The Infinite Image:
Digital Media's Boundless Aesthetic

by

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Abstract

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This dissertation analyzes the perception of endlessness in digital media from the 1970s to today, a characteristic which I argue is unique to live, networked screens and is deeply imbricated with the rise of platform capitalism. Digital media have frequently been characterized as boundless, as a continual, almost elemental, stream of images and information. From claims of "information overload" in the 1970s, to the cloud metaphors used today, networked media have been understood and experienced as expansive and without limits. This dissertation traces the history of this tendency, focusing on what I term the "infinite aesthetic" of digital media. The infinite aesthetic can be found in the infinite scroll of social media feeds and search results, in the loops of a GIF and the proliferation of a meme, in the auto play function of a streaming platform and the background animations of a video game. These new never-ending moving images accompany the rise of 24/7 networks and the neoliberal workplace, and the yoking of mobile computing with the attention economy. This dissertation traces four major case studies that represent the emergence of infinite images as an emblematic genre of the digital age, and how they relate directly to transformations wrought by post-Fordist capitalism. I argue that the centrality of this aesthetic underpins how the culture of twenty-first century platform capitalism came to be perceived as not only an endless, frictionless flow, but one characterized by exponential growth.

This history began in the late 1960s with a little-known experimental video art lab in the Bay Area where artist's investigations into the new electronic medium of video pioneered the possibilities of an ever-renewing, live image. In this first chapter, "A Counterfeit Infinity: Video Art and Real-Time Aesthetics," I show how these innovations in the aesthetics of the live video feed were key to the transformation of computers from calculating machines into interactive visual media devices. In the second chapter, "Without Limits: the Animated Screensaver and 24/7 Computing," I trace the development of the infinite aesthetic to a new genre of moving images - the animated screensaver - which I argue played a central role in the shift to "always on" computing. I analyze how the screensaver's infinite aesthetic becomes aligned with neoliberal notions of productivity by supporting the practice of leaving the personal computer on at all times. The third chapter, "Without End: The Infinite Scroll and Platform Capitalism," turns to the history

of the “infinite scroll,” which has its roots in the nineteenth-century stock ticker – a historical connection that underscores the imbrication of live, continually unfolding media and the temporal demands of late capitalism. Finally, “Cryptic Futures: The Endless Deferrals of Web3” examines the recent emergence of crypto art and NFT trading as emblematic of the intensification of speculation and the normalization of indebtedness under post-Fordist capitalism. To the endless work time and endless attention mining of the last thirty years of internet culture, we can now add the endless deferral of the future that arises from the perpetual states of indebtedness that fuel finance capitalism.

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From Feedback to Feed: The Boundlessness of Digital Media

In October 2021, amidst renewed backlash about the invidious effects its algorithms have on the wellbeing of users, Facebook announced a major rebranding. The company would now be known as Meta Platforms. The new name is a reference to the "metaverse," the notion that all virtual spaces could be combined into one vast virtual world. The reference signaled Facebook's investment in VR technologies as the latest *terra nova* in digital media. As the iconic social media company has begun to lose ground to competing platforms in recent years, its diversification into different products was inevitable. "We are at the beginning of the next chapter for the internet, and it's the next chapter for our company too," Facebook founder Mark Zuckerberg said in a statement announcing the rebranding.[1]

It was a symbolic moment: a company that epitomized Web 2.0, that led the way in many innovations in how the internet has been experienced and monetized during the last fifteen years, had come of age. Since Facebook's founding in 2004, the platform – and the web as a whole – had shifted from a predominantly text-based medium, to one that is visual, mobile, and live. Now, as Zuckerberg narrated it, Facebook was at the brink of a new frontier. Meta's vision is to "help people connect, find communities, and grow business"[2] by bringing social interactions into the metaverse. Facilitating social interactions in a virtual context is what Facebook has always done, and Facebook's goals for the metaverse represent its continued investment in the strategies of platform capitalism.

The company illustrated this vision in a promotional video, which depicted a digital avatar of Zuckerberg interacting with colleagues and friends within an animated three-dimensional space. Zuckerberg's avatar narrates the benefits of the platform from the fictionalized space of his metaverse home screen.[3] A luxurious modernist living room looks out onto an eerie natural landscape that fuses snow-covered pines with tropical palm trees. Zuckerberg's metaverse home is arrayed with various artifacts, including a suit of armor and a space suit, an orrery, a globe and a telescope - symbols of the exploration and conquering of space (the armor bears more than a passing resemblance to that of a seventeenth-century Spanish conquistador). The notion of digital virtual space has, since the 1970s, been associated with fantasies of colonialism, from the "lone hunter" on the frontier of the American west who inspired early computer networks in the 1970s, to the "console cowboys" who filled cyberpunk narratives of the 1990s.[4] Although Meta was careful to avoid literal references to the frontier in its promotional rollout of the metaverse, the visual rhetoric is clear. As Zuckerberg stated in a speech announcing the rebranding, "meta" comes from the Greek word for "beyond." Having exhausted the resources of the social media platform, the company must now expand into new realms to attract and retain users.

As Nick Couldry and Ulises Mejias have observed, the ways in which platforms such as Facebook extract attention and information from their users echo the colonial strategies of industrial capitalism. As the colonial expansions of industrialized nations in the eighteenth, nineteenth, and twentieth centuries were motivated by demand for material resources and new markets, platform capitalism's drive for more data motivates the pursuit of new areas of attention and social life to commodify. Couldry and Mejias put it bluntly: "Data relations enact a new form of data colonialism, normalizing the exploitation of human beings through data, just as historical colonialism appropriated territory and resources and ruled subjects for profit. Data colonialism paves the way for a new stage of capitalism whose outlines we only glimpse: the capitalization of life without limit."[5] Meta's Horizon World (the VR version of its social media platform), as well

as products such as Amazon and Google's smart speakers, and Apple's wearable tech, monitor increasingly expanded areas of user's lives. Facebook's diversification into VR is motivated by a goal shared by the "big four" – Facebook, Amazon, Apple, Google – to be what Siva Vaidyanathan calls "the operating system of our lives," a meta-interface through which users conduct increasing amounts of daily living. As Vaidyanathan says, "If Facebook becomes the operating system of our lives, we could ignore it and it would still respond, monitor, record, profile, sort, and deliver data – and more."[6]

Facebook/Meta revealed a new logo to accompany its rebranding: the interlocking loops of an infinity symbol. The logo retains the iconic blue color of Facebook's previous branding along with its sans-serif simplicity. Critics have pointed out that the new logo strategically distances the company from evidence that the platform's thumbs up "like" symbol (its prior logo) had negative psychological effects on its young users. But the infinity sign is a fitting symbol for the company that more than any other popularized the "infinite scroll." When Facebook turned its platform from a compendium of disparate profile pages into a continuous stream of information updated in real time, it helped launch an entire new economy of mobile phone-based applications, which in turn has played a key role in the dominance of what has variously been called platform capitalism, surveillance capitalism, and data capitalism.[7] This economy is largely based on extracting value from the time users spend on a given platform, by accumulating information from users' interactions and selling this data to other businesses along with advertising. Automatically loading more information – be it search results, product listings, or social media posts – and presenting it in a seemingly unending stream has proven to be highly effective within this economy. Because it is so successful at retaining attention and facilitating consumption, the infinite scroll has been at the center of a recent backlash against major platforms, with many decrying its addictive affects and the ways in which platforms manipulate users' emotions and behavior.[8] Yet unending streams remain ubiquitous, particularly on mobile apps, from social media platforms such as TikTok and Instagram, to messaging services, e-commerce apps, and media players such as Spotify or YouTube.

The infinite scroll is one of digital culture's defining aesthetics. This is not only due to its pervasiveness, but because it exemplifies qualities that distinguish digital media as distinct from many preceding mediums. As I elaborate in this dissertation, the aesthetics of digital culture are characterized by a marked boundlessness and unendingness, a negentropic quality that resists endings or closed forms. This is particularly pronounced in the new genres of moving images that have emerged with computation. There are tendencies fundamental to computation and electronic media that allow the impression of endlessness to thrive. I describe below how the principle of nonlinear feedback, as elaborated in the midcentury cybernetics from which modern computing emerged, describes systems that – rather than being subject to entropy and the inevitability of an ending – are continuously self-renewing, thus introducing the potential for endlessness to media. This, coupled with the iterativeness of programming logic, give digital media a marked tendency towards boundless temporalities. This quality has been exploited to great effect by contemporary capitalism. As Marx wrote: "Capital is the endless and limitless drive to go beyond its limiting barrier."[9] Digital technologies, which contain a pronounced tendency to automatically and continuously iterate, are particularly suited at stoking this drive.

This dissertation traces the history of digital media's tendency for endlessness, and the fantasies of limitlessness which are embedded in these technologies and the culture that surrounds them – what I call the "infinite aesthetic" of digital media. The infinite aesthetic can be found in the loops of a GIF, the proliferation of a meme, the auto play function of a streaming music

platform, the background animations of a video game, the home screen of a smart TV, or in the generative aesthetics of digital art.[10] While related, the infinite aesthetic is distinct from the general "infoglut" of the internet.[11] It is a distinct temporality – not just "too much," but never ending. While at times the infinite aesthetic is perceived as exhilarating or sublime, it is increasingly experienced as exhausting, even stressful.[12] This is perhaps best exemplified in the notion of "doomscrolling" that emerged during the pandemic to describe the experience of anxiously, endlessly, scrolling through social media feeds of bad news. While digital media's infinite aesthetic begins with the thrilling promise of a technology that would extend human consciousness and capacity – it is rooted in cybernetic theory and in the experimental, psychedelic aesthetics of expanded cinema – its history is deeply imbricated with the rise of 24/7 global networks and the emergence of the attention economy. This dissertation tracks this history in an effort to better understand the interrelationship of digital media, neoliberal capitalism, and contemporary visual culture.

1 Infinite Loop

The infinite is a potent motif in Silicon Valley tech culture. The address of Apple's campus and former headquarters in Cupertino California is 1 Infinite Loop, a reference to an infinite loop in computer programming, a sequence of instructions written in such a way that they will repeat endlessly. A number of tech companies use an infinity symbol in their logo, including Boomerang, the now-defunct app for short video loops on Instagram; Microsoft's development software Visual Studio; Infinity, a workplace management platform; and EV Connect, an electric vehicle infrastructure company. It is easy to see the appeal of a construct through which the programmer has the power to create something typically associated with the sublime and the divine. To create something – even a computer program – that will last forever suggests a power over time and matter. As a mathematical concept, the infinite functions something like a black box, in the same way that computation does. Mathematics has developed systems for working with the infinite while side-stepping its uncontainable and undefinable qualities. In a popular history of the infinite, science writer Brian Clegg observes: "Scientists and engineers use [the infinite] quite happily because it works - but they consider it a black box, having the same relationship with it that most of us do with a computer or a mobile phone, something that does the job even though we don't quite understand how."[13] While in practice an infinite loop in a computer program would generally be considered an error, the notion of creating a program that will last forever invokes an irresistible sense of mastery over time, and even matter.

When Apple moved its headquarters from 1 Infinite Loop to its new Apple Park campus in 2017, it reinforced its reference to the infinite through the architecture of the building, which forms a perfect circle. In aerial views the groundscraper building, designed by Norman Fraser with input from Apple's chief designer Jony Ive, forms a massive loop, one mile across. In line with the aesthetic of seamless glossy minimalism – which has characterized Apple since the second generation of products introduced with the iMac in 1998 – the Apple Park building has entirely glass walls, with no visible seems, edges or gaps. A pair of 2019 photographs by Andreas Gursky emphasizes this aesthetic. One photograph features a series of Apple's iconic products on plinths,

the other a portrait of Jony Ive, both set against the backdrop of the seamless reflective lines of the building. The succession of Apple products recede into the distance as the corridor loops out of sight, an endless line of continuously updated products. In the portrait of Ive, dressed in the minimalist white he is famous for, the designer leans against an immense curved window. Mirrored by his own reflection in the glass, he appears suspended in space, gazing out upon an unseen landscape. It is an image of mastery, with Ive confidently poised within the horizonless postmodern space. As a landscape portrait it bears more than a passing resemblance to Caspar David Freidrich's *Wanderer Above the Sea of Fog* (1818) - both images feature a lone figure, hands in pockets and knee cocked slightly as he leans forward, contemplating a formidable grey and white landscape.

Andreas Gursky, *Jonathan Ive* (2019).

Gursky is known for his postmodern landscapes - turning the vastness of late capitalist institutions, from the endless rows of books in an Amazon fulfillment center to the sea of bodies on the floor of the Tokyo stock exchange, into stunning visual evocations of the sublime.[14] In Kant's definition of the sublime – as feelings of awe experienced when confronted with a phenomenon that exceeds one's ability to fully comprehend it – this is often found in the natural world, invoked by the power of a constantly plummeting waterfall or a vast landscape that recedes beyond one's vision. In Gursky's work the sublime is invoked by the enormity and power of global capitalism. In his portrait of Jony Ive, the romantic figure is surveying an infinite landscape not of the natural world, but one "designed by Apple in California."

The notion of something without end or without limits - that which by definition exceeds one's perception or even mental ability to grasp - is inevitably associated with the sublime, the divine or metaphysical realms. Theological texts from the Bhagavad Gita to St. Augustine's City of God have equated the infinite with the divine. There is a tradition in ancient philosophy of attempting to name or attain numbers of great magnitude: the Buddha is said to have been given the mental challenge of counting a vast series of numbers, and Archimedes attempted to estimate the number of grains of sand on a beach. The genealogy of the infinite that Silicon Valley tech culture embraces is that of Western mathematics, with roots in Greek antiquity. For the ancient Greeks, the infinite evoked deep anxieties, what historian of mathematics Eli Maor calls a "horor infiniti."[15] The word they used for infinity was *apeiron*, which meant something without bounds - it was perceived as something fearful, out of control. The history of Western philosophy is full of dramas of genius confronted with the enormity of the infinity. Galileo was working on a treatise

on the infinite during his final days under house arrest, and Georg Cantor, the inventor of set theory, was institutionalized many times for mental breakdowns, supposedly precipitated by his intensive study of the infinite. Kurt Gödel was similarly said to suffer mental breakdowns from his grappling with the infinite while working on his incompleteness theorem in the aftermath of World War II. The romance of these stories - of powerful intellects driven to insanity by the effort to tame the infinite – has obvious appeal to an ethos that grows out of both psychedelic counterculture – with its interest in mind-expanding experiences – and the academic culture of engineering and mathematics, where maverick genius is idolized.

Against Entropy

Beyond this cultural history of the infinite, Silicon Valley's embrace of the endless grows out of cybernetic theory of the postwar period which defined systems in terms of potentially endless feedback loops. The computing culture of the 1970s, from which the personal computer, visual computing, and the infinite aesthetic emerged, was deeply influenced by cybernetic theories of the postwar period. The more popular discourses – those outside of the context of the research lab – which were embracing the new technology of computation and experimenting with its possibility as a means of cultural expression, were particularly influenced by the work of writers such as Norbert Wiener and Gregory Bateson, who published highly popular books introducing cybernetic ideas to a mass audience.

In *The Human Use of Human Beings: Cybernetics and Society*, Norbert Weiner mapped out his theory of how systems self-regulate. The process of control via feedback is what underpins both organic and cybernetic systems. A thermostat will constantly monitor the temperate in a room and automatically adjust the heat based on the feedback of this information, in the same way that a mammal's body will monitor and regulate its temperature. As laid out by Weiner, these parallels between organic and electronic systems can also be understood in terms of entropy. Entropy describes the tendency of all matter in a closed system to decay, for order to dissolve into disorder. Negative entropy is thus the counter tendency – towards greater order – which is uniquely found in living organisms. Wiener describes life as specifically defined as those pockets where matter's tendency toward chaos is reversed, as where we find "enclaves of increasing organization." This is the crux of the cybernetic parallel between living beings and feedback machines: both can be described as reversing the tendency towards entropy. He writes:

> "In Gibbs' universe order is least probable, chaos most probable. But while the universe as a whole, if indeed there is a whole universe, tends to run down, there are local enclaves whose direction seems opposed to that of the universe at large and in which there is a limited and temporary tendency for organization to increase. Life finds its home in some of these enclaves."[16]

While Weiner is describing systems on a theoretical and macro level, his description of the centrality of negative entropy to cybernetics has echoes in the idea of an infinite loop in computer programming, as something that resists the natural tendency towards an end.

Entropy was invoked frequently in postwar discourse and found its way into the art world. Both Robert Smithson and Rudolph Arnheim declared the sameness and seriality of Minimalism to be entropic. Gene Youngblood similarly used entropy as a metaphor for condemning any art that appeared to be repetitive or derivative. Expanding on Wiener's cybernetic theories, Youngblood described information as an anti-entropic force, in that it functioned as a sort of energy, injecting change into the system. For Youngblood, good art - because it was rich in

information - was productive and full of life, whereas mass entertainment was characterized by uniformity. In the "cyberscat" discourse of 1960s and 70s, it was feedback machines that would bring about the life-renewing, expansive art that would be the antidote to the perceived homogeneity of the previous generation.[17]

Norbert Weiner revisited the theory of feedback in the second edition of *Cybernetics*, where he outlines distinctions between what would later be considered first order and second order cybernetics. In supplemental chapters published in 1961, Weiner elaborates on the distinction between linear feedback - or a closed loop - and nonlinear feedback. Linear feedback expresses a closed loop system, in which homeostasis is maintained - such as a thermostat or an automatic door opener. Nonlinear feedback is progressive and will continuously alter course based on the input of new information. To illustrate the principle, Weiner describes a short Walt Disney documentary of a road runner attacking a rattlesnake. Rather than repeating the same pattern again and again to evade the rattlesnake, the road runner learns from the snake's behavior and continuously adjusts his actions. In electronic and digital systems this type of feedback is often considered an error. Its aural manifestation is the screech of a microphone placed too close to its source. It can be experienced visually when a camera is connected to a monitor on a closed loop, creating the same mise-en-abyme effect of two mirrors placed opposite one another. Nonlinear feedback can in theory continue *ad infinitum* - because it is not reverting to stasis, but rather continuously altering itself, it has no inherent limits.

Never ending media

Although writing about pre-digital technology, Weiner's observations about negative entropy and feedback in cybernetic systems describe an essential phenomenon of digital media. Qualities that are characteristic of the digital – liveness, interactivity, mutability – are manifestations of feedback's fundamental open-endedness. Digital media theory of the last twenty years has concerned itself with defining what is new about the phenomena of computation. If we take seriously the notion that computation represents a technological rupture, there is much that can be said about how digital media are distinct from previous media, from the "crisis of indexicality" in film studies and the qualities of programmability and executability, to the tensions between controlling protocols and the perception of freedom digital media engender, to the belief that digital networks and computation exceed our phenomenological grasp.[18]

My contention is that the unendingness of feedback, whether a closed loop or nonlinear, is one of the most distinct characteristics of digital media. The predominantly closed forms of previous media give way to a regenerative, negentropic, open-endedness in the digital. A short film made in 2008 by the Italian artist duo Les Liens Invisibles illustrates this. The video, entitled *Neverending Happy End*, is a supercut of the end cards of old Hollywood movies. The words "end," "the end," "fin," accompanied by a swelling score, are seamlessly edited into one long sequence. Whether screened in the context of a gallery, or streaming on a dedicated website, it is presented on an automatic loop so that it indeed seems endless. The piece is emblematic of a shift happening in film culture in the mid-2000s. The form for film that had dominated the last hundred years - something linear, often narrative, with a specific beginning and a definite ending - was giving way to something else. As was very evident in the early 2000s, when many early films had been lost to fires or decay, celluloid is subject to the forces of entropy. Running a film through a projector - even re-watching an electronic VHS tape - will soon result in its faltering and eroding.

The effects of entropy and friction are much less evident in digital copies, which give the impression of being able to continue endlessly. Ultimately this is a myth – computers, like everything, are subject to entropy – but endlessness is a persistent and animating fantasy of digital culture, facilitated by the automatic iterations applied to most moving images online. *Neverending Happy End* was released the same year that Netflix introduced streaming content, and while streaming video in 2008 was still nascent, it quickly became a dominant mode for consuming moving images. As I recount in this dissertation, the mid-2000s is also when social media platforms, blog aggregators, and search engines begin to pioneer the never-ending stream as a mode of presenting media online.

The quality of seeming unendingness was previously found in broadcasting, in the continuous stream of programming over the airwaves in radio or television. This is the quality that Raymond Williams describes as "flow" - the way in which programs in television give the appearance of a continuous stream. Williams, writing in the late 1970s, is describing a profound shift in media, one brought about by the emergence of global networks. Although airwaves had always been continuous and in theory "always on," the reality of broadcasting until this point was more discrete and rhythmic. Programs followed a diurnal pattern, were bounded by the formal conventions of half hour programming blocks, and until the 1990s or later the programs did end for the day at a certain hour, especially outside of urban areas. The changing practices Williams identifies as contributing to flow, such as the way in which advertising is interjected at increasing intervals within the program, blurs their endings, thus giving the impression of a seamless stream – result from the influence of cable networks, globalization, and the commercialization of broadcasting. In the late 1970s broadcasting was beginning to see the influence of networked globalization that would pave the way for commercial Internet in the 1990s. As Manuel Castell's outlined in *The Rise of the Network Society*, beginning in the 1970s, globally connected telecommunications and the internet wrought profound changes in economic and social life.

As I describe in this dissertation, unending media are deeply imbricated with the advancing of global neoliberal capitalism. New never-ending moving images accompany the rise of 24/7 networks and the neoliberal workplace, and the yoking of mobile computing with the attention economy. In the following chapters I trace three major case studies that represent the emergence of infinite images as a central genre of digital culture, and how they relate directly to transformations wrought by post-Fordist capitalism. A coda looks at how the current state of the infinite image is revealing of the intensification of speculative and distributed finance.

If the genealogy of the infinite aesthetic includes televisual flow within the context of post-Fordist information economy, it equally emerges from the beginnings of real-time visual computing. As the applications for computers expanded to include the generating or transmitting images, a new, uniquely computational aesthetic emerged. These new types of imagery arise from the research laboratories that developed the technologies for visual computing. Early computer art ranges from the intricate designs produced on analog computers by the Whitney brothers to Manfred Mohr's iterative computer drawings and Charles Csuri's programmed animations.[19] In parallel to these algorithmic experiments in using computers to produce art, artists were experimenting with video synthesizers to explore the visual possibilities of the live electronic video screen.

This history of the infinite aesthetic begins with "A Counterfeit Infinity: Video Art and the Emergence of Real-Time Aesthetics," which examines a lesser-known video art lab in the Bay Area – the National Center for Experiments in Television – in which some of the earliest experiments in real-time visual computing were worked out. This chapter situates the roots of the

infinite aesthetic in these artistic experiments of the early 1970s. By examining how artists embraced video feedback to create novel visual experiences – from the dizzying *mise en abyme* of the camera pointed at its own video feed, to immersive kaleidoscopic installations – this research reveals how the regenerative temporality of live video feedback supports the perception of electronic and digital images as negentropic, continuously unfolding. The endless images at NCET were embraced as sublime, as extending human perception and cognition, and were associated with psychedelia, what Theodore Roszak calls "a counterfeit infinity" in his influential study of the 1960s counterculture.

Chapter two, "Without Limits: The Animated Screensaver and 24/7 Computing," traces the infinite aesthetic to a new popular format: the animated screensaver. One of the most widespread early algorithmic moving images, the screensaver played a central role in the shift to "always on" computing. By supporting the practice of leaving the computer screen on at all hours, the screensaver normalized the 24/7 temporalty of the network. The infinite aesthetic here becomes aligned with neoliberal notions of productivity at all hours, and the screensaver, like the *mise en abyme* of the video art above, is representative of emerging digital culture's fantasies of limitlessness.

A third chapter, "Without End: The Infinite Scroll and Platform Capitalism," examines the history of the infinite scroll as the emblematic aesthetic and a central organizing principle of mobile platforms. In the historical emergence of the infinite scroll we see dominant metaphors for the internet shifting from a web of distinct sites to something continuously flowing – from pages to streams. This shift naturalizes the internet, turns it into something like a renewable resource, a river that will always replenish itself. This fantasy of limitlessness is related to platform capitalism's extractive logics. Just as the ideology of industrial-colonial capitalism framed the natural world as freely available for extraction, digital capitalism frames social life – and increasingly other areas of experience – as an endless resource to be exploited.

A key precursor to the infinite scroll of social media feeds is the stock ticker – one of the first real-time informational scrolls, which arose in the 1930s. By looking at the rhetoric of addiction and speculation that surrounds both scrolls, we can see how the form of the endless scroll has been used to extract not only attention in the present, but financial value in the future as well. This theme of speculation, gambling and futurity comes to the foreground in the latest genres of digital images, the NFT, which are supported by blockchain technology, giving the promise of a more enduring digital image. This final chapter, "Cryptic Futures" concludes with observations about how the expansive endlessness of digital media of the last fifty years is taking on new characteristics that are associated with the speculative finance that has come to dominate global capitalism. I argue that we see this shift in trends in the visual culture of Web3, which indexes the disordered, individualized, constantly shifting temporality of speculative finance. In analyzing some of the prevailing trends in crypto art, we see a return to the abstract and iterative visual tropes that typified early computer-generated art. NFT art holds out a negentropic promise – touted as a format for digital art that is more enduring than more ephemeral formats for creating or hosting art online. But whereas the endlessness of previous types of digital media were linked with expanding consciousness or productivity, the endlessness of the NFT is linked with speculative futurity. The economy around making, selling, and trading crypto art is a highly speculative one, with the monetary value of a given NFT pegged not to an intrinsic cultural or utilitarian value, but rather its potential future value. As one formula put forward by an NFT firm quite baldly put it, "Speculative value * (Aesthetic Value + Utility) = NFT value."[20] Having arisen as a popular phenomenon against the backdrop of the global pandemic in 2020-21, interest in blockchain

enabled technology can be understood as an expression of increasing anxiety about the future. But more than a response to the precarity of contemporary life, crypto can be read as a symptom of perpetual states of indebtedness and the endless deferrals of the future under finance capitalism.

In tracing the history of the endlessness of digital media, we track a transformation in the culture of time, from something standardized and quantified to something constantly shifting and renegotiated. If time under industrial modernity was something that was regulated and made homogenous through technologies and practices such as the global standardization of clocks and Taylorization, time under digital capitalism is more fluid and individualized.

True Time

The theme of individualization was one that arose again and again in researching the infinite aesthetic. The experiments in video synthesis analyzed in chapter one are in dialogue with the 1960s and '70s rhetoric of cybernetics and systems theory, which emphasized technology as a means for expanding the sensory perceptions of the empowered individual. As Gene Youngblood expressed this sentiment, new computer aided image making technologies "promise to extend man's communicative capacities beyond his most extravagant visions."[21] This notion is expressed strikingly through the mirroring effect of video feedback in 1970s video art. A piece created at the NCET experimental video art lab by artist and poet Joanne Kyger exemplifies this. In the work, *DESCARTES* (1970), the image of the artist's body is placed at the center of a *mise en abyme* effect created by video feedback loop. Her image, at the center of the screen, seems to engender myriad iterations of itself, blooming outwards to the edges of the screen, as she recites Descartes' "Discourse on the method." There are formal ways in which these visual feedback loops center the individual. As Erwin Panofsky's study of Renaissance perspective observes, the lines of three-point perspective converge on the eye of the individual, creating a heightened sense of the perceiver as at the center of the observable world.[22] The concentric shapes created by the video feedback loop – particularly in a figurative piece like *DESCARTES* - reinforce this sense of the centered individual as the source of all knowledge.

In the 1980s, where the infinite aesthetic is manifest in the animated screensaver, it is used to personalize the personal computer. Within the context of the white-collar workplace, screensavers were used to add an individual stamp to what was otherwise a generic piece of industrial office equipment – one reviewer at the time referred to screensavers as "monogramming for office computers."[23] Furthermore, within the workplace the screensaver became associated with mood regulation: it was touted for the soothing effect produced by watching the gently iterating animations. While the screensaver encouraged the practice of keeping computers on at all hours by preventing screen burn in, it was suggested that this meditative effect might solve the related problem of human burn out. Screensaver fans in the 1980s and 1990s likened the hypnotic effect of watching a screensaver's gently pulsing permutations to watching a lava lamp, or to the calm produced from a cigarette break - the soothing effect of which refreshed the worker, allowing them to avoid burnout. Here we see the infinite aesthetic enlisted in the interest of optimizing the productivity of the office worker.

As the infinite aesthetic unfolds in the streams of social media feeds in the early 2000s, its association with the individual is once again foregrounded. The ways in which the phenomenon of social media center the individual subject have been widely discussed. This often takes a moralizing attitude, with Millennials condemned as the "me generation" or the "selfie generation." (Despite the fact that the mirroring capacity of real time screens was first embraced by the video

artists of the 1960s and 70s who made use of mirroring as one of the medium-specific qualities of the new medium - what led Rosalind Krauss to famously term the medium of video to be narcissism itself.[24]) When it comes to the infinite aesthetic of social media, the endless scroll is not only endless, but it is entirely unique to a given user. It here enacts a sort of double mirroring, as the algorithmically selected information of the feed "reflects" back to the user their own interests, taking their inputs and feeding it back to them.

Streaming video and audio platforms with their endless flow of content echo many of the qualities of broadcast television. Aside from the sheer volume of content, one of the key distinctions from televisual flow lies in the high level of individualization that these platforms entail. This occurs through the phenomenon of "narrowcasting," whereby the content of channels is tailored to a specific user based on their past viewing habits. However, it isn't just the content that is individualized, but the time in which it is consumed as well. Timeshifting is not an option with streaming platforms as with precedents such as cable DVR, it is a necessity. Where broadcasting used to provide a shared, simultaneous experience (even when not live), streaming platforms are highly asynchronous. Even when a program is released at a particular time and day of the week, the exact moments when different viewers will experience the program will differ by various degrees.

As Sarah Sharma has pointed out, time under contemporary global capitalism is experienced as a highly individualized phenomenon. In Sharma's study of the cultural politics of time, not all laborers experience time in the same way - for some it is tedious and slow, for others a scarce resource. If time in modernity was standardized, regulated, quantified, measured - through practices such as scientific management, the standardization of time, in the twenty-first century becomes far more fluid and diverse. Sharma writes, "we exist in multiple, entangled temporalities" in "an uneven multiplicity of temporalities that is complicated by the labor arrangements, cultural practices, technological environments, and social spaces that respond to this so-called globalized, speedy world."[25] A taxi driver will feel time as something uneven and over which he has little control, as he is alternately stuck in traffic, or speeding to fit in as many rides as possible; whereas a corporate executive at a yoga retreat will experience her mastery over time as both a tool for self-optimization and a luxury.

This multiplicity and fluidity of contemporary time can be seen in other phenomena. For example, Google TrueTime, a proprietary system established by Google to regulate sequence across its cloud computing platform Spanner. TrueTime is described as a "distributed clock;" it is a system of timestamping information at infinitesimally specific intervals, to guarantee a sequence of events or transactions.[26] Because computerized transactions occur at such a rapid rate as to appear simultaneous to most traditional clocks, Google TrueTime establishes not so much the time that a transaction takes place as its sequence within a given time. This is especially useful for financial transactions, in which funds are processed at such incredibly rapid rates that automatically confirming the sequence of transactions is essential. For the search engine, mastery of time has always been important, if not as important as volume of information. For every second of delay in loading results, Google loses users. This is behind the imperative to automatically load more results that led to the adoption of the infinite scroll.[27] In a sense, phenomena like Google True Time undo the global standardization of clocks that occurred in the nineteenth century, when railroads and telegraphs necessitated the establishment of a synchronized, public sense of time. These technologies are emblematic of broader shifts in the experience of time, as something that is not shared but rather individual.

The Long Trip

Another major theme that emerged in tracing the history of the infinite in digital media was that of addiction. It is a cliche to describe the infinite scroll in terms of addiction, with numerous popular books and documentaries elaborating the harmful effects of extensive social media use and the addictive properties that are built into their interfaces. But drugs and addiction are themes that recur throughout the history of the infinite aesthetic.

In the 1960s counterculture, mind-altering drugs were embraced with the belief that hallucinogenic drugs could allow the user to access higher states of consciousness, to perceive what was imperceptible in everyday life, or to access the sublime. The infinite is a common motif in the culture of psychedelia, visualized in whirling spirals and iterative abstract designs and mandalas. These motifs abound in the experimental film and video art of the era, and particularly that produced at NCET, the experimental video lab in Northern California. The infinite is visualized in rippling concentric circles produced by the video feedback between the camera and monitor. The pattern is featured on the poster advertising Ken Kesey's historic psychedelic gathering, the Trips Festival: whirling black and white lines converge in a circle, at the center of which is the undulating line of an oscilloscope. These references to the oscilloscope and to video feedback overtly connect the perceptual experiences of psychedelia with the new electronic technology. As mentioned above, Theodore Roszak's study of the New Left and the Hippies of the 1960s, *The Making of the Counter Culture*, describes the embrace of psychedelics as leading to a "counterfeit infinity." For Roszak and other critics of hippie culture, the lofty goals of psychedelia were just as likely to lead to drug abuse as to spiritual awakening. At NCET, feedback is derided in part because of its addictiveness, with one critic writing, "Feedback is a whore: its prettiness can be so enticing that time and energy are destroyed."[28]

The abstract and iterative nature of screensaver animations were also closely aligned with psychedelics. Not only are there anecdotes of watching screensavers while under the influence of mind-altering substances, but the screensaver was also cast as having a soothing effect or being able to increase concentration - similar to the role that microdosing plays in Silicon Valley tech culture today. But it is the infinite scroll that has received the most attention for its addictive properties. A good deal of scholarly research and popular writing have documented the intentionally addictive properties of mobile media interface design.[29] The beguiling qualities of commercial interface designs, coupled with the apparent endlessness of the automatically loading results of the scroll are what allow it to be exploited to such success by platforms premised on attention and engagement.

The Deluge

Meta's recent venture into VR technology can be read as a return to the cyberpunk themes of a previous generation. The metaverse is in many respects a recasting of the "cyberspace" popular in the 1990s as a metaphor for the experience of using the internet. As the world wide web became commercialized in the 1990s and spread in popularity, it was frequently described in spatial terms. This enthusiasm for the internet as an endless space is seen in the earliest imaginings of virtual digital space. In John Perry Barlow's writing on the virtual in the 1970s, he articulated a fantasy

of computers providing access to a world that is not only limitless in terms of space, but where one is not subject to the forces of entropy. He writes:

> "Despite the current confines of my little office-island, I know that I have become a traveler in a realm which will be ultimately bounded only by human imagination, a world without any of the usual limits of geography, growth, carrying capacity, density or ownership. In this magic theater, there's no gravity, no Second Law of Thermodynamics, indeed, no laws at all beyond those imposed by computer processing speed...and given the accelerating capacity of that constraint, this universe will probably expand faster than the one I'm used to."[30]

Barlow casts computers as unconstrained by natural laws, enabling limitless expansion. Echoing similar rhetoric to that of Wiener, Smithson, Arnheim, and Youngblood, who sought out the anti-entropic in art and culture, he defines computation as a technology uniquely capable of escaping inertia and decay. These fantasies of mastery over time and space persist in futurist projects such as The Long Now Foundation, founded by Stewart Brand, the influential countercultural figure whose Whole Earth Catalog influenced the embrace of personal computing.[31] The Long Now is engaged in the process of building a monumental clock that will last for 10,000 years. This effort betrays a fantasy of mastery over death, a belief in the ability for technology to prevail over the inevitability of entropy.

As Wendy Chun has argued, the spatial metaphors of the internet as cyberspace reinscribe in the context of digital networks colonialist fantasies of exploration and exploitation.[32] The idea of the internet as an "electronic frontier," an exoticized non-western landscape, is pervasive in cyberpunk narratives and in the popular culture of computing more broadly. The most recent incarnation of cyberspace as the "metaverse" is not so different, its colonialist fantasies manifest in how it frames personal information as a natural resource. Meta's infinity symbol not only represents an infinite virtual place, but endless data capture and capitalization. The metaverse's association with Web3 and distributed finance underscores how virtual space continues to be linked with fantasies of capitalist extraction.

If industrial colonial capitalism perfected the conquest of space and the exploitation of natural resources; data capitalism is invested in conquering time, as platforms seek to attract attention and acquire ever more information from their users. The infinite aesthetic in digital media appeals to these desires for endless expansion. The myth of negentropy that I argue defines computation, with its promise of continuous renewal, frames digital media as something fluid, alive, and thus natural. Once the infinite aesthetic came to be truly yoked to digital capitalism, the rhetoric surrounding it became increasingly that of natural phenomena. The infinite scroll and the smartphone devices used to support it are described in terms of waterfalls, infinity pools, and streams. The effortless continuousness of the infinite aesthetic in its many manifestations promises us that the digital imagery that we consume exist in an endless stream, and a stream is a resource that will always be replenished.

In his later writing Wiener turns to Goethe's story of the sorcerer's apprentice to illustrate the fearful power of nonlinear feedback. Although not mentioned specifically, it is not unlikely that Wiener was influenced by the Walt Disney interpretation of this tale in the 1940 film *Fantasia*. In both the fable and the Disney rendition, an apprentice overhears magical words spoken by his master that will charge inanimate objects with a lifelike force. While his teacher is away one day the apprentice uses this spell to charm a broomstick into life to carry out his chore of carrying water from a well. The enchanted broomstick performs this task as instructed, efficiently and continuously. But the apprentice does not know the command to make the broom stop – and like

a computer program stuck in an infinite loop – its repetitive actions threaten to literally overwhelm the apprentice. He is on the verge of drowning in the deluge created by the broom's repeated trips to the well when the sorcerer returns and speaks the words that stop the spell. In the Paul Dukas orchestral interpretation of Goethe's story, the iterative nature of this experience is foregrounded: the repetitive rhythm of the music becomes terrifying in its force as it is amplified in volume and tone with each successive iteration. In the Disney rendition, the episode comes to its dramatic climax with the apprentice seen caught at the bottom of a powerful whirlpool, its powerful waves rising high above, threatening to overpower him.

For Wiener, the story illustrates the dangers of learning machines with unchecked power. He writes, "the point is that the agencies of magic are literal-minded…. If we program a machine for winning a war, we must think well what we mean by winning."[33] It is a somewhat poignant point, given the origins of Wiener's theories with programming WWII gun-controllers. The uncontrollable chain reaction that threatened Wiener's generation was that of nuclear war. Today's anxieties about power oscillating out of control are centered on increasing economic precarity and the climate crisis. The indeterminacy of a media stream with no perceivable end speak to these contemporary worries about the endless deferrals of indebtedness, the uncertainty of political instability, and the unpredictability of climate related disasters. The history of the infinite aesthetic of digital media reveals how an essential characteristic of computational technologies - their negentropic potential for constant renewal - became inextricably linked with an economic exploitation of time and information. But it also charts how one of digital culture's prevailing aesthetics has expressed different ideas as it has evolved over the last fifty years and continues to represent distinctly different attitudes depending on one's position. What for some is experienced as exhausting or overwhelming, alternately represents expansiveness and promise for those in a position to benefit from the promise of new digital technologies. The following dissertation traces the historical emergence of a prevailing aesthetic and an organizing principle in digital culture – a tendency towards the continual deferral of endings, which is intimately linked with capitalism's constant drive for endless expansion.

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[2] "Introducing Meta: A Social Technology Company," press release, Meta Newsroom, October 28, 2021, https://about.fb.com/news/2021/10/facebook-company-is-now-meta/.

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[26] As Google describes it: "the system behaves as if all transactions were executed sequentially, even though Spanner actually runs them across multiple servers (and possibly in multiple datacenters) for higher performance and availability. In addition, if one transaction completes before another transaction starts to commit, the system guarantees that clients can never see a state that includes the effect of the second transaction but not the first. […] For example, suppose that you have created a banking application on Spanner and one of your customers starts with $50 in their checking account and $50 in their savings account. Your application then begins a workflow in which it first commits a transaction T_1 to deposit $200 into the savings account, and then issues a second transaction T_2 to debit $150 from the checking account. Further, assume that at the end of the day, negative balances in one account are covered automatically from other accounts, and a customer incurs a penalty if the total balance across all their accounts is negative at any time during that day. External consistency guarantees that because T_2 starts to commit after T_1 finishes, then all readers of the database will observe that the deposit T_1 occurred before the debit T_2. Put another way, external consistency guarantees that no one will ever see a state where T_2 occurs prior to T_1; in other words, the debit will never incur a penalty due to insufficient funds." https://cloud.google.com/spanner/docs/true-time-external-consistency.

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A Counterfeit Infinity: Video Art and the Emergence of Real-Time Aesthetics

In 1968, Brice Howard, a public television producer and mid-level administrator from New York City, arrived in the San Francisco Bay Area to head up a newly founded experimental video lab. The National Center for Experiments in Television (NCET) was charged with exploring the possibilities of emerging electronic media. Howard selected a handful of artists from among the many drawn to the Northern California counterculture and gave them free rein to produce experimental media using the lab's video equipment. These artists collaborated to produce a body of work that engendered novel aesthetics for the new electronic screen. In a report on the findings of the lab, Howard emphasized the lab's goals in embracing electronic media. For Howard and the artists at the NCET lab, electronic media would provide the paint and canvas of the new era. Echoing a modernist mid-century investment in medium-specificity, Howard went so far as to declare the electron itself to be a medium, writing: "The [electron] is here. It is material with which we can make."[34] In their work at the lab, the NCET artists explored what was unique to these tools. More than anything else, it was the live feedback possible with video equipment that set it apart from other media. The electron beam tracing a line across the video monitor instated a liveness and an immediacy which the artists exploited in the video works produced at the lab.[35]

Video art of the 1970s is frequently considered in relation to the dominance of the medium of television in the postwar period, with artists and scholars alike positioning these works as critiques of mainstream broadcasting. However, the NCET innovations with the electronic screen are far more in dialogue with a different medium gaining dominance in the 1970s: the personal computer, a technology that relied on the live, real-time capabilities of the electronic monitor. Contemporaneous to the NCET experiments with real-time video, the field of computation was also experiencing major innovations. The late 1960s and early 1970s were a watershed moment for the transformation of computers into visual devices. What had previously been a medium of texts and numbers delivered on punch cards became increasingly visual due to innovations in user interfaces. The temporality of computing was shifting from the model of batch processing - which required significant periods of latency - towards real-time, interactive modes. These intertwined innovations paved the way for the personal computing revolution, which radically altered the nature of computation. Although the NCET artists used electronic devices to produce their work (rather than digital computers), their innovations run parallel to - and feed into - developments in computer graphics and real-time, screen-based computation. The visual language that develops at this historical emergence of real-time computing and the graphical interface reveals much about how computers structure visual information. Because of the liveness, the responsiveness, of video, these experiments were a key site in which the aesthetics of the then-emerging field of computer graphics were worked out.

One of the most distinctive visual effects to come out of NCET was the trope of visual feedback, or repeated images generated by pointing the camera at a live monitor – the visual analog to the screech produced when a microphone is placed too close to its sound source and the amplification oscillates out of control. Feedback between the camera and the monitor produces seemingly endless repetitions of the image, reverberating out from the center of the screen in a cascading *mise en abyme.* The NCET artists were infatuated with this effect and used it extensively. An emblematic example from the Center's first year is *Feedback with Jazz* (1968), a

short piece that was created as a live visual accompaniment to a musical performance. The video is entirely abstract and uses the repetition generated by the feedback between camera and monitor to produce rippling bands of black and white that appear to recede, tunnel-like, towards a distant

NCET, *Feedback With Jazz* (1968). Poster design by Wes Wilson (1966).

vanishing point. The soundtrack captures the voices of the video technicians giving occasional commands to one another, emphasizing the live, performed nature of the piece. The regularly alternating circles of black and white ripple like fabric and appear to flow towards a vanishing point in the corner of the screen.

The piece's graphic alternation of black and white bands is evocative of the machinic repetition of 1960s Op Art, particularly as filtered through the psychedelic vision of the Bay Area counterculture. *Feedback With Jazz* offers a fluid time-based version of a trope that appears in several emblematic posters of the Bay Area psychedelic culture. Repeating lines or concentric circles converging on a vanishing point are the central pattern in Wes Wilson's poster for the 1966 Trips Festival, in posters for Ken Kesey's Acid Tests, and on the album cover for Timothy Leary's *L.S.D.* (1966). In the case of these countercultural posters, the infinitude of the vanishing point, coupled with the visual stimulations of Op, are suggestive of the hallucinogenic experience of psychedelics. The pulsing line of an oscilloscope – an icon of the electronic age – at the center of Wes Wilson's poster is expressive of the interrelationship of psychedelics and new media in countercultural discourse. As historian Fred Turner has observed, the Trips Festival was a pivotal moment in bringing together the worlds of psychedelics and experimental electronic art in their shared investment in novel and expanded sensorial experiences.[36] Video art and closed-circuit television were among the myriad multi-media spectacles on display at the festival and were embraced by artists in the late 1960s and early 1970s for their potential to technologically extend or enhance human perception.

In Theodore Roszak's *The Making of a Counter Culture*, his influential account of the cultural transformations wrought by the post-war youth culture, Roszak terms the experience of psychedelics a "counterfeit infinity." Though psychedelic evangelists like Kesey and Leary promise sublime experiences, expanded perception, and the attainment of greater truth, Roszak argues that in practice psychedelics are more likely to lead to false or facile revelations.[37] Although

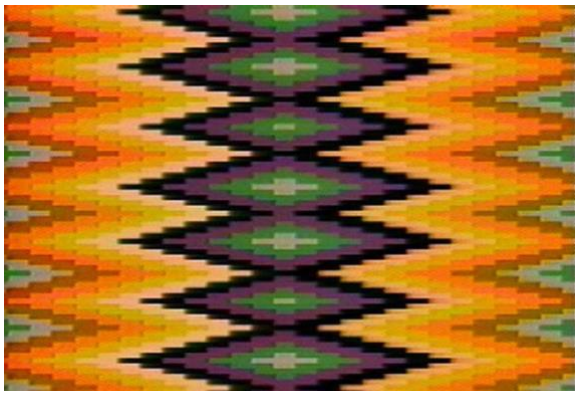
the video art produced at NCET is steeped in the ethos and aesthetics of psychedelics, this chapter traces a different sort of "counterfeit infinity" that emerges in these artworks: the impression produced by live feedback that electronic screens engender endlessly continuous image streams. The feedback loop of video, along with related experiments using video synthesis and mirroring installations to iterate and automatically repeat the moving image that this chapter will explore, represented more than just a visual tic at NCET. Feedback inaugurated a fundamental rupture in the form of moving images, transforming them from something with discrete and finite duration, to something open-ended, and continually renewing. The feedback loop of video continually takes in new information to produce an image that is constantly unfolding. While scholars such as John Hanhardt, David Antin and Rosalind Krauss have famously theorized video's liveness,[38] this chapter will analyze how the videos produced at NCET are significant for their innovation of an aesthetic that is generative, ongoing, and suggestively infinite. Histories of digital art tend to consider video art and computer-generated images to have distinct genealogies, however I argue that – due to the feedback mechanisms inherent to their shared real-time screens – they are indeed closely linked.

This chapter explores this aesthetic through three illustrative case studies, which explore the aesthetic possibilities of live electronic screens. I begin with a series of short videos that were among the first real-time moving images created entirely on an electronic device. Stephen Beck's *Video Weavings* use textile-like patterns to foreground the scanlines that comprise the monitor-based image and explore the nature of camera-less, entirely synthesized electronic moving images. At a time when computer graphics were highly limited, Beck was able to create intricate, colorful images in real-time on his video synthesizer. This section provides an example of the emerging genre of video synthesis, an important precursor to computer generated imagery. Stephen Beck's *Video Weavings* are highly iterative, displaying a computational logic for moving images that are regenerative and continuously unfolding.

After establishing NCET's connections to the emergence of real-time computing, this chapter turns to one of the most emblematic of NCET's innovations: the trope of using feedback to create dizzyingly iterative images. This effect is a striking visual expression of postwar cybernetic theories of feedback, which underpins the "aliveness" of biological organisms and cybernetic systems. Cybernetic theories of technological enhancement are thematized in these video artworks, which use feedback to evoke a technologically or pharmacologically extended human sensorium. The feedback loop was particularly well suited to the psychedelic meditations embraced by the countercultural artists: as it gestures towards the infinite it challenges perception and even cognition.

These psychedelic influences can also be seen in the chapter's final case study: the Videola, a large collective viewing apparatus which expanded the video image in time and space by positioning the monitor within a cone of mirrors. The Videola intersects with contemporaneous experiments in large-screen and immersive moving image environments, at the same time as it enacts a temporality that is both unbounded and live. The unboundedness of these images, so different from the linearity of film and the segmentation of television, is met with some ambivalence, with many deriding NCET's trippy effects and extensive use of feedback as facile and anti-intellectual. Yet the artists at NCET celebrated the unbounded video image for its freedom and expansiveness. They embraced electronic media for its ability to empower the individual, to extend perceptual or cognitive capacities and create novel visual regimes for the emerging information technologies. The infinite aesthetics produced NCET at this moment of experimentation and invention for computer-generated imagery were deeply influential in coeval

and subsequent developments in digital visual culture.



Stephen Beck, *Video Weavings* (1974).

Stephen Beck, *Video Weavings* (1974).

Video Weavings: Creating the Electronic Image

The National Center for Experiments in Television was one of three television laboratories founded in the late 1960s with a grant from the Rockefeller Foundation. The centers, each associated with a public broadcasting station - KQED in San Francisco, WNET in New York and WGBH in Boston - were envisioned as spaces for research and experimentation with the relatively new mediums of television and video, and there was growing enthusiasm for its potential as a mass medium. At this time video had become newly portable and affordable for use by individual artists. While the subsequently founded labs at WNET and WGBH are generally more well-known - especially the New Television Workshop at WGBH which would become famous as the site of Nam June Paik's seminal experiments with video - NCET was the most formally experimental of the centers and was distinct for its emphasis on video synthesis and abstraction over figurative, lens-based imagery. NCET's experiments in electronically produced imagery gave a distinctive style to the work produced there.

NCET began in 1967 as the KQED Experimental Television Lab, a pilot program housed at the Bay Area public television station. After some success in its first years, the program was expanded into the autonomous NCET and moved into its own space in downtown San Francisco, although it remained associated with the public television station.[39] NCET had an educational mission, and Howard himself was an educator and an advocate of video: like many in the late 1960s and 1970s, Howard saw the medium of video as having potential to put the means of making media in the hands of the wider public. In addition to their experimentation at the San Francisco lab, Brice Howard and several of the NCET artists fulfilled this mission to broaden access by visiting college campuses to encourage students to learn how to use video, establishing satellite programs at several universities across the country.[40] Many artists and advocates at this time embraced the newly accessibly medium of video for its potential to subvert mainstream media. Several artist-led television stations or video exchanges were founded with the goal of educating the public in media production and disseminating these works. In addition to the highly influential Rockefeller-funded labs, other notable artist-led video networks included Ant Farm's *Media Van* and *Truckstop Network* (1970) and the video collectives TVTV in San Francisco and Videofreex in New York (1969-1978).

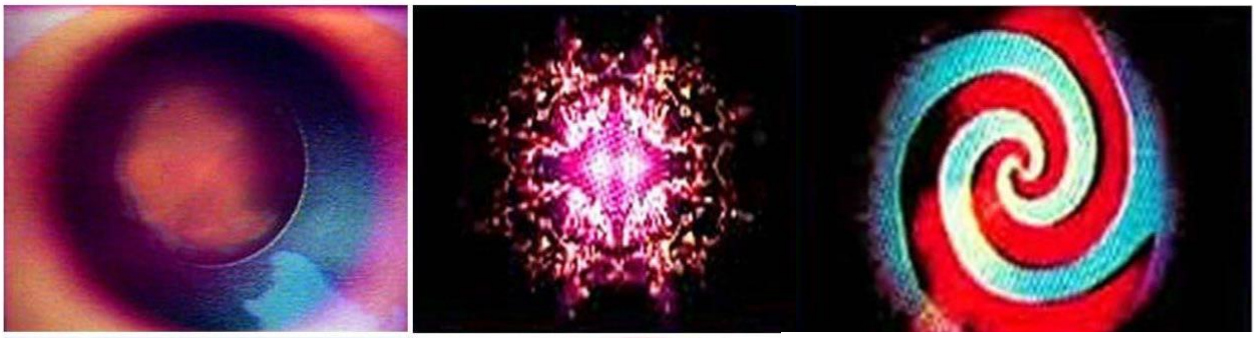
This investment in video's potential to use the mass medium of broadcasting for commentary or critique was an animating principle for many of the first artists to embrace the

medium. At the time of video art's infancy in the 1960s and 1970s, the medium was seen as practically interchangeable with television. Nam June Paik's earliest forays into video were primarily interventions in the medium of broadcasting. His piece *Exposition of Music-Electronic Television* (1963) was comprised of television receivers which had been modified by Paik so that the broadcast pictures were distorted into abstract forms. Many influential early video artworks were expressly critiques of broadcast television, such as David Hall's *TV Interruptions* (1971) - short videos which interrupted television broadcasts in Scotland - and Richard Serra's *Television Delivers People* (1973), uses scrolling text to display an argument that television "delivers" the audience as a product to corporate advertisers. These works foreground the asymmetry inherent to the institution of broadcasting in the U.S., in which corporations dictate the content and form of the mass medium. In 1975, critic David Antin went so far as to assert that in fact all video art - because of its close technological ties to television - was implicitly about television, famously claiming television as the "frightful parent" of video.[41] Antin cites several video works which, though not expressly about television, evoked its visual rhetoric: Vito Acconci's *Undertone* (1972) and John Baldessari's *Inventory* (1972) channel the mannered narration and direct address of news programs; Richard Serra's *Prisoner's Dilemma* and Eleanor Antin's *The Ballerina and the Bum* employ television's limited editing, single-camera setups and almost exclusive use of close-ups.

While this televisual rhetoric can be identified in certain NCET video works, the center was deeply invested in using video to innovate entirely new aesthetics. Although the NCET artists used KQED's broadcasting equipment - and occasionally broadcast their pieces on its programs - they were far less interested in broadcasting as a medium than in using electronic technology for novel audio-visual forms. About his decision to recruit an intentionally interdisciplinary group of artists, Howard reportedly claimed that he explicitly wanted "people who didn't care much about television,"[42] instead enlisting poets, filmmakers, painters, sculptors and musicians, as well as engineers, who would explore the new possibilities of electronic image creation.

Key among these investigations into electronic media's potential was Stephen Beck's Direct Video Synthesizer – one of the first devices for generating an entirely electronic, camera-less moving image. Stephen Beck was an engineering student at the University of Illinois when he first visited NCET on spring break in 1970. He had begun experimenting with a device for synthesizing color television - modeled after the Moog audio synthesizer - and was looking for television stations that would be interested in his concept. Of his first visit to NCET he later recalled, "I was expecting to walk into this high-tech lab with all this fancy electronic equipment. But, no - it was in an alley off of Third Street, around the corner from KQED studios, behind the *Rolling Stone Magazine* office."[43] Beck was immediately taken with the countercultural atmosphere of experimentation at NCET, which he described as a video Bauhaus. Brice Howard invited Beck to join NCET as an artist-in-residence, so he enrolled at UC Berkeley and joined the team at the center.

It was Howard who named Beck's process "direct video synthesis," because rather than manipulating a camera image, it generated the signal itself.[44] Many video processers at the time, such as that created by Nam June Paik and Shuya Abe, worked by altering the signal input from a video camera. The image could be manipulated by adding color (colorizing), superimposition (mixing), replacing a masked area of the image with another feed (keying), raster manipulation (shifting the height and width), and fades and wipes. Beck's synthesizer instead generated entirely original images on the monitor by directly controlling the movement of electrons on the cathode ray tubes. Patterns and shapes could be generated by altering the electronic current, producing



Stephen Beck, *Visual Music* (1972).

variations in form, texture, color, brightness, and motion in real time. As Beck described the difference between Paik's device and his own: "Paik was always trying to tear things apart, while I was trying to put things together."[45]

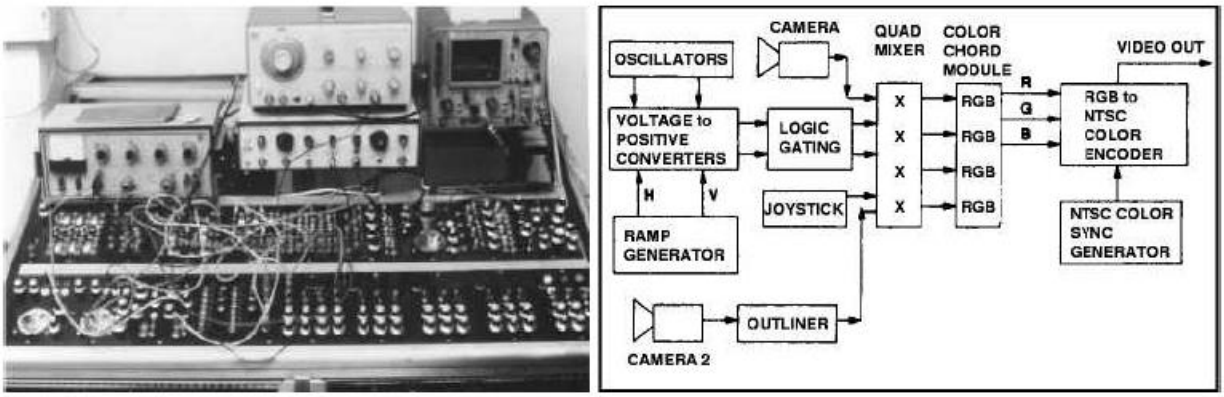
One of Beck's first pieces completed with the Direct Video Synthesizer was a composition called *Illuminated Music*, which he performed live on the KQED television station in 1972, following the nightly news. The piece was composed of entirely abstract, colorful imagery generated in real-time with the video synthesizer. Swirls, vortices, and spirographic patterns rendered in glowing acid greens and magenta shifted and mutated in time to music by Yusef Lateef. As Beck recounts, "the KQED people told me that the switchboard lit up like a Christmas tree once my images started broadcasting. People were calling in, going 'What is this? It's great!…' [or] 'You broke my television!'"[46]

Undermining the functioning of the television set was not accidental. As critic Lucinda Furlong pointed out, looking back at the emergence of video processing as a genre in the 1970s, video was so closely associated with television that this sort of visual assault on the screen was seen as a direct challenge to the broadcasting institution. "Challenging the institution of television in the late 1960s also meant creating images that looked different from standard TV. Thus, 'image processing' as we now know it grew out of an intensive period of experimentation that for some, in a vague way, was seen visually to subvert the system that brought the Vietnam War home every night."[47] Furlong argues that video processing as a genre of art defined itself in opposition to television.

Video processing – especially the abstract, nonobjective work created by Beck – set itself apart not just from television but from the broader field of lens-based video art. Art historian Kris Paulsen has observed that the artists at NCET put forward a different notion of the medium-specificity of video than that of dominant art world narratives. She argues that "Rather than focusing on the mimetic properties of the camera and its ability to produce and transmit representational images, which dominated discussions of video's formal character, the NCET artists turned their attention to the abstract, electronic structure of the cathode ray screen. They located the essential properties of video not in the live transmission of a camera image, but in the blinking pulse of the electron beam."[48] Video was seen by Beck, Howard, and other NCET artists not as a representational, photographic, medium but one of synthetic, electronic image. As Paulsen observes, NCET "created a genre of video based on the screen rather than the camera."[49]

Stephen Beck himself saw his work as illuminating the visual capacities of the video screen. Beck claimed, "People had no clue as to how television worked, how video worked, and

the fact that there is a scanning of a horizontal electron beam and vertical scanning and so on. I



The Beck Direct Video Synthesizer, from Dreher, *History of Computer Art*, IASLonline Lessons, 2011.

was trying to come up with a metaphor to help make that association, and I realized that the way the video image is constructed has a relation to textiles."[50] His *Video Weavings*, a series created in 1974/5 on the digital device that succeeded the analog Direct Video Synthesizer, are abstract images composed in grid-like and repetitive patterns.[51] Short sequences of stripes, diamond and chevron patterns in alternating colors move outwards from the center of the screen along horizontal and vertical lines. The patterns intentionally evoke those in traditional woven materials: for Beck, the way in which textiles produce patterns via a grid of horizontal and vertical threads was analogous to the way the electron gun of a video or CRT screen produced an image from vertical and horizontal scan lines. [52]

As a system for generating non-lens-based images, Beck's video synthesizers were in dialogue with the contemporaneously emerging field of computer graphics. Beck's devices shared with computer graphics the status of images entirely synthesized by an electronic device. However, the Direct Video Synthesizer was distinct from most computer-generated imagery at the time for its ability to produce images live, in "real-time." As Stephen Beck himself described it:

"At this time, all a computer could do was draw a monochrome dot on an oscilloscope screen, or maybe a line, and if you wanted to do anything with computer graphics in dynamic kinetic cinematic fashion, you had to use a film camera and do stop-action animation, one frame at a time. It could take even a fairly hefty IBM-1170 tens of minutes to an hour just to compute the position of one thousand dots. What I wanted was real-time, lush, rich color interested through manual play on a keyboardlike device."[53]

Unlike the majority of moving images being produced by computers up until this time, the capacity of video to manipulate the image live was unique. The dominant model of computing in the 1960s was batch processing, whereby a program would be fed into a machine via punch cards or magnetic tape, with the results produced after the fact, sometimes hours later. Artists using computers to generate images mostly relied on output devices such as printers or microfilm plotters to render their programs into graphics. This is how groundbreaking computer films of the late 1960s and early 1970s such as Charles Csuri's *Hummingbird* (1967) and Stan VanDerBeek and Kenneth Knowlton's *Poemfields* series (1965-1969) were produced.[54]

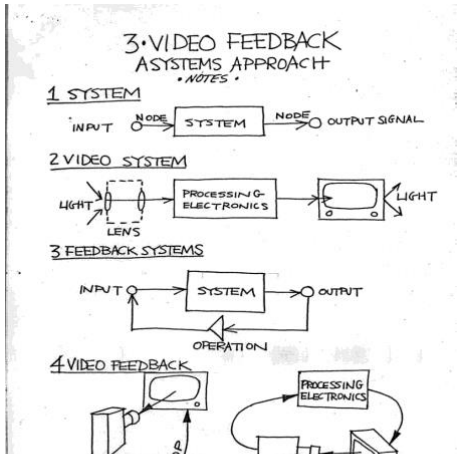
Compared to this mode for generating moving images, video was far more interactive and responsive than the computer. In an interview in Gene Youngblood's *Expanded Cinema*, an iconic text from the period on computer-generated moving images, Brice Howard described the key characteristics of video to be its potential to capture process unfolding in real-time:

> "What you are experiencing [with video] is process… All the tapes […] are records of process, records of discovery, […] And what is really the richest part of [video], less its technology, less its cubist nature, less its incredible colorations and shapes and motions and excitements - it's now, it's capturing the damned actual with all of its aberrations." [55]

Video was a medium of real-time manipulation of the image at a time when computer graphics were extremely limited. Though real-time computer screens date back to the MIT Whirlwind in the early 1950s, and despite major innovations in the 1960s, such as Ivan Sutherland's Sketchpad graphics system (1963) and Douglas Englebart's design for the mouse (1968), interactive graphics remained limited to a handful of research programs. At the same time that Beck was developing his system for generating electronic images on the video screen, a major revolution in interactive computer screens and graphics was taking place. The early 1970s would see the emergence of Xerox PARC's SuperPaint system (1973), the XEROX Alto – with one of the first graphical user interfaces - and the Atari video console (1972). The liveness of the CRT display is essential to these systems, in that unlike other output devices for computers - plotters and printers - it allows one to see the image immediately, as it is being created.[56]

Although the monitor of video and the computer rely on similar CRT screen technology, there are important distinctions. As Jacob Gaboury has argued, the ability to store and retrieve the image (via the technology of the frame buffer) is a fundamental distinction between computer graphics and video.[57] While Beck could generate and manipulate electronic images with his device, these must typically be generated live – there was limited possibility to manipulate a stored image. While video processors could work with video previously recorded to a magnetic tape, they were far more limited in how they could use this material than a computer could in calling up saved pixels. Despite these material distinctions, video synthesis was an influential, if indirect, predecessor to computer-generated imagery. Stewart Brand concludes his iconic 1972 *Rolling Stone* profile of hacker culture by invoking Beck's video synthesis experiments at NCET as representing an exciting way forward for computer graphics. Brand declared, "If I were a computer manufacturer I'd pay the closest attention [to NCET]."[58] Brand's article narrates how innovations such as Ivan Sutherland's *Sketchpad* and the game *Spacewar!* were pioneering the use of real-time interactive graphics in computing. Compared to the highly limited black and white graphics available to *Spacewar!* and *Sketchpad*, Beck's video synthesizer was producing far more dynamic and colorful graphics. As a more widely available medium for visual artists, video processing

Joanne Kyger, DESCARTES (1968).



Bill Gwin, "Feedback: How to Make it…" (1969).

equipment such as Beck's system were a useful site for these early experiments with the aesthetics of electronic screens. Liveness, as an essential quality shared by both the monitor of computer graphics systems and of the video, was fundamental to this experimentation.

Feedback: Video's *Mise en Abyme*

Video's capacity for real-time manipulation has been central to theorization of the medium since its infancy. Artists immediately embraced video for its unique ability to produce a live image in real-time, and in particular for how this immediacy produced an effect analogous to that of a mirror.

The artist using video's real-time capacities to view his or her own reflected image became a ubiquitous trope in the video art of the period, to such an extent that critic Rosalind Krauss famously described this mirroring effect of the medium as enacting a narcissism fundamental to the medium. Krauss identifies a genre of video art from the early 1970s in which artists produced real-time images of themselves, always a medium-close-up of the artist gazing into the camera with the aid of a monitor. She wrote: "Unlike other visual arts, video is capable of recording and transmitting at the same time - producing instant feedback. The body is therefore as it were centered between two machines that are the opening and closing of a parenthesis. The first of these is the camera; the second is the monitor, which reprojects the performer's image with the immediacy of a mirror."[59]

For Krauss, video is problematic in that it addresses no external object - there is no object or "other" of video art, only the subjectivity of the artist themself, rebounded upon itself. The mirroring effect of the video-monitor configuration leaves the artists in a "prison of a collapsed present,"[60] with no possibility for critique, contemplation, or change. In a response to Krauss, art historian Anne Wagner argued that in fact the conventions and technology of video foreground the presence of the viewer and the public over the mirror image of the artist. Revisiting Krauss' example of Acconci's *Centers* (1971), in which the artist sights down his outstretched arm, pointing at the center of the screen, Wagner argues that though Acconci was pointing at his own image in the creation of piece, the effect is of pointing outwards, at the viewer. His gesture is an emphatic address ("you" "Hey!"[61]), rather than a narcissistic turning inward. Citing video art's roots in performance art, which deploys optical technologies (mirrors, photos, movie cameras), "to foreground an audience's understanding that it is what is being seen,"[62] Wagner argues that video's address of the viewer, "[Summons] you into the present moment, as an audience, and sometimes, under selected circumstances, to make you all-too-conscious of that fact. By these means the performance becomes double-sided; actor and viewer are locked in a pas de deux."[63]

Krauss' and Wagner's critiques - though divergent in their attitudes towards the politics of video - both identify video as a medium of liveness, a technology which emphasizes simultaneity between the representation in the monitor and the thing represented. For Krauss, the video artist is locked in a "collapsed present", a mirroring that ultimately leads nowhere but back to itself. While the NCET artists, similar to those described by Krauss, exploit video's capacity for liveness, the emphasis is less on simultaneity than on a present unfolding in time. The crux of this distinction is a particular quirk of the video technology: as artists working with video equipment quickly discovered, when the camera is pointed at a live monitor, the closed circuit creates rippling, recursive forms, replications of the image that seem to repeat *ad infinitum*. The mirroring between the monitor and the camera effectively recreates the *mise en abyme* created by two mirrors placed

at an angle to one another, continually rebounding the same image back to itself. Whereas the feedback loop established between monitor and camera was used in works like Acconci's *Centers* to mirror the live image of the artist, the same technical phenomenon was used by the artists at NCET to explore abstract aesthetic forms which expand outwards.

NCET artist Bill Gwin, in a research document produced for the center, commented on the seductiveness of the feedback technique, which he and the other artists used to generate unique patterns. He wrote: "It is produced by the most simple complement of electronic tools, a camera and a display monitor. By manipulating these two objects the artist can conjure limitless variations of stunningly complex imagery. In the early days of discovery, feedback is magic: spirals, flowers, mandalas burst forth with the touch of a fingertip and regenerate themselves indefinitely on the screen."[64] These forms can be further manipulated by adjusting the electronic variables, which introduce color, reversed polarity, time delays and other effects. The feedback effect was embraced by so many early video artists that it quickly became a cliché. Gwin commented that the ease of producing this stunning effect led to its overuse, recounting: "Several years ago, a poet visiting the Center observed: 'feedback is a whore.' Its prettiness can be so enticing that time and energy are destroyed without leading to any serious expression or work. In this situation, it's been fun, but may be almost counter-productive to art."[65]

The concept of feedback was popularized by Norbert Wiener's theories of cybernetics, which – although first elaborated in the late 1940s – were increasingly in vogue amongst artists in the 1960s.[66] Major exhibitions such as *Cybernetic Serendipity* at the ICA London in 1968, and *TV as a Creative Medium* at Howard Wise Gallery in 1969, helped popularize the intersections of art and new communications technology. Writing in 1976, critic David Antin noted video art's embrace of cybernetic theory, claiming that discourses around video espoused a certain "cyberscat," "a kind of enthusiastic welcoming prose peppered with fragments of communication theory and McLuhanesque media talk."[67] NCET was in the thick of this broader movement in art of the 1960s and 1970s that reflected an increased awareness of cybernetic theory, as information technologies were adopted outside of research institutions. While NCET demonstrated a tendency toward "cyberscat" in most areas of artistic output, this was most direct in the center's embrace of electronic feedback.

Most broadly, feedback describes the process of a self-regulating system, whereby a dynamic system uses the input of information to regulate its operations. A common example is a thermostat, which will monitor the temperature of a space and automatically adjust heat output to maintain a given temperature. Wiener borrowed the concept from electrical engineering and applied it to a wide range of systems – not just electrical or mechanical but organic and social as well. Wiener argued that the shared process of feedback – of automatically controlling the functioning of a system by monitoring the input of information – was the basis of an analogy between machines and living organisms. He wrote:

> "It is my thesis that the physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback. Both of them have sensory receptors as one stage in their cycle of operation: that is, in both of them there exists a special apparatus for collecting information from the outer world at low energy levels, and for making it available in the operation of the individual or of the machine. […] The information is then turned into a new form available for the further stages of performance. In both the animal and the machine this performance is made to be effective on the outer world."[68]

Feedback, as a process that occurs in both living things and machines, forms the backbone of cybernetic theory, but it took on a life of its own in popular discourse in the 1960s and 1970s. As scholar Daniel Belgrad has argued, feedback was a powerful metaphor, emphasizing the interrelationship of the components of a closed system, for a wide range of artistic and cultural discourses in the 1970s, from information theory and ecology to improvisation and ambient music.[69] The NCET artists participated in this cultural embrace of feedback and cybernetics through their experiments with artist-machine configurations.

Technically any simple relationship of video to camera is actually one of feedback: new information is taken in via the lens of the camera and alters the patterns on the monitor. Feedback of this sort was exploited by artists using video for its real-time mirroring properties (such as the artists described by Krauss) as well as installations making use of closed-circuit video, such as Dan Graham's *Video Corridors* (1969-70), to mirror the presence of the viewer in the gallery. The *mise en abyme* effect deployed by the NCET artists - by which the loop between camera and monitor generates continual repetitions of the image - is the result of a particular kind of feedback, or nonlinear feedback. Feedback in a closed system will maintain homeostasis, such as is the case with a thermostat continually regulating an even temperature. In the case of video feedback, a closed system entails the straightforward mirroring of a video monitor representing what the camera sees. Nonlinear feedback, on the other hand, will continue to transform exponentially.[70] In the original version of *Cybernetics*, Wiener discusses nonlinear feedback in terms of error and catastrophe: a system that goes into "unrestrained and increasing oscillation" would be unmanageable.[71] The *mise en abyme* effect exploited by the NCET videos is essentially a glitch achieved when the electrical signal received by the monitor goes into unrestrained repetition. It is analogous the effect created when an audio speaker is placed too close to the microphone – the microphone will continue to amplify its own signal until it oscillates out of control. In the visual case of video feedback, the effect is of nested images repeating until they disappear into a vanishing point.

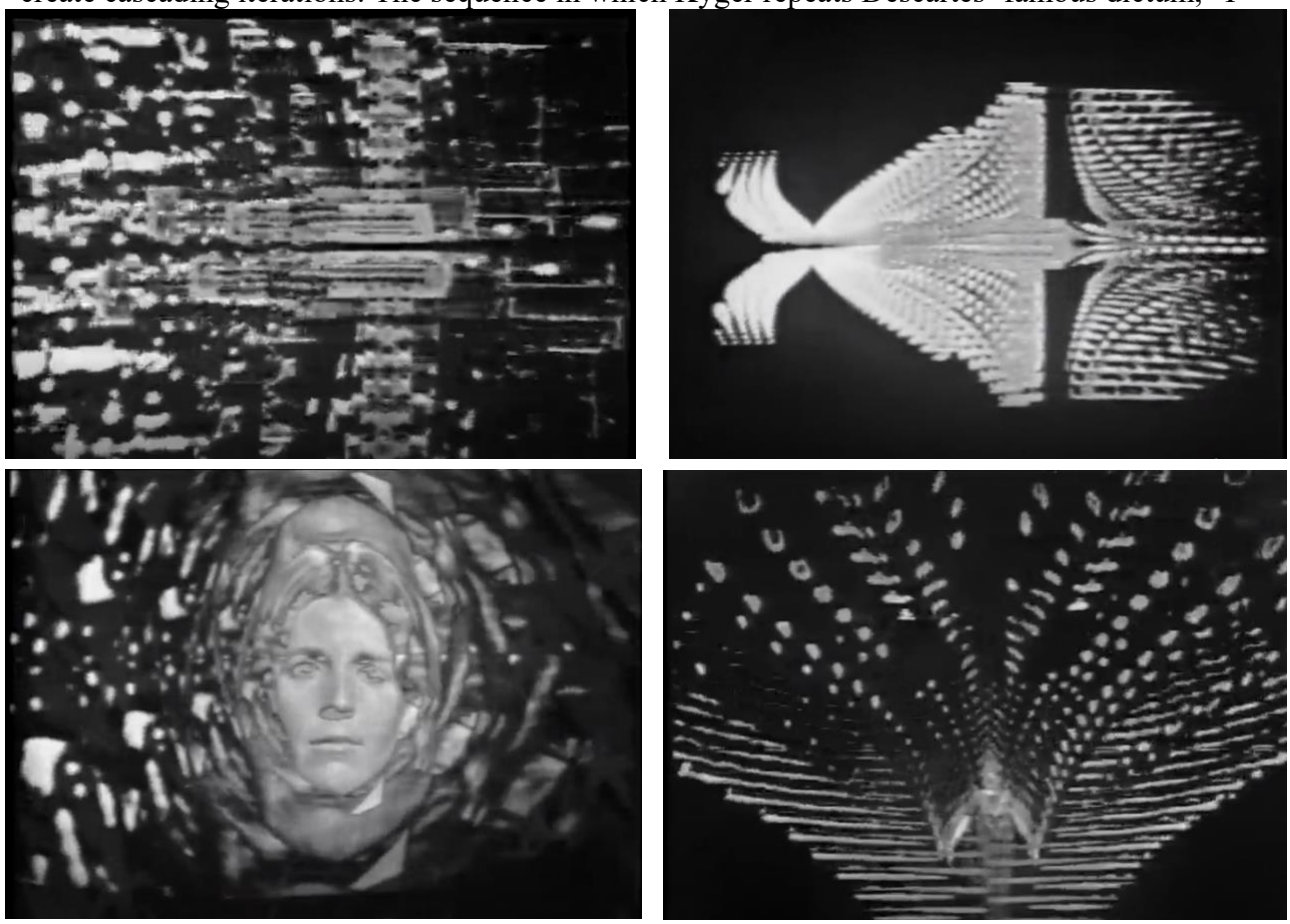
In the revised edition of *Cybernetics*, released in 1961, Wiener no longer sees nonlinear feedback as an error, but rather the basis of learning or self-reproducing machines.[1] It describes a process of ongoing adaptation and change – whereby the system continually adjust itself – not just returning to homeostasis but adapting and learning. It is the difference between an automatic door opener that simply reacts to a current stimulus and an intelligent being that learns and adapts based on a store of past information. NCET's creative experiments with nonlinear feedback are generative, not only in the sense that they produce novel aesthetics, but that these forms themselves seem to regenerate automatically, as the nonlinear feedback produces seemingly endless iterations within the image.

While the feedback trope found its way into many of the video works produced by NCET in its first year of operations, one of the longest and most conceptually rich is *DESCARTES* (1969), which uses nonlinear feedback to explore themes of the technologically enhanced human. A collaboration between poet Joanne Kyger, Loren Sears, and engineer Robert Zagone, the eleven-minute black and white video features extensive use of nonlinear feedback to manipulate the central image of Kyger's face and body. Her form seems to produce countless repetitions of itself, reverberating outwards towards the edges of the screen. Zagone described the effect as causing her to "blossom like a phoenix," [72] which speaks to nonlinear feedback's associations with rebirth and regeneration.

In a voiceover, Kyger recites a poem adaptation of Descartes' "Discourse on Method." Mirroring the six parts of Descartes' essay, Kyger's piece also meditates on the nature of reason

and the possibility of self-knowledge. The video references tropes of television, featuring found news footage (largely of the institutions critiqued by the counterculture: college graduation, office workers in a city, soldiers carrying a flag), as well as tape of Kyger acting out domestic scenes on a stage set. Wearing an apron, she fluffs pillows, folds laundry, and smokes a cigarette.[73] Kyger's pointed use of gendered tropes suggests a critical view of television's role in shaping perception and identity.

These televisual images are interspersed with sequences of intensive use of feedback to create cascading iterations. The sequence in which Kyger repeats Descartes' famous dictum, "I



Joanne Kyger, *DESCARTES*, 1969.

think hence I am," begins with entirely abstract, kaleidoscopic pattern of light radiating rapidly outwards from a central vanishing point. Just as she recites the iconic line, the image of her face resolves from the darkness, and hovers translucently over the starfield of receding points of light. The sequence visualizes the mind-body split: the *mise en abyme* of the abstract light field representing pure cognition, filtered through a disembodied head floating in a dark non-space.

The subsequent section, however, enacts a subtle reversal of the Cartesian dualism: here everything proceeds from the body. Kyger raises her arms in a dramatic gesture, from which a steady stream of pulses of light emit, receding towards the edge of the frame as they repeatedly echo the motion of her arms. Kyger's body occupies a central point, from which all lines radiate outward, engendering ongoing repetitions of her form.

The work is critical of the Cartesian dualism, favoring an embodied knowledge over one based on pure cognition. As Theodor Roszak pointed out, this was a common theme in countercultural discourse.[74] Belgrad also observed that this 1960s critique of Cartesian dualism was particularly central to ecological branches of feminist thought, which embraced precisely the embodied, carnal knowledge that Enlightenment thought derided.[75] Kyger's vision of a female that rejects the restrictive performance of traditional gender roles in favor of one where her body is centered and powerful articulates this embrace of embodied knowledge. However, it is in particular a body that is enhanced by technology: Kyger's "blossoming like a phoenix" is enabled by its imbrication within the feedback loop of video.[76]

The image of Kyger, engendering apparently infinite echoes of her own image through her outstretched arms, can be seen to be in dialogue with countercultural ideas about technologically-enhanced consciousness. McLuhan's highly influential text proclaiming media to be "extensions of man" had been published only a few years earlier.[77] McLuhan's argument that all technologies extend and amplify human perception resonated with a generation that was embracing new electronic and computational media. As historian Fred Turner elaborates in his study of the Bay Area counterculture's influence on the rise of neoliberal tech culture, the counterculture, fueled by the cybernetic theories of Buckminster Fuller, Gregory Bateson and Marshall McLuhan and the back-to-the-land ethos of hippie culture, embraced a wide variety of new technologies for their ability to augment human activity. In particular, the Bay Area hippies were interested in technologies that were perceived to extend sensory perception and cognition. These groups had a fascination with Zen Buddhism, psychedelic drugs and other theories, technologies and practices of amplifying the mind. Turner writes, "For the New Communalists, the key to social change was not politics, but mind."[78] The new information technologies – especially computers – were similarly embraced for their potential to radically extend human memory and intellect.

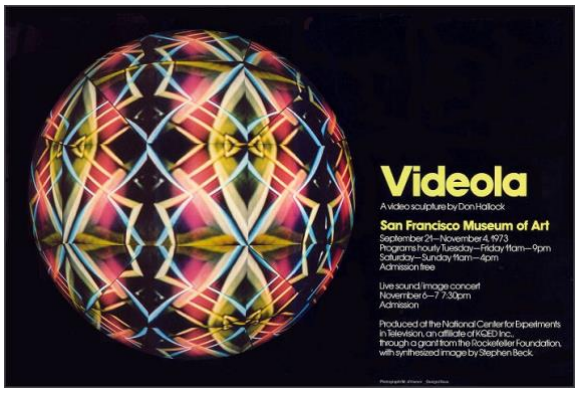
A key aspect of video's particular "cyberscat" appeal was its capacity to enfold the human user into its imagery via the feedback loop. Pioneering video artist Frank Gillette, in an essay outlining his definitions of video as a medium articulates this belief in video as a tool for enhancing the body via feedback, writing:

> "The video network, in this sense, is the extension of a neurophysiological channel, the connection between the world and the visual-perceptual system terminating in the prefrontal neocortex. Video can thus become a record of the resonance between that channel - eye/ear/prefrontal neocortex - and natural processes in time…. Through a kinesthetic signature which individuates the 'loop' - eye-body, the technology itself, and the process being recorded - the artist transmutes random information into an aesthetic pattern."[79]

Gillette casts video as incorporating the human body into the technology through the feedback loop. This idea is given stunning visual expression by *DESCARTES*: Kyger's technologically-enhanced body radiates outwards, her form visually amplified and extended by the feedback loop. She embodies feedback, her figure transmuted into fluttering pulses of light on the video screen.

The NCET artist's use of video feedback to generate new visual forms echoes the perception of video as a generative, cybernetic art form. In cybernetic terms, they visually enact a negative entropy – they produce a stream of moving images that is continually regenerating. The uncanny capacity for video feedback to automatically replicate the image is taken to an extreme in another project of NCET - the Videola, a large immersive moving image installation.

Into Infinity: The Videola



NCET Videola, installation view and publicity, 1969.

One of NCET's most unique endeavors was an installation built to expand the video monitor into an immersive kaleidoscopic display. This experimental device emblematizes the infinite aesthetic of cybernetic video art by expanding the image outward, emphasizing its seemingly endless iterations in space and time. Built between 1972 and 1973 by Don Hollock, the Videola was an experiment in creating an immersive audio-visual experience from a single video monitor. The device was essentially a giant mirrored funnel with a color monitor at one end, creating a circular video image, five feet wide, that continually refracted and mutated. A pyramidical form of conjoined mirrors was laid on its side forming a 20-foot tunnel converging around the monitor at the far end. The result, as the artist described it, was a "sphere of continuously moving video, floating in black space."[80] Hallock estimated that one hundred viewers could watch the Videola at a time. It was shown for six weeks at the San Francisco Museum of Modern Art, from September to November 1973. Six one-hour programs of pre-taped video – much of it produced by Stephen Beck on the video synthesizer - were shown during the day, with a live improvised concert of synthesized images and sounds shown one evening.

The circularity of the image produced by the Videola was relatively unique. While there are historical precedents for circular moving images in emerging or experimental screen media – such as the iris effect of silent cinema, Duchamp's *Rotoreliefs* in the 1920s, certain television sets (such as the 1949 Tele-Tone), radar screens, and early computer graphics displays such as the Whirlwind – the square or rectangular screen is the typical standard.[81] The imagery of the Videola was colorful, highly abstract, and constantly shifting. The press release that accompanied the SFMOMA exhibition described the image presented on the Videola as:

> "…. Ranging from totally synthesized video that could be compared to hard-edged painting, to images in the abstract expressionist style, to work with figures and images likened to collage, to highly ornamental and colorful work in the style of art nouveau. The surface is always in motion (real motion, rather than implied motion), with time a compositional element in each work."[82]

Due to the mirrors enclosing the video monitor, the shapes displayed on the screen were repeated horizontally and vertically, appearing to iterate and move outwards.

While smaller than most cinematic screens, the Videola significantly expanded the size of the electronic monitor. Reflecting on the device years later Hallock wrote, "Previous to the Videola, no one had devised a way to escape the tyranny of the rather small standard television

screen as a space in which to create or display video art - especially to a large number of spectators."[83] The late 1960s saw a proliferation of experiments in multi-screen, widescreen, or immersive screen spaces: the multiscreen displays at Expo '67 in Montreal were widely commented on as representing a revolution in the presentation of moving images, and Stan VanDerBeek's Movie-Drome (1965) turned a repurposed grain silo into an immersive projection space. While wide-screen projection had been used in cinema for decades (dating back to Abel Gance's epic three-screen projection of *Napoleon* in 1927 and gaining wide-spread adoption in the 1950s), electronic images were still confined to small screens of roughly twenty-seven inches. The Videola was distinct as an attempt to magnify a single monitor-based image.

The discourses around the rise of immersive image environments in the 1960s ranged from a celebration of immersive installations as cybernetic expansions of the human sensorium, to deriding them as representing new heights in distraction. In *Future Shock*, the 1970 bestseller in which journalist Alvin Toffler argues that postwar American life was characterized by accelerating rates of change, Toffler cites the multi-screen displays at 1967 Montreal World's Fair as an example of the fragmentation, overstimulation and "information overload" of contemporary society. He writes that viewers at the fair "were confronted not with a traditional movie screen on which ordered visual images appear in sequence, but with two, three, or five screens, each of them hurling messages at the viewer at the same time."[84] With multiple moving images demanding the viewer's attention at the same time, the postmodern subjects described by Toffler struggled to block out excessive information and protect themselves from the assault on their senses.

Gene Youngblood describes the massive multiscreen displays at Montreal's Expo '67 within the broader context of immersive audio-visual performances of the 1960s. For Youngblood and many of the artists he analyzes, these multi-media environments comprise experiments in new modes of communication and new sensory experiences. Youngblood suggests that the simulating nature of the abstract moving images provide the possibility for a nonverbal "transnational communication."[85] Youngblood cites Francis Thompson, the designer of *Labyrinthe* at Expo '67, a spectacular multi-room installation of massive moving image displays in various configurations. Thompson proposes an immersive environment in which the screen entirely surrounds the viewer, "expanding and swallowing a huge audience."[86] Such an environment would introduce a mode of communication that would be "emotionally, physically, and intellectually overwhelming."[87] The sensory overload that Toffler critiqued as short-circuiting intellectual activity, Youngblood and Thompson celebrate for the same qualities. Francis Thompson, in describing his proposed 360-degree moving image environment, wrote: "Your images should come out of this great, completely surrounding area and hit you in the eye or go off into infinity. So you're no longer working with a flat surface but rather an infinite volume."[88] The circularity of the space allows for an ever-expanding, boundless, image.

The Videola used mirrors rather than multiple screens to expand the image. Because of the *mise en abyme* created by the mirrors positioned at an angle from one another, the effect was to suggest an image expanding endlessly in time as well as space. The image on the monitor is reduplicated continually from all angles. As Hallock described it: "The video signal is in continuous movement, so that the various graphic elements are constantly appearing, kaleidoscopically, out of nowhere, and subsequently disappearing again… into themselves."[89]

Like much of the imagery produced at NCET, the Videola was described as deeply meditative, with one spectator reportedly likening the experience of watching the Videola to "gazing into the insides of my own mind."[90] Hallock himself described the effects of the Videola in New Age buzzwords, evoking timeless cycles of seasons and rebirth, spiritual motifs, and "life's

fundamental symmetries." [91] In language that echoed the countercultural embrace of technology for its mind-enhancing properties, Hallock suggested that with the Videola, the art and the viewer were in a mutually constitute, shifting relationship. For the artist, the hypnotic, abstract, effects of the Videola acted upon the consciousness of the viewer: the video "appears to have bypassed… consciousness for most spectators and resulted in something rather hypnotic. As many visitors have described it, the Videola experience was like a form of meditation."[92]

In typical countercultural rhetoric, Hallock draws parallels between the circular aesthetics of the Videola and symbols of wholeness or the eternal in a wide variety of Eastern spiritual and mystic traditions. In descriptions of the Videola, he collapses together Hindu mandalas and the Taoist Yin/Yang symbol with Mezo-American patterns and Leonardo DaVinci's Vitruvian Man to invoke a vaguely defined non-Western spirituality. Similarly, he invokes forms from the natural world - the rings of a tree or the symmetry of a flower - to describe the replicating, iterative patterns of the Videola. For Hallock, the Videola provides an experience of "pure perceiving", of "surrender", a metaphysically transformative experience.[93] He writes, "The mission of most art [is] to draw us into a deeper communion with ourselves, each other, and life in general."[94] The Videola is perceived above all as a "consciousness transforming instrument."[95]

Hallock saw the Videola as part of the lineage of abstraction in modernism, comparing his work to abstract expressionism, as well as Color Field paintings and Op Art. Hallock values abstraction in art primarily for its potential to produce experiences of meditative introspection in the viewer. Hallock's reading of abstraction suggests that it provides an experience of awe and serenity, one that adherents to the counterculture were particularly primed for. According to the artist, the culture of San Francisco in the 1970s, was receptive to the Videola's aesthetic: "Even the plainly paradoxical, and to the general public a bit perplexing, like the lithography of M. C. Escher, was being enthusiastically accepted… Abstractionism was, thus peculiarly appropriate for its era, as was the very popular symmetry of tie-dyed fabric during the agony of the Vietnam war."[96]

Hallock's view of nonobjective art as a tool to "draw us into a deeper communion with ourselves, each other, and life in general"[97] is in line with modernist theories of abstraction as expressive of inner states, a view which was becoming outmoded by the 1970s, with art turning towards a more conceptual mode.[98] In a wide-ranging analysis of abstract art in the postwar period, art historian Briony Fer identifies the emergence of a serial aesthetic in painting and sculpture.[99] According to Fer, repetition in art of the 1960s - such as the repeated forms of Rothko's color field paintings, the repetitive grids, circles, and lines of Eva Hesse, Hanne Darboven and Yayoi Kusama, or the serial logic of lists as a form in Ed Ruscha's stain paintings (1969), and Richard Serra's *Verb List* (1967-68) - provide a sense of the artwork extending in time. As Fer argues, the open-endedness of these serial works enacts a shift away from the Greenbergian approaches to painting and sculpture and towards more conceptual, time-based forms. They provide a bridge between the abstract formalism of modernism and the time-based forms of postmodern art.

A prime example of the boundless serial logic of art in the 1960s is the work of Yayoi Kusama, whose installations and paintings of repetitive forms seem to multiply without limit. In 1965, Kusama virtualized this effect by installing her repeated organic forms within a mirrored chamber, so the shapes appeared to extend endlessly within the *mise en abyme* created by the mirrors. (Similarly, in 1966 artist Lucas Samaras installed *Mirrored Room* – a square chamber comprised entirely of mirrors – in the Albright Knox Gallery in Buffalo, NY.) The Videola is situated within these explorations of the automatic and seemingly inexhaustible repetition of the image. Taken together, these works suggest a shift in which the infinite - displaced from the

vanishing point of renaissance perspective - returns to art in the form of an open-ended seriality.

Yayoi Kusama, *Phalli's Field*, 1965.

Yayoi Kusama, *The Souls of Millions of Light Years Away*, 2013.

Pamela Lee has described the temporal qualities of post-war art as representing a chronophobic tendency. According to Lee, durational art in the 1960s - from the serial forms of minimalism, to the video, kinetic art, performance, and systems esthetics - demonstrates a marked ambivalence around the question of time. This ambivalence, Lee argues, can be attributed to postwar information technology, with its emphasis on accelerated models of communication, influencing perceptual experience. According to Lee, artists and critics of the postwar period attempt to "master [time's] passage, to still its acceleration, or to give form to its changing conditions."[100] What makes the Videola, like the mirrored rooms of Kusama and Samaras, particularly imbued with time is that the configuration of mirrors produces an image that automatically and continually repeats, their potentially endless repetition gesturing towards the infinite.

The mirrored structure of the Videola is modeled on the mechanics of the kaleidoscope: both devices use a cone of mirrors to create a refracted sphere of continually self-replicating patterns. Due to its abstract, mandala-like refractions, the kaleidoscope became a ubiquitous metaphor in the 1960 and 1970s for psychedelia and the dizzying experience of contemporary society. In *Future Shock*, Toffler describes "…the racing rate of change that makes reality seem, sometimes, like a kaleidoscope run wild."[101] The kaleidoscope has been a persistent metaphor for the visual distortions produced by psychedelics: as early as 1898 Havelock Ellis described the visual experience of hallucinogenic drugs as "images of the kaleidoscope, symmetrical groupings of spiked objects… Then… a vast field of golden jewels, studded with red and green stones, ever-changing … They would spring up into flower shapes beneath my gaze, and then seem to turn into gorgeous butterfly forms or endless folds of glistening, iridescent fibrous wings of wonderful insects."[102]

NCET Videola, 1973.

Kaleidoscope.

The kaleidoscope dates to 1816, when it was invented by the Scottish physicist Sir David Brewster, and quickly became a popular novelty. In its simplest form it is made of two mirrors placed at an angle, usually of about sixty degrees. Brewster's original version had chips of glass at one end which would be reflected by the mirrors to create patterns. Jonathan Crary, in his influential study of how nineteenth century optical toys participate in modernity's transformation of perception, observes that the kaleidoscope was deployed as an ambivalent metaphor for the visual experience of modernity. He cites how the kaleidoscope emblematized highly divergent attitudes: as a metaphor for the exciting variety of modern experience on the one hand, and as representative of that which is insubstantial mimicry on the other. As Crary observes, Baudelaire himself used the kaleidoscope as a symbol of all that he embraced about the experience of modernity. Crary summarizes Baudelaire's attitude thus: "to become a 'kaleidoscope gifted with consciousness' was the goal for the 'lover of universal life.' In his text it figured as a machine for the disintegration of a unitary subjectivity and for the scattering of desire into new shifting and labile arrangements, by fragmenting any point of iconicity and disrupting status…."[103] The kaleidoscope's shifting patterns were a visual metaphor for the multiplicity and the exhilarating rate of change of modernity.

On the other end of the spectrum, Crary observes that Marx and Engel's deployed the kaleidoscope as a metaphor for anti-intellectual tautology. Because the kaleidoscope produces its images by copying, via mirrors, it was seen as facile illusion. Crary recounts:

"The multiplicity that so seduced Baudelaire was for them a sham, a trick literally done with mirrors. Rather than producing something new the kaleidoscope simply repeated a single image. In their attack on Saint-Simon in *The German Ideology*, a 'kaleidoscopic display' is 'composed entirely of reflections of itself.' According to Marx and Engels, Saint-Simon pretends to be moving his reader from one idea to another, while actually holding the same position throughout."[104]

For Marx and Engels, the problem with Saint-Simon is that his logic is too recursive, based on "decomposition and proliferation"[105] of the same idea, in the same way that a kaleidoscope is limited to refracting an existing image. This critique of the artificially reproduced image resonates with Roszak's description of psychedelically-induced perception as a "counterfeit infinity."

Crary also remarks upon a third discourse of the device, which has to do with its capacity to

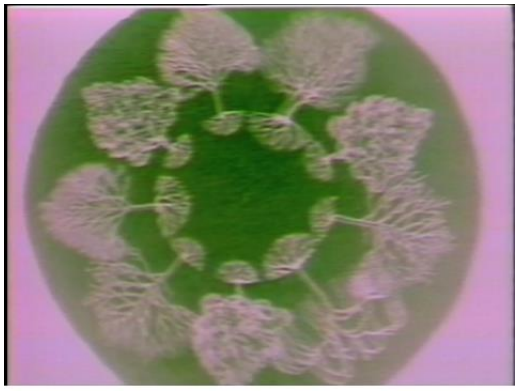
automatically repeat itself. Brewster saw the kaleidoscope as a tool of efficiency – he believed that, like the camera obscura, it could be used by artists to generate patterns and designs. Writes Crary: "He saw it as a mechanical means for the reformation of art according to an industrial paradigm. Since symmetry was the basis of beauty in nature and visual art, he declared, the kaleidoscope was aptly suited to produce art through 'the inversion and multiplication of simple forms.'"[106] Brewster claimed the kaleidoscope would "create in an hour what a thousand artists could not invent in the course of a year."[107] Effectively, Brewster saw the kaleidoscope as an automatic image-producing machine.

The kaleidoscope can be seen as one of several technologies for the automation of image production. As Friedrich Kittler has observed, there is a long history of image-automating devices, beginning with the camera obscura.[108] For Kittler, computation is the latest in this lineage. What makes computers unique from its predecessors, according to Kittler, is that computers transpose optical laws into numbers. While neither the Videola nor the Beck Direct Synthesizer, which produced the electronic images at the center of the Videola, were digital computers, as non-optical, electronic moving image devices they were an important intermediary step in the evolution of visual computing. The Videola's strategies of kaleidoscopically replicating the moving image anticipates algorithmic methods for creating iterative, automatically transforming moving images.

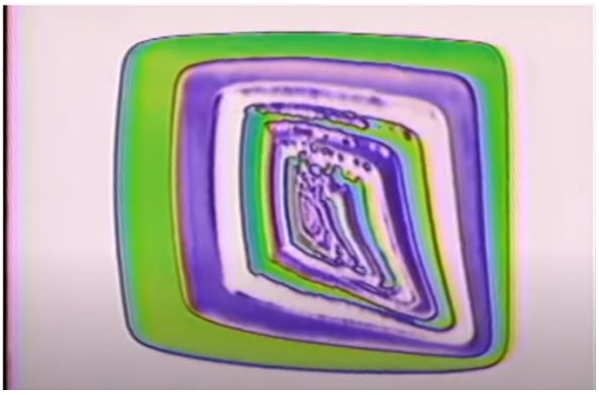
Conclusion

Symmetrically refracting patterns, such as those generated by the kaleidoscope, formed the basis of some of the earliest computer-generated images. In Stewart Brand's *Rolling Stone* article about early visual computing he cites one of the earliest visual programs, which became an inspiration for the *Spacewar!* game: "Somebody had built some little pattern-generating programs which made interesting patterns like a kaleidoscope."[109] The program, "Snowflake," was written for the PDP-1, the first minicomputer, by an unknown programmer in the mid-1960s.[110] The program featured pulsing spots of light arrayed in star-like patterns on the PDP-1's circular CRT screen, spinning and radiating outwards in kaleidoscope-like patterns. The repetitiveness of the image – of quadrants repeated multiple times – which was a function of the mirrors in a kaleidoscope is here the function of code.

Such refracting patterns became a common trope in emergent computer-generated images, particularly moving images, such as the computer films of John and James Whitney. The iterative aesthetics of moving images generated by code are foregrounded in the animated screensaver – one of the most widespread early uses of computer-generated moving images - which relied heavily on this sort of intricate but repetitive patterns to create persistently changing images. The screensaver, as will be discussed in the following chapter, draws upon and elaborates the generative aesthetics worked out by the artists at NCET. The projects at NCET – the repetitive abstractions of the Beck Direct Video Synthesizer, the negentropic repetitions of nonlinear feedback, and the mirrored *mise en abyme* of the Videola – for the first time work out the potential for boundless ongoing images, which finds more full expression in the popular genres of computer-generated imagery that emerge in the 1980s and 1990s with the embrace of personal computing.



Stephen Beck, NCET, *Video Ecotopia* (1976).



James Crutchfield, *Space-Time Dynamics in Video Feedback* (1984).

Brice Howard left NCET in 1974, and the center then severed its ties to KQED and moved across the bay to a space in Berkeley. As the original members dispersed to pursue other projects and sources of funding for experimental television disappeared, the center disbanded in 1975. One of the last works produced at NCET before it disbanded was a pilot for a television program called Ecotopia. Based on the best-selling novel about environmental separatists in the Pacific Northwest, the Ecotopia television program was both a dramatization of the novel and a formal experiment into what "Ecotopic television" might look like. The program unites a culmination of the visual tropes worked out by the NCET artists - computer-generated images, circular and repetitive patterns moving outwards in time and space - with ecological motifs. This fusion of the unbounded, iterative computer imagery with ecological themes is indicative of shifting perceptions of computing at this time. As Fred Turner recounts, the back-to-the-land hippies embraced computers as another technology that would allow humanity to live in harmony with nature. Yet there is a deep irony to this. As computing moves out of the mainframe era, the perception of these machines as resource heavy – as massive assemblages that are scheduled around the clock – gives way to the impression of computers as personal devices for tapping into an information space whose infrastructure is largely invisible. The shift to personal computing elides the materiality of computing. As I will discuss in the following chapter, the iterative, negentropic imagery pioneered at NCET plays an important role in the virtualization and ephemeralization of computation.

While the trope of video feedback's *mise en abyme* quickly exhausted itself in visual art, it reappeared a few years later in a different milieu. A postdoctoral researcher at UC Berkeley created a short film documenting his use of video feedback to study nonlinear dynamics. The video and accompanying scientific paper, published in 1984, demonstrated self-organization and pattern formation in image-processing systems, a study which formed the kernel of James Crutchfield's highly influential discoveries on nonlinear processes. (Crutchfield went on to produce several key studies which led to the emergence of chaos theory.) His research takes advantage of the physics of the video feedback loop to generate patterns from which are derived findings about chaotic behavior. As Crutchfield argues in the publication of his findings, "video feedback [is] an almost ideal test bed upon which to develop and extend our appreciation of spatial complexity and dynamical behavior."[111] Video's capacity for continual self-renewal formed the basis of a new understanding of order in complex systems.

It was a similar experimental simulation in a UC Berkey engineering lab – this time Jack Eastman's experiments with Monte Carlo randomization simulations - that inspired the patterns in

one of the first moving image genres native to the personal computer: the animated screensaver. With the screensaver the iterating abstractions of video synthesizers and feedback loops become enfolded in the digitally iterating designs of the personal computer. The animated screensaver, one of the most popular and ubiquitous genres of digital moving images in the 1990s, participates in the rise of new computing cultures, in which computers are left on around the clock, always accessing - and always accessed by - the new information network.

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[34] Brice Howard, "Videospace," *National Center for Experiments in Television Report to the US Department of Health, Education & Welfare Office of Education*, 1972.

[35] For an extended discussion of how NCET located the medium-specificity of video in the electron beam, see Kris Paulsen, "In the Beginning, There Was the Electron," *X-Tra*, Winter 2013, https://www.x-traonline.org/article/in-the-beginning-there-was-the-electron/

[36] Fred Turner, *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (Chicago: University of Chicago Press, 2008), 65-68.

[37] Theodore Roszak, *The Making of a Counter Culture* (Garden City, NY: Anchor Books, 1969), 159.

[38] John Hanhardt, "Introduction," in *Video Culture: A Critical Investigation*, ed. John Hanhardt (Rochester, NY: Visual Studies Workshop Press, 1986), 9-26; David Antin, "Video: The Distinctive Features of the Medium," in *Video Culture: A Critical Investigation*, ed. Hanhardt John (Rochester, NY: Visual Studies Workshop Press, 1986), 147–66; Rosalind Krauss, "Video: The Aesthetics of Narcissism," in *Video Culture: A Critical Investigation*, ed. John Hanhardt (Rochester, NY: Visual Studies Workshop Press, 1986), 179–91.

[39] It is worth noting that the center operated in relative isolation from the larger world of '60s and '70s video art. "Despite the strength of the work produced at NCET, it was mostly working in isolation from the larger community of artists in San Francisco, few of whom even knew of its existence. Within the broadcast community, NCET's professional outreach and educational efforts raised awareness about alternate possibilities for television; however, except for the artists who had the privilege of working there, NCET ultimately did not have an immediate impact not he larger development of contemporary art." Glenn Phillips, "Introduction," in *California Video: Artists and Histories*, ed. Glenn Phillips (Los Angeles: Getty Publications, 2008), 2.

[40] Specifically, Southern Illinois University, Southern Methodist University in Dallas, and the Rhode Island School of Design.

[41] David Antin, "Video: The Distinctive Features of the Medium." For a similar discussion of early video artists as staging a critique of television, see David Ross, "Truth or Consequences: American Television and Video Art," in *Video Culture: A Critical Investigation*, ed. John Hanhardt (Rochester, NY: Visual Studies Workshop Press, 1986), 167–78.

[42] Marita Sturken, "Private Money and Personal Influence: Howard Klein And the Rockefeller Foundation's Funding of the Media Arts," *Afterimage* 14, no. 6 (January 1987).

[43] Interview in Glenn Phillips, ed., *California Video: Artists and Histories* (Los Angeles: Getty Publications, 2008), 42.

[44] Eric Siegel's Electronic Video Synthesizer (1970) similarly generated a signal rather than relying on input from a video camera. See Thomas Dreher, "History of Computer Art," IASL Online, accessed September 9, 2020, http://iasl.uni-muenchen.de/links/GCA.pdf. Other synthesizers of the early 1970s include the Rutt Etra Video Synthesizer, Steina and Woody Vasulka's "George Brown Multi-Level Keyer," 1973; Dave Jones's Colorizer, developed at the Experimental Television Center ca. 1970. See Lucinda Furlong, "Notes Toward a History of Image-Processed Video," Afterimage (Summer 1983), 35-38.

[45] Furlong, "Notes Toward a History," 36.

[46] Interview in Phillips, ed., *California Video: Artists and Histories*, 44.

[47] Lucinda Furlong, "Tracking Video Art: 'Image Processing' as a Genre," *Art Journal*, Fall 1985, 234.

[48] Paulsen, Kris. "In the Beginning, There Was the Electron."

[49] Paulsen, "In the Beginning, There Was the Electron."

[50] Interview in Phillips, ed., *California Video: Artists and Histories*, 45.

[51] The *Video Weavings* were displayed at museum exhibitions as well as popular spaces such as the windows of Bergdorf Goodman in New York as part of an exhibition on textiles, and in 1982 on the enormous Mitsubishi "Diamond Vision" plasma screen at Shea Stadium.

[52] On the intersections of 1970's tech culture and indigenous craft see Lisa Nakamura, "Indigenous Circuits: Navajo Women and the Racialization of Early Electronic Manufacture," *American Quarterly* 66, no. 4 (December 15, 2014): 919–41. Beck himself describes them as an homage to indigenous craft. "Video Weavings is a link between the modern (video) and the ancient (weaving) technologies. Video Weavings are based on poetic mathematical rhymes, or algorithms, visualized in real time on the warp and weft of video's horizontal and vertical scanning electron beams, color phosphors, plasma cells, and LCD pixels. In my Video Weavings, millions of patterns appear, many of which resemble or replicate the same patterns found in textiles woven by ancient peoples such as the Pueblos of the southwestern North American continent, the Nairobi of Africa, the Hindu of India, the Aborigines of Australia, and by many peoples in China and Japan. The idea, then, for Video Weavings is to reflect upon, acknowledge and honor the links between the most modern electronic visual display systems, and the ancient art of weaving, though the common connection of the matrix." (From an essay by Stephen Beck appearing in the catalog for the InfoART exhibition at the inaugural Gwangju Biennale in Korea, 1995. Cited on his website, https://www.stevebeck.tv/weav.htm).

[53] Interview in Phillips, ed., *California Video: Artists and Histories*, 43. Similarly, writing in 1967, Michael Noll observed, "the computer medium is still restrictive in that there is a rather long time delay between the running of the computer program and the production of the final graphical or acoustic output." A. Michael Noll, "The Digital Computer as a Creative Medium," *IEEE Spectrum*, Vol. 4, No. 10 (1967), 93.

[54] For a detailed history of the importance of the microfilm plotter on early computer art, see Zabet Patterson, *Peripheral Vision: Bell Labs, the S-C 4020, and the Origins of Computer Art* (Cambridge, MA: MIT Press, 2015).

[55] Gene Youngblood, *Expanded Cinema* (New York: Dutton, 1970), 284.

[56] Jasia Reichardt, observed that the CRT display had "distinct advantage in that it could be used interactively, that is, it allows direct address to the person drawing so that he can alter the image or the data with no significant lapse of time." Jasia Reichardt, *The Computer in Art* (London: Studio Vista, 1971) 10, cited in Andrew Utterson, "Early Visions of Interactivity: The In(Put)s and Out(Put)s of Real-Time Computing," *Leonardo* 46, no. 1 (2013), 70.

[57] Jacob Gaboury, "The Random-Access Image: Memory and the History of the Computer Screen," *Grey Room* 70 (March 1, 2018), 24–53.

[58] Stewart Brand, "Spacewar!," *Rolling Stone* (December 7, 1972), 56.

[59] Krauss, "Video," 181.

[60] Krauss, "Video."

[61] Anne Wagner, "Performance, Video, and the Rhetoric of Presence," *October* 91, no. Winter (2000), 68-69.

[62] Wagner, "Performance, Video, and the Rhetoric of Presence," 69.

[63] Wagner, "Performance, Video, and the Rhetoric of Presence," 69.

[64] Bill Gwin, "Video Feedback: How to Make It; An Artist's Comments on its Use; a Systems Approach," archived at Experimental Television Center Video History Project, https://www.videohistoryproject.org/video-feedback-how-make-it-artists-comments-its-use-systems-approach.

[65] Bill Gwin, "Video Feedback."

[66] Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (Boston: Avon Books, 1967).

[67] Antin, "Video: The Distinctive Features of the Medium," 147–66.

[68] Wiener, *The Human Use of Human Beings*, 37.

[69] Daniel Belgrad, *The Culture of Feedback: Ecological Thinking in Seventies America* (Chicago: University of Chicago Press, 2019*)*.

[70]A nonlinear system is one in which the change of the output is not proportional to the change of the input.

[71] Norbert Wiener, *Cybernetics: Or, Control and Communication in the Animal and the Machine*, Second Edition (Cambridge, MA: MIT Press, 1961), 102.

[72] Robert Zagone and Walt Bjerke composed the special effects for *DESCARTES*. "The most successful piece in my estimation was Descartes, and that Joanne Kyger and I did. We did it three times and it was take three that we liked. And here's where the technical aspects of the KQED studios came in. There was an old switcher that they had, and it had a clipper on it – a clipper was akin to what would be used now as controlling the video – brightness, getting the picture right. But this was an old switcher that had a little knob on it. So what we did – Walt Bjerke and myself – when we did the feedback with Joanne when she blossoms like a phoenix, we ran that clipper way up, and the feedback was so intense it fluttered. Now, you probably can't do that anymore. You could probably do it digitally, but you couldn't do it mechanically anymore cause modern day switchers don't have that ability." Interviewed by John Minkowsky, May 2008. Excerpted at The National Center for Experiments in Television, http://ncet.torusgallery.com/zagone/zagone.html. Accessed December 6, 2022.

[73] Rani Singh describes *DESCARTES* as mimicking the conventions of the soap opera. Rani Singh, "Joanne Kyger," in *California Video: Artists and Histories*, edited by Glenn Phillips (Los Angeles: Getty Publications, 2008), 146–49.

[74] Theodore Roszak, *The Making of a Counter Culture* (Garden City, NY: Anchor Books, 1969).

[75] Belgrad, *The Culture of Feedback*, 64.

[76] Kyger's technologically enhanced female anticipates the central figure in Donna Haraway's "A Cyborg Manifesto." Donna Haraway, "A Cyborg Manifesto," in *The Cybercultures Reader*, ed. David Bell and Barbara Kennedy (Routledge, 2000), 292–324.

[77] Marshall McLuhan, *Understanding Media: The Extensions of Man* (Cambridge: MIT Press, 1994).

[78] Fred Turner, *From Counterculture to Cyberculture*, 36.

[79] Cited in Chris Meigh-Andrews, *A History of Video Art: The Development of Form and Function* (New York: Berg, 2006), 63-64.

[80] Don Hallock, "All You Need to Know To Build a Videola," PDF, The National Center for Experiments in Television, http://ncet.torusgallery.com/videola/videola.html. Accessed December 6, 2022.

[81] The DEC PDP1, the first minicomputer (on which the game *Spacewars!* was written) also had a round screen.

[82] SFMOMA Press Release, "The Videola," N.D. 1973. Retrieved 6/1/20 http://ncet.torusgallery.com/videola/videola.html.

[83] Hallock, "All You Need to Know To Build a Videola."

[84] Alvin Toffler, *Future Shock* (New York: Bantam Books, 1971), 168.

[85] Gene Youngblood, *Expanded Cinema* (New York: Dutton, 1970), 387.

[86] Youngblood, *Expanded Cinema*, 354.

[87] Youngblood, *Expanded Cinema*, 356.

[88] Youngblood, *Expanded Cinema*, 358.

[89] Hallock, “All You Need to Know To Build a Videola.”

[90] Dan Hallock, “The Videola,” See Lion Productions, accessed September 12, 2020, http://seelion.torusgallery.com/videola.html.

[91] “Arthur's Round Table, the 'hoop of the nations,' circles of the seasons, and cycles of life, imply equity, completion and the regeneration of all things. The sphere embodies perfect integration of all possible circles and cycles. A mirror image expresses life's fundamental symmetries, and the kaleidoscope speaks with mysterious eloquence of infinity itself. Within the phenomena represented by these forms play out the intricate, self-luminous patterns and poetry of all existence.” Hallock, “The Videola.”

[92] Hallock, “All You Need to Know To Build a Videola.”

[93] Hallock, “All You Need to Know To Build a Videola.”

[94] Hallock, “All You Need to Know To Build a Videola.”

[95] Hallock, “All You Need to Know To Build a Videola.”

[96] Hallock, “All You Need to Know To Build a Videola.”

[97] Hallock, “All You Need to Know To Build a Videola.”

[98] Sol LeWitt, “Paragraphs on Conceptual Art,” *Artforum*, June 1967; Lucy Lippard and John Chandler, “The Dematerialization of Art,” Art International 12:2 (February 1968), 31-36; Alexander Alberro, “Time and Conceptual Art,” in *Tempus Fugis* (catalog) (Kansas City: Nelson-Atkins Museum of Art, 2001).

[99] Briony Fer, *The Infinite Line: Re-making art after modernism* (New Haven: Yale University Press, 2004).

[100] Pamela M. Lee, *Chronophobia: On Time in the Art of the 1960s* (Cambridge, MA: MIT Press, 2006), xii.

[101] Toffler, *Future Shock*. 10. See also: “The Kaleidoscope, Magic in a Tube, is Enjoying Revival,” *Smithsonian Magazine*, November 1982.

[102] Cited by Chrissie Iles, “Liquid Dreams,” in *Summer of Love: Art of the Psychedelic Era*, ed. Christoph Grunenberg (London: Tate Publishing, 2005), 80. Similarly Barry Curtis observes: “Albert Hoffman’s first account of the effects of LSD described ‘an uninterrupted stream of fantastic images of extraordinary plasticity and vividness, accompanied by an intense kaleidoscopic play of colours.’” Barry Curtis, “Building the Trip,” in *Summer of Love: Art of the Psychedelic Era*, ed. Christoph Grunenberg (London: Tate Publishing, 2005), 164.

[103] Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century (Cambridge: MIT Press, 1990),* 113-114.

[104] Crary, *Techniques of the Observer*, 113-114.

[105] Crary, *Techniques of the Observer*, 116.

[106] Crary, *Techniques of the Observer*, 116.

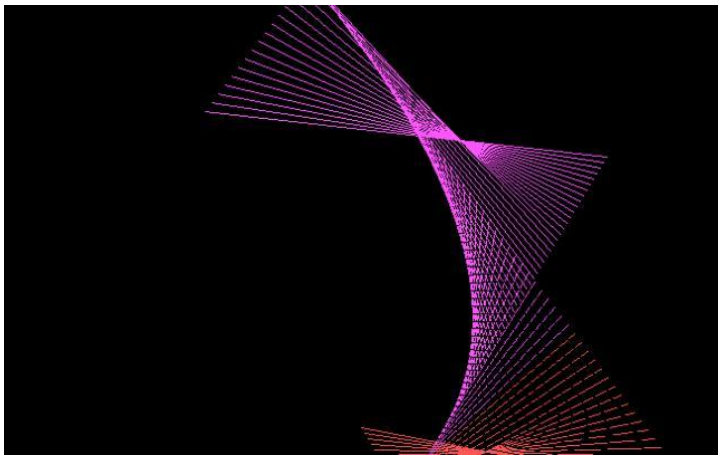
[107] Crary, *Techniques of the Observer*, 116.

[108] Friedrich Kittler, “Computer Graphics: A Semi-Technical Introduction,” translated by Sarah Ogger, *Grey Room*, no. 2 (Winter 2001), 30–45.

[109] Brand, “Spacewar!.”

[110] A representation of this program can be viewed here: “Lyle Bickley explains the PDP-1 (and we play the original Spacewar!)”, YouTube, https://www.youtube.com/watch?v=1EWQYAfuMYw&ab , accessed December 6, 2022. See also, “DEC PDP-1 Snowflake Pattern on Monitor,” Computer History Museum: https://www.computerhistory.org/pdp-1/302b0352d9c7f251168d635bfdab65b4, accessed December 7, 2022; Landsteiner Norbert, “Snowflake Archeology (DEC PDP-1),” Now Go Bang! — mass:werk Blog, https://www.masswerk.at/nowgobang/2019/snowflake-archeology, accessed October 23, 2020.

[111] James P. Crutchfield, “Space-Time Dynamics in Video Feedback,” *Physica*, 1984, 191.



Never Idle After Dark: the Animated Screensaver and the Emergence of 24/7 Computation

Highly iterative and often abstract animations, such as those embraced in the body of work produced at the NCET video art lab in the 1970s, find expression in the aesthetics of a new popular genre of computer-generated moving images in the 1980s. A relatively simple utility, the animated screensaver was one of the most popular types of software of the 1990s and was ubiquitous during a period of the rapid adoption of personal computing in the workplace and home. As the dominant model of the computer shifted from large mainframe calculating machines to personal devices, the screensaver reflected the embrace of computation as a visual medium and as a technology for individual use. For one thing, one of the key functions of the animated screensaver was as an expression of personal identity, as users select or customize screensavers which express individual taste, turning a mass-produced business machine into a reflection of oneself - truly putting the "personal" in personal computing.

The screensaver - through the uniquely iterative nature of its animations - participates in the emerging perception of computing as an endless resource. With the continually renewing designs of the animated screensaver, as well as their relation to the practice of never turning off the computer, we see the emergence of the sense of computation as something ongoing, indefinite, continually available. The discourse of the screensaver is a paradoxical one: on the one hand emphasizing the materiality of the screen (the purpose of the software is after all to preserve the health of the display), and on the other a belief in computation as potentially limitless, almost elemental - a model which works to elide the materiality of computers. This paradox at the heart of the screensaver reveals a profound shift in computing happening at this time, as the materiality of the computer is obfuscated in favor of a vision of computing as virtual.

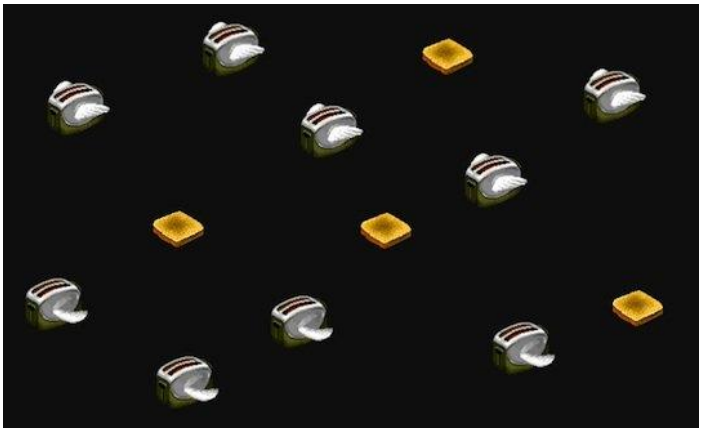
With the emergence of personal computing and the graphical interface, computers for the first time had visual displays which could actually be idle for long periods of time, an impossibility during the mainframe era when the enormous cost of running a computer ensured that the machine was never idle. The way in which the screensaver handles this newfound idleness presents a further paradox, one which suggests the emergence of neoliberal notions of productivity at all hours. With the screensaver, the personal computer is never truly allowed to be inactive, but rather fills

downtime with endless images that ensures the computer always remains on, always at hand to be put into use at a moment's notice. As personal computers become associated with communications networks and the world wide web during this historical period, the screensaver is a powerful representation of new notions of computers as ways in which to access a global network that is perceived as always on.

The peak popularity of the screensaver in the 1990s coincides with the adoption of the Internet outside of major research institutions. The screensaver, like the contemporaneously emerging Internet, speaks to late capitalism's need to make use of idle time: consumer networks emerged in part as a way to capitalize on unused after-hours computer power and package it to domestic users after hours. [112] It is perhaps telling that the most popular commercial screensaver software was called After Dark– while personal computers introduce the potential for idleness, the screensaver allows the computer to remain on and ready for use around the clock.

This chapter provides a history of a ubiquitous yet undertheorized piece of software which existed at an important moment of emergence for digital culture. In particular, I will examine the most iconic screensaver software, and one of the best-selling business utilities of its time, Berkeley Systems' After Dark. Many of the themes of the infinite aesthetic in 1970s video art – psychedelia, self-actualization, and cybernetics – are central to the discourse surrounding the screensaver. Not only does the screensaver help to personalize the personal computer, but the rhetoric also surrounding the screensaver reveals that these animations are indicative of, and even seen as participating in, notions of self-optimization and productivity that were emerging with the neoliberal workplace in the 1980s and 1990s. As the screensaver negotiates the adoption of computing into new areas of lived experience, it is indicative of new perceptions of digital culture as a limitless, even elemental, resource. The fundamental indeterminacy of the duration of the animated screensaver, its potential to continue *ad infinitum*, articulates a logic of endless renewal which aligns with the emergence at this time of a networked digital culture that operates continually, at all hours.

Flying Toasters – personalization, mood regulation, and the neoliberal workplace



"As I poise the mouse to run ST Writer, I hear a voice from the kitchen. "Hey, can you help with the groceries?" Eager to dispel my current computer-addict image, I proceed to the car and bring in the groceries. One thing (submarine sandwich) leads to another (Miller Lite), and it is eight hours later that I return to my ST. I scream. A dim trash can has appeared in the upper right-hand corner of the ST Writer menu screen as well as the edit screen."[113]

This account, by programmer and Atari ST enthusiast Richard Leinecker, introduced a new screensaver program written by Leinecker in a 1989 edition of *ST Log* Magazine,[114] and describes the then-familiar problem of screen burn-in, which occurred when the same image was left on a CRT (cathode-ray tube) monitor for too long. Screen burn-in first became a noticeable issue in the 1970s when video gamers playing Pong for long periods of time "noticed the large, block score number outlines and the primitive playing field had somehow left black ghosts of themselves in their television screens."[115] CRT displays are coated with phosphor, which emits light when activated by a beam of electrons. Although the beam of electrons is constantly moving across the screen, if the same image is left on for too long the beam will continually return to the same part of the screen and eventually permanently burn that image into the phosphor. This creates a ghost image that will display on the monitor, no matter what program is running.[116] This problem could be avoided by installing a utility program which would automatically blank the screen after a certain period of inactivity. Most PCs in the 1980s had some mode of blanking the screen, whether manual or automatic. Manual modes of blanking the screen included a dial on the outside of the monitor, command key screensavers, or control panel brightness settings. Apple Macintosh computers, for example, were released with a knob to adjust the brightness of the display,[117] as well as *AutoBlack*, a shareware program which would automatically blank the screen after a period of time.[118]

In the account quoted above, Leinecker relates how he began with a simple screen blanking program: "The next day I installed a screen-saver program, and it worked like a charm. When I did not hit a key, or move the mouse for about ten minutes, the screen went black." Before long, however, Leinecker makes a discovery: "Then, in a computer shop, I saw a Mac II that had been idle for a while. It seemed to be showing a fireworks demo. The patterns were randomly generated, creating an interesting and varied series of explosions. I became addicted to the show as I awaited the next unique pattern - until I hit a key and instantly saw the Mac II desktop. The salesman informed me that what I had seen was simply a screen-saver program."[119]

What Leinecker had seen was Pyro!, a utility for the Apple MacIntosh that, instead of simply blanking the screen, would turn the screen into a simple animation of pixelated white explosions against a black background. While the most straightforward solution to the problem of burn-in is to blank the screen, more elaborate animated screensavers arose. Leinecker's account suggests that these animated screensavers respond to a sense that time must be filled. He describes working on a project that involved long periods of wait time while information loaded. He decides to produce a screensaver that entertains the user - "No more boredom while data loaded"[120] - and writes an animated screensaver inspired by the fireworks display he saw on the mac in Atari ST Basic. While animating the screensaver did have certain functions - for example, there was no way to visually distinguish a screen blanked by a screensaver program from a screen that has been powered down, which might result in some confusion - for the most part the justifications offered by the early developers of animated screensavers are that they are less boring than the simple screen blanking.[121] This phobia of boredom is indicative of certain practical realities of computing - that there are often times when the user's desire for real-time interactivity are frustrated by the need to wait for complex data processing to take place.

In addition to entertaining the user, the animated screensaver serves to personalize the individual computer. In the 1980s, programmers made one-off, simple black and white animations for specific computers,[122] while Apple produced the black and white Pyro! screensaver, featuring animated fireworks display, for its PCs.[123] The key innovation of the After Dark screensaver was to offer a program that packaged together multiple animations, thereby giving users the ability to

customize their computer. While the hardware of the computer itself was not easily personalized, the screen becomes an important way for PC users to put an individual stamp on their device. Arguably the most iconic of After Dark's modules was Flyer Toasters, a whimsical animation of a fleet of winged chrome appliances flying diagonally across the screen. The winged toasters are an image that takes an industrial, mass-produced object and turns it into something cute and unique. It is a telling metaphor for this moment in the emergence of personal computing: the toaster is a decidedly domestic appliance, an aspirational motto for the computer at a time when it is migrating into the domestic setting for the first time. Indeed, contemporaneous reviews of After Dark frequently commented on the role it played in the emerging perception of computers as personal machines. A *New York Times* review from 1993 makes just this observation, writing: "A little toaster bravely flying is a neat metaphor for an appliance whimsically acquiring soul and spirit."[124]

After Dark was developed by a team at a small startup in Berkeley, CA called Berkeley Systems led by Patrick Beard and Jack Eastman. Eastman began experimenting with computer generated graphics while working on his PhD in physics at UC Berkeley in the 1980s. He recalls, "*Scientific American* magazine had some articles around that time that gave some algorithms for drawing simple on-screen animations - falling raindrops, expanding water ripples, expanding starfields. I thought these looked like fun and coded a few up and expanded on them, getting more and more sophisticated and drawing on my physics and math background to have things be more complicated and less predictable."[125] Eastman had the idea to turn the graphics into a screensaver and began to engineer a program for the operating system that would automatically run different screensavers. Patrick Beard connected Eastman to Berkeley Systems, where they continued to develop the program as commercial software. After Dark 1.0 - containing 15 different animated screensaver designs - was debuted at the *Macworld* Expo in August 1989.[126]

The product was successful enough that Berkeley Systems committed to developing a second version. It wasn't until After Dark 2.0, which included two of the most iconic modules for the first time - Fish! and Flying Toasters - that the software achieved commercial success.[127] According to *The New York Times*, in 1993, "Berkeley Systems, with an estimated $50 million in annual sales, is the dominant designer of screen savers. Its ubiquitous After Dark program is the heart of as much as 90 percent of the installed market."[128] In 1992 it was reported that After Dark outsold Microsoft Windows in four out of six months.[129] While After Dark cornered the market on commercial screensavers, it was not unique: after After Dark 1.0, Berkeley Systems acquired the popular freeware screensaver software, Magic, developed by Bill Stewart and Ian MacDonald around the same time as Eastman *et al.* were creating After Dark.[130]

In addition to the innovation of allowing users to select from among multiple modules, After Dark allowed for the customization of various modules themselves, giving an even greater level of personalization. After Dark 3.0 (released in 1994) featured twenty-eight distinct animated modules, each customizable. Users could adjust the speed with which the animations moved across the screen, add sound effects, or select different design options. The module Messages, for example, allows users to input a different brief text message, and adjust size and font. Gravity, which features a simulation of a bouncing ball, could adjust the size and speed of the ball, or allow for the balls to collide with one another. One review of After Dark likened the customizable animated screensaver to "monogramming for office computers."[131] Another observed that, in wasting excess microprocessing power and memory, the screensaver enacted a display of wealth and power. "Slapping fake marble 'wallpaper' on the screen may be the equivalent of a robber baron's slapping real marble on the front of his Newport 'cottage.' Screen savers require memory

and microprocessing power; they show off computer strength. You proclaim great wealth by wasting it, Veblen preached, excess power by using it frivolously. El Fish, for example, takes 4 megs of hard disk space, or 16 times the total of an original IBM PC."[132]

The screensaver coincides with a major shift in the conception of the computer, from primarily a powerful calculator or accounting tool to an individual multi-purpose media machine. As narrated by Paul Ceruzzi, the history of computing is the transformation from a "fast scientific calculator" to "a machine for general data processing" to a "real-time information processor that worked symbiotically with its users" to "an appliance that was both useful and fun," to a "window to a global network."[133] Screensavers are emblematic of the personal computing revolution's individualization of the computer and the computer's domestication and embrace as something nonthreatening and user-friendly. The screensaver's ability to personalize the computer can therefore be seen as more than just whimsy, but rather an important strategy for the transformation of the data-processing machine into an individual communications and media device.

Moreover, by facilitating the impression that the computer is a creative extension of the individual, the screensaver participates in discourses of the 1980s and 90s about individuality and labor. A companion book to After Dark quips: "With the knowledge you'll gain from this book, After Dark could become a new form of self-expression, a vehicle for computer folk art, a stimulating hobby, or perhaps the key to living a full and meaningful life you've always dreamed of."[134] While this quote is knowingly facetious, it is indicative of the rhetoric around computing at this time as liberatory. As Fred Turner describes in his account of the intertwined histories of the Bay Area counterculture and Silicon Valley tech culture, personal computers came to be seen as tools enabling an independent, mobile worker. Turner describes a back-to-the-land branch of the 1960s counterculture who "turned toward technology and mind as foundations of a new society."[135] Steeped in cybernetic theories of mind-enhancing technology, this community embraced computers for their potential to augment human intellect.

Rose (After Dark 2.0) *Lapis* (John Whitney, Sr. 1966

Many of the abstract animations in After Dark visually reference the avant-garde cinema described by Gene Youngblood as expanding human consciousness, as articulating a cybernetic aesthetic, an emerging human-machine symbiosis. The module "Rose," for example, features looping, and spiraling mandala patterns composed of dots very similar to the films of John Whitney. Modules such as "Spiral Gyra" and "String Art," which are composed of permutations of simple line figures resemble John Stehura's computer film *Cybernetik 5.3* (1969), and other abstract screensavers are evocative of the films of Jordan Belson, Charles Csuri, or Stan VanDerBeek, all of which participated in psychedelic expanded cinema of the 1960s and 1970s counterculture. Youngblood believed that the nonfigurative, rhythmic qualities of the abstract

designs in these films comprised a "synesthetic" aesthetic - they explored human perception and even human consciousness. Youngblood claimed that the aesthetic experiments of expanded cinema were "an attempt to approximate mind forms."[136] But they were not just representations of any consciousness - they comprised expressions of an expanding human-machine consciousness.

Many of After Dark's screensaver animations appear to be deeply influenced by the aesthetics of psychedelic culture, which embraced mind-altering drugs as another new tool for provoking an expanded mind. Screensavers are frequently described as "hypnotic," "mesmerizing," "entrancing," and anecdotes abound of pairing drug use with watching screensavers for a prolonged period of time. Jack Eastman recounts that he came up with the concept for the flying toasters during a late-night visit to the kitchen when, sleep deprived, he deliriously looked at his toaster and imagined it with wings.[137] While Eastman accounts for the image as the result of sleep deprivation, it is tempting to connect the hallucinatory quality of the flying toaster to the psychedelic drug culture of Northern California.

On the surface, screensaver animations might appear to be distracting or unprofessional: plenty of the modules feature cartoonish or silly animations, from the innocuous - such as the versions of After Dark that featured images from *The Simpsons* or *Star Trek* - to the obnoxious, such as the optional sound effect for Flying Toasters which plays a version of Wagner's "Ride of the Valkyries." The PR material for one screensaver argued that the program was "guaranteed to reduce productivity."[138] However, in certain ways the animated screensaver plays into discourses about cultivating ambience to stimulate worker productivity and motivation. In his study of atmospheric media in Japan, Paul Roquet argues that certain ambient media (such as Muzak) can be seen to perform a mood regulation function, thereby participating in neoliberal cultures of somatic self-regulation and self-care. He argues that ambient media, such as soft music or ambient screens allow users to regulate their mood, an important technique for neoliberalism in promoting an impression of an autonomous self and a happy, fulfilled worker. [139] He writes: "Personal media use holds out the promise of self-determination, but the technologies also serve as ways for governments and other social institutions to offload more and more of the labor of subjective maintenance onto an increasingly isolated subject."[140]

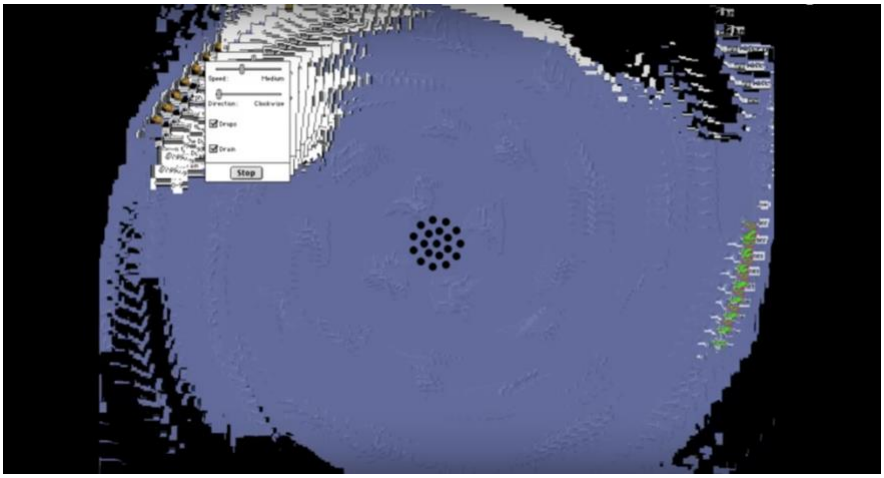
Contemporaneous descriptions of screensavers in the 1990s workplace suggest that they were received as performing this mood regulation. Erfert Fenton, contributing editor to *Mac World* magazine and author of a companion book for After Dark, wrote that screensavers: "reduce stress; they are fun, decorative and they can be soothing after a long day."[141] Reviewing a suite of After Dark games released by Berkeley Systems in 1999, inspired by the screensaver animations, technology critic J. C. Herz wrote: "Everyone who uses a computer has experienced that moment when the screen saver turns itself on and you don't resume typing. You don't reach for the mouse. You just sit there for a minute, glassy-eyed, exhausted and brain-fried, staring at the screen, contemplating . . . flying toasters."[142] For Herz, playing the games appears actually to be less of a distraction and more a self-soothing experience:

> "You take deeper breaths. Your heart rate slows down. You blink less. And pretty soon you're in a complete state of flow, immersed in a pursuit whose only purpose and consequence is to bring about this very state of mind. For nonsmokers, an easy puzzle is the closest you can get to having a cigarette..… in a workplace suffused with politics and deadlines and other people's demands, adults are not looking for more stimulation. They're looking for stress relief. And a low-key computer game is a cheap and convenient way to cool out. We don't need screen savers for our computer monitors anymore. We need screen savers for our brains, to keep us from glaring at incomplete information, to keep us from

becoming needlessly agitated. To keep us from burning in."[143]

As screen burn-in itself became less of a justification for the screensaver, the idea of "brain burn in" takes its place.[144] By the 1990s computer screens had evolved so that screen burn-in was less of a real concern. As a *New York Times* feature from 1993 pointed out: "The paradox of screen savers is that in all but the most demanding office and laboratory environments, these programs are not necessary. 'You would have to leave an image on your computer continually for a week before you'd see any real screen burn,' said Tim Bajarin, president of Creative Strategies International Inc., a market research firm in Santa Clara, Calif."[145] If the hardware issue of screen burn-in was becoming less of a problem, the primary function of the screen saver as it was most widely adopted was actually personalization, privacy (hiding any sensitive files open on the desktop when workers are away from their computers), and entertainment.

"Down the Drain" – virtualization, the screen, and the "space" beyond



Many popular animated screensaver designs can be read as a commentary on the so-called "black boxing" of computation occurring at this time. In drawing on the abstract visual rhetoric of mathematics – such as geometric shapes, motion simulations, and iterative patterns - many screensaver animations exhibit a desire to comprehend computers as mathematical machines. As computation becomes obscured by the graphical layer, these screensavers experiment with visualizing computation through abstract designs, often referencing the aesthetics of geometry and mathematical simulation. This genre of screensaver deploys geometric abstraction and repetition in attempts to visualize the mathematical processes of computers and explore an aesthetic native to computation.

The animated screensaver's popularity coincides with major transformations in the culture of computing, as the dominant model of the computer in public imagination shifts from a highly technical calculating machine used predominantly in research settings or large businesses, to a friendly device for everyday personal use. This process entails a certain level of obscuring of computation, as the internal processes are largely hidden from view to the casual user who interacts via GUI rather than programming languages. Whereas using computers in the mainframe era required a certain amount of knowledge about them and how they worked, with the PC, using the computer requires less specific knowledge about their operations. As computer historian Martin Campbell-Kelly points out, by the mid-1990s, "the personal computer had been transformed from an unfriendly technological system into something approaching an information appliance…. [I]t

was the graphical user interface that opened up the computer to the wider society. Instead of typing complicated commands, *users could now simply point and click their way through the most complex software, while knowing essentially nothing about the inner workings of a computer*."[146] The screensaver participates in the adoption of these machines into personal life – presenting a model of the computer not as a calculating device but as a window onto a world.

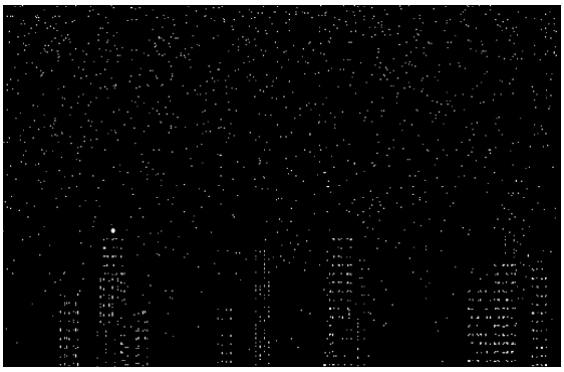
Major genres of the animated screensaver modules reflect this cultural shift. The layer of abstraction represented by the GUI is a significant departure from punch card or even command-line interactions with the computer, which necessitates a certain knowledge of and ability to communicate in the language of computation. With the screensaver we see a working-through of this process of burying computation in favor of more purely visual interactions via the screen. One such genre are those animations which visualize the mathematical processes on which computation is based. These modules depict gravity simulations, Lissajous patterns, Mandelbrot sets and other visual artifacts of mathematical simulations or the laboratory – a category which will be elaborated below. The second major genre that can be seen to represent the shift in computers from calculating machines to personal tools are those screensavers which suggest the screen as opening onto a virtual space – these represent the computer screen as a "window onto a world," depicting three-dimensional spaces within the monitor such as underwater landscapes, a city skyline, or a starry night sky. For example, one of the very first animated screensavers was Apple's *Stars!*, a simple black and white animation that simulated the perspective of one moving through a star field. A familiar trope used in science fiction film and television to visualize intergalactic travel, this sort of animation relies heavily on Renaissance perspective to simulate movement through three-dimensional space: points or rays of light move along straight lines from a vanishing point in the middle of the screen. After Dark's module "Warp!" (an homage to both the Apple screensaver and to the warp drive of *Star Trek*) is emblematic of the category of screensaver animations which visually emphasize the computer as a virtual space. This genre of screensaver evokes a three-dimensional space beyond the frame of the screen.

Anne Friedberg, in her influential study of virtual windows in the history of art, argues that one of the most significant characteristics of the visual culture of personal computing is the annihilation of space in favor of an aesthetic of flatness.[147] With the use of multiple, overlapping windows on the same screen, she argues that the designs of computer interfaces have more in common with Cubism, than with the simulated three-dimensional space of Renaissance perspective. The graphical user interface consciously makes use of the metaphor of the desktop to organize the user's access to information on the computer. The desktop was a visual, spatial metaphor for organizing documents and images with which everyone was familiar.[148] Visually, a desktop covered with files is a flat surface, which would by nature involve stacking and layering rather than a sense of depth. Friedberg argues, "The 'windows' trope is emblematic of the collapse of the single viewpoint; it relies on the model of a window that we don't see through, windows that instead overlap and obscure, and are resizable and movable."[149] If the menus, files, and windows of the graphical user interface provided access to the virtual world of the computer that was visualized as flat and Cubist, the After Dark animations depicting space is one way in which we see that the spatial metaphor was very much still present in the visual culture of emergent personal computing.

While plenty of After Dark animations depict a shallow or flat screen space, some of the most iconic animations represent the screen as a window onto a virtual space. The module Fish! depicts an underwater scenario, as though one is peering into a fish tank. With colorful fish floating across the screen horizontally, the animation gives a distinct impression of view onto a virtual

underwater space. Sandy gravel on the bottom of the screen fades into darkness in the background, and the continual coming and going of fish gives the impression of offscreen space. In the slightly updated version of this module offered in After Dark Deluxe, deep space is more pointedly rendered, with lines in the sand on the bottom of the image receding towards a vanishing point in the distance.[150] Other modules represent the screen as a window onto a figurative space include "Rainstorm," an animation of droplets moving vertically from top to bottom on the screen to suggest falling rain, and "Zot!" which depicts forks of lightning crossing the screen. "Starry Night," which is the default module for After Dark, represents a view of a city skyline against a field of stars.

Zot! (After Dark 2.0)



Night Lines (After Dark 2.0)

After Dark's tenure as a popular software, from its launch in 1989 to 1996, when the final version was released, was a period of rapid growth in the personal computing market, as prices for computers dropped significantly.[151] This coincides with expanding personal use of commercial networks, the privatization of the Internet, and the creation of the World Wide Web.[152] When connected to the Internet, the personal computer becomes more than an information processor - it becomes an interface to other (information) spaces. As many have observed, networked computing in the 1980s and '90s was dominated by spatial metaphors, such as William Gibson's cyberpunk novel *Neuromancer*, and John Perry Barlow's descriptions of virtual reality.[153]

In a 1990 article, Barlow describes at length the potential applications for virtual reality. Up until this point, and in Barlow's article, the term cyberspace is applied primarily to three-dimensional simulated visual environments. Barlow posits VR's potential as a technology for interfacing directly with the computer, and ultimately as a communications technology, thereby fusing the spatial regime of VR with the information technology of the networked personal computer. For Barlow, VR's most exciting application would be to erase the interface, allowing the user to commune directly with the machine. He describes how computing has evolved towards more immediate and visual forms of interaction, writing: "Over the last twenty years, our relations with these magic boxes have become intimate at a rate matched only by the accelerating speed of their processors. From the brutal austerity of batch-processed punch-cards to the snuggly Macintosh, the interface has become far less cryptic and far more interactive."[154] For Barlow, virtual reality could do away with the need for peripherals like the keyboard, mouse, and even the screen itself. Interfacing directly with the computer via VR allows for computation to be imagined in terms of depth. This goes beyond the flat spatial configuration of the GUI, which Barlow sees as insufficient: "The metaphorical desktop remains flat as paper. There is none of the depth or actual spatiality of experience." Barlow argues that the mind doesn't organize documents in alphabetized indexes but navigates memory spatially as in the memory palace described by Thomas Aquinas. One of virtual reality's key affordances, according to Barlow, is the potential to

allow the user to navigate the computer as a three-dimensional environment.[155] In another article that same year, Barlow applies the term cyberspace specifically to the internet, which he describes in spatial terms as a frontier. "Whether by one telephonic tendril or millions, they are all connected to one another. Collectively, they form what their inhabitants call the Net. It extends across that immense region of electron states, microwaves, magnetic fields, light pulses and thought which sci-fi writer William Gibson named Cyberspace. Cyberspace, in its present condition, has a lot in common with the 19th Century West."[156]

If Barlow was conceptually making the connection between VR technologies and networked computing, the screensaver extends this connection, by applying spatial metaphors to the interface through which the internet is accessed. After Dark's visual rhetoric of the computer screen as a window onto a virtual space provides a strong visual representation of this spatial turn in computing in the early 1990s. The spatial modules of the animated screensaver play into these fantasies of cyberspace, representing the computer screen as a window onto a (continual, ongoing) space within the screen.

But it is not without a certain ambivalence: while many of the After Dark animations depict the screen as a window onto a virtual space, just as many depict the screen as a barrier to the space of computation. Another major genre of the animated screensaver are those designs which foreground the surface of the screen. In this genre of screensaver animation, the desktop remains partially visible during the animation, but is distorted or otherwise disordered. For example, with "Bugs," animated insects – ladybugs, cockroaches and others – crawl across the surface of the screen while the desktop remains visible beneath them. "Boris" – in which an animated cat walks across the screen, and "Mowin' Man," in which a human figure pushes a lawnmower up and down the screen, similarly layer a figurative animation over the visible desktop. "Spotlight" features a dark screen with four roving circles that reveal the image of the desktop beneath. "Punch Out" involves simple geometric shapes in black appearing on the desktop to give the impression that the shapes have been cut out of the screen surface to reveal a blackness underneath. With "Down the Drain" the entire desktop appears to dissolve into a swirling whirlpool pattern.

These last two modules, in hinting at something behind the flat "space" of the desktop, exhibit a productive ambivalence. They emphasize that the desktop is an easily manipulated illusion and suggest something beyond the layer of the GUI. The GUI introduces a visual, metaphoric layer to computing, adding a further layer of abstraction than with batch processing or command-line interfaces. Similarly, to Barlow's fantasy of entering directly into the computer as a cyberspace, the screensaver animations take up metaphors of the computer as a space, but one which the user is separated from by the screen.

"Down the Drain" is representative of this category of modules which distort the picture plane. This animation is emblematic of much of the metaphorical work the screensaver performs: as the image of the desktop swirls and disappears "down the drain," it implies a deep space beyond the screen (into which the image disappears). It also seemingly disturbs the screen surface, thereby emphasizing the screen as a barrier – albeit a highly illusionistic one – between the user and the "space" of computation, or the "cyberspace" of the Internet. In his history of network infrastructures, Tung-Hui Hu describes the Victorian sewer system as an important predecessor to twentieth-century communications networks. The sewer is a model for how cloud computing produces a sense of private individual user from a shared resource: "sewers kept each household's private business private even as it extended the armature of the state into individual homes."[157] But it is also a fitting model for the internet in that it is a continually available and constantly moving resource – as Hu points out, telecommunications networks are described in similar terms

to water or electricity, as a utility that is piped into the home, a continual flow connecting the private space of the home to a public network beyond.[158]

"Mandelbrot": calculating machines and negentropic fantasies

Screensaver animations are iterative, displaying a logic of perpetual change. The screensaver is unique as a moving image in that it will continue without repeating for an indefinite, potentially infinite period of time. While they follow established parameters, it is impossible to entirely predict what they will do. This is achieved by programming randomness into the animation. The toasters will fly across the screen within certain parameters, yet certain aspects of the sequence – the exact trajectory, the color of the toast, and so on – draw on libraries of randomization code to ensure that they do not repeat. This randomization is necessary to ensure that different phosphors on the screen are activated, yet also has the benefit of providing an animation that is continually changing and of highly variable duration – anywhere from three seconds to three days.[159] These iterations allow the animation to continue indefinitely.

The After Dark animations, as with a good deal of early computer-generated animations, draw on the visual rhetoric of mathematics, data visualizations and simulations. One of the largest genres of After Dark animations are those designs which reference visual traditions of mathematics and geometry. These animations feature moving designs in the style of projection rays, polygons, fractals, curvilinear patterns, and other abstract shapes which refer to or borrow from the visual culture of mathematics and physics. Both obliquely and specifically, they reference the history of computer-generated imagery, which has its roots in mathematical simulations and modeling.

Because computers were originally employed solely in a research environment to process information and perform complex calculations, the earliest moving images generated on computers illustrated mathematical principles. As art historian Cynthia Goodman observed:

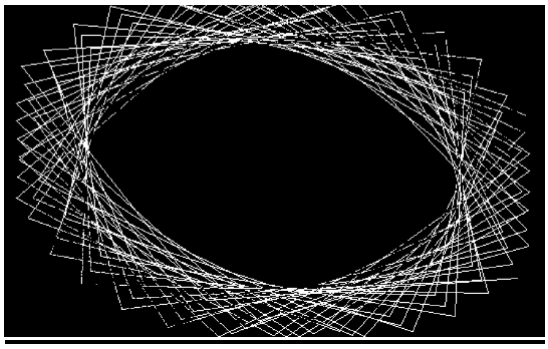
> "The work of most scientists and artists capitalized on the number-crunching feats computers excel at…. Artworks and scientific studies alike were based primarily on the effects achieved by the transformation of a linear configuration through one or more mathematical functions. The mathematical processes most frequently used were randomness (that is, programming the computer to produce unpredictable results within a framework of established parameters); iteration (the repetition of an operation with slight changes at each repetition); and interpolation."[160]

As a classic example of such imagery, one of the earliest computer-generated images was A. Michael Noll's *Gaussian-Quadratic* (1962-3), a tangle of straight black lines intersecting at various angles, which was the result of Noll's experiments at Bell Labs in the visual effects of programmed randomness.[161] Similarly, *Trajectories of a Ricocheting Projectile* (1964), an elegant sweep of parallel sine curves, is a motion graphic produced by the United States Army Ballistic Research Laboratories.[162]

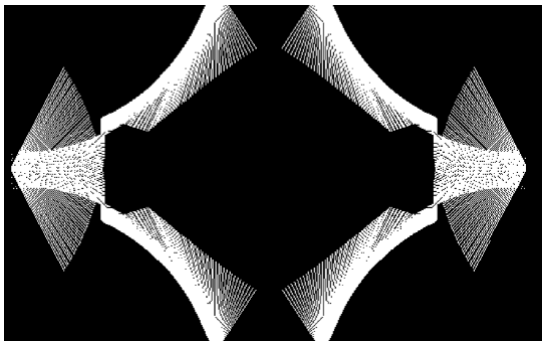
A graphics that visualizes the mathematical processes of computational machines becomes necessary: these are machines whose systems of operation are largely invisible to us. As Zabet Patterson observes: "With the advent of the electronic circuit, technology is no longer shaped by push and lever, gear and wheel. Instead, it begins to be comprised of machines whose functioning is no longer, strictly speaking, visible, at least in the ways in which the technology of the machine era had been visible. These new machines operate at a level of essentially invisible forces."[163] According to Patterson, the computational art produced at Bell Labs in the 1960s becomes a way of working through, attempting to understand and render visualizable the processes of the machine

(E.g., Knowlton's *Studies in Perception*).

The After Dark animations borrow from these aesthetics of simulation and mathematical processes, often referencing iconic imagery from the history of computer graphics. For example, one of After Dark's modules, "Gravity," features an animated 3D ball bouncing up and down, slowly losing height as if weighed by gravity. One of the first computer graphics programs written - in 1949 for MIT's Whirlwind mainframe computer[164] - was a visual simulation of a bouncing ball. A public demonstration of the Whirlwind on Edward R. Murrow's television show "See it Now" in 1951 featured the Whirlwind's visual simulation of the flight path of a rocket - a bright dot arcing across the screen - which calculates the amount of fuel remaining and the velocity at any given point in its flight path.[165]



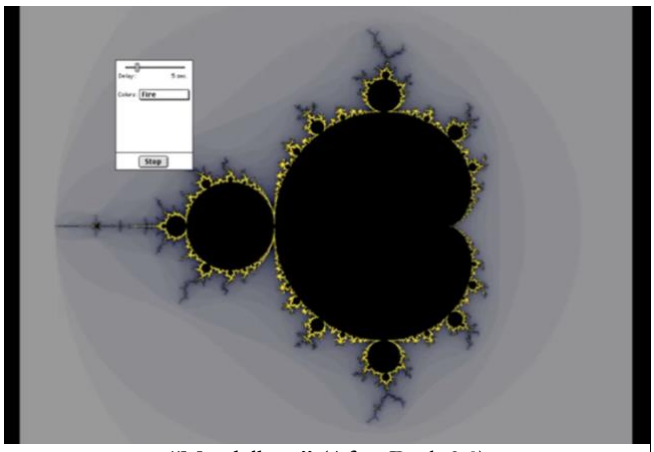
Lissajous, After Dark 2.0



Spiral Gyra, After Dark 2.0

Another icon of postwar physics that is embraced by After Dark is the Lissajous pattern. The "Lissajous" module refers to curvilinear patterns created on an oscilloscope to measure electricity (named after a 19th century French mathematician, Jules Antoine Lissajous, who studied wave motion). Lissajous curves are the same patterns used by Ben Laposky in his Oscillons, electronic monitor-based images considered an important precursor to computer generated images. These Lissajous-inspired patterns were taken up in midcentury design and computer art. Grant Taylor writes, "In the twentieth century, the Lissajous figure became popular as a schema for design, effectively making a shift from the purely scientific to the cultural. Many experimented with harmonograph tracing machines, pendulum pattern makers, and other analog devices…. The aesthetic curvilinear effects produced by analog drawing machines and electronic oscilloscopes parallel early computer art."[166]

Fractal geometry is another icon of computer-aided scientific experimentation taken up by After Dark. The "Mandelbrot" module was named after Benoit Mandelbrot, a mathematician at the IBM Watson Research Center in the 1970s whose studies of noise in telephone lines eventually lead him to the discovery of fractal geometry. Fractals are patterns made up of a potentially infinite series of ever smaller versions of themselves. The After Dark "Mandelbrot" module represents fractal geometry with the branching droplets and spirals that are popularly used to



"Mandelbrot" (After Dark 3.0)

visualize Mandelbrot's principles. Mandelbrot's fractal geometry is itself a product of the personal computer. PCs allowed mathematicians to engage in trial-and-error experimentation, and to visualize the results of these experiments with the striking images of complexity that captured the imagination of scientists and the wider public in the 1980s. Although infinitely complex, fractal geometry does not require a great amount of computing power. As James Gleick observes, "to send a full description of the [Mandelbrot] set over a transmission line requires just a few dozen characters of code. A terse computer program contains enough information to reproduce the entire set."[167]

Fractal geometry, like iteration and recursion more generally, are emblematic of the science – new in the 1980s and 1990s – of chaos and complex systems. The recursive symmetry of fractals, like a *mise en abyme*, seem to repeat without end. As James Gleick describes it, "In the mind's eye, a fractal is a way of seeing infinity."[168] N. Katherine Hayles observes that the science of chaos reconceptualizes the second law of thermodynamics: "It envisions a world that can renew itself rather than a universe that is constantly running down, as nineteenth-century thermodynamics believed."[169] Like fractal geometry, the iterative, effortlessly renewing patterns of the animated screensaver stage a tendency towards a negentropic temporality: giving the impression that they are not subject to entropy but will rather go on indefinitely.

In the 1970s John Perry Barlow articulated just this fantasy of computers providing freedom from the world of friction and entropy, writing: "Despite the current confines of my little office-island, I know that I have become a traveler in a realm which will be ultimately bounded only by human imagination, a world without any of the usual limits of geography, growth, carrying capacity, density or ownership. In this magic theater, there's no gravity, no Second Law of Thermodynamics, indeed, no laws at all beyond those imposed by computer processing speed."[170] The screensaver's negentropic iterations articulate this same fantasy, visualizing computation as something that is not bound by material limits. With screensaver programs this goes beyond a visual aesthetic of endlessness: due to the screensaver's purpose in preventing screen burn-in through constant motion, the screensaver made it possible for the personal computer to remain always on. "After Dark" is a telling name, for it encouraged PC users to leave their computers on for extended periods of time, even - as the name of the software implies - after they have gone home for the day or gone to sleep. Indeed, the default screensaver for After Dark is "Starry Night," a module depicting a city skyline against a starry night sky.

If Barlow saw this expanding universe as exciting, today these fantasies of unendingness, when manifest in computation, are the subject of much anxiety. Jonathan Crary has argued that late-stage capitalism is characterized by a pervasive never-ending temporality, in which the rhythmic cycles of day and night give way to a sense of perpetual "24/7" temporality. [171] Crary argues that networked personal computers have led to a global economy operating twenty-four hours a day, seven days a week, an economy which penetrates the most intimate spaces at all times. According to Crary's formulation, in an age of globalization the market is always on, and we, through our networked devices, are always accessing and accessed by the machinery of capitalism. While on the one hand the screensaver facilitates this shift to "24/7" temporality, in which networks and computers never sleep, their very existence signals the vulnerability of the material (in this case the CRT display). This is the contradiction at the heart of the screensaver: between the animations that offer a vastly large, potentially infinite, number of iterations, which suggest the computer will go on and on, *ad infinitum*, and a material display subject to burn-in.

[112] As Campbell-Kelly *et al.* point out: "Rather like electric utilities, business-oriented time-sharing services suffered from wildly fluctuating demand. During nine-to-five office hours, the service was used to capacity, but in the evening when the business day was over, and on weekends, the system was heavily underused. In 1978, with the arrival of personal computers, CompuServe's founder and leader Jeff Wilkins saw an opportunity to sell this spare capacity to computer hobbyists… Subscribers could access the system at off-peak times for a few dollars an hour." Martin Campbell-Kelly et al., *Computer: A History of the Information Machine* (Boulder, CO: Westview Press, 2014), 271.

[113] Richard Leinecker, "The Ultimate Screensaver," *ST-Log Magazine*, no. 35B (September 1989): 18–30.

[114] Published in the 1980s for the Atari ST and other Atari 16-bit computers.

[115] Ross Scott Rubin, *Cool Mac After Dark* (Carmel, IN: Hayden, 1992): 2.

[116] See a useful description of burn-in in Erfert Fenton, *Art of Darkness: The After Dark Companion* (Berkeley, CA: Peachpit Press, 1992), 3.

[117] "Truthfully, Apple provides an advanced, state-of-the-art technological solution to [the problem of burn-in]: the brightness knob. On Macs that don't have a brightness knob - like the Macintosh Classic and old Macintosh Portable - Apple provides the Brightness control panel. Unfortunately, you can set neither the software nor the knob to lower the brightness after a given period of time. And don't ever try to make them produce hypnotic swirls of color!" Rubin, *Cool Mac After Dark*, 2.

[118] For a "Thankfully Brief History of Screen Savers," see Rubin, *Cool Mac After Dark*, 3.

[119] Leinecker, "The Ultimate Screensaver."

[120] Leinecker, "The Ultimate Screensaver."

[121] Kivolowitz, "A completely blank screen is exceedingly boring." 64

[122] For example, for the Commodore Amiga, Perry Kivolowitz, "Screen Saver," *Amazing Computing* 1 (August 1986): 63.

[123] Automating the screensaver is one of its most important features - as Leinecker's story above demonstrates, burn-in was likely to occur from accidentally forgetting to turn off the screen - although it did pose engineering challenges. In a preface to a screensaver program published a 1986 edition of *Amazing Computing*, developer Perry Kivolowitz describes the challenge of writing a program that would detect user inactivity across multiple programs. He also emphasizes the importance of finding ways to distinguish user inactivity from CPU inactivity. "Let's say you had a graphics program that spent a huge amount of time computing before it rendered its results into a window. While the computation takes place, the machine is, of course, not idle and therefore the screen saver won't kick in. However, if you go to lunch while your Amiga chugs away, your monitor displays the same unchanging view for a potentially long time." Kivolowitz, "Screen Saver," 63. In order to determine that the user is no longer actively using the screen, Kivolowitz designed his program to detect intervals of time without user input from the keyboard or mouse, not a straightforward task because it requires detecting input to multiple possible programs at once.

[124] Phil Patton, "Silly Screens," *The New York Times*, July 18, 1993, sec. 9.

[125] Rafaël Rozendaal, "Interview with Jack Eastman," in *Sleep Mode: The Art of the Screensaver*, Online Exhibition Catalog (Rotterdam: Het Nieuwe Instituut, 2017), https://sleepmode.hetnieuweinstituut.nl/en/jack-eastman.

[126] Fenton, *Art of Darkness*, viii.

[127] According to Bill Stewart and Ian MacDonald, "After Dark quickly became the top-selling software product in the world. We sold more copies than Microsoft Word, Mac computers and even Windows itself for a time." Bill Stewart, "Screensavers," *Software Dynamics Corporate Website* (blog), accessed September 5, 2019, https://www.sdispace.com/screensaver.html.

[128] Michael Malone, "The Executive Life; Personal Statements of the Computer Kind," *The New York Times*, January 3, 1993, sec. 3.

[129] "Berkeley Systems Inc., based here, has topped the personal computer software best seller charts in 1992. At Egghead Inc., one of the nation's top software retailers, the modest program has in four of the last six months even outsold Microsoft's best-selling Windows - a full-blown master control system for computers." John Markoff, "Turning a Computer Screen Into a Window on Whimsy," *The New York Times*, October 16, 1992, sec. D.

[130] Bill Stewart, "Screensavers," *Software Dynamics Corporate Website* (blog), accessed September 5, 2019, https://www.sdispace.com/screensaver.html.

[131] "After Dark may be the start of the monogramming of office computers -- various ways of putting the user's personal stamp on an impersonal machine." Markoff, "Turning a Computer Screen Into a Window on Whimsy."

[132] Phil Patton, "Silly Screens."

[133] Paul Ceruzzi, *A History of Modern Computing* (Cambridge, MA: MIT Press, 2003), 345.

[134] Fenton, *Art of* Darkness, ix.

[135] Fred Turner, *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (Chicago: University of Chicago Press, 2008), 33.

[136] Gene Youngblood, *Expanded Cinema* (New York: Dutton, 1970), 222.

[137] Rozendaal, "Interview with Jack Eastman."

[138] "Fractals are the beautiful and haunting images generated from the Mandelbrot Set, a bit of mathematical arcana that of course is unnecessary to explain here. A Touch of Chaos, from Bourbaki of Boise, Idaho, produces a slide-show-like series of these images that serve as screen savers. The company says that the program is 'guaranteed to reduce productivity,' and it is right; you are reluctant to press a key or move the mouse, which makes the patterns disappear, and get back to work." L. R. Shannon, "The Waltz Of the Screen Savers," *The New York Times*, January 12, 1993, sec. C.

[139] Paul Roquet, *Ambient Media: Japanese Atmospheres of Self* (Minneapolis: University of Minnesota Press, 2016), 14.

[140] Roquet, *Ambient* Media, 14.

[141] Malone, "The Executive Life."

[142] J. C. Herz, "Flying Toasters That You Can Play With," *The New York Times*, April 29, 1999, sec. G. For Herz, playing the games appears to be less of a distraction and more a mood regulating experience. "You take deeper breaths. Your heart rate slows down. You blink less. And pretty soon you're in a complete state of flow, immersed in a pursuit whose only purpose and consequence is to bring about this very state of mind. For nonsmokers, an easy puzzle is the closest you can get to having a cigarette. It's like doodling while you talk on the telephone. Like scribbling hatch marks on scratch paper, it's a way of slowing time. It puts a damper on the cacophony. It fosters a sense of privacy. If you're playing solitaire, the mental office door is closed…. in a workplace suffused with politics and deadlines and other people's demands, adults are not looking for more stimulation. They're looking for stress relief. And a low-key computer game is a cheap and convenient way to cool out. We don't need screen savers for our computer monitors anymore. We need screen savers for our brains, to keep us from glaring at incomplete information, to keep us from becoming needlessly agitated. To keep us from burning in. Where technology is concerned, a little Zen never hurts."

[143] Similarly: "There is something decidedly tranquil about sitting back and watching sheep contentedly frolic and graze. And if you're stuck in the office and can't get to the country, watching a little cartoon sheep scamper around your computer's screen and head-butt your icons can be relaxing in its own right." J. D. Biersdorfer, "Screen Mates for Fun or Profit," *The New York Times*, February 24, 2000, sec. G.

[144] In a similar discussion of brain burn-out v. screen burn-in in *The Art of Darkness* companion book, the author writes: "After Dark's modules take care of a problem that is just as damaging - if not more so - than screen burn-in: brain burn-out. Numerous studies involving assorted bored primates have shown that animals (including you, dear

reader) have a need for stimulus variation, known in layman's terms as something interesting going on. After Dark's modules certainly fill that requirement, offering a variety of absorbing patterns, sounds, animations, and even games." Fenton, *Art of Darkness*.

[145] Malone, "The Executive Life."

[146] Campbell-Kelly et al., *Computer*, 273.

[147] Anne Friedberg, *The Virtual Window: From Alberti to Microsoft* (Cambridge: MIT Press, 2006), 2.

[148] Campbell Kelly et al describe Douglas Englebart as early as the 1950s researching an "'electronic office' - a system that would integrate text and pictures"; they cite the Xerox Alto minicomputer released in 1975 as the first computer to be operated with a visual desktop environment. Apple and Microsoft in the 1980s popularized the concept. Martin Campbell-Kelly et al., *Computer*, 258.

[149] Friedberg, *The Virtual Window*.

[150] Jacob Gaboury has argued that the trope of analyzing computer graphics in terms of perspective overlooks the significant ways in which computer-generated images are in fact a departure from optical/photographic images. Any reliance on Renaissance perspective in computer generated images is a simulation after the fact of previous representational styles. Jacob Gaboury, "Hidden Surface Problems: On the Digital Image as Material Object," *Journal of Visual Culture* 14, 1 (April 2015): 40-60. It's important to note that while the After Dark animations depict figurative space, their reliance on Renaissance perspective to produce the illusion of depth is actually fairly minimal (particularly in the earlier versions of After Dark). Space is suggested metaphorically rather than through geometrically rendered three-dimensional depth. A number of After Dark 2.0 modules depict the screen as a window onto a virtual world, while rendering this world in two dimensions.

[151] Turner, *Counterculture to Cyberculture*, 212.

[152] Wendy Chun, *Control and Freedom: Power and Paranoia in the Age of Fiber Optics* (Cambridge, MA: MIT Press, 2005); Turner, *Counterculture to Cyberculture*, 213.

[153] In *Control and Freedom*, Wendy Chun recounts how the metaphor of the internet as virtual space enables colonialist fantasies of freedom and control.

[154] John Perry Barlow, "Being in Nothingness: Virtual Reality and the Pioneers of Cyberspace," *Mondo 2000*, Summer 1990.

[155] John Perry Barlow, "Crime and Puzzlement," *Whole Earth Review*, Fall 1990.

[156] Barlow, "Being in Nothingness."

[157] Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge: MIT Press, 2015), 41.

[158] Hu, *Prehistory of the Cloud*., 58.

[159] Jack Eastman, creator of After Dark, drew on his experience using randomization – such as Monte Carlo simulations – in his doctoral research in physics, conducting research at the Stanford Linear Accelerator, in creating randomly generated animations for the screensaver.

[160] Cynthia Goodman, *Digital Visions: Computers and Art* (Syracuse: Everson Museum of Art, 1987), 21.

[161] Grant D. Taylor, *When the Machine Made Art: The Troubled History of Computer Art* (New York: Bloomsbury, 2014), 33.

[162] While much scholarship has analyzed the digital image in relation to photographic media (Manovich, Rodowick, etc.), Zabet Patterson and Jacob Gaboury have argued that computer graphics are moving images that are not based on a photographic model of representation but rather on a mathematical one. Patterson writes that computer generated images are based on a "diagramatics of vision that prioritizes abstraction, function, and system above all else." Zabet Patterson, *Peripheral Vision: Bell Labs, the S-C 4020, and the Origins of Computer Art* (Cambridge, MA: MIT Press, 2015), 22. For example Zacaj's *Simulation of a Two-Gyro Gravity-Gradient Attitude Control System* (simulation of orbiting objects) is a visualization of a mathematical scenario. Patterson writes: "The diagram – as a mode of representational practice – marks a shift from a concern with the perceptual qualities of the object to

a concern with its undergirding conceptual relationships. […] Sinden and Zajac saw [their films] as affording the unique ability to visualize concepts that had never before been amenable to photographic representation. …they provided an image of a structural organization that itself was inimical to photographic capture This scientific empiricism does not depend on the regime of the photographic for its claim to truth value – and it helped to extinguish the photograph's claim to truth even before digital manipulation ultimately sealed its fate." Patterson, *Peripheral Vision*, 22.

[163] Patterson, *Peripheral Vision*, 60.

[164] Goodman, *Digital Visions*, 19.

[165] Jay W. Forrester and the WHIRLWIND Computer on "See It Now," December 16, 1951, YouTube, accessed December 22, 2022, https://www.youtube.com/watch?v=5ZQP4G3Qwb4.

[166] Taylor, *When the Machine Made Art*, 70.

[167] James Gleick, *Chaos: Making a New Science* (New York: Penguin, 1987), 221.

[168] Ibid., 98.

[169] N. Katherine Hayles, *Chaos and Order: Complex Dynamics in Literature and Science* (Chicago: University of Chicago Press, 1990), 12.

[170] John Perry Barlow, "Being in Nothingness."

[171] Jonathan Crary, *24/7: Late Capitalism and the Ends of Sleep* (London: Verso, 2014), 29.

Without End: The Infinite Scroll and the Aesthetics of Platform Capitalism

If video art pioneered the infinite aesthetic with its regenerative feedback loops, and the screensaver cemented the relationship of the form to 24/7 global information networks, it is the infinite aesthetic's manifestation in the infinite scroll of social media feeds and search results in the early-mid 2000s that marks its embrace as the defining aesthetic of digital capitalism. The dominant business model of the web today is premised on offering a digital infrastructure through which people can access goods and services; these platforms accrue value by skimming a percentage of the money exchanged on the platform (such as Lyft or Amazon) or by selling advertising space (such as TikTok and Facebook). Almost all of these platforms also collect data from users' interactions on the platform, which is also commodified or used in targeting advertising. There is an imperative for the platform to not only acquire and retain as many users as possible, but to maximize the amount of time spent on the platform. To this end, automatically and continually loading more information in the form of the endless or "infinite scroll" allows platforms to retain and increase user interactivity.

The endless scroll of digital media has heterogenous origins, emerging from blog aggregators, search engines, and PC-based social media services. Its success is intimately connected with the smart phone and mobile social media applications. Around 2007, a number of features converged to produce the infinite scroll. Nascent social media platforms shifted from a compendium of pages to a continuous "news feed;" changes in cell network bandwidth enabled the proliferation of smartphones; and multitouch touchscreens made the actions of scrolling and swiping more fluid and effortless. The infinite scroll as a mode for organizing information online intensified the increasing boundlessness, fluidity, dematerialization, and seeming endlessness of digital culture.

Continuous real-time feeds of information are not entirely new – indeed they go back to the earliest telecommunications with the telegraph, the stock ticker, and teletype machines in the nineteenth century and early twentieth century. But there are two things that are distinct about the digital infinite scroll: firstly, the sense of volition they produce – the sense that the user is controlling the feed – and secondly, their nonlinearity – they are algorithmically disordered and are therefore typically not chronological or linear. Both of these innovations are linked in UX (user experience) design to the highly engaging properties of the scroll, a quality which has recently given rise to moral panics around the detrimental social and psychic effects of the infinite scroll.

Because of concern over the reportedly addictive properties of social media, recent years have seen a marked backlash against the tech industry. The "infinite scroll" has become emblematic of the negative qualities of networked media: they are isolating, addictive, distracting, mindless. In 2018, Aza Raskin, one of the UX designers who worked on an early version of what we now call the infinite scroll, came out publicly against the feature, calling it "behavioral cocaine."[172] Raskin's publicity tour condemning the irresponsibly of social media design is part of the recent "techlash," reacting against the perceived addictive or harmful qualities of social media.[173] Yet while a whole genre has arisen around how individuals can mitigate digital media's harmful effects, and while interface designers now caution against using the infinite scroll (on the basis that it is perceived as stressful and exhausting)[174] - it continues to be central to how platforms

such as Google, Instagram, Twitter, TikTok, Netflix, and YouTube structure their content.

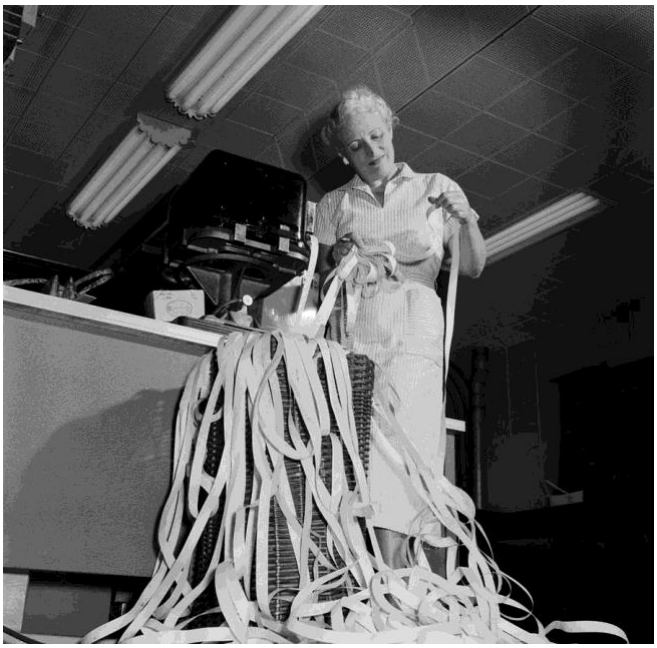
If the infinite scroll - bottomless, continuous, addictive, mundane - has become an emblem of the ills of digital media, where did this method of organizing information come from? How has it been used by digital platforms to commodify time and attention? It is a system that has reappeared several times in the history of information technology, from the nineteenth century telegraph machine to the scrolling teletype printers that were the first output devices for computers, to the continuous scroll of early PC command line interfaces. Through tracing this history of the continuous networked scroll, we can see that while this form has always been tied to notions of disposable real-time information, it is transformed by digital media into a much less chronological, more indeterminate feed. This chapter will examine what the infinite scroll reveals about liveness and real time on the internet, about digital platforms' manipulation of attention, and about the dominance of platform models of digital capitalism. The endless scroll is not only emblematic of neoliberalism's constant states of deferral, anxiety, and addiction, but is central to how platform capitalism generates a seemingly endless desire for more.

A Brief History of the Informational Scroll

Scrolling as a form of reading information dates back to antiquity: papyrus scrolls, some as long as seventy feet, were common in ancient Egypt, and in Greece scrolls of papyrus were the standard format for organizing text. It wasn't until the first century AD that scrolls were replaced by the codex format in Europe, although they continued to flourish in other parts of the world – in Japan scrolls containing paintings and text were popular from the early ninth century up until the seventeenth, for example.[175] The codex had several affordances that were important for its subsequent widespread adoption as a primary format for storing and disseminating text in Europe: it was more cost-effective than the scroll in that it allowed for printing on both sides of the paper; it was more compact; it freed the hands of the reader; and it made it easier to refer to a specific portion of the text.[176] These properties of the codex have been related to early Christianity's emphasis on the text, and subsequent hermeneutic traditions. Literary scholar Christian Vandendorpe observes that many of these key advantages of the codex were lost when text was initially converted to digital formats. Pagination, easy cross-referencing by flipping between different parts of a book, tactility and portability were all lost with early computers, from the printer output devices of the mainframe period to the command line interfaces of early PCs, up until the dominance of the graphical user interface in the 1990s.

The first scrolls of the industrial era were teletype printers used to automatically transcribe telegraph messages. While pioneered in the mid-nineteenth century, it wasn't until the early twentieth that this technology wise widely put into use. Samuel Morse's first telegraph had a printer, printing dots and dashes instead of letters. According to a popular business history of the Teletype corporation, "That original Morse printer was abandoned as far back as 1844 because a man who could be trained to read dots and dashes could just as easily be trained to listen to them."[177] The first commercial teletypewriter was produced by the Morkrum Company for Western Union in 1912. Typewriters had been used previously by telegraph operators to simultaneously transcribe and translate messages received in morse code into plain language, however the teletypewriter automated the process. The device received signals which were printed directly into text on paper tape at a speed of forty words per minute. In 1915 the Associated Press adopted the Mokrum teletypewriters to distribute news from its central New York office to hundreds of newspaper offices around the country. In the 1920s the company changed its name to

Teletype Corporation as teletype machines gained popularity, installed in corporate offices, banks and newsrooms. By 1920 more than half of all telegraph messages were transmitted by teleprinters.[178]



Reading a ticker tape.

A 1932 profile of the Teletype Corporation in *Fortune Magazine* describes the experience of using the teletype thus:

> "You would sit down at the machine which, so far as you are concerned, would much resemble a typewriter, both in appearance and in operation. There would be a keyboard, much like a typewriter keyboard except for its having three banks of keys instead of four. There would also be a paper on a roller, but it would be a roll of paper instead of a sheet of paper, and the roller, motor-driven, would do its own turning. The sideway motion of the paper would also be automatic, and when the end of a line was reached, you would press a key and the paper would automatically move itself back to the starting position… The rapidity of your communication would be limited only by the time that you and the banker took to think of what you had to say, and by his and your speed in operating the keys."[179]

This description emphasizes the novelty of the interactive, real-time nature of the device. Like the telephone, the telegraph allowed for instantaneous communication, printing the responses onto the continuous scroll of paper. The teletype was significantly faster than the morse key telegraph machines it replaced. The long strips of paper produced by telegraph machines were ubiquitous for decades, and the telegraph continued to be used until the it was replaced by fax and internet communication.

From the beginning of the industrial era, teleprinter technology diversified into multiple uses – for personal and business communication as well as for specialized services such as the news wire or the stock ticker. The stock ticker was essentially a specialized teletype service for distributing financial information. Invented in 1867 by E. A. Calahan (and shortly thereafter

improved and co-opted by Thomas Edison), the device transmitted stock prices via telegraph lines which were printed onto rolls of paper tape. In a study of the early twentieth century stock ticker, Braxton Soderman argues that in tuning the user's attention to the continual presence of the market, the ticker produced "modern, speculative subjects calibrated to financial markets."[180] It provided a material, visual manifestation of the (abstract) financial markets. Soderman writes: "It visualized the flow and fluctuations of capital itself, creating a modern conduit for observing the circulation of abstract data. This marked the emergence of the representation of capitalism in 'real time.'"

Operators watch ticker tape, 1918.

As Soderman observes, in the early twentieth century the stock ticker was associated with gambling and "mental intoxication."[181] He cites a 1927 book called *The Psychology of Speculation* in which the author describes the intense allure of the device:

> "The gyroscopic action of the prices recorded on the ticker-tape produces a sort of mental intoxication, which foreshortens the vision by involuntary submissiveness to momentary influences. It also produces on some minds an effect somewhat similar to that which one feels after standing for a considerable time intently watching the water as it flows over Niagara Falls. Dozens of people, without any suicidal intentions, have been drawn into this current and dashed on the rocks below."[182]

Such descriptions illustrate the intense pull that the scroll of information, unfolding in real time, had on subjects. A large part of this allure is due to the fact that the information provided by the ticker could be used in financial gambling. The stock ticker trained the emergence of what Soderman calls a "speculative subject," a future-oriented subject, who believes in his agency over of the market. This entwining of real-time information with an impression of control reemerges in the twenty-first century with the scroll of social media feeds, which is also associated with gambling, addiction, and the speculative time of finance, as I elaborate below.

In the 1960s teletype technology provided the standard input-output devices for computers. The first commercially successful "minicomputer" - the DEC PDP-8, released in 1965 - came with a

Teletype output device for IBM System 360 mainframe computer.

teletype terminal for input and output. The PDP-8 inspired a subsequent boom in minicomputers. As computer historian Paul Ceruzzi has observed, these minicomputers paved the way for the personal computer: "Minicomputers, in particular those operated by a Teletype, introduced the notion of the computer as a personal interactive device. Ultimately that notion would change our culture and dominate our expectations, as the minicomputer yielded to its offspring, the personal computer."[183] Early real-time computing environments used command-line interfaces drew upon the organization system of the teletype machine, unspooling text in real time, the only difference being that they appeared on a screen rather than paper. With the advent of the graphical user interface in the late 1970s, the ongoing scroll was more or less sidelined from personal computing, as the metaphors of windows, files and pages came to dominate the organization of space.

The scroll re-emerges in the 1990s in cable broadcast with the advent of the 24-hour news cycle, as the stock ticker or news feed on the bottom of the screen. The televisual news feed was modeled after the practice of transmitting timely news via news wire services, so named because they were originally transmitted via telegraph.[184] It is in this incarnation, as a "news feed," that it becomes translated into the mobile interfaces of Twitter and Facebook, and is why Twitter's interface – text-based, brief, and instantaneous – has frequently been described as a digital incarnation of the telegraph.

What the mechanical and digital scrolls share is a linear organization of the transmission of real-time information - whether printed onto paper or displayed on screen, the stream of information is continuous and ongoing. Due to the timely and fast-changing nature of the information transmitted, these scrolls are intended for transmission, not storage. The paper teletypes often scrolled straight from the machine into a wastebasket. What mattered was not a record of the message, but rather the delivery of a continual up-to-date stream of information. The

repurposing of the paper from these scrolls for use as confetti in "ticker tape parades" underscores its ephemeral and disposable nature.

While timeliness and disposability are still important characteristics of scrolls in the digital era, digital scrolls represent a key departure from paper scrolls. Firstly, with the digital scroll we see an intensification of the sense of user volition. Whereas the reader of a stock ticker or a telegram is a relatively passive subject – they can only pick up the scroll and peruse the information as it comes in – with digital scrolls, the activity of scrolling, of swiping or calling down more information, is an essential part of the experience. With digital scrolls, the activity of scrolling is transferred from the machine to the person – *scrolling* is now an activity performed by the user. As I will describe below, this plays into the strategies of platform capitalism, which thrives on the user's sense of empowerment, on the impression of control.

Secondly, the digital scroll is distinct from previous scrolls in that it is not necessarily continuously chronological. While the scroll of social media feeds gives the impression of unspooling in a linear fashion, typically these platforms do not present a faithfully chronological record of posts. Rather, platforms such as Facebook, Instagram, and Twitter use algorithms to organize the order of each individual's feed. By prioritizing different information for each user, the algorithm is designed to ensure the feed contains the right rhythm of the mundane and the unexpected to keep the scroller scrolling. Ultimately these algorithmically individualized feeds mean that, while the information of social media is potentially instantaneous, it is not a shared, synchronized transmission as with previous information technologies such as radio and television.

"Just Give It To Them": Inventing the Infinite Scroll

In the early 2000s, in the wake of the crash of the first dot-com bubble as commercial websites struggled to capitalize on the relatively new medium, UX designers for search engines began to address a perceived problem: visitors were typically only looking at the first page of results before giving up and going elsewhere. As designer Aza Raskin described it:

> "The problem is that every time a user is required to click to the next page, they are pulled from the world of content to the world of navigation: they are no longer thinking about what they are reading, but about how to get more to read. Because it breaks their train of thought and forces them to stop reading, it gives them the opportunity to leave the site. And a lot of the time, they do."[185]

The solution to Raskin's problem was to automatically load more results as users scrolled to the bottom of the list. As Raskin articulated it, "Don't force users to ask for more content: just give it to them."[186] Raskin launched his new "just give it to them" approach to browsing in a blog aggregator – the Humanized Reader - hosted by his consulting firm's website.

Though Raskin is cited as one of the inventors of the infinite scroll, other sites were introducing similar approaches to organizing search results around this time. One of the earliest to use it was Microsoft's image search. Microsoft software engineers Hugh Williams, along with his colleagues Nick Craswell and Julie Farago, came up with the concept for MSN Search (later rebranded as Bing) after studying user data for the site that indicated that while three-quarters of normal users only read through the first page of results, users of image search typically searched much longer.[187] As Williams observed: "It's an obvious step forward when you know that users are suffering through clicking on pagination for the bulk of their queries, and that they want to consume many images before they click. Well, perhaps the simplest invention would have been

more than twenty images per page (say, 100 images per page) – but it's a logical small leap from there to 'infinity.' While we called it 'infinite scroll,' the limit was 1,000 images before you hit the bottom." The technique was originally called Windows Live Search and was released in beta on March 8, 2006.[188] A patent filed by Williams and his team in February 2006 describes the technology thus:

> "A unique object navigation system, user interface, and method that facilitate faster and smoother navigation of objects are provided. For example, the system can generate a plurality of objects that can be rendered on a display space that spans a single page in length, thereby mitigating the need to navigate through multiple pages. The system can determine the length of the page according to the number of objects generated. To view off-screen objects, an infinite scroll component can be employed. The amount of scroll space needed to view the plurality of objects can be determined in part by the length of the page and/or by the number of objects. The objects can also be viewed in a film strip format that is infinitely scrollable. The film strip view allows a view of the objects to be maintained while also viewing a selected object in greater detail at the same time."[189]

The analogy of the film strip here is telling: infinite search was a way of organizing information in the browser that was fluid and in motion.

When Asa Raskin's HCI (Human Computer Interface) design consultancy released their own version of infinite scrolling the same year, he posted a teaser on their blog for the new design innovation. The brief post set up the problem of "page chunking" with web results:

"Chances are that you've done a search where you haven't found what you're looking for on the first page. If so, then you've had to click on the unhelpfully numbered more-result pages: There's no semantic meaning in these numbers; there's no telling what's lurking behind a representing numeral's bland exterior. If I find something good on the fourth page, I'll be unlikely to find it again without aimlessly clicking on random number after random number. Normally, if I don't find what I want on the first page, I'll usually just give up."[190]

Raskin's solution, "Don't force the user to ask for more content: *just give it to them*," is representative of the breathless tech jargon of its day, which touted simplicity, efficiency, and good design, promoting the impression that certain design solutions were somehow natural and inevitable. "Just give it to them," sounds like a release; it resonates with openness and fluidity and – one of the Internet's defining characteristics - freedom. Do away with pagination: the floodgates were opened for an effortless flow of search results. The infinite scroll adheres to the principles of a popular web design guru, Steve Krug, who argued that "don't make me think" is the most important law of web usability. Krug writes: "As far as is humanly possible, when I look at a Web page it should be self-evident… I should be able to 'get it' – what it is and how to use it – without expending any effort thinking about it."[191] By eliminating distractions this form of "don't make me think" design is efficient and time saving. Krug argues that this sort of effortlessness builds confidence in a website and its products, writing "On the internet, the competition is always just one click away, so if you frustrate users they'll head somewhere else."[192]

Three days after Raskin's teaser post, Humanized announced its brilliant solution to the "problem" of losing frustrated readers to page chunking. The design of the site's new blog aggregator, Humanized Reader, presented the entirety of a user's RSS feed in a scrolling list, without pagination. Raskin wrote: "We call it Humanized History, and we're hoping that you don't even notice what it is, because that's sort of its point: to let you spend more time reading, and less

time thinking about navigation."[193]

Humanized was a small design firm based in Chicago led by Raskin, Jono DiCarlo, Atul Varma and Andrew Wilson. Raskin, who claims to have come up with the idea for infinite scroll, continued to proselytize for the new feature. In a 2008 talk Raskin delivered to employees at Google called "Don't Make Me Click,"[194] he outlined a proposal for how Google could improve the design of its search results by reducing interaction on the Google homepage, and thereby preventing users from leaving the site. In a similar manner to how he first described his innovation in the blog post above, he describes the pagination of the search results as semantically meaningless. As he points out, the page numbers listed at the bottom of the search results "just mean: 'go someplace further into the search history.'"[195] Raskin proposed that removing the pagination in favor of an endless scroll simplified the process of perusing search results. In his presentation to Google employees, Raskin demonstrated how his Humanized blog reader worked. In what later came to be colloquially called "The river of new" style, new blog posts would be added to the top of the list, and the user could scroll down to see the history. As Raskin says, "It's just sort of this infinite page." The site loaded more information as the user scrolled, prompted to automatically do so by the action of scrolling rather than clicking on a page. "You never have to stop and ask for more content, so what do we see? People looking at more and more things."[196]

From a Book to a Stream: Facebook News Feed

Although Raskin has pitched himself as a, if not the, inventor of the infinite scroll, it was an idea that was emerging simultaneously in multiple platforms. While search results and RSS feeds were a logical place for the infinite scroll due to the vast amount of information they provided the user, the rise of infinite scroll is inextricable from social media and the mobile phone. On September 5, 2006, Facebook rolled out a major new feature, which completely transformed the two-year-old platform and would come to epitomize a new era of social media. The feature – News Feed – radically transformed how users interacted with Facebook, and by some accounts doubled the number of pages users were viewing within two months of its launch. Up until this point Facebook users could only glean recently updated information about their friends by navigating directly to their pages. The Facebook redesign transformed the website's landing page into an automatically generated list of updates from all of a user's friends. Following the "just give it to them" ethos that was popular in HCI, the feature automatically served up information that a user would previously have had to search for. Ruchi Sangvhi, the News Feed product manager, described it thus: "News Feed … updates a personalized list of news stories throughout the day, so you'll know when Mark adds Britney Spears to his Favorites or when your crush is single again." [197] Zuckerberg described the new feature as enacting a shift from an "Encyclopedic" model for Facebook - a compilation of pages with information on each given user - to a stream of news.[198] As Zuckerberg cannily pointed out, the news feed effectively reversed the scroll-to-codex transformation.

Zuckerberg had been bullish about the concept of News Feed, which was not a straightforward development from a technical perspective. To customize every Facebook user's homepage, the developers had to write algorithms that would detect every piece of new information, determine what would be most interesting, and publish these items in reverse chronological order in a timely fashion. Although News Feed didn't offer real-time updates until two years later, for the concept to work it had to continuously update the feed throughout the day. Then-President of Facebook Sean Parker has noted: "It was the biggest technology challenge the

company had ever faced."[199]

News Feed was launched at a pivotal time for the young company. Having spread rapidly throughout the population of college students during its first two years, Facebook's protentional for growth was at risk of maxing out.[200] Moreover, in 2006 Facebook was being aggressively courted by Yahoo, which at that time offered to buy the company for $1 billion. Facebook's developments in Fall 2006 - the release of News Feed, along with its plan to open Facebook up to anyone who wanted to join (no longer restricting registration to college students) – gave Facebook executives enough confidence in the company's growth to resist Yahoo's offer. Their gamble paid off, and Facebook became more successful than ever at attracting users and investors.[201]

Facebook News Feed was a significant development in how social media operated and has become the dominant model for other platforms. Social media was no longer a compendium of individual pages, but a continuously and automatically updated stream. As Marc Zuckerberg described it on the ten-year anniversary of its launch:

> "For more than two years, Facebook was just a collection of profiles. You could visit a friend's page to look up some basic details about them, but there was no way to see updates from all your friends or be sure they saw yours. With News Feed, all of a sudden you could share with all your friends at once. And you could see what was happening with all your friends in one place. News Feed was the first real social feed. It was such a fundamental idea that now, 10 years later, every major social app has its own equivalent of News Feed."[202]

Since 2006, subsequent changes to Facebook's homepage design have continued to emphasize the feed or flow nature of Facebook.[203] Despite initial resistance from some users who were disturbed by the perceived privacy incursion of publishing their posts on a centralized feed, user engagement purportedly doubled after Facebook introduced News Feed. Tech journalist Fahrad Manjoo described its influence in 2013: "News feed is the basis for Facebook's popularity, the thing that initially set it apart from every other social network, and the reason hundreds of millions of us go back to the site every day… Either directly or indirectly, it's the inspiration for just about every social-media feature that has come along since."[204] While News Feed was a major and influential transformation for social media, turning Facebook from a compendium to a linear and continuously updating feed, it wasn't until 2009 when facing competition from Twitter that the News Feed became a continuously updated, "real-time" stream.

"What are you doing now?": Twitter and the Emergence of Real-Time Scrolling

Unlike Facebook or search, when Twitter was launched in the summer of 2006 it was a service specifically designed for mobile phone use. The service effectively coupled the social networking features of MySpace or Facebook with the mobility and brevity of text messaging. Although officially launched in 2006, it was in 2007, when a new version debuted at the South By Southwest convention that it debuted to a mass audience. Originally called Twttr, the free application provided a public short messaging service (SMS). Users could use the platform to text brief messages to a group of friends by texting a message to one number (40404), which would then be broadcast to everyone in the user's network. Messages could be sent and received either through an interface on the twitter website, via SMS to one's mobile phone, or using Twitter's own mobile phone application. While Twitter's earliest web layouts were not continuous (there was a "more" button at the bottom of the page for loading results), it was soon an early – and still one of the most popular – adopters of the infinite scroll.

Twitter's original slogan in 2006 was "A global community of friends and strangers answering one simple question: What are you doing?" Inspired by the popular practice of AOL instant messenger "away" statuses, which often provided specifics about what an individual was supposedly doing at the time, Twitter posts were from the beginning designed to be real-time information. This speaks to the unique sense of liveness associated with Twitter. This era of emerging mobile media and social media marks a shift in the temporality of social media - from reporting on the past (even if recent past) to an emphasis on the present. Similarly, while Facebook had previously been an encyclopedia of general information about an individual, with its introduction of the "what are you doing now?" status update feature (inspired by pressure from the popularity of Twitter), the website capitalized on the internet's capacity to broadcast individual information instantaneously. For a while this wasn't strictly live - the Facebook News Feed was updated every thirty minutes – but as broadband capacity increased this became almost instantaneous. Twitter therefore marks a shift that was occurring in the tense/temporality of the internet, as used daily by a mass audience.

Because of its instantaneity and brevity, Twitter has been compared to the telegraph, and the related technology of the news wire. The latter analogy is reinforced by the fact that Twitter has from the beginning been embraced by journalists and news outlets. But while Twitter has been celebrated for its potential for inexpensive and accessible dissemination of information, it has also been subject to critiques of information overload, the notion that there is so much data produced that not only can it not be meaningfully processed, but that it is harmfully overstimulating. In 2008 Twitter addressed these critiques directly, arguing that Twitter messages were "rhetorical" and did not require a response (it is unclear how this prevents information overload, since the reader still has to read through those tweets.) In a post on the Twitter homepage, the platform was described as "ambient," as though the experience of Twitter was not one of consuming information, but rather letting it wash over you. "Twitter is ambient," the post reads. "Updates from your friends and relatives float to your phone…. You can step in and out of the flow of information as it suits you and it never queues up with increasing demand of your attention."[205]

This notion of mobile media as ambient is also articulated by scholar Kate Crawford, who argues that the "chatter" of social media posts, the banal, phatic communication they produce, is a sort of "ambient intimacy."[206] Twitter's defense against information overload went so far as to argue that not only is Twitter not a source of information overload, but it is a tool that will help users cut through the glut of data. A 2008 post on the Twitter website wrote: "Users are very much in control of whose updates they receive, when they receive them, and on what device. … Simply put, Twitter is what you make of it – [users can] receive a lot of information about your friends, or just a tiny bit. It's up to them." This notion that digital technologies themselves provide the solution to information overload is something acknowledged by Mark Andrejevic, who identifies a turn to computational strategies for cutting through the mass of information. Andrejevic argues that the overwhelming amount of information in contemporary society has led to a mistrust in truth or knowledge, and a belief that we can use technology to somehow bypass comprehension or analysis and cut directly to conclusions. He identifies a dominant attitude "of savvy mistrust and suspicion toward discourse," which is "combined with the attempt to bypass representation entirely to get at a more immediate ground for action."[207] We effectively outsource analysis to algorithmic tools such as predictive policing, body language analysis, or sentiment analysis in marketing data. In Twitter's rhetoric describing its platform as a tool for filtering information we see a similar mistrust of the individual's power to comprehend.

Twitter is representative of a watershed moment in the history of mobile computing. As

mobile media historian Gerard Goggin points out 2006-7 – the year Facebook News Feed, Twitter, and the iPhone were all released - was a turning point for mobile internet. There were two important technical developments around this time: the introduction of more dual-mode devices that enabled cell phones to access Wi-Fi networks, and improvements in mobile broadband.[208] Although social media was established on computers, they are inextricable from the simultaneous rise of mobile internet. Twitter in particular was perfectly suited for mobile use. As Goggin states: "It cleverly extends the affordances of text messaging, [and] like the internet, it works across different platforms."[209] Being "device agnostic" allowed Twitter users to seamlessly move between personal computers and mobile phones. In this way it bridged a transition for social media from computer-based web browsers to mobile applications. While smartphones had been gathering momentum for several years (the first mobile phone with a computer, the Simon Personal Communicator, was released in 1993) the introduction of the iPhone in 2007 launched an increasingly visible, desirable, and multi-use mobile device. As the first phone to combine a highly responsive touchscreen, web-enabled applications, and high-resolution media players, the iPhone was poised for a much wider range of uses for smartphones than just checking email and maps. Having grown out of the popular Apple iPod, the iPhone fused telecommunications functions with audio-visual media, which is what social media feeds do so well.

"This Infinity Pool": The iPhone Touchscreen

Steve Jobs introduces the iPhone, which featured touch scrolling for the first time, 2007.

Steve Jobs began his storied 2007 keynote at the MacWorld conference with characteristic hype, saying: "Every once in a while a revolutionary product comes along that changes everything."[210] The revolutionary product was the iPhone, which – along with subsequent smartphones – did play a role in transforming computing and mobile communications, and giving rise to a whole new subset of the IT industry - the "App economy" - which grew up around the

success of smartphone based services such as ridesharing and dating apps.

The iPhone was the result of several years of efforts on Apple's part but was also made possible by broader technological and infrastructural changes. Developments in processor hardware (the new ARM11 chip) meant that cell phone processers were finally fast enough to combine the telephone, computer, and Mp3 player in a small hand-held device. The iPhone was not strictly speaking the first device to feature any of its most lauded technologies – it was not the first smartphone, not the first touchscreen, not even Apple's first telephone (the ROKR released in 2005 piloted several of the iPhone's innovations). As Goggins observes, its enthusiastic reception was the result of Apple's careful marketing strategies (for example, manufacturing the lines outside of its Apple stores to generate hype). [211] Nevertheless, its successful integration of internet connectivity, the touch screen, appealing design, and technologies such as the accelerometer and the camera, its quickly established popularity made the iPhone a landmark in the evolution of mobile phones.

At the time that the iPhone was launched, the smartphone market was dominated by BlackBerry (with Windows Mobile as a competitor), which was largely perceived as a business tool, pitched to a corporate market. What distinguished the iPhone from BlackBerry was that it was much more user friendly – it had a pleasurable interface that looked cool and was fun to use. Although it was a luxury item and status symbol given its high price tag, the iPhone was marketed to a wider audience than the BlackBerry. In his introductory keynote, Jobs pitched the iPhone as a merging of the popular iPod media player with a mobile phone and internet connectivity. Unlike the Blackberry, the iPhone had a fully Internet-capable browser.[212] Whereas previously smartphones had applications for a circumscribed set of services – email, phone book, calculator, etc. - the iPhone really was a computer in your pocket. It was the first phone with which users could browse any website that they would visit with a computer. Previous smartphones used the WAP wireless application protocol, which allowed mobile users to only access stripped down, low resolution or text only versions of websites. One of Apple's key innovations with the iPhone was its exclusive partnership with AT&T to offer higher bandwidth for the iPhone.[213] The new data

Advertisement for the Apple iPhone X.

limits meant that a wide new range of applications were possible: maps, instant messaging, as well as web browsing and steaming media.

One of the iPhone's splashiest innovations was its touchscreen. Jony Ive, Apple's head of industrial design, has said that the iconic sleek, smooth design was inspired by "this infinity pool, this pond, where the display would sort of magically appear."[214] Up until this point, touchscreens were relatively awkward – requiring a stylus or a fair amount of pressure to operate (e.g., the glitchy touchscreen interfaces of ATMs). While the iPhone was not the very first phone with a touchscreen (the LG Prada and HTC Touch both featured touchscreens), it was certainly the most widespread and popular device to use the technology. This was due to Apple's significant overhauling of the touchscreen technology. The iPhone used glass, not plastic like previous models, which allowed it to maintain a clear and luminous screen. The glass screen allowed the iPhone to play high-resolution video. (Apple pioneered the use of an obscure type of glass that was highly durable and less prone to cracking and breaking than traditional material.) The iPhone's touchscreen sensors were unique as well, deploying multitouch technology, with which continuous parts of the screen could be activated – this allows for the iPhone's pioneering of touching and swiping as modes of interaction. When Jobs demo-ed the swipe scrolling feature in his keynote, it was a literal showstopper - the audience broke into applause. The *New York Times* review remarked that with the new touchscreen interface "the screens have a physics all their own. Lists scroll with a flick of your finger […] much faster than scroll bars."[215]

Multitouch has a relatively long history, including a specialized touchscreen used in the 1970s at the CERN particle accelerator, and a tablet developed for Xerox PARC in 1984 by Bill Buxton. In 2005, Apple acquired a company called FingerWorks, which produced touchpad input devices that were used by individuals with impaired movement in their hands. FingerWorks' technology became the base from which the iPhone touchscreen was developed.[216] While it might not have been the first, Apple's multitouch screen was the most effective. As Bill Buxton has said, "Up until that point, you poked, you prodded, you bumped, you did all this stuff, but nothing flowed, nothing was animated, nothing was alive, nothing flew. You didn't caress, you didn't stroke, you didn't fondle. [..] Things jumped; they didn't flow."[217] Buxton's description is revealing of how essential the interface design of the iPhone was to its success, and what set it apart from its competitors. There was a unique fluidity and seeming immediacy to the iPhone, as the touchscreen interface gave the appearance of more direct, unmediated interaction with the device.[218]

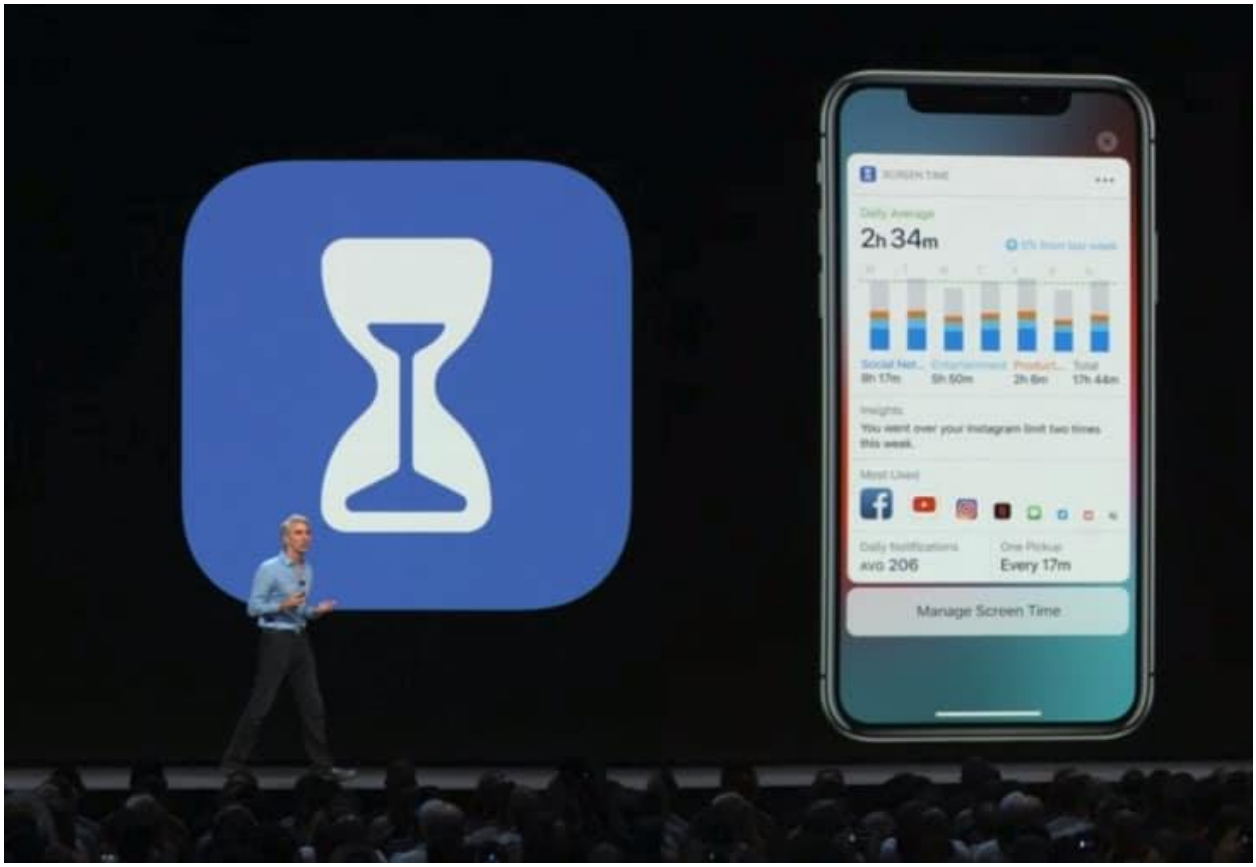
Touch scrolling was emphasized in the iPhone's original marketing campaign, which was simply a close-up of a hand showing off everything that was capable with the new device. This anonymous user makes phone calls, searches the internet, watches YouTube videos, but above all scrolls: he scrolls through lists of search results online, through the library of songs, through photos.[219] In addition to the touchscreen interface, the advertisements also show off the iPhone's other iconic innovations such as inertial scrolling (the appearance of drag slowing down an automatically scrolling list of results) and the gyroscope (which enabled the phone to automatically reorient itself when turned on its side). Unlike previous internet-enabled mobile devices, the iPhone gave the appearance of greater ease and mobility in accessing the internet. As one reviewer observed at the time:

> "The iPhone will make access to the Internet on the move a much more pleasurable affair. […] Anyone working their way through a lengthy series of drop-down menus or trying to type accurately on a tiny keyboard finds the experience frustrating, and may also be unable to access parts of the Internet. What Apple set out to do was to

> give the user unrestricted access to the Internet via an operating system (OS) comparable to that found on most desk-top computers as well as to simplify the process of making voice calls, listening to music and managing contact lists. That was achieved by replacing the keyboard with a touch-screen that could immediately replace one set of button functions with another according to whether the user wanted to make a voice call, send an e-mail or whatever."[220]

A large part of the iPhone's charm lay in the way it made accessing the internet while on the move an increasingly fluid and effortless activity. Lev Manovich has described Apple's design as emblematic of an "aesthetics of disappearance," a style whereby the technology is rendered increasingly invisible.[221] The ease of scrolling introduced by the iPhone's multitouch touchscreen was an ideal interface for the "just give it to them" design of Twitter and Facebook News Feed's infinite scroll.

"Never Look Away": Addiction, Feedback, Flow



The business model of platforms like Facebook and Twitter relies on users spending as much time as possible scrolling and clicking through their feeds. The innovations outlined above – the removal of pagination in search results, Twitter and Facebook's continuous, automatically updating feeds of information, the fluidity of multitouch touchscreens – are all related to this imperative. As Nick Srnicek articulates it: "the platform business model is predicated upon a voracious appetite for data that can only be sated by … constant outward expansion."[222] The

platforms need new users, more data, more time on device in order to generate value. In the case of social media, they do so by mining users' social interactions. "Platforms are designed as a mechanism for extracting and using that data: by providing the infrastructure and intermediation between different groups, platforms place themselves in a position in which they can monitor and extract all the interactions between these groups."[223] Because the strategy of social media requires them to increase the time spent using their platforms, they benefit by maximizing the pleasurable, even addictive qualities of the platforms.

Siva Vaidyanathan argues that the addictive or habit-forming qualities of social media are central to these platform's design. Contrary to claims that the harmful effects of Facebook – the bullying, the surveillance, the misinformation – have to do with either the content or with specific users' habits, Vaidyanathan argues that the ills of Facebook can be directly attributed to the functioning of the platform itself. In the case of Facebook's habit-forming effects, Vidyanathan describes how the platform retains the attention of its users by delivering pleasure in unpredictable intervals.[224]

As psychologist Adam Alter points out in a popular book on internet addiction, like the rats studied in psychologist B. F. Skinner's famous study of behavioral addiction, "we're more driven to seek feedback when it isn't guaranteed."[225] This reward structure is central to one of Facebook's key innovations: the "like" button. Alter observes: "What had begun as a passive way to track your friends' lives was now deeply interactive … Users were gambling every time they shared a photo, web link, or status update. A post with zero likes wasn't just privately painful, but also a kind of public condemnation."[226] App designer Rameet Chawl has described the Facebook 'like' button as "our generation's crack cocaine."[227] (A number of sociological studies have come out documenting the harmful effects of social media, which led Facebook to remove the numerical tracking of likes on its platforms.) These platforms' addictive techniques, and how central these are to how social media operate, are no secret. Shoshana Zuboff writes: "Facebook's marketing director openly boasts that its precision tools craft a medium in which users 'never have to look away,' but the corporation has been far more circumspect about the design practices that eventually make users, especially young users, *incapable* of looking away."[228]

In addition to unpredictable results, sensory feedback is an essential characteristic to the addictiveness of social media. In the influential design bible, Don Norman's *The Design of Everyday Things,* feedback is described as one of the fundamental principles of interaction. "Feedback must be immediate: even a delay of a tenth of a second can be disconcerting. If the delay is too long, people often give up, going off to do other activities."[229] Alter cites feedback as an essential dynamic in any behavioral addiction, and especially the ways in which video games, social media and other networked apps engage users. Alter narrates how game designers amplify feedback, particularly the kind that matches the physical sensations of game play to those of the real world. This sort of immediate sensorial feedback is why the iPhone's touchscreen interface is so engaging – it mimics the physics of the real world and gives users the sense of tactilely manipulating the interface.

A sense of agency and control is a hallmark feature of digital media. From the 1990s to the mid-2000s, the new phenomenon of web surfing was characterized according to a freedom of movement, as an agential experience, that distinguished it from other types of media consumption such as television or cinema. As Tara McPherson described the experience of web surfing, "unlike television, which parades its presence before us, the Web structures… a liveness which we navigate and move through, often structuring a feeling that our own desire drives the movement."[230] While the "just give it to them" of the infinite scroll is potentially less active than

traditional web browsing, whereby the user is intentionally seeking out specific websites to visit, neither is it as passive as the experience of broadcast viewership. While scholars have pointed out the sense of control or agency associated with the practice of channel surfing,[231] television is mostly characterized as a medium that delivers a continuous stream of information to a passive viewership. Raymond Williams' concept of flow is premised on a televisual spectator who is passively receiving the continuing sequence of television programming. Televisual flow is powerful precisely because it compels the viewer to not click away. Williams writes, "…many of us find television very difficult to switch off …again and again, even when we have switched for a particular 'programme,' we find ourselves watching the one after it and the one after that. The way in which the flow is now organized, without definite intervals, in any case encourages this."[232] Unlike television, social media scrolling presents an illusion of agency, in that the user needs to actively draw down the feed. The social media user is not the passive couch potato but is actively choosing to receive more information. The action of scrolling gives the illusion of participation. This is again, a phenomenon associated with digital media - a quality that Tara McPherson called "Volitional mobility," that replaces the planned flow of television. She writes, "we feel we create the sequences rather than being programmed into them."[233]

In a study of the digital transformation of the gambling industry in the last thirty years, anthropologist Natasha Dow Schull provides an insightful case study into how interactive digital media are engineered to extend "time on device." Schull's research on how machine gambling is intentionally designed to extend time on play, to maximize the affective rewards and frictionlessness of the games in order to extract more value from users, is analogous to similar techniques used in social media feeds. She identifies a tension between frictionlessness and agency that is essential to maintaining the user's attention. The machine gamblers Schull studied most often described the feeling as a trancelike or hypnotic state. Schull conceptualizes this pleasure in terms of the psychological concept of the "flow state," in which the subject is pleasurably and completely immersed in an activity. A term introduced by psychologist Mihaly Csikszentmihalyi in his 1975 text, *Beyond Boredom and Anxiety: Experiencing Flow in Work and Play*, "flow" is described as being in an optimal state of absorption in a task, such that external awareness and concerns recede.

This feeling of complete absorption and presence is maximized in the video gambling interfaces that Schull studies. The interfaces of casino games are designed to be as immediate and impediment-free as possible. Ergonomic features encourage prolonged playing: "machine designers expedite 'continuous gaming productivity' by eliminating obstructions in the physical and temporal flow of the wagering activity."[234] Moreover, "Visual consistency, acoustic harmony, tactile confirmation: designers seek to extend time-on-device by creating an intimate reverberation between technical elements and the human senses."[235] In the same way that the tactile feedback of the iPhone interface gives the illusion of a more immediate interaction with a given application, machine gambling seeks to remove impediments, inconveniences, or even reminders of the outside world. They have perfected the principles of "just give it to them," by removing opportunities to stop playing.

Affective flow was originally theorized in relation to boredom and anxiety, and Schull observes that video gambling's addictive design creates affective states that prey on people's need to escape contemporary anxieties and uncertainty. "The solitary, uninterrupted process of machine play […] tends to produce a steady, trancelike state that 'distracts from internal and external issues' such as anxiety, depression, and boredom."[236] This is especially the case with the gambling industry - the potential for monetary reward is a particular lure for those who are financially precarious. Scholars of digital media have described similar connections between constant media

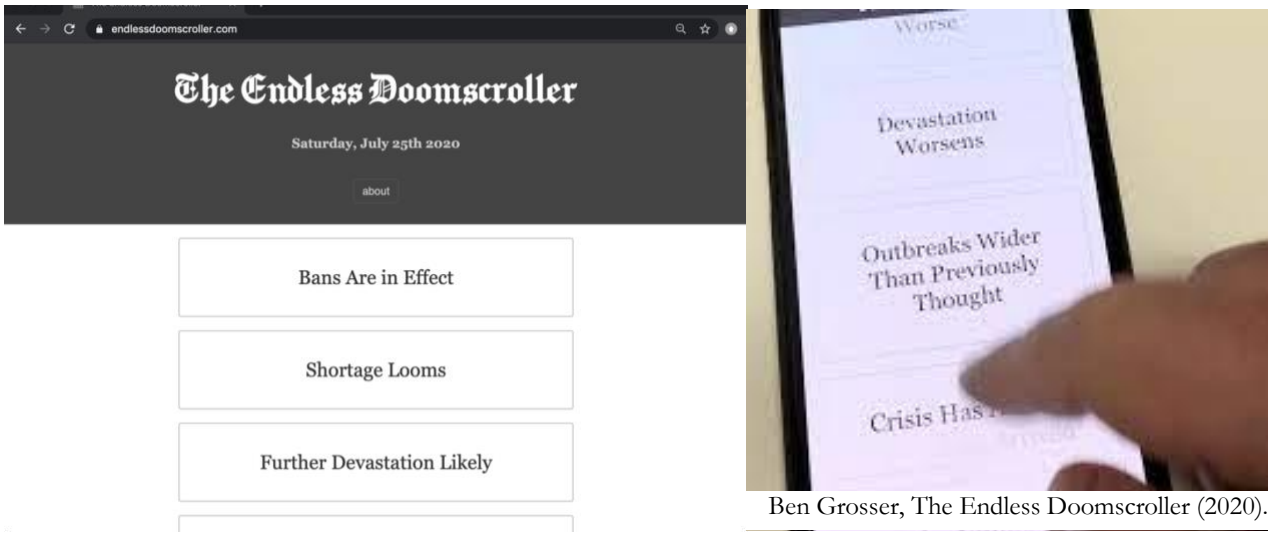
use and anxiety. In her study of buffering, Neta Alexander observes that the precarity of neoliberalism leads to perpetual states of anxiety. For Alexander, buffering – the state of suspension while waiting for media to load – exemplifies and exasperates the perpetual anxiety of neoliberalism and networked society. "Every time our fingers either click the mouse or touch the screen, we try to gain control by asserting our power over the machine. We thus fill – as well as feel – the empty time with neurotic, anxious movements..."[237] Ironically, social media can be a direct contributor to these contemporary anxieties. The negative emotional impact of social media, especially on young people, is well documented.[238] These platforms create a vicious feedback loop between the production of anxiety, and the alleviation of its effects.

Wendy Chun has observed that networked culture thrives on anxiety and the impression of constant states of crisis. Drawing on Mary Ann Doane's characterization of the temporal categories of live television as information, crisis, and catastrophe, Chun argues that the mode of crisis – an acute and timely situation that demands action – dominates networked media. She writes:

> "Crises have been central to making the internet a mass medium to end mass media […] Crises are central to experiences of new media agency, to information as power: crises - moments that demand real time response - make new media valuable and empowering by tying certain information to a decision, personal or political. … Crises mark the difference between 'using' and other modes of media spectatorship/viewing, in particular 'watching' television, which has been theorized in terms of liveness and catastrophe. […] New media is a crisis machine: the difference between the empowered user and the couch potato, the difference between crisis and catastrophe. From the endless text messages that have replaced the simple act of making a dinner date to the familiar genre of 'email forwarding accidents,' crises promise to move us from the banal to the crucial by offering the experience of something like responsibility, something like the consequences and joys of being in touch.'"[239]

Precisely because the crisis demands action – unlike information which washes over us, or catastrophe, which we watch with powerless awe – crisis feeds social media addiction. As Neta Alexander observed, our constant anxious scrolling may be read as an attempt to exert a sense of control.

The interdependence of crisis and scrolling is foregrounded in the notion of "Doomscrolling," which emerged in 2020 to describe the experience of compulsively scrolling



Ben Grosser, The Endless Doomscroller (2020).

through feeds of apocalyptic news (the pandemic, the climate crisis, the January 9th storming of the Capitol). In an effort to critique the ways in which social media feeds exploit crises, artist Ben Grosser produced an installation and website called *The Endless Doomscroller*, which presents an unending stream of cataclysmic headlines. As Grosser explains, "Doomscrolling isn't just a natural reaction to the news of the day—it's the result of a perfect yet evil marriage between a populace stuck online, social media interfaces designed to game and hold our attention, and the realities of an existential global crisis. Yes, it may be hard to look away from bad news in any format, but it's nearly impossible to avert our eyes when that news is endlessly presented via designed-to-be-addictive social media interfaces that know just what to show us next in order to keep us 'engaged.' More doom (bad news headlines) compels more engagement (via continued liking/sharing/posting) which produces more personal data, thus making possible ever more profit."[240] Grosser's *Endless Doomscroller* presents a stream of crisis headlines that have been entirely stripped of specifics. For Grosser, stripping away the content allows the mechanisms, rather than the content, of the platform to be the emphasis. The stream of vague proclamations - "Outlook Grim," "Crisis is Growing," "The Numbers Look Bad" – underscore a sense of rising panic and apocalyptic thinking.

While Grosser's project dramatizes the negative associations with scrolling, the infinite scroll remains as prevalent as ever as a mode of organizing the transmission of media. The history of the emergence of the infinite scroll, and its imbrication with the temporal demands of platform capitalism, reveal how the negentropic qualities that are unique to digital media have been uniquely maximized by platforms. The iterative, automatically produced, stream of media in the infinite scroll reinforce the sense that digital media are an endless resource. In the historical emergence of the infinite scroll we see dominant metaphors for the internet shifting from a web of distinct sites to something continuously flowing – from pages to streams. From "the river of new" that described blog aggregators in the mid-2000s, to the "infinity pool" of the iPhone touchscreen, aqueous and natural motifs naturalize the internet, turning it into something like a renewable resource, a river that will always replenish itself. This fantasy of limitlessness plays into longstanding capitalist fantasies: just as the ideology of industrial capitalism framed the natural world as freely available for extraction, digital capitalism frames social life as an endless resource to be exploited.

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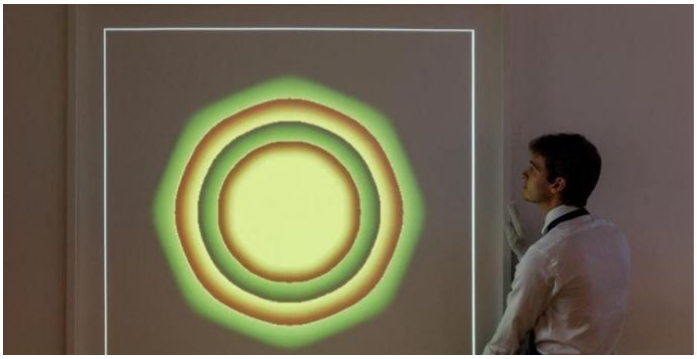
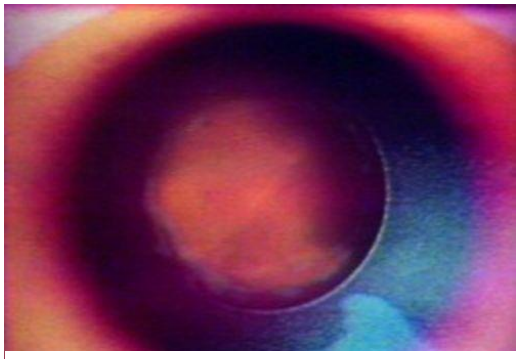
Cryptic Futures: The Endless Deferrals of Web3

The endlessness that has characterized the aesthetics of digital media since the emergence of visual computing in the 1960s continues to structure much of our networked culture. The iterative, indeterminate, ongoingness of the screensaver's generative animations or of the social media scroll is present in the ubiquitous autoplay functions of streaming media sites and in the interface design of myriad mobile applications - not only social media apps, but news readers, e-commerce apps, media players and search engines. As much as it ever was, the internet is perceived as the "headless, anarchic, million-limbed" structure described by Bruce Sterling in the early days of the world wide web.[241] In recent years there has been a return to this utopian rhetoric that expressed the expansiveness of the early web, in part as a backlash to the corporatization of the internet under Web 2.0 and the emergence of platform capitalism. Proponents of the nascent Web3 - the internet based on blockchain technology – emphasize that its decentralized, nonhierarchical nature holds the potential to redistribute power, sidestep existing institutions, rewrite the rules, and foster community and collaboration. NFTs, one of the most visible phenomena of Web3, are touted as a populist art - a way around the gatekeeping of the established art world. In a representative example of the rhetoric that surrounds crypto art, at a major NFT convention in 2021 entrepreneur Enara Nazarova hailed NFTs as "a modern counterculture… [that will take us] from hierarchies to a networked world."[242] Her comment echoes the countercultural rhetoric of the 1960s and 1970s from which personal computers and the world wide web emerged, which hailed these technologies for potential to empower the individual and level pre-existing social hierarchies through the free circulation of ideas. Nazarova ended her talk with a rousing cry of the catchphrase: "To infinity and beyond!" Still, the internet is cast as a boundless space of exhilarating possibility.

The infinite aesthetic is freely embraced by the NFT community. To the extent that there are trends and tendencies in the field of crypto art, many of the tropes that have typified computer art from the beginning proliferate. Iteratively repeating patterns recall the expanded cinema of the 1960s and '70s, such as the early computer films of John and James Whitney or Stephen Beck's Video Weavings. Hypnotically swirling shapes and seamless video loops echo the *mise en abyme* of video feedback, while abstract patterns recall the blocky wireframe animations of early computer-generated imagery. NFT art has a tendency to celebrate uniquely digital aesthetics, embracing memes, pixel art, glitch, vaporwave, and generative graphics.

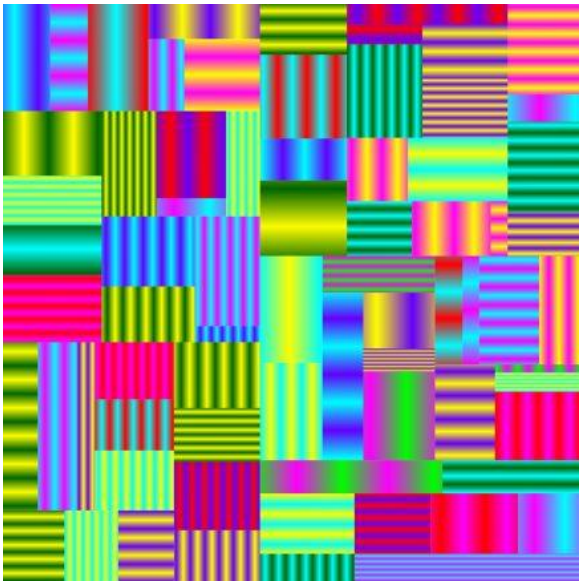


Kevin McCoy's *Quantum* (2014-2021) at Sotheby's auction in 2021.

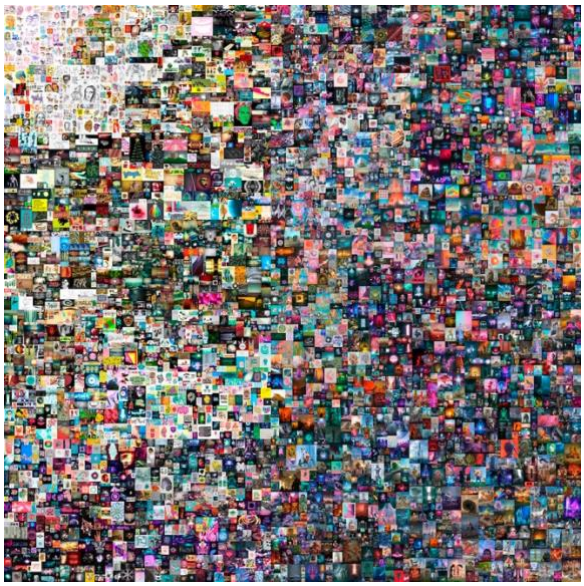


Stephen Beck, *Visual Music* (1973)

Some of the most famous NFTs are visual expressions of the infinite. What is often considered the first ever NFT is a short looping animation entitled *Quantum* (2014) by the artist Kevin McCoy. The abstract image features pulsating concentric circles of neon color in the center of a black frame, which the artist describes as "an ongoing, abstract, cycle of birth, death, and rebirth."[243] McCoy created the original piece with software engineer Anil Dash at an event at the New Museum of Contemporary Art in New York in 2014. McCoy, who had been involved in digital art for years, was attempting to find ways to authenticate digital works for the art market, and the two made use of the relatively recent blockchain technology to create a certificate of authenticity on the blockchain to verify the digital video as unique. More recently, a generative series of NFTs entitled *Endless Nameless* (2021) by the artist Rafael Rozendaal gained attention when it raised $430,000 as a benefit for the digital art organization Rhizome, the largest donation in the organization's history. *Endless Nameless* is a limited edition of 1000 algorithmically generated images, each a square divided into subsequently smaller sections of randomly selected bars of color. Each edition of *Endless Nameless* loops continuously, giving the impression of an endless succession of lines moving within the image.



Rafael Rozendaal, *Endless Nameless* (2021)



Beeple, *Everydays: The First 5000 Days* (2021)

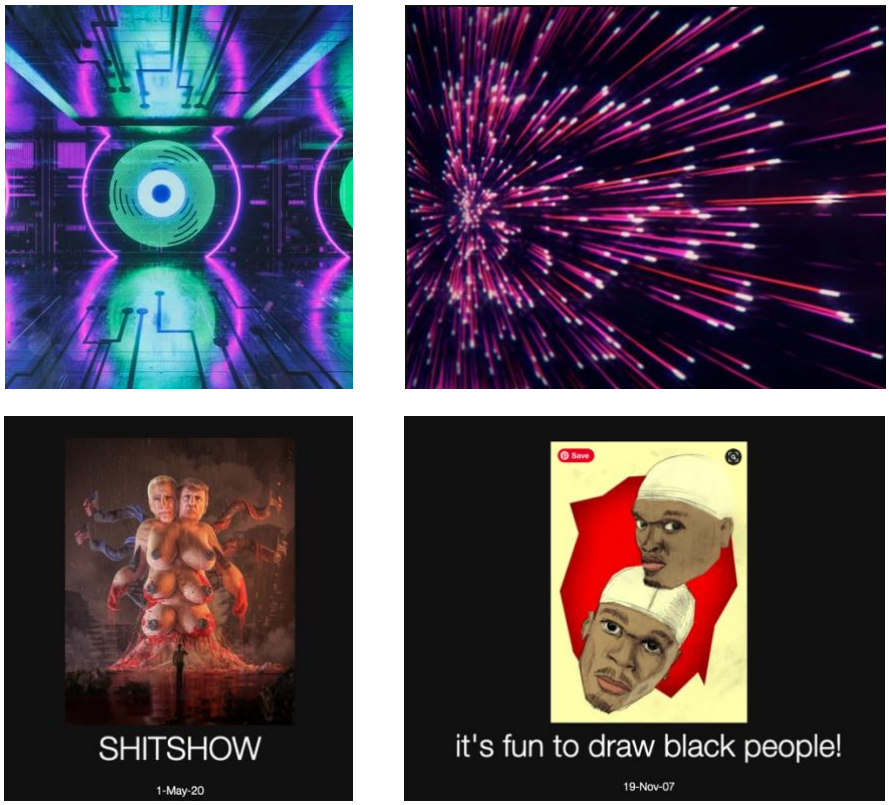
Arguably the most famous NFT to date is *Everydays: The First 5000 Days* by the relatively obscure artist Mike Winkelmann, who goes by the moniker Beeple, which sold for a record-breaking sixty-nine million dollars at the Christie's auction house in 2021. The sale was not only the first purely digital artwork to sell at Christie's and the highest price for a digital artwork ever, but it was the third highest price ever paid for the work of a living artist, behind Jeff Koons and David Hockney.[244] The sale of Winkelmann's NFT set off a furor over crypto art, marking the moment when what had previously been a relatively fringe phenomenon entered the mainstream. Some lauded NFTs for opening up the art market to non-specialists and allowing digital artists to

be compensated for their work, while others condemned it as a fad and a speculative bubble.

Everydays is typically rendered in media representations as a vast grid of minuscule images. The work is a compilation of computer-generated images that the artist created over the span of thirteen years. Although the individual images are organized chronologically, the work apprehended at this remote scale - taking in all 5,000 images at once - has no apparent visual logic. Although similar in some respects to Chuck Close's later paintings, which arrange a multitude of abstract images in such a way that in aggregate they resolve into a meaningful image, Winkelmann's work does the inverse - it takes a vast number of distinct images (many figurative), obscuring much of their signification when taken all together.

The majority of the *Everydays* images are composed using Cinema4D, a popular software for creating three-dimensional computer graphics. While many of the images depict satirical cartoonish figures or fantastical scenes, a great many of the images are abstract. Like a good deal of NFT art, their iterative designs are evocative of early computer-generated art, from Ben Laposky's oscilloscope drawings of the 1959s and A. Michael Noll's *Gaussian-Quadratic* (1962), to Vera Molnar and Manfred Mohr's computer drawings of the 1960s. These iconic images all directly comment on their means of production - a sort of "cinema of attractions" of early computer art, to use Tom Gunning's term for the earliest moving images showing off what was possible with the new medium. In part the same is true for Beeple's *Everydays* – its images originated as the artist's attempts to master the (then new) Cinema4D animation software. In reflecting the aesthetic range of new CGI technology, the images are also evocative of the feedback loops created at NCET, the Bay Area video art lab in the late 1960s, where artists pioneered visual aesthetics for new electronic tools. Wineklmann's abstract animations, like the repetitive machine-generated abstractions at NCET, provide a visual spectacle; what is less clear is their intellectual or cultural value.

Winkelmann began publishing online the images that would come to comprise *Everydays* in May of 2007, within a year of the launch of Facebook News Feed and Twitter. His project - sharing personal information and creative output online, often daily - reflects the early 2000s blog culture that epitomized this phase of Web 2.0. Spanning from 2007 to 2021, *Everydays* provides a record of almost the whole duration of Web 2.0. And the work comprises some of the most distinctive and least savory aspects of Web 2.0 - many of the images in *Everydays* are shockingly racist, misogynistic, homophobic and bratty outbursts. While the artist's more recent work is often generously read as satirical (unflattering images of Donald Trump and Hillary Clinton are common tropes), as critic Ben Davis points out, it is difficult - if not impossible - to find any culturally or conceptually redeeming qualities to the majority of his work. Racist caricatures with the caption "It's fun to draw black people," and pornographic images of young women seem to express, rather than comment on, the divisive and dark rhetoric that proliferates on social media platforms. As Davis points out, it's hard to imagine the Christie's auction house hanging these individual images in its galleries - at least not without igniting considerable debate. Which points to the fact that the content of *Everydays* is the least meaningful aspect of the work.



Images from Beeple's *Everydays*

Beeple's series of artworks produced daily follows the logic of canonical works of conceptual art such as Tehching Hsieh's *One Year Performances* (1978-1986) or On Kawara's date paintings (known collectively as *Today*, 1966-2013). Yet, while these works index time, process, and labor - the Beeple piece, because it only became meaningful when sold at auction, indexes the speculative crypto art market more than it does anything else. It is hard not to read this - an artwork that only exists as a commodity and a cultural flashpoint, with nothing at its core but the visual equivalent of thousands of childish tweets - as deeply cynical. But then again, maybe this is what makes it the ultimate networked artwork - it directly indexes the glut, the mundanity, of social networks. The framing of these images into a single commodified artwork represents a culmination of this phase of the internet, and its transition into the financialization of Web3. Other high-profile NFT sales underscore this sense of a sea change: for example, Time Berners-Lee sold the original source code of the World Wide Web as an NFT in 2021,[245] and that same year Jack Dorsey sold an NFT of the first tweet.[246] It would seem that Web 2.0 is being repackaged as a commodity for exchange in web3.

Everydays is unique for being a financially significant artwork that has had remarkably little cultural significance, at least until the point of its record-breaking sale. Unlike the other top-selling artworks by living artists (such as Jeff Koons, Gerhard Richter, and David Hockney), very few people had actually seen it at the time of its sale, even including the buyers.[247] It hasn't been featured in exhibitions or shows or written about outside of the context of the novelty of its medium and the sale. The buyer who purchased Beeple's NFT is a digital asset investor, Vignesh

Sundaresan (who goes by the pseudonym Metakovan) who has been very clear that he purchased the work as a financial investment. "I think this is going to be a billion-dollar piece - I don't know when," he has said.[248] Sundaresan, a tech entrepreneur based in Singapore, and an early investor in cryptocurrency, is the founder of Metapurse, an investment firm that works exclusively in crypto currencies. The purely speculative nature of the sale later became even more apparent when it was reported that Sundaresan was actually a business partner of Mike Winkelmann's, suggesting that the two orchestrated the sale to inflate the value of Sundaresan's cryptocurrency firm.[249]

As Ian Bogost has argued, the function of NFTs is ultimately to "turn digital data into speculative financial instruments." He writes: "Like any security, an NFTs worth has less to do with what it is than what it might be worth. Just as the pork-futures commodity trader is not principally interested in taking delivery of pig meat, so the NFT trader is not necessarily concerned with the usefulness or even the symbolic value [of the NFT]."[250] This is openly acknowledged and indeed embraced by the NFT community. Reporting on a 2021 NFT convention, Ben Davis noted a presentation called "The Master Formula for NFT Value," in which Justin Herzig, co-founder of the NFT firm Own the Moment, shared his "formula for success" in NFT investing: that "Speculative Value * (Aesthetic Value + Utility) = NFT Value."[251] As this equation makes clear, the cultural significance or any other function an NFT might have are of lesser importance than its status as a financial investment.

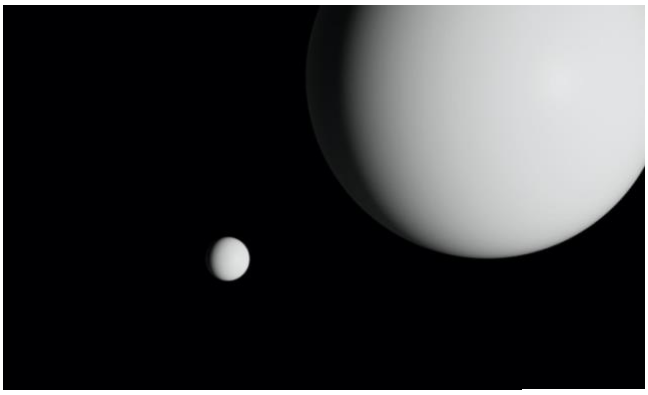
Presentation at NTF.NYC 2021, from Ben Davis.

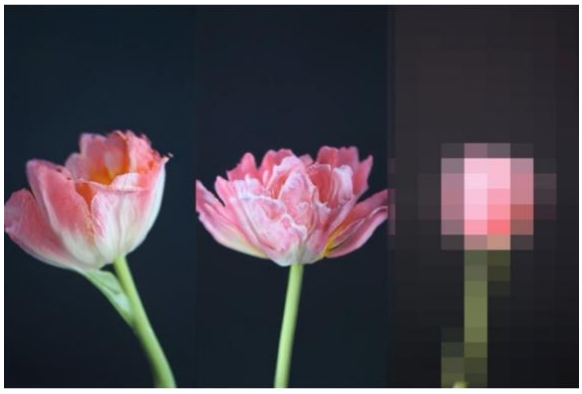
Since the 1980s, art's function as a financial investment has grown. Art historians cite the 1973 sale of the collection of Robert and Ethel Skull as a landmark in the evolution of investing in art. The couple had purchased numerous works early in the careers of artists who would go on to be extremely famous (for example, they purchased a work directly from Robert Rauschenberg in the late 1950s for only $900). The auction was enormously successful, and thereby, according to curator Barbara Haskell, "established the idea that modern art could be a really effective money-making tool."[252] As Noah Horowitz catalogs in *The Art of the Deal*, the trend of buying and selling art for a profit intensified after the burst of the dot com bubble in the early 2000s: at the time "speculation was rife about how to make money from art and there was a sharp rise in the number of art investment funds seeking to strategically buy and sell artworks for profit."[253] The art market's abstracting of an artwork's cultural or artistic value from its financial value is made all the more evident when one considers the rise of practices such as collectors keeping their art in storage facilities in international freeports where they are exempt from taxes. Journalist Georgina Adam quotes an anonymous New York dealer revealing that "in the last year, I only physically saw one piece of art that I negotiated. Everything else was bought and sold via jpegs and remained in storage."[254] In this light, the fact that so few people had seen Beeple's *Everydays*, is in line with what one would expect. This is what Hito Steyerl terms "duty-free art" – art that remains hidden

in freeport tax havens and exists solely for financial investment. As she writes:

> "They move from one storage room to the next without being seen. They stay inside boxes and travel outside national territories with a minimum of tracking or registration, like insurgents, drugs, derivative financial products, and other so-called investment vehicles. For all we know, the crates could even be empty."[255]

The centrality of financial speculation to Web3 is evident in an NFT project called *Merge* by the artist Pak. The work, a dynamic NFT, was sold in "open editions": unlike with a limited edition, a potentially limitless number of copies can be sold. *Merge* depicts a graphic of a white 3D sphere against a black field. The sphere grows in size depending on how much money the buyer spends on it. During the 48-hour period of the sale, buyers were allowed to purchase as many units of *Merge* as they wanted. Units were initially priced at $575 and increased throughout the sale. Buyers also receive a dynamic NFT that represents the total volume of all units sold. Because collectors can buy or sell units after the sale on the secondary market, the piece is continually in flux. Supposedly 28,000 buyers purchased *Merge* units, generating a total sale of $91 million. Merge is a revealing example of NFT art because its subject matter is its own value: *Merge* is just a white circle on a black background – what makes it unique is its ability to index its own sale in real time. A similar project, *Plantoids* (Primavera De Filippi, 2015) is composed of robotic sculptures shaped like plants that light up and "come alive" any time someone donates bitcoins to an online wallet associated with the piece. On the one hand, the way in which the robots respond to input from distant individuals can be read as a representation of a potentially diverse community distributed in space, united around this common interest. And yet the fact that the mechanism for interacting is cast in the terminology of finance (and indeed literally does involve financial transactions), represents how in Web3 the mechanisms of distributed networks are almost entirely coopted by financialization.





Pak, *The Merge* (2021) and Anna Ridler, Bloemenvieling (2019)

The British artist Anna Ridler takes a critical view on the speculative nature of the crypto economy with her work *Bloemenveiling* (2019). The project is an auction of NFT tulips, a reference to the Dutch "tulip mania," the seventeenth century speculative bubble of tulip bulbs. Ridler created 100 short video pieces of AI-generated tulips, which were then sold as NFTs on the Ethereum network. A network of bots participated in the sale alongside the human collectors,

thereby artificially raising the value of each NFT, a gesture meant to mimic the automated trading algorithms of high frequency trading. After a week, however, the AI tulip is "blighted," and the moving image can no longer be viewed. What remains is just the record of the sale on the blockchain, and the contract, which can in fact still be traded. As the artist explains: "While the artificial intelligence behind the moving image pieces has the potential to generate infinite flowers, the enormous, distributed network behind Ethereum is used, at great environmental cost, to introduce scarcity to an otherwise limitless resource."[256]

This is the irony of the NFT: transforming a medium that was once embraced for its potential to create endlessly proliferating copies into one of artificial scarcity. Digital images are fundamentally reproducible, and this has been part of their appeal. Ironically, digital art, especially net.art, initially represented a critique and alternative to the high-finance art world, partly because it was difficult if not impossible to collect. This ideal is exemplified in the now-iconic *Simple Net Art Diagram* (MTAA, ca. 1997). The simple illustration of two computer terminals linked by a line and the words "the art happens here," articulates the popular notion that net.art is action, performance, communication, that it is intangible and in transit. MTAA, the artist duo who created the work, released it under a Creative Commons license, allowing others to reuse it. This embrace of the internet as a space for the circulation of images outside of the structures of capitalism is Hito Steyerl's oft-cited essay, "In Defense of the Poor Image," which celebrates the wide circulation and reappropriation of low-resolution, low-value images made possible online.[257] Yet Steyerl acknowledges the inherent tensions involved in an anti-hegemonic, anti-capitalist art that is facilitated by the commercial world wide web. "On the one hand, [the poor image] operates against the fetish value of high resolution. On the other hand, this is precisely why it also ends up being perfectly integrated into an information capitalism thriving on compressed attention spans, on impression rather than immersion, on intensity rather than contemplation."[258]

As digital art became increasingly mainstream, the immateriality of this art came to be seen as a challenge to be overcome. As Erika Balsom argues in her study of art "after uniqueness", "circulatory reproducibility has been conceived of as both a utopian promise and the site of a dangerous inauthenticity."[259] If, as Walter Benjamin so famously pointed out, photography and film's infinite reproducibility has radical potential for open and egalitarian access, it also leads to some anxiety about the status of the art object. For decades the art world has made recourse to limited editions and certificates of authenticity in an attempt to rein in the photographic image's tendency towards proliferation. The practice of placing artificial limits on the number of prints that can be made is longstanding in photography and has become commonplace in collectable moving image art as well.

In recent years there have been attempts made by the digital art world to adopt these models. Curator Christiane Paul, for example, has directly addressed the inherent difficulty in collecting, preserving, and supporting digital art, positing strategies for making this ephemeral work assimilable in traditional art institutions. [260] The gallerist Kelani Nichole, who founded a gallery specializing in digital art, has advocated for adapting the certificate model to digital works. When a digital work is acquired through her Transfer gallery, the collector receives (a certificate of authenticity as well as a physical file of the object and occasionally some display or physical artifact). Nichole has been an early advocate of NFTs as a way to easily incorporate digital art into the art market. NFTs make it easy to buy and sell digital art, although what you are actually buying

and selling is not always clear. Ian Bogost points out that an NFT is a certificate of sale but does not include rights to reproduce the image or even the original file – you are essentially buying the certificate of ownership but not the work itself.[261]

If certificates of authenticity have been an acceptable practice within the art world for decades, what makes NFTs different? In theory, as long as there have been digital files it has been possible for Christie's to sell a certificate of authenticity for a digital artwork. Why are NFTs suddenly so valuable? Part of the appeal of crypto art is that a traditional certificate of authenticity was backed by the institutions of the art world – galleries, museums, scholars, critics – as well as existing financial institutions. Whereas crypto art is backed by the blockchain. In investing in crypto art as opposed other types of art, speculators are betting on the collapse of these existing institutions.

Previously a fringe phenomenon, Cryptocurrencies and NFTs didn't really enter mainstream discourse until the pandemic. The received wisdom is that, with a large part of the world interacting mainly through the internet, the increase in disposable funds coupled with extreme anxiety and uncertainty, led to a population primed for internet speculation. As Tressie McMillan Cottom has pointed out, the majority of crypto investors are nonwhite and non-college-educated.[262] Crypto's promise of individual wealth, of bypassing the institutions that have denied access to economic prosperity, appeals to those who are the most financially precarious.

The theory behind blockchain emerged in response to a previous moment of uncertainty - the 2008 financial crisis. The notion of a currency based on a distributed ledger is attributed to a 2008 paper by the pseudonymous Satoshi Nakamoto entitled "Bitcoin: A Peer-to-Peer Electronic Cash System." When trust in existing financial institutions was compromised, Satoshi offered a financial system "based on cryptographic proof rather than trust." Satoshi wrote: "What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. Transactions that are computationally impractical to reverse would protect sellers from fraud, and routine escrow mechanisms could easily be implemented to protect buyers."[263]

The distributed nature of crypto appeals because it promises to remove centralized power. But while the blockchain circumvents existing institutions such as the world financial system or government regulations, it merely displaces trust in these social institutions to trust in an algorithmic system. Like so many computational technologies, blockchain remains a complex mystery to many. Those who understand and control the technology have a significant advantage. And while in theory Web3 is more egalitarian, due to the complexity involved in mining blockchain, the reality is that mining activities - the process of completing complex calculations to verify an entry on the ledger - are centralized with a few powerful commercial enterprises. A further irony stems from the fact that because it is unregulated and little understood, scams and exploitation are frequent occurrences.[264]

We can read the recent interest in blockchain enabled technology as symptomatic of rising insecurity, of apprehension about the future. Speculation and the promise of future reward appeal when traditional avenues of wealth and security are threatened. Writing about the COVID19 pandemic, Judith Butler noted a rising sense of mourning for the future. She writes: "Before the pandemic, the future horizon was already closing or closed for many people forced to move between jobs, who saw no real increase in wages, and found that rents, debts and medical costs belonged to the expanding category of 'the unpayable.' Their entire sense of future is structured by that unpayable debt: it becomes a form of bondage, infinite and without end."

Speculative digital media like cryptocurrency, crypto art, and computerized high frequency trading all normalize an intensification of indebtedness. Feminist scholar Lisa Adkins, writing about how the 2008 global financial crisis intensified the exploitation of domestic debt, observes that post-Fordist capitalism is characterized by a logic of speculation. Value in this system is accrued from commodifying personal debt, in the form of mortgages, credit-card debt, unpaid parking fines, buy-now-pay-later apps, student loans, and similar forms of predatory lending.[265] In this system the default mode is not a linear repaying of debt, but remaining in a constant state of indebtedness. Because securitization benefits from debt, there is an imperative to maintain a constant state of indebtedness. Repayment schedules are variable, flexible and adjustable. Payments are deferred, are re-packaged and sold in constantly fluctuating markets. Adkins argues that for this reason, time in post-Fordist society is not linear and homogenous, as it was under industrial capitalism, but "nonsynchronous, indeterminate, and unpredictable." It is "a time in which pasts, presents, and futures do not flow chronologically or in sequence but are open to a constant state of revision."[266]

Sarah Sharma, in her analysis of the contemporary culture of time, observes that time in late capitalism is not experienced the same by everyone. Time, she argues, is experienced in highly unequal ways. "Temporalities do not experience a uniform time but rather a time particular to the labor that produces them. Their experience of time depends on where they are positioned within a larger economy of temporal worth."[267] Those who are advantaged experience time as a resource to be capitalized on and improved upon; those who are disadvantaged are more likely to experience time as a source of pressure, as an exceedingly scarce resource. A white-collar executive optimizes her time with carefully calibrated time management systems and fetishizes the ability to master time through yoga retreats, meditation, and "slow" food. A taxi driver, however, experiences time as something external, that he has little control over – it is governed by the meter or the pace of the traffic around him and can be a source of both intense pressure and intense boredom.

Futurity is similarly experienced in unequal ways. For investment firms, venture capitalists and art collectors, the future is a space of capitalist expansion, a resource to be exploited. The future they are exploiting is often that of the indebted. In the 1960s, countercultural guru Stewart Brand embraced spatial metaphors of networked culture as a wide-open frontier. These metaphors of the electronic frontier, reenacting settler colonialism within the imagined spaces of the network, structured much of the culture of the early web. Today, Brand's efforts are centered on a fantasy of colonizing the future. His new project – The Long Now Foundation – is centered around building a clock that will run for 10,000 years, thus extending the present to a distant point. The Long Now exemplifies not only the hubris of Silicon Valley tech culture and its penchant for the technological sublime but represents its attempts to colonize the future. More than one tech billionaire has invested in a massive security bunker that will allow them to withstand environmental disaster and societal collapse – they are betting on it.[268]

In this dissertation I have tried to make an argument about the experience of time in the digital age. My animating question has been to ask how digital and networked technologies have affected our experience of time. In many ways, the story I have tracked has been one of the intensification of trends begun under modernity: of the telescoping of space by global information networks, of acceleration and instantaneity, the result of telecommunications infrastructures and computation technologies that perform their tasks at imperceptibly fast speeds. I have argued that the rupture of computation is to introduce a negentropic temporality to contemporary visual culture. The regenerativity at the heart of cybernetics (which nonlinear feedback describes) points to a shift,

from closed forms with inevitable endings, to iterative, looping, or ongoing forms, where the ending is constantly deferred. This unendingness is everywhere in digital culture, and I have outlined a few of its key instantiations in this study. Since its emergence in postwar cybernetics to the present, the infinite aesthetic of digital culture has transformed in ways that are in sync with how digital culture more broadly has evolved. Initially embraced for its mind-expanding and individual-empowering capacities, the infinite came to be enlisted in the capitalist structures of 24/7 networks and the attention or platform economies.

The question I am left with, in observing the infinite aesthetic's prevalence in Web3, is whether tracking this history has anything to suggest about future trajectories in the culture of time. In tracing the emergence and evolution of the infinite aesthetic since the beginning of real-time visual computing in the late 1960s, we can see that the temporality of digital culture has been a persistent presentness. The infinite aesthetic reflected the immediacy of real-time computing and its capacity to mirror and respond instantaneously. It was evident in new styles that emerged with the personal computer, such as the generative animation of the screensaver, with its continuous iterations. And it was exploited with great success by the attention economy in the infinitely scrolling social media feed. Now with the emergence of crypto art, the present is less important. The NFT exists not for the present, but for its future value.

To the endless work time and endless attention of the last thirty years of internet culture we can now add the endless deferral of the future, of perpetual states of indebtedness, speculative bubbles and the endless renegotiating of time. If time in the industrial revolution was about quantifying, commodifying standardizing time, in finance capital, an abstraction of time itself becomes the commodity. Finance capital is characterized by futures trading – turning the promise of the future into something that can be sold and resold now. As mathematical historian Brian Rotman points out, since the 1970s, money has ceased to be tied to commodities and trade and has the become a tautological sign. Money is itself a commodity to be bought and sold. This "xenomoney," as he calls it "signifies the possible relationships it can establish with future states of itself. Its 'value' is the relation between what it was worth, as an index number in relation to some fixed and arbitrary past state taken as an origin, and what the market judges it will be worth at different points in the future."[269] But the future and the present are unequally distributed. For some the future is an exciting space of possibility, where fortunes are made by cashing in on the artificially inflated value of xenomoney before it collapses. For most the future is ever deferred, as they remain in a perpetual state of indebtedness and anxiety.

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BitAcces which set up 100 Bitcoin ATMs in 18 countries between 2013-2015. In the blog, he revealed that he developed an interest in crypto in 2013. Sundaresan also announced a $500,000 fellowship for 'crypto storytellers' funded by his crypto investment firm, Metapurse." Priya Pareek, "Meet MetaKovan," *Republic World*, Mar. 19, 2021, https://www.republicworld.com/entertainment-news/whats-viral/india-born-entrepreneur-identifies-himself-as-mystery-buyer-of-beeples-69-dollars-mn-artwork.html.

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