between material surface and illusionistic depth. Applying the rhetoric of window and screen that Friedberg articulates, one can imagine viewing the two ambassadors as an act of looking through a virtual window. This fantasy is disrupted, however, through the presence of the smeared skull. The skull does not exist within the three-dimensional space of the painting, but instead appears as an object that is literally not of that world, or, as Hansen writes, an “envoy from elsewhere” [Hansen 2006, 202]. The fact that Holbein’s skull does not inhabit the same virtual plane is reinforced by the fact that its shadows are not cast from the same light source. It is as if an imaginary pane of glass covers this “window” and the skull has been smeared over its transparent surface. There is a figure/ground oscillation as the painting moves between drawing attention to itself as a window as well as a screen. This hypermediated effect of *The Ambassadors*, in which multiple lighting sources create layered windows into heterogeneous visual orders is also at work in *Echochrome*.

[12] The Sony Move is part of the latest generation of controllers for mainstream consoles and competes with other motion-control sensors such as the Wii Remote and the hands-free Kinect for the Xbox 360. The Kinect is a human interface device that is able to track real-time 3D video using a grid of infrared laser beams. It reads the physical gestures and voice commands of the player. These technologies call attention to the player's body, situating them much more explicitly in a spatial relationship to the games being played. Unlike *The Ambassadors* and *skulls* that unsettle the human body through the tension produced between the virtual and the physical, these controllers attempt to suture the two realities together in a way that appears seamless and intuitive.

[13] Continuing this minor tradition of "shadow play" alongside *Echochrome II*, the more experimental offerings from the independent developers producing *Closure* (2012) and *Unfinished Swan* (2012) focus on shadows as their main game mechanic. In the Flash-turning-console game *Closure*, a puzzle platformer which follows *Echochrome*'s what-you-see-is-what-you-get logic, designers Jon Schubbe and Tyler Glaiel program onscreen objects that physically persist only if illuminated. In the procedural architecture of *Closure* blackness *is* nothingness — any unlit object simply ceases to exist allowing the childlike player-character to tiptoe through dimly lit walls and tumble through shadows cast on the floor. Recalling the aesthetic of Edward Gorey's *Gashlycrumb Tinies* (1963) and, like *Limbo* (2010), following lone children through Purgatory, Schubbe and Glaiel present a child's-eye view of a world turned black and white, a world in which anamorphic light and shadow distort physical reality. Like the reader of *Gashlycrumb Tinies*, the player uncovers the many ways in which she can plunge into nothingness. Lying at the opposite end of the color spectrum, *The Unfinished Swan* is an experimental prototype developed by Giant Sparrow. The game is a first-person shooter set in a field of blinding whiteness. Luckily, the player wields a kind of paint or shadow gun used to differentiate the otherwise invisible geometry of each level as one progresses. In both *Closure* and *Unfinished Swan*, 3D space and the architecture therein do not exist without some form of anamorphic shading.

Works Cited

Aarseth 1997 Aarseth, Espen J. *Cybertext: Perspectives on Ergodic Literature*. Baltimore: The Johns Hopkins University Press, 1997.

Bogost 2012 Bogost, Ian. *Alien Phenomenology*. Minneapolis: University of Minnesota Press, 2012.

Bolter 1999 Bolter, Jay David, and Richard Grusin. *Remediation: Understanding New Media*. Cambridge: MIT Press, 1999.

Bryant 2010 Bryant, Levin. *Flat Ontology*. *Larval Subjects*. February 24 2010. http://larvalsubjects.wordpress.com/2010/02/24/flat-ontology-2/.

Caillois 2001 Caillois, Roger. *Man, Play, and Games*. Translated by Meyer Barash. Chicago: University of Illinois Press, 2001.

Clark 1998 Clark, Andy, and David J. Chalmers. "The Extended Mind". *Analysis* 58 (1998), pp. 7-19.

Damisch 1995 Damisch, Hubert. *The Origin of Perspective*. Translated by John Goodman. Cambridge: MIT Press, 1995.

Deleuze 1986 Deleuze, Gilles. *Cinema 1: The Movement-Image*. Translated by Hugh Tomlinson and Barbara Habberjam. Minneapolis: University of Minnesota Press, 1986.

Friedberg 2005 Friedberg, Anne. *The Virtual Window: From Alberti to Microsoft*. Cambridge, MA: MIT Press, 2006.

Galloway 2006 Galloway, Alexander R. *Gaming: Essays on Algorithmic Culture*. Minneapolis: University of Minnesota Press, 2006.

Hansen 2006 Hansen, Mark B. N. *Bodies in Code: Interfaces with Digital Media*. New York: Routledge, 2006.

Harman 2002 Harman, Graham. *Tool-Being: Heidegger and the Metaphysics of Objects*. Chicago: Open Court, 2002.

Harpold 2009 Harpold, Terry. *Ex-Foliations: Reading Machines and the Upgrade Path*. Minneapolis: University of Minnesota Press, 2009.

Henderson 1984 Henderson, Linda Dalrymple. "The Fourth Dimension and Non-Euclidean Geometry in Modern Art: Conclusion". *Leonardo* 17: 3 (1984), pp. 205-210.

Iwata 2011 Iwata, Satoru. *Iwata Asks: Super Mario Galaxy.Vol. 4: Shigeru Miyamoto*. *Wii.com*. 2011. http://us.wii.com/soft_smg.jsp.

Kirsh 1994 Kirsh, David, and Paul Maglio. "On Distinguishing Epistemic from Pragmatic Action". *Cognitive Science* 18: 4 (1994), pp. 513-549.

Lacan 1998 Lacan, Jacques. *The Four Fundamental Concepts of Psychoanalysis: The Seminar of Jacques Lacan Book IV*. Edited by Jacques-Alain Miller. Translated by Alan Sheridan. New York: W.W. Nortion & Company, 1998.

McCormick 2011 McCormick, Rich. “E3 2011: Our John Carmack Video Interview Covers Rage, the PC, and Gamma Corrected Anti-Aliasing”. *PC Gamer* (June 8 2011). http://www.pcgamer.com/2011/06/08/e3-2011-our-john-carmack-interview-covers-rage-the-pc-and-gamma-corrected-anti-aliasing/.

Meillassoux 2008 Meillassoux, Quentin. *After Finitude: An Essay on the Necessity of Contingency*. New York: Continuum, 2008.

Mitchell 1994b Mitchell, W.J.T. *Reconfigured Eye: Visual Truth in the Post-Photographic Era*. Cambridge: MIT Press, 1994.

Nideffer 2007 Nideffer, Robert. “Game Engines as Embedded Systems”. In Victoria Vesna, ed., *Database Aesthetics: Art in the Age of Information Overflow*. Minneapolis: University of Minnesota Press, 2007. pp. 211-242.

Oliver 2009 Oliver, Julian. *levelHead*. *Selectparks.net*. 2009. http://selectparks.net/~julian/levelhead/.

Panofsky 1996 Panofsky, Erwim. *Perspective as Symbolic Form*. Translated by Christopher S. Wood. Cambridge: Zone Books (MIT Press), 1996.

Pliny, Bk 35, Ch 43 none, Pliny, the Elder. *The Natural History*. Edited by John Bostock Henry T. Riley and Karl Friedrich Mayhoff. Somerville: Perseus Digital Library. http://www.perseus.tufts.edu/cgi-bin/ptext?lookup=Plin.+Nat.+toc.

Seaman 2000 Seaman, Bill. “Motioning Toward the Emergent Definition of E-phany Physics”. In Roy Ascott, ed., *Art, Technology, Consciousness Mind@large*. Portland: Intellect Ld., 2000.

Sony 2008 Sony Computer Entertainment Inc. *Echochrome Official Trailer*.

Thacker 2010 Thacker, Eugene. *After Life*. Chicago: University of Chicago Press, 2010.

ten Bosch 2011 ten Bosch, Marc. *Miegakure: A Puzzle-Platformer in Four Dimensions*. Video Game, Marctenbosch.com, 2011. http://marctenbosch.com/miegakure/.